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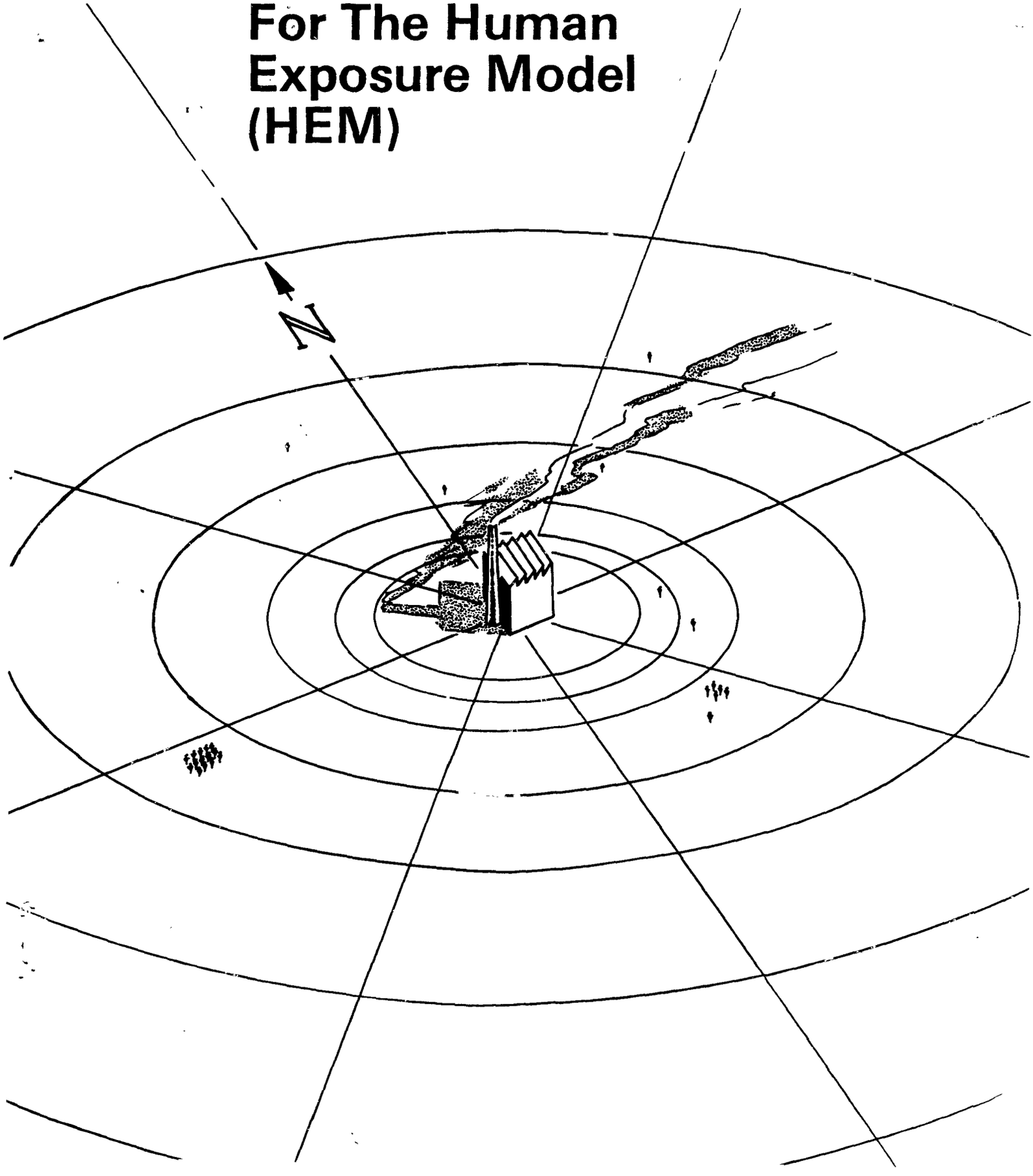
User's Manual For The Human Exposure Model (HEM)



USER'S MANUAL

FOR

THE HUMAN EXPOSURE MODEL (HEM)

Pollutant Assessment Branch
Office of Air Quality Planning and Standards
June 1986

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TABLE OF CONTENTS

Title	Page
Chapter 1	1-1
1-1. Introduction	1-1
1-2. When To Use SHED or SHEAR	1-2
1-3. Permanent Data Bases	1-2
1-4. Computer Access	1-9
1-5. Risk Estimates	1-11
Chapter 2	2-1
2-1. Introduction to SHED	2-1
2-2. Input Data	2-1
2-3. Dispersion Modeling	2-6
2-4. Assumptions	2-18
2-5. Using the SHED Model	2-20
2-6. Using Output from other Dispersion Models	2-37
2-7. Output from SHED	2-40
Chapter 3	3-1
3-1. Introduction to SHEAR	3-1
3-2. Input Data	3-2
3-3. Dispersion Modeling	3-5
3-4. Assumptions	3-10
3-5. Using the SHEAR Model	3-11
3-6. Using Output from other Dispersion Models	3-35
3-7. Output from SHEAR	3-37
References	R-1
Appendix A	A-1
Appendix B	B-1
Appendix C	C-1
Appendix D	D-1
Appendix E	E-1

List of Figures

Figure		Page
1-1.	Locations of STAR Stations	1-7
2-1.	Effects of Chemical Reactivity on Concentration Distribution of Chloroprene	2-8
2-2.	Effect of Building Wake on Concentration Distribution of Chloroprene	2-10
2-3.	Impacts of Release Height on Concentration Distribution of Chloroprene	2-11
2-4.	Pairing of BG/ED with Concentration Points Within a 3.5 Km Radius	2-14
2-5.	Log-linear Interpolation Scheme	2-16
2-6.	Summary of SHED Data Entry Format	2-31
2-7.	Typical SHED Data File	2-32
2-8.	Summary of the Input Data	2-41
2-9.	Individual Plant Concentration Grid	2-42
2-10.	Map of Population Centroids and Population by Grid	2-43
2.11.	Map of Population Centroids and Population by Patch	2-44
2.12.	Cummulative Summary	2-46
2-13.	Overall Summary	2-47
3-1.	@Qual Card for SHEAR	3-14
3-2.	Population Extraction Data for SHEAR	3-16
3-3.	Exclusion Data for SHEAR	3-19
3-4.	Chemical and STAR Data for SHEAR	3-20
3-5.	Point Source and Prototype Data for SHEAR	3-23
3-6.	Area Source Data for SHEAR	3-26
3-7.	Summarization Data for SHEAR	3-28

3-8. Plot Data for SHEAR 3-31

3-9. Selection of Center for Listing of Concentrations 3-33

3-10. Point Source and Prototype Data for SHEAR 3-34

3-11. Selection of ISC Output Files 3-36

List of Tables

Table		Page
1-1.	The SHED and SHEAR Models	1-3
1-2.	Comparison of SHED and SHEAR Results	1-4

Chapter 1

1-1. Introduction.

The Human Exposure Model (HEM) is a general model designed to estimate the population exposed to air pollutants emitted from stationary sources and the carcinogenic risk associated with this exposure. The HEM is comprised of (1) an atmospheric dispersion model, with included meteorological data, (2) a population distribution based on Bureau of Census data and (3) a procedure for estimating risks due to the predicted exposure. The only inputs needed to operate this model are source data, e.g., plant location, height of the emission release point, the temperature of the off gases, etc. Based on source data, the model estimates the magnitude and distribution of ambient air concentrations of the pollutant in the vicinity of the source. These concentration estimates are coupled with the population to estimate public exposure to the pollutant. The HEM then predicts population risks if a unit risk number determined from health data is input for the pollutant.

Within HEM there are two basic models, the Systems Applications Human Exposure and Dosage (SHED) model and the Systems Applications Human Exposure And Risk (SHEAR) model. The SHED model was developed to access sources on a nationwide source category basis, e.g., all primary copper smelters. It is generally faster and more economical to run SHED than SHEAR for major point sources (large producers and users). The SHEAR model was developed from SHED to model hot spots, or smaller regions with more than one source. In addition to modeling major point sources, SHEAR can also be used to model prototype sources (model plants) and area sources. Since the applications and actual data input of SHED and SHEAR vary, these aspects will be discussed in separate chapters of this manual.

1-2. When to Use SHED or SHEAR.

As explained above, SHED and SHEAR are two models within HEM which differ slightly in their purpose and scope. Table 1-1 summarizes the differences between the two models. This summary yields the following conclusions of which model should be used in a particular analysis:

1. Use SHED when addressing national exposure from one chemical.
2. Use SHEAR when addressing multiple chemicals from a source or group of sources and the assumption is valid that risks to human health can be approximated simply by adding together the risks from each chemical studied.
3. Use SHEAR when the source is located near uninhabitable areas such as large bodies of water and where the nearest population centroid is close (less than 1.0 km) to the plant.
4. Use SHEAR to assess the impact of area or prototype sources in small geographical areas.

These guidelines should assist in determining which model to use for a particular analysis. To show the possible differences which could be expected with SHED and SHEAR, the same plant was modeled using SHED and SHEAR. The results are outlined in Table 1-2. For more detail on the model differences please refer to Chapters 2 and 3.

Certain components of SHED and SHEAR are similar, for example, the meteorological and population data bases. The subsequent sections of this chapter will address those features common to both models.

1-3. Permanent Data Bases

Four major types of data are essential for assessing exposures to and dosages of atmospheric chemicals:

TABLE 1-1. THE SHED AND SHEAR MODELS

AREA EVALUATED	SHED	SHEAR
SCOPE	NATIONAL (MAJOR POINT SOURCES)	LIMITED GEOGRAPHICAL AREA ANALYSIS (MAJOR POINT, PROTOTYPICAL*, AND AREA** SOURCES)
POLLUTANTS	SINGLE POLLUTANT RUNS ONLY	MULTIPLE POLLUTANTS
NUMBER PEOPLE EXPOSED	DOUBLE COUNTS IF SOURCES SITED NEAR EACH OTHER	NUMBER OF PEOPLE EXPOSED HELD CONSTANT
INDIVIDUAL RISK	MORE REALISTIC ESTIMATE (GENERALLY OVERESTIMATES SLIGHTLY)	UNDERESTIMATE
RESOURCES	INEXPENSIVE TO RUN	MORE EXPENSIVE

* ASSIGNS MODEL PLANTS RANDOMLY TO BG/ED CENTROIDS

** EMISSIONS ASSIGNED TO POPULATION OR ASSUMED TO BE UNIFORMLY DISTRIBUTED OVER AREA SPECIFIED

TABLE 1-2. COMPARISON OF SHED AND SHEAR RESULTS

2 Plants Modeled in New York City (50 Km Radius)

MEASURES	SHED	SHEAR	RATIO SHED/SHEAR
Maximum Lifetime Risk	2.4×10^{-3}	5.9×10^{-4}	4.1
Annual Incidence	1.0	1.0	1
Total No. of People Exposed	27,400,000	13,700,000	2
No. of People Exposed to Incremental Risk			
$>10^{-3}$	1,285	0	
$>10^{-4}$	32,270	43,900	
$>10^{-5}$	927,000	1,380,000	
$>10^{-6}$	13,700,000	9,460,000	
$>10^{-7}$	27,000,000	13,500,000	
$>10^{-8}$	27,400,000	13,700,000	
Maximum Concentration Modeled	8.0×10^{-1} (.2 Km, NE)	8.0×10^{-1} (.2 Km, NE)	
Cost (1986)	$ 6.63	$ 61.50*	

* This is the cost of running the point source portion of SHEAR only. To run point source, you must first run a population routine called XTRACT which would cost additional dollars. The exact amount depends largely on the population density of the area modeled. New York City is >$100.

> Emissions inventories of chemicals

> Atmospheric reactivities of chemicals

> Meteorological data

> Population distribution data

The first two of the four types of data bases are data specific for each chemical. These data must be input for each risk assessment for SHED or SHEAR. These data bases are covered under each section entitled "Input Data" in the SHED and SHEAR chapters.

Meteorological data and population distributions do not vary with the specific chemical but depend on geographic location. These are permanent data bases in the program. The remainder of this section provides further detail on these data bases. Systems Applications, Incorporated (March 1983 and May 1983) provide more detail on the creation of these data bases.

Health data are essential to derive population risks from population exposure. However, these data are provided in the form of a unit risk estimate, which is derived external to the exposure model. This health data type will not be discussed in this manual.

Meteorological Data

The dispersion computations carried out by the HEM require data on wind speed, wind direction, and the intensity of atmospheric turbulence. The turbulence intensity is represented by the atmospheric stability class. These data are provided by a permanent data base in the program known as the Stability Array or STAR data set.

Acquisition and Processing of STAR Data

Martin and Tikvart (1968) developed the STAR program from routinely collected meteorological data to generate frequencies and percentage frequencies of wind direction by speed classes for each stability category.

The specifications of stability categories depending on wind speed and sky cover were set up by Pasquill (1961) and were modified by Turner (1964). The program was adopted for use at the National Climatic Center (NCC), where archived records of all national reporting weather stations are kept. The most up-to-date version of the STAR data from all STAR stations in the country was obtained on magnetic tape from NCC, and the matrices of STAR frequencies used in the program were taken from these tapes.

The data sets on the NCC tapes were reprocessed into a format which includes 16 wind directions, six wind speed classes, and seven stability categories with categories A, B, C, and D_{day} in the daytime and categories D_{night}, E, and F in the nighttime. There are data sets for 312 stations in this reprocessed STAR data file. Figure 1-1 shows the locations of these STAR sites.

STAR Station Selection

By default, meteorological data recorded at the STAR station nearest to the source are used in the dispersion modeling for SHED. The nearest station is typically input for SHEAR, as well. (See Appendix A for location of the nearest STAR station.) However, local meteorological trends and topographic features may be more important factors in selecting a STAR station than is the absolute distance between the source and the station. A STAR station with climatological conditions most similar to those of the source of emissions may not be the nearest station, so the STAR stations may be manually selected to account for such situations.

Detailed STAR Selection Process

As stated previously, STAR stations can be manually selected such that they are in similar local meteorological regimes and are influenced by

Figure 1-1. Locations of STAR Stations

similar orographic (topography on the scale of mountain ranges) conditions as the emission sources. Major features which should be considered include the following:

> Surface thermal patterns, which can affect the local wind. For example, the local sea-land breeze wind system is usually limited to surface-based layers several hundred meters thick. Since this region is the atmospheric layer into which chemicals are emitted, consideration of these winds is important for chemical plants located on ocean coasts or adjacent to large lakes. Another example concerns foehn winds (winds flowing down mountains), the influence of which should be considered for emissions sources located in Montana (Chinook wind) and in Los Angeles County (the Santa Ana wind).

> Wind patterns may be obtained from the Climatic Atlas (U.S. Environmental Data Service, 1968) and from maps of the U.S. Geological Survey (1:500,000; 1:125,000).

> Topographical effects, such as that of mountain-valley wind. The behavior of the wind in ridge-valley topography depends both on the relationships between the wind direction and the solar azimuth, and on the orientation of the ridge lines and valleys. These local wind effects should be taken into consideration in the selection process, especially for emissions sources located in the valleys of the Cascades and coastal ranges (northwestern states) or the Appalachian Mountains (eastern states).

> Urban effects, including wind, low disturbances by urban thermal or frictional elements such as organized patterns of urban skyscrapers (Chicago, New York City, Los Angeles metropolitan, etc.). Such

features substantially influence airstream and, consequently, the diffusion of air contaminants. If an emission source is located in a small city, and if STAR stations in a large city and in a small city are equidistant from the emission source, then preference should be given to the STAR station in the small city.

Population Distribution Data Base

The HEM program uses the latitude and longitude from the input data in determining the population of the study area. The permanent data base is comprised of the 1980 Census Data Base broken down by Block Group/Enumeration District (BG/ED). Further information on this data base and the manner in which it is accessed is covered in the following sections.

Population Data Processing

The population data base contains the population centroid coordinates (latitude and longitude) and the 1980 population of each BG/ED in the country (about 300,000 centroids in 50 states plus the District of Columbia) as found in Master Area Reference File 2 (MARF2). In addition, the data base contains large arrays of descriptive and summary population statistics. While these data may be a valuable adjunct in certain types of exposure analyses, the size of the complete file interferes with efficient access to the small subset of information needed for most exposure calculations. For this reason, the permanent data base contains only the essential information in a form that permits rapid access to the relevant study area.

1-4. Computer Access

The HEM program is currently run on the National Computer Center's (NCC) UNIVAC computer system located at Research Triangle Park, N.C. The computer may be easily accessed by terminals located at Research Triangle

Park and at EPA's facilities in the NC Mutual Building in Durham, NC. Terminals in the Mutual Building are presently located in Rooms 934, 624, 654, 653 and 646A.

Access can also be obtained via the EPA regional offices or through any organization using the NCC system. To gain access to the computer, users must have an account to which the computer time will be charged and a user ID. Within the Environmental Protection Agency, user IDs and accounts are obtained through the ADP coordinator by contacting Pete Carter at (919) 541-3522. For information concerning interagency agreements contact Jim Obenchain at (919) 541-2122. To set up a contract for the NCC UNIVAC outside of EPA, contact Ms. Weaver of National Technical Information Service (NTIS) at (703) 487-4805. Ms. Weaver can send the appropriate forms which must be completed and returned. Ms. Weaver will also upon receipt of the completed paperwork, contact EPA to obtain an account number and user ID. To establish equipment compatability call TELE Communications at (919) 541-4506, FTS 629-4506 or (800) 334-0741.

The HEM is frequently under revision to ensure that the best information is incorporated. This manual will thus soon become outdated. Therefore, before attempting to operate HEM, please contact Michael Dusetzina, Brenda Riddle or George Duggan of the Pollutant Assessment Branch, at (919) 541-5645 or FTS 629-5645. These personnel can alert you to changes in the model and can help in deciding which version of the model may be most appropriate for your application. Once one of these is contacted and you have an account number and a compatible terminal, HEM may be run by following the instruction detailed in sections 2-5 and 3-5.

1-5. Risk Estimates

The HEM produces estimates of annual incidence and maximum individual lifetime risk. These numbers, however, should not be construed as the absolute health risks. HEM was designed to screen, 1) substances to be regulated, 2) source cagtegories to be regulated and 3) alternative control techniques. To produce results inexpensively with limited data (as required by screening techniques), HEM makes many simplifying assumptions. Since these assumptions are common among HEM runs, the results can be compared. Therefore, HEM results should be used only to compare within similar substances, scenarios, etc. for decision-making and <u>not</u> be presented as absolute values of risk.

The assumptions required to estimate the health risk with HEM involve both estimating the exposure to a substance and estimating the health effects due to this exposure. These assumptions are outlined below.

<u>Exposure Assessment</u>

The HEM estimates concentrations of a substance in the ambient air at specific points around a source. It is known, however, that pollutant exposure occurs for exposures other than ambient air exposures (i.e., food, water) and populations move through different microenvironments. This model also employs a number of simplifying assumptions including:

1. It is assumed that most exposure occurs at population weighted centers (centroids) of block group and enumeration districts (BG/ED) as the locations of actual residences are not contained in available databases. The model relies on information provided in a database developed by the U.S. Census Bureau.

2. It is assumed that people reside at these centroids for their entire lifetimes (assumed to be 70 years for calculating cancer risk).

3. It is assumed that indoor concentrations are the same as outdoor concentrations.

4. It is assumed that plants emit pollutants at the same emission rate for 70 years.

5. It is assumed that the only source of exposure is the ambient air and resuspension of pollutants via dust is not considered.

6. It is assumed that there is no population migration or growth.

7. The model does not provide for descriminating exposure situations that may differ with age, sex, health status, or other situations.

8. The model is designed to model for flat terrain.

Table 1 presents the directional impact some of these assumptions may have on the risk results. It is important to note that these estimates may not be universally applicable to all pollutants and source categories. Nevertheless, they should serve as a useful qualitative description of the effect each assumption may have on the risk estimates.

There is also uncertainty associated with various specifications required for running the HEM as well as uncertainty associated with the variables specified. These model specifications and variables include:

1. Given the variations in meteorology each year and with each location, there is uncertainty as to the extent to which the meteorological station used to model the site modeled is representative. This includes the selection of urban or rural for stability.

2. There is uncertainty associated with the emission estimates and the plant parameters used to characterize the emission source.

3. If the plant is not correctly located, there will be a problem in the matching of population census data with concentrations, which alters

TABLE 1. DIRECTIONAL IMPACT OF SIMPLIFYING ASSUMPTIONS ON RISK ESTIMATES

MODEL ASSUMPTION	MAXIMUM INDIVIDUAL RISK	AGGREGATE RISK	COMMENT
Exposure at centroids	Underestimates	Minimal underestimate	SHEAR underestimates risk close to the plant due to this assumption
Exposure at receptors	Overestimates occasionally	Minimal overestimate	SHED can overestimate with this assumption if no one lives at the highest concentration level
Indoor exposure equals outdoor	Overestimates	Overestimates	This assumes no indoor sources of the pollutant
Immobile population	Overestimates	No effect	Aggregate is unaffected because population leaving are replaced at the same rate
No individual behavior patterns	Underestimates	Underestimates	Individuals are at a higher risk due to outdoor or closer activities
Flat terrain	Underestimates	Underestimates	Unless the source is higher than the surrounding area, the plume impacts on rough terrain

risk estimates.

Table 2 presents some of the specifications required by HEM and the directional impact of selecting one specification rather than another. Again, these impact estimates may not apply to all situations and sources but may provide useful information for the general trend.

Unit Risk Value

The unit risk value constitutes all of the health risk information input required by the HEM. The uncertainty involved with the unit risk estimate depends on the amount, type and quality of data used in its development. For instance, when only animal data is available, a statistical upper bound is used to calculate the unit risk. When human data is available, a maximum likelihood estimate is used to estimate the unit risk. Although these are similar, the upper bound is often higher than the maximum likelihood estimate by a factor of 2 or 3. There are several areas that contribute to the uncertainty associated with the unit risk or cancer potency estimates developed by the Carcinogen Assessment Group. These areas are divided in a number of different ways but the following grouping is reasonable:

1. Extrapolation: Animal-to-man or route-to-route.

2. Absorption: When route-to-route extrapolation is employed it is necessary to examine, if available, absorption estimates that have been derived from controlled exposure studies using concentrations that are reasonably similar to the ambient exposures.

3. Model Specifications: The consistency of model specifications used in calculating the cancer unit risk estimates.

4. Pharmacokinetics: The consideration of pharmacokinetics especially for studies requiring route-to-route extrapolation.

TABLE 2. COMPARISON OF RISK ESTIMATES BASED ON VARIOUS HEM SPECIFICATIONS

MODEL ASSUMPTION	MAXIMUM INDIVIDUAL RISK	AGGREGATE RISK	COMMENT
Urban vs rural	Higher estimates	Lower estimates	Rural setting results in more stable meteorology and higher distant concentrations. Urban setting is less stable but generally produces higher maximum individual risk.
Stack height (low vs high)	Higher estimates	Somewhat higher estimates	Taller stacks cause greater dispersion within the 50 km area and hence lower concentrations
Exit velocity (low vs high)	Higher estimates	Higher estimates	Higher velocities cause more dispersion and lower concentrations
Emissions	Proportional	Proportional	Concentrations and risk are proportional to emissions
Diameter (small vs large)	Higher estimates	Higher estimates	Only affects the risk occasionally
Location			
Small city	Higher/lower	Higher/lower	Location of sources determines affected BG/EDs. Large cities are more likely to have consistent population density. Location can have a very large impact for small and medium cities.
Medium city	Higher/lower	Higher/lower	
Large city	Minimal	Minimal	

Chapter 2

2-1. Introduction to SHED

SHED is a model within HEM that is used primarily for major (specific) point sources (usually producers or large users of specified chemicals) on a nationwide basis. Each source in SHED must be specifically located by longitude and latitude. For each source the release parameters must be described, these include stack height, exit velocity, emission rate, etc.

SHED is relatively fast to run. After input of the data, the program may take only ten minutes of computer time to run as many as one hundred sources. This rapid processing causes SHED to be relatively inexpensive to run.

2-2. Input Data

As discussed in Section 1-2, the meteorological data and population data are part of the internal computer data base. The necessary input data falls into four categories:

> Source Location

> Emissions Data

> Vent Parameter Data

> Atmospheric Reactivities of Chemicals

Source location, emissions data and vent parameter data are always necessary to analyze sources. The atmospheric reactivities, however, are only necessary when the chemical is extremely reactive. For example, the atmosphere half-life should be specified for those chemicals with half-lives of less than three or four hours. The following section provides additional guidance on the information needed and possible sources of the information. How to input the data into a file for use by the program is discussed in Section 2-5.

To link the computed exposures to the cancer risk of the population, the unit risk estimate must also be included. Generally, these estimates are obtained from the Carcinogen Assessment Group in a Health Assessment Document (HAD) for the chemical. A unit risk estimate is the estimated risk of cancer to an individual if that individual is exposed to one $\mu g/m^3$ of the chemical for their entire lifetime. Hence it is expressed in units of $(\mu g/m^3)^{-1}$. If the unit risk is unknown, HEM assumes a risk of 1.0. The results then merely reflect the concentrations and the number of people exposed to those concentrations without estimating the health risk from that exposure. The "annual incidence" and "maximum individual risk" numbers reported using a unit risk of one may simply be multiplied by the correct unit risk number when it becomes availabale.

Source Location

The geographic location of the source must be identified in order to run the SHED portion of HEM. Specific point source locations may be determined generally from a variety of published sources. These include:

> Directory of Chemical Producers and Chemical Economics Handbook, published by Stanford Research Institute.

> "Chemical Marketing Reporter."

> U.S. Government publications, such as the U.S. Tariff Commission's Synthetic Organic Chemical Production and Sales."

> Reference guides, such as the "Kline Guide to the Chemical Industry."

> Other sources, such as trade associations, trade journals and periodicals, and technical journals and periodicals.

> Existing EPA exposure and risk reports.

Once the general locations (company name, city and state) of the point source are determined, geographic coordinates must be assigned. Geographic coordinate information can also be determined from a variety of sources. These include:

> Personal communication with state air agencies and/or EPA regional offices.

> Emissions inventory files (e.g., the National Emissions Data System (NEDS).

> United States Geological Survey Maps (U.S.G.S).

> Existing EPA exposure and risk reports.

In some instances, these sources will be able to provide geographic coordinates in Universal Tranverse Mercator (UTMs) units. These may be converted by use of a computer program on the UNIVAC system to geodetic coordinates (latitude/longitude). To use this program, please refer to Appendix B.

Emissions Data

Emission factors can be developed to estimate the emissions from the production, consumption, and incidental formation of the various chemicals assessed. The emission factor is expressed as the total kilograms of a specific chemical lost to the atmosphere per kilogram of the chemical produced or used. Multiplication of the emission factor by the quantity of the chemical produced or used at an individual site or in a specific geographic region during a specific time period yields the estimated emissions of the chemical, in kilograms, for that location.

The total emissions resulting from the production of a chemical or chemical intermediate use of a specific chemical are a summation of process, storage, and fugitive emissions losses:

> Process emissions are discrete losses that occur at process vents from reactors, columns, and other types of plant equipment.

> Storage emissions include losses from the raw material feed, in-process and final product storage tanks, as well as from loading and handling losses.

> Fugitive emissions are losses that result from plant equipment leaks, visual openings, evaporation from waste products, and other non-discrete sources.

If possible, emission factors should be determined for each of these types of emissions. To develop specific chemical emission factors various methods are available. Each method produces its own level of reliability of the resulting data. Below are listed some of these methods, in decreasing order of reliability:

> Plant Site Visits: Data are collected by actual site visits or from letters to producers. In certain instances this actual data from a few producers may be useful for preparing model plant parameters for a large number of producers.

> State Air Emission Inventory Questionaires (EIQs): The air EIQs for most manufacturing sites are on file at various state air agencies throughout the United States.

> Other Published Sources: A variety of published reports for different chemicals and types of sources have been prepared by EPA and for EPA by contractors. The most recent publications should be used.

> Engineering Estimates: Occasionally certain pollutants are produced or used in a similar manner. In such cases, estimates from an unknown process can be made by generalizing from a similar, previously defined process. In other instances, an emission factor for an unknown chemical intermediate use of a specific chemical can be calculated based on a weighted average factor of all other known chemical intermediate uses of the same chemical.

Once the emission factor is determined it must be multiplied by the plant's consumption to determine the emission rate required for input to the HEM.

Vent Parameter Data

Vent parameter data are necessary for dispersion modeling of the chemical emissions. The vent parameter data in each of the chemical summaries include the number of process and storage tank vents, vent height, vent diameter, gas discharge temperature, gas emission velocity, fugitive discharge area, and building cross-sectional area. These data can be obtained from the same four source levels discussed above, under emission factors. Some data are supplied by producers during site visits, some data are obtained from EIQs, and some from other published reports or text books.

Atmospheric Reactivities of Chemicals

A variety of studies have reported the lifetime or atmospheric residence time of many listed chemicals. Often, however, the basis for the decay rates are not given and reconciliation between studies tends to be impossible. In this instance, all available data and best engineering judgment should be used.

Most chemical destruction of gaseous compounds in the atmosphere occurs by one of the following three mechanisms:

> Photolysis

> Reaction with free radicals (chiefly hydroxyl)

> Reaction with atmospheric oxidants (chiefly ozone)

The process of photolysis and reaction with hydroxyl radicals occur only during daylight hours. Hydroxyl radicals have a short atmospheric residence time and require a continuing photolytic source to maintain their concentrations. Thus, if no source for the hydroxyl radical exists, no reaction will occur.

The HEM is generally constrained to a study area in a 50 km radius of the source. In most instances, the reactivity of a chemical is not sufficiently high to cause significant removal before the material is dispersed to this distance. Therefore, this input to the HEM can be left blank with the model assuming no atmospheric decay. Some chemicals, however, do have high reactivity (e.g., formaldehyde) and should be analyzed for this behavior.

2-3. Dispersion Modeling

The previous section discussed the information necessary to run the SHED model. This section explains how that data is used to give the resulting exposure/dosage estimation.

The concentration patterns caused by major point source emissions depend most strongly on four factors.

> Emission rate

> Source elevation above terrain (stack height); effective plume elevation may, in turn, depend on meteorological factors

> Wind vectors (speed and direction)

> Dispersive effects (intensity of atmospheric turbulence)

The dispersion model in SHED is a Gaussian model in the climatological form of the EPA's Climatological Dispersion Model (CDM) in that it uses the same basic dispersion algorithm, is coded and used to estimate the annual average ground-level concentrations resulting from emissions of major point sources. Flat terrain is assumed.

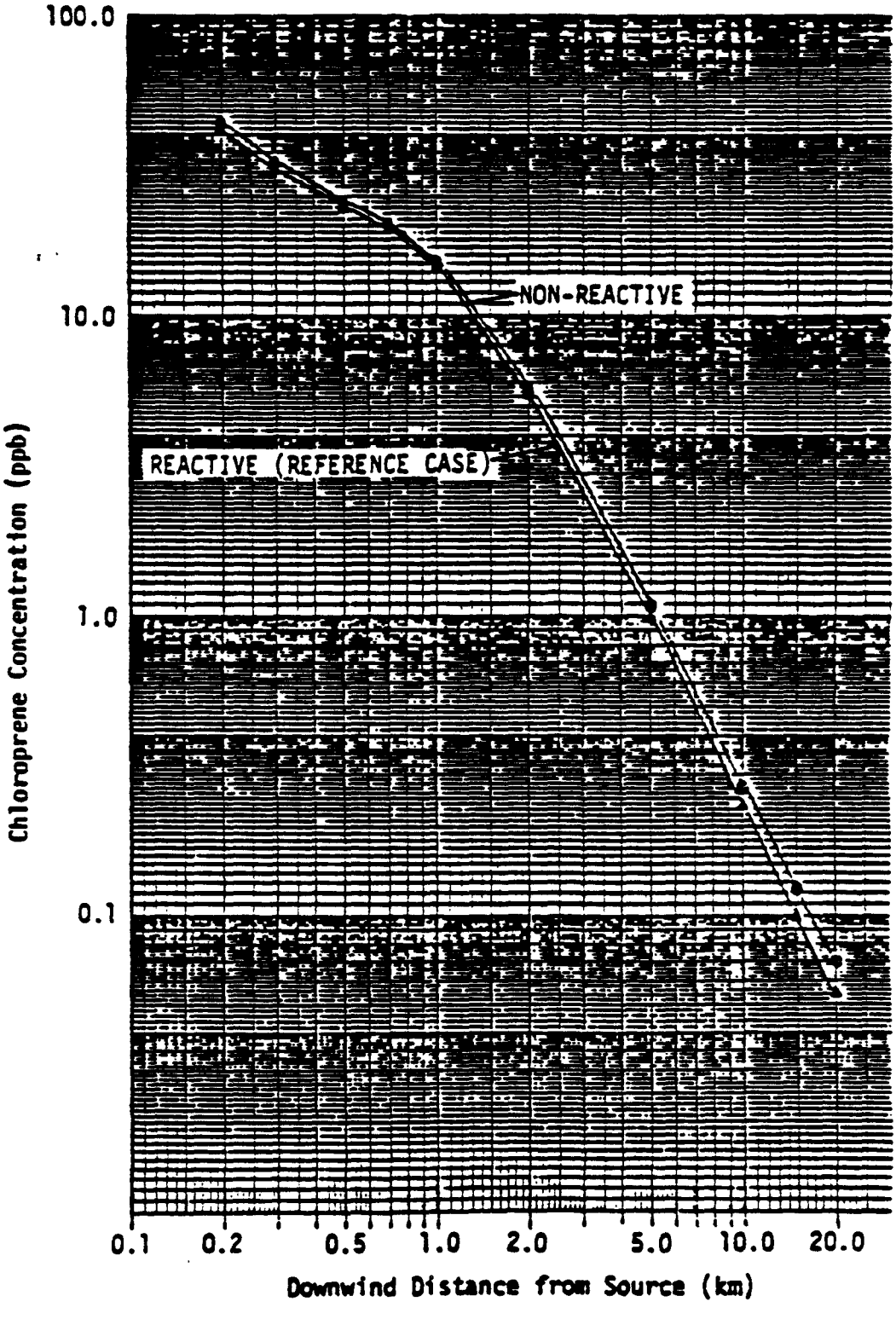
The maximum radius generally considered in the exposure/dosage estimation is set as 50 km for major point sources. Concentrations are estimated for 10 receptors--0.2, 0.5, 1.0, 2.0, 5.0, 10.0, 20.0, 30.0, 40.0, and 50.0 km from the source--along each of the 16 wind directions. In some instances

there may be more than one type of point source (each with its characteristic release height, emissions rate, etc.) within a single plant. Fugitive emissions (valve and flange leaks, etc.) that are random and indeterminate but not negligible can be approximated by an area or volume approximation at a reasonable level above the ground (1-10m). This is the height range typical of outdoor plumbing. Each emissions category is modeled individually, and the total ground-level concentrations resulting from plant emissions are then computed by summing the individual estimates.

The dispersion algorithm can also treat chemical formation and decay, enhanced dispersion caused by building wake effects, and release or stack height. These features are discussed in the following subsections.

Chemical Reactivity

The detailed approach adopted in estimating the effect of chemical reactions on ambient concentrations is shown with chloroprene as an example. Chloroprene is an organic compound that is decidedly photoreactive in the atmosphere. Based on preliminary calculations conducted with the estimated chloroprene atmospheric decay rate, approximately 90 percent of the chloroprene emitted into the sunlit urban atmosphere would be removed within an hour through reaction with hydroxyl radicals and ozone molecules. However, the chemical decay rates are much lower in the nighttime or under overcast conditions. Figure 2-1 displays a comparison between the resulting concentrations along a single wind direction with and without the chemical decay computed for a chloroprene example. Because the atmospheric reactions change atmospheric concentrations over time, the reactivity of a compound has less impact on the concentrations near the emissions source than further downwind. The difference in concentrations between the two curves of



Source: Systems Applications, Incorporated computations using SAI dispersion model and SAI reactivity estimates.

FIGURE 2-1 EFFECTS OF CHEMICAL REACTIVITY ON CONCENTRATION DISTRIBUTION OF CHLOROPRENE

Figure 2-1 at 200 meters from the source is about 3 percent (43.2/41.9 - 1); at 20 km from the source the difference is about 30 percent (0.070/0.054 - 1).

Building Wake Effect

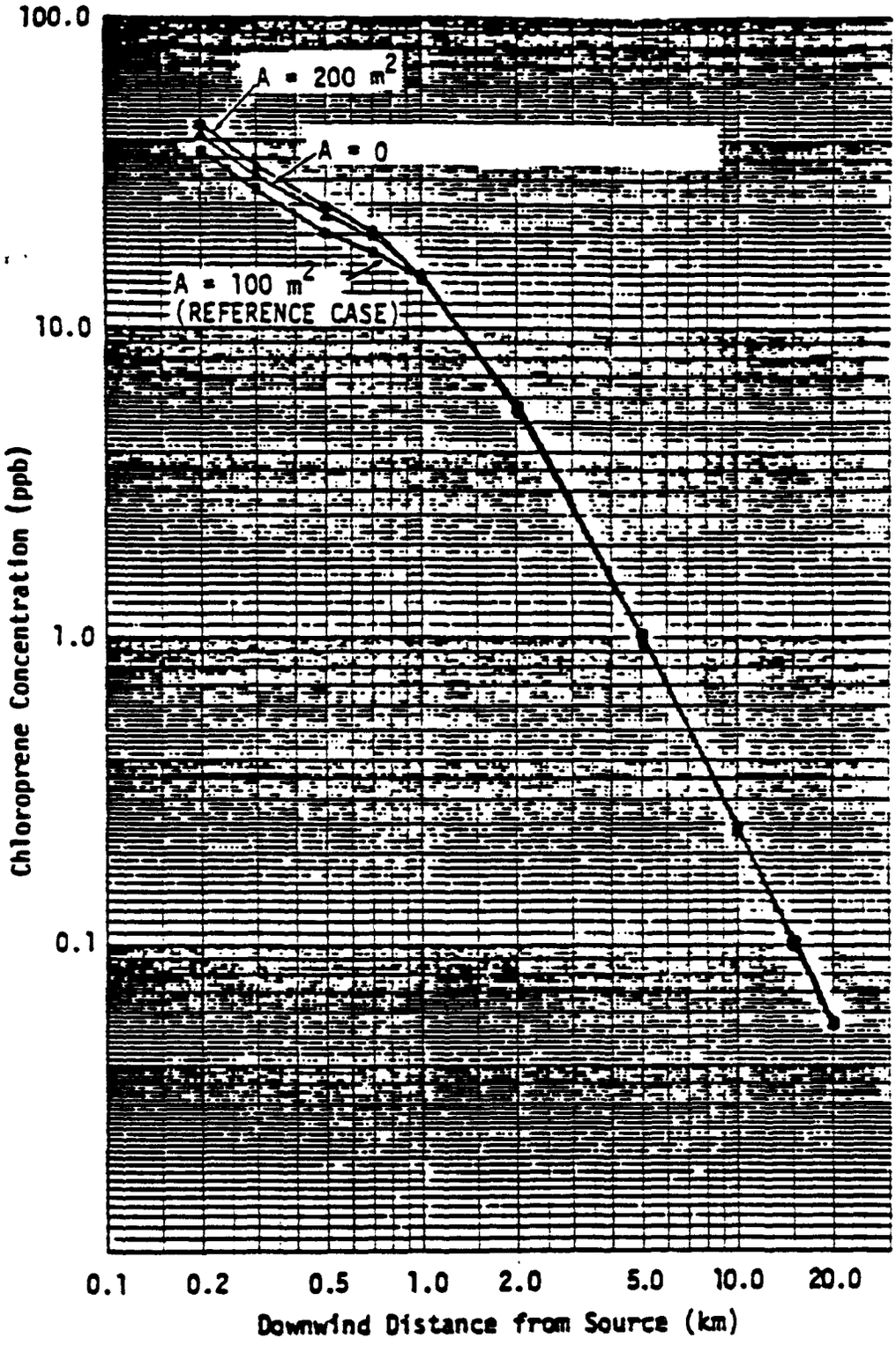
Pollutants emitted into the wake of a building are subject to an enhanced dispersion (e.g., the concentration is reduced very quickly by the turbulence on the lee side of the building). If a dispersion analysis ignored this effect, the occurrence of high concentrations would be overestimated.

The ground-level concentrations that result from different building structure dimensions are depicted in Figure 2-2, where the major parameters for estimating these concentrations are the same as those of the reference case. Clearly, the building wake effect would have insignificant impacts on ground-level concentrations at points further downwind from the source than 1.0 km. However, sources with larger building effects would result in larger ground-level concentrations near the sources. Additional analyses that assess the precise impacts of building wake effect may be required to determine the extent to which the example in Figure 2-2 is site-specific.

Release Height

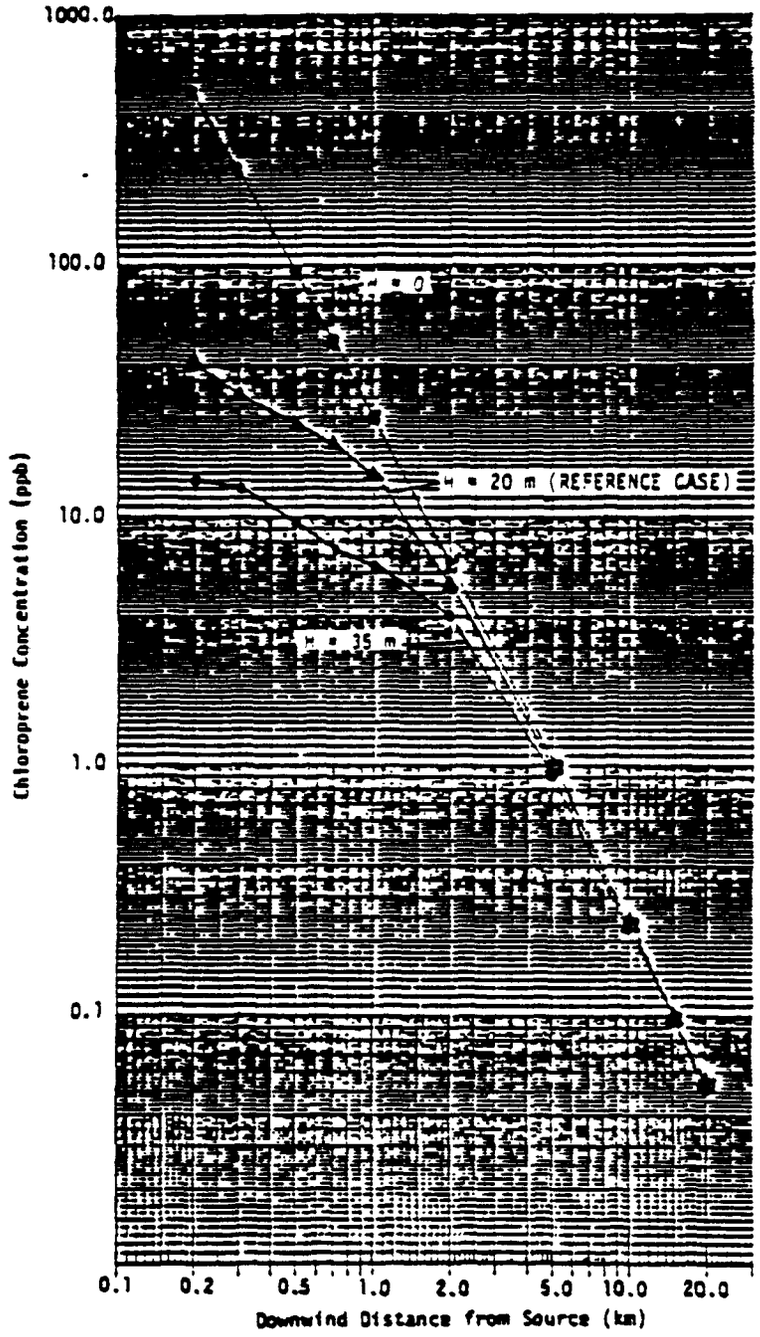
The exact release height of a source can have a great effect on ground-level concentrations. As Figure 2-3 shows, concentrations resulting from ground-level emissions (H = 0) can be more than 10 times as great as those resulting from emissions at a moderate height (H > 20 m). However, these differences become insignificant further downwind (R > 5 km).

Figures 2-1, 2-2, and 2-3 indicate that groundlevel concentrations decrease approximately log-log linearly with distance at receptors more



Source: Systems Applications, Incorporated computations using SAI dispersion model and SAI building wake algorithms.

FIGURE 2-2 EFFECT OF BUILDING WAKE ON CONCENTRATION DISTRIBUTION OF CHLOROPRENE



Source: Systems Applications, Incorporated computations using SAI dispersion model and Briggs' plume rise formulas

FIGURE 2-3 IMPACTS OF RELEASE HEIGHT ON CONCENTRATION DISTRIBUTION OF CHLOROPRENE

than 2 km from the source. A plot of this log-log linear relationship could be used to interpolate concentrations at specific locations within the range of 2 to 50 km from the source.

Exposure and Dosage Estimation Scheme

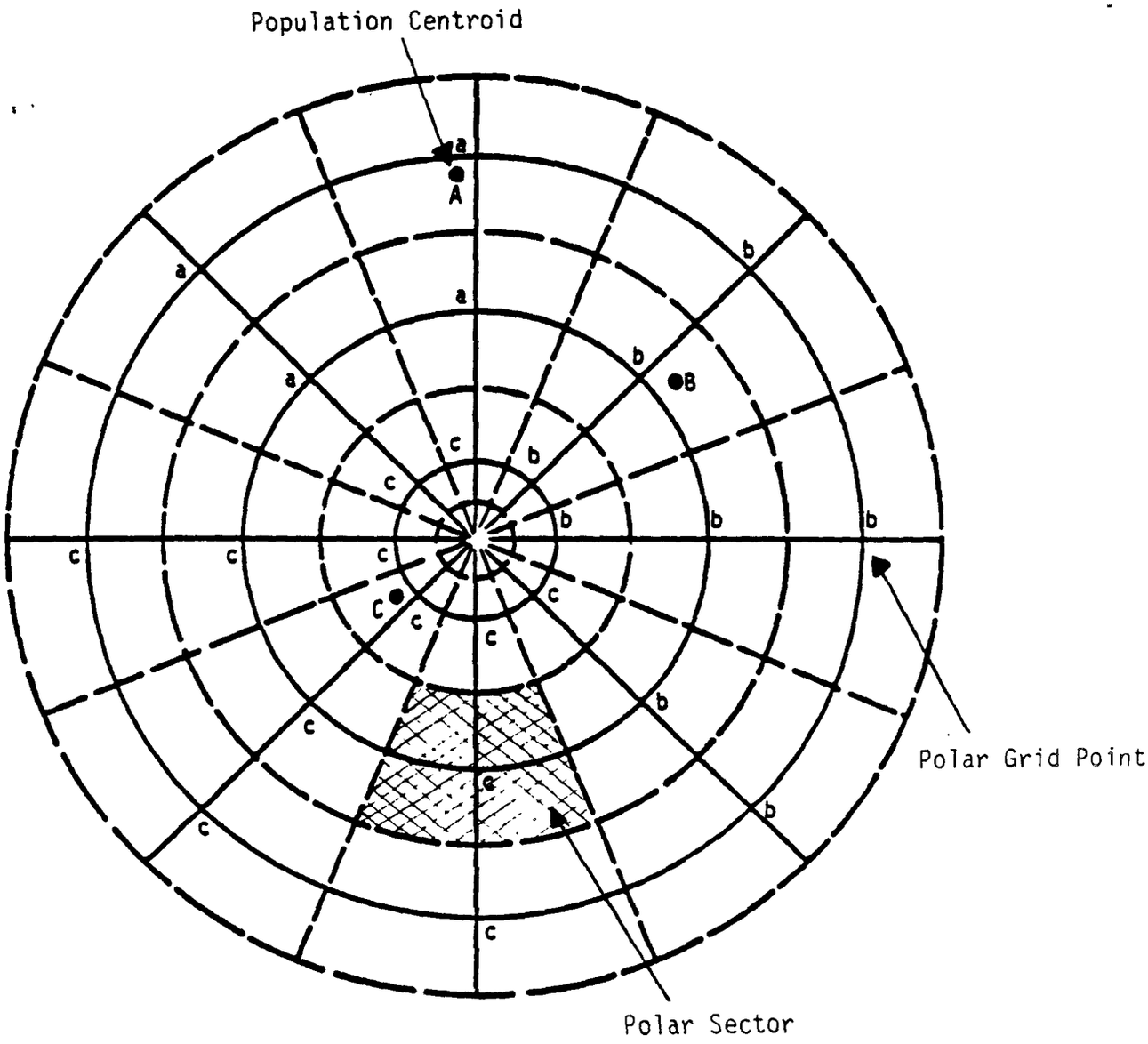
The dispersion modeling approach is coded in a standard Fortran program. The output of the program is a concentration array for 160 receptors around the plant (10 receptors along each of the 16 wind directions). These are the sum of concentration patterns resulting from all sources within a plant. This subsection outlines the basic approach used in combining the concentration pattern with the population distribution pattern around a plant. Three terms are defined here that will be used frequently in the following discussion. A polar grid point is one of the 160 receptors at which concentrations are estimated by the dispersion modeling. A population centroid is the population-weighted geographical center of a BG/ED for which geodetic coordinates are known. A grid cell is defined as the area bounded by two radial arcs and two wind directions.

Exposure is the product of the population and the concentration to which that population is exposed. To form this product, both the concentration and the population must be known at the same location or point. The SHED model uses a two-level interpolation scheme to pair the concentrations with populations prior to the compution of dosages and exposures. The two-level approach is appropriate because the concentrations are defined on a radius-azimuth (polar) grid pattern with non-uniform spacing. This means that at small radii the grid cells are much smaller than BG/EDs while at larger radii the grid cells are much larger than BG/EDs. Interpolation techniques are most appropriately applied by interpolating values of the factor defined on a coarse network (larger) at the locations of the finer (smaller) network, thus

maximizing the resolution and minimizing the uncertainties of interpolation. As previously mentioned, the fine/course relationship between polar grid cells and BG/EDs varies with radius. Hence, the two level approach allows the BG/ED population to be interpolated to the grid point when the BG/EDs are larger than the grid cells and allows the grid point concentration to be interpolated to the BG/ED centroid when the reverse is true. The details of this approach are outlined below. The numbers used assume the analysis is to be completed for a 50 km radius. If the maximum radius changes, so will the radii of the grid points.

For BG/ED centroids located between 0.2 km and 3.5 km from the source, populations are apportioned among neighboring polar grid points. There are 64 (4 x 16) polar grid points within this range. Associated with each of these grid points, at which the concentration is known, is a smaller polar sector bounded by two concentric arcs and two radial lines. The boundary concentric arcs are defined by radii of .10, .35, .75, 1.5, and 3.5 km and the boundary radial lines are drawn right in the middle of two wind directions. These boundary lines are represented by the dashed lines in Figure 2-4. Each of the polar grid points are assigned to the nearest BG/ED centroid identified from the census data set. The population at each centroid is then apportioned among all polar grid points assigned to that centroid according to the area of the polar sector associated with the grid point. For example, all of the polar grid points (labeled b) nearest population centroid B would be assigned a certain proportion of the people in B. The ratio between the area of the polar sector and the area assigned to the population centroid determine the proportionment. Thus, the population density is assumed to be the same for all polar sectors assigned to a single centroid. Figure 2-4 shows that the grid points closer to the source are boxed in by much smaller

Figure 2-4. Pairing of BG/ED with Concentration Within A 3.5 Km Radius



A, B, C - Locations of BG/ED Centroids

a, b, c - Polar grid points to be allocated a portion of population reported at centroids A, B, C, respectively.

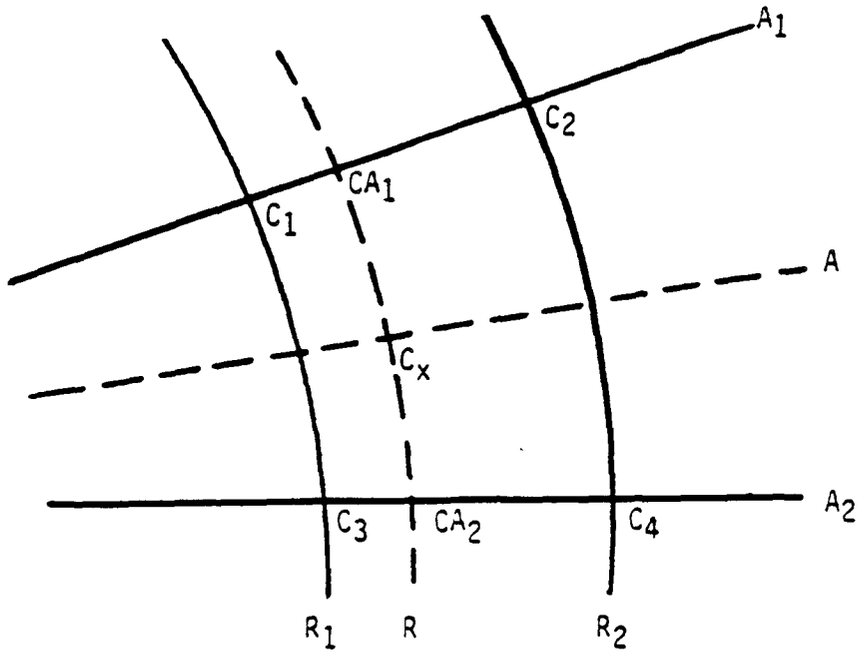
sectors than those further away. Hence, the b grid points closer to the center will receive a smaller apportionment of the people from population centroid B than those further away. Both concentration and population counts are thus available for each polar grid point.

Log-log linear interpolation is used to estimate the concentration at each ED/BG population centroid located between 3.5 km and 50 km from the source. Concentration estimates for 96 (6 x 16) grid points (receptors at 5.0, 10.0, 20.0, 30.0, 40.0 and 50.0 km from the source along each of the sixteen directions) resulting from dispersion modeling are used here as reference points for this interpolation. For each ED/BG centroid, four reference points are located at the four corners of the polar sector in which the centroid is located. These four reference points (labeled C_1, C_2, C_3, and C_4) would surround the centroid (C_x) as depicted in Figure 2-5. As shown in Figures 2-1, 2-2, and 2-3, there is a linear relationship between the logarithm of concentrations and the logarithm of distances for receptors more than 2.0 km away from the source. This relationship is used to estimate the concentrations at points CA_1 and CA_2 (see Figure 2-5). These estimates, are then linearly interpolated with the polar angle to determine the concentration at the centroid (C_x). Using the two-level approach, concentrations and populations are paired up for the 64 concentration grid points within 3.5 km of the source and for all BG/ED centroids located between 3.5 km and 50 km from the source.

The total dosage was then computed as follows:

$$\text{Total Annual Dosage } (\mu g/m^3\text{-person}) = \sum_{i=1}^{N} P_i C_i \quad ,$$

Figure 2-5 Log-linear Interpolation Scheme



Given:

A = The angle in degrees subtended clockwise about the source from due south to the BG/ED centroid;

A_1 = The angle from due south to the radial line immediately counterclockwise from A, or passing through A if there is an exact match;

A_2 = The angle from the south to the radial line immediately clockwise of A_1 (A_2 is 0 if it is due south);

R = The distance from the source to the BG/ED centroid;

R_1 = The distance from the source to the largest circular arc of radius on grid that is less than R;

R_2 = The distance from the source to the smallest circular arc of radius on grid that is greater than or equal to R;

C_1 = The concentration value at (A_1, R_1);

C_2 = The concentration value at (A_1, R_2);

C_3 = The concentration value at (A_2, R_1);

C_4 = The concentration value at (A_2, R_2); then

$$CA_1 = \exp\ (\ln C_1 + (\ln C_2 - \ln C_1)\ (\ln R - \ln R_1)\ /\ (\ln R_2 - \ln R_1)$$

$$CA_2 = \exp\ (\ln C_3 + (\ln C_4 - \ln C_3)\ (\ln R - \ln R_1)\ /\ (\ln R_2 - \ln R_1)$$

$$C_x = CA_1 + (CA_2 - CA_1)(A - A_1)\ /\ (A_2 - A_1)$$

where P_i = the population at point i, C_i = the annual average concentration at point i, and N = the total number of grid points and ED/BG centroids with a specified combination of concentration and population (representing the entire area within 50 km of the source).

The population exposed to each of a number of concentration levels, L_j, was computed by:

$$\text{Exposure to } L_j \text{ (person)} = \sum_{i=1}^{N} P_i S_i(C_i, L_j) \quad ,$$

where

$$S_i = \begin{cases} 0 & , \quad \text{if } C_1 < L_j \\ 1 & , \quad \text{if } C_i \geq L_j \end{cases} \quad .$$

The dosage of the fraction of the population that is exposed to concentrations greater than or equal to each of a number of concentration levels, L_j, was computed by using the following summation:

$$\text{Annual Dosage at } L_j \text{ (ug/m}^3\text{-person)} = \sum_{i=1}^{N} P_i C_i S_i(C_i, L_j) \quad .$$

Note that the annual dosage at the minimum concentration within 50 km of the source will equal the total annual dosage.

The concentration levels at which exposure is to be estimated are selected by an exponential function coded in the program.

2-4. Assumptions

In order for SHED to be simple, run quickly and require as little input data as it does, certain assumptions must be made. This section outlines the necessary assumptions to provide the user with an understanding of the limitations of the model and the need to consider such limitations in the use of the output data.

Population Count Errors

The SHED model uses census data to the BG/ED level. Although this is the smallest defined population unit, it still places on average approximately 800 people at one point. In reality, some people will reside closer to the plant and may be more highly exposed. For others, the modeled exposure will be an overestimate of the actual exposure.

Another problem occurs when two plants are located within 50 km of one another. The people who are exposed to both plants will be counted twice in the summation of the exposed population. Although the number of people will be an overestimate, the dosage (people times concentrations) is not affected by the overlap of the study areas. Two people each exposed to a concentration X from one of two plants is regarded as the same amount of exposure as a single person exposed to a concentration of X from both. Populations may be partially doublecounted if sources are close to each other, but aggregate exposure is not.

The SHED model may also mislocate people if a plant is located near a large body of water. The manner in which SHED spreads the population to the concentrations within the 3.5 km radius allows the program to assign

people to areas which may be covered by bodies of water. One potential problem may arise if the program determines a maximum concentration to which people are exposed that is located over a lake or other body of water. In this case, it could be argued that no one is actually exposed to this concentration. For those sources that appear to produce maximum concentrations, identification of the receptor location and consultation of topographical maps to verify public exposure is recommended. If the maximum receptor is located in an area where people would not reside, the next highest receptor should be used or that plant should be modeled individually with a different more specific model.

Concentration Pattern Errors

The concentration patterns used in the exposure computations are obtained through atmospheric dispersion modeling based on known source characteristics and weather patterns at nearby stations. Naturally, any deviations in these estimates from the true pattern directly affect the exposure results. Thus, if the nearest STAR station is 50 - 100 miles away, the weather patterns may not be representative of the weather patterns in the area around the source.

The program also assumes flat terrain. This is especially crucial when dealing with sources in a valley/mountainous area because the STAR station will not give adequate information to model the wind patterns accurately.

In addition, the SHED model uses a Gaussian dispersion model to determine the concentrations around the source. This model is based on how gases will act when dispersed from a stack. Thus, if the pollutant is fibrous or particulate, such as asbestos, the assumption that the pollutant behaves as a gas may misrepresent the actual dispersion pattern.

The assumption is also made that the annual average weather conditions continually persist and that the source emits at the annual average amount. At times, these averages may not be representative over shorter terms. It also assumes that each recorded wind persists in a given direction long enough to yield dispersion out to 50 Km.

Commuting Pattern Errors

There are also time-dependent aspects of the exposure problem. The exposure program uses a time-averaged concentration pattern for each source, so that the time dimension is ignored in the computations. If the population distribution were essentially constant over the averaging time period, the resulting estimates would be true averages. However, population distributions are constantly changing as people commute to work, go shopping, and take longer trips. Particularly in urban industrial centers, the shifts in populations and concentrations throughout the day may be highly correlated; thus, the actual exposure may differ considerably from the value obtained by matching time-averaged concentrations with population distributions based on census addresses. Whether the exposure is over- or underestimated depends on whether populations in the vicinity of a source are drained (e.g., because people leave residences near the source for work in an urban center) or are augmented (e.g., because of employment near the source).

2-5. Using the SHED Model

To use the model you must first obtain (1) a user ID, (2) an account number and (3) a project ID. These may be obtained by following the instructions in Section 1-3. You, the user, may then access and use the HEM by the procedures described throughout this chapter.

Logging On

Generally, when you approach a hard-wired terminal, the screen will be blank but the terminal is on. To get the Sperry log on directions push the button labeled transmit (or XMIT). The screen should now look like this:

```
**************************************************
*                                                *
*      Welcome  to the Sperry 110/82 System!     *
*                                                *
*      "Tab" to the desired session and XMIT     *
*                                                *
*           DEMAND for a DEMAND session          *
*                                                *
*           MAPPER for a MAPPER session          *
*                                                *
**************************************************
```

The small rectangle in the upper left corner is the cursor. The cursor may be moved by pressing any of the directional keys, the space bar, the back space, tab forward or tab back. The easiest way to position the cursor in this instance is to press TAB FWD as indicated by the directions. This should place the cursor immediately following the first "DEMAND" on the screen. Now press XMIT. If you are accessing the model through a modem, you must establish communication with the UNIVAC computer. The commercial phone number for the NCC is (919) 541-4642. Long distance users can use TELENET to reduce phone charges. Please refer to Section 1-4 for the appropriate contact personnel who can help with more specific instructions. Once you are connected with the NCC, press XMIT. The screen will write the options for access. Type UNI and hit XMIT.

After requesting the UNIVAC demand mode with either the hardwired system or the modem connection, the screen should roll up and write the following:

```
xxxxxxxxxxxxxx  ENTER USER ID/PASSWORD:
```

If the soe (>) or prompt and cursor appear above the line, type

@@INS 11 and XMIT. This should move the cursor below the line. The very first time you log on to the terminal, you must type your user ID, a slash (/), your user ID again, a slash (/) and your password. The password is your own invention but after the first log on remains the same until changed (i.e., remember what you used). After the first log on, you simply type your user ID, a slash (/) and your password. At any time, you may change your password when you log on. UNIVAC requires that you change your password every 90 days. This is accomplished by typing your user ID, a slash (/), your old password, a slash (/), and your new password. Remember to hit XMIT, enter or return in order to enter any line. The system should respond with:

```
* Destroy user-ID/password entry
* UNIVAC 110 Operating System
  Enter Run ID or (CR) for default to USER ID
```

The Run ID consists of 2-6 characters which are chosen from A-Z and 0-9 only. As a National Computer Center (NCC) user, the first two characters of the Run ID should be your NCC bin number. The last four characters can be anything which will allow you to identify your run. The user's initials are often chosen for this reason.

Always press XMIT enter or return after typing any line to be entered.

The computer will then ask a series of questions which you, the user, answers. The example below shows the questions the computer will ask (underlined here to distinguish from user response) and the user's response to each question.

```
Enter Run ID or (CR) for Default to USER ID
08XY
Enter Account Number
69096FRZ
Enter Project-ID
ABCD
```

Enter UID

SASDPHEP

After typing each response, the user must hit XMIT for the transmission of the response. After entering the final response, the computer will type out several lines of information. For example:

Run Number 46

Last Run at: 072784 140637

Date: 073084 Time: 103448

*** News Current as of 11:19:47 on 07/23/84 ****

When the computer stops typing information and the cursor stops beside an soe (>) you are logged on to the computer and ready to begin.

* * *

NOTE: For all the instructions below, all information within commands which are specific to your file or run will be typed in small letters and contained in parentheses. For example, @@CONS RC (run id) means type @@CONS RC Ø8PT if Ø8PT is the run id of the run you needed to check. Do not type the paretheses.

* * *

Cataloging Files

The UNIVAC system works with two types of files; data files and program files. Contrary to its title, the program file is used only for storage and may be broken into elements to store several sets of data. The data file has only one set of data and is available for use by the program.

In order to use the HEM, a program file must be cataloged to store data and two data files must be cataloged in order to run the program

(one more data file must be cataloged in order to run Decay rates for the chemical). To catalog these files certain commands must be entered which basically name the files. Many catalog options are available but the catalog statements conventionally used to catalog the files for HEM are:

```
Program file:   @CAT,P (FileName).,F33,NCCØ4Ø
                 1-12 Alphanumeric characters

  Data files:   @CAT,P  (Qualifier)*Gauss-in.,F33, NCCØ4Ø
                 1-12 Alphanumeric characters

                @CAT,P  (Qualifier)*Gauss-out.,F33,NCCØ4Ø
                      SAME AS ABOVE

                @CAT,P  (Qualifier)*Decay.,F33,NCCØ4Ø
                      SAME AS ABOVE
```

Please type the above lines exactly as they appear except the "Filename" and "Qualifier" should be your own invention. The Filename in Line(1) may be any alphanumeric name with 1-12 characters. The Qualifier lines (2), (3) and (4) may also be any alphanumeric name of 1-12 characters. The Qualifier used in line (2) must, however, be exactly the same as the Qualifier in lines (3) and (4).

Once this is accomplished, you have cataloged all the files you will ever need to catalog to run HEM. As previously mentioned, the program file cataloged by line (1) can store a large number of files under various element names. To run the program you can empty the GAUSS-IN file and add the data from the element. This must be done because data files (GAUSS-IN is a data file) cannot be broken into elements. By emptying and reusing the GAUSS-IN. file, however you only need one.

At this time, a discussion of file names is pertinent. A program file name has three primary parts: the qualifier, file name, and element name.

It looks like this:

Qualifier*Filename.Element

The cataloging instructions given above do not give the program file a qualifier. Hence, the system assumes that the project ID (which was used to log on) is the qualifier. If a different project ID is used to log on, the old project ID must be included as the qualifier when calling the file. Otherwise the Filename.Element is sufficient to call the file.

Data files have only two primary parts because data files have no elements. Data files look like this:

Qualifier*Filename.

In the case of HEM data files the file name is always GAUSS-IN, GAUSS-OUT and DECAY. The qualifier is not the project ID but whatever was assigned when the files were cataloged.

Now that all necessary files have been cataloged, data can be entered using the instructions below.

Entering Data

To enter data into a file a text editor must be used. Several text editors are available but the most frequently used on the UNIVAC for HEM is the Maryland Editor. PC users familiar with the PC editor and KERMIT or XTALK can create a file in the proper format on the PC and send the file to the UNIVAC. A text editor has various commands which allow data to be input, changed, rearranged and/or deleted. A summary of often used commands for the Maryland Editor is shown in Appendix C. At this point it is important to read Appendix C and become somewhat familiar with the commands listed. A complete list of commands for the Maryland Editor may be found in the "Text Editor User's Guide" by Hagerty and Sibbald (1975).

To call the Maryland Editor, enter the command @EDM, a space, the file name which has been cataloged, a period and an element name.

For example:

```
@EDM Filename.Element (An element is any alphanumeric name
                       including "-" which has 1-12 characters)
```

The first time this file element is accessed, the element is created and the editor automatically places you in input mode. The UNIVAC will respond with:

```
EDM 29B1 MEM 02/28/86  16:34 I(0):F
INPUT
>
```

Please hit XMIT, enter or return as suggested in Appendix C to get to the edit mode and use the commands listed there to input the data. When you hit XMIT, or when you enter an element that has been created previously, the UNIVAC responds with:

```
EDIT
*>
```

Once in the edit mode, the file is ready for entering data. The format in which data must be entered for HEM is discussed in the following subsection.

Data Format

The HEM is designed such that the program reads numbers from certain columns and rows of data. If the numbers are not in the proper position, the computer will misread the data. This can cause unusual and incorrect results or prevent the program from completing the run. Thus, this section is very important to follow closely. To check to see if a line has been entered correctly type P and XMIT. This should print the line. Next type SC and XMIT. This will print a scale of numbers under the line to make column counting easier.

Each line of data, referred to as a card, has a specific function and format. The first card to be entered is entered once for each run and contains the following information [Remember to type I and a space in order to enter the data in the edit mode]:

Columns 1 - 5 = Greater than or equal to the number of plants; right justified (used as scratch space allocation)

Columns 6 - 10 = Blank spaces

Column 11 = Indicator as to whether maps are to be produced as part of the output, (Maps - Table of estimated BG/ED and Population at centroid by 16 wind directions and 10 distances), T = Yes, F = No

Column 12 = Indicator as to whether the exposure analysis should be performed out to each ring distance separately, T = Yes, F = No

Columns 13 - 23 = Unit risk number for lifetime risk

Next, one set of three cards is entered for each facility. They contain the following information:

Card 1, Columns 1-80 = The name of the chemical being modeled.

Card 2, Columns 1-80 = The location of the facility given as the facility name, city and state.

Card 3, Columns 1-6 = Latitude of the facility in degrees, minutes, seconds. (Two digits each with no spaces or symbols between, e.g., 414900).

Columns 7-13 = Longitude of the facility in degrees (must be three digits), minutes, seconds. (e.g., 0784900).

Columns 14-18 = Star site identification number. This is the location to be used as a source for meteorological data by the model. It is optional and if a number is not provided (the field is left blank) the

program will automatically find the closest source of meteorological data and use it (see note below).

Columns 19-38 = Meteorological data values which may be left blank if such meteorological data are not available. The program will automatically use standard values for these fields. (19-23 = ambient temperature in degrees Kelvin, 24-28 = temperature lapse rate to be used for D stability, 29-33 = temperature lapse rate to be used for E stability, 34-38 = temperature lapse rate to be used for F stability). (See note below)

* * *

NOTE: To make data entry easier, enter all columns of consecutive data using I, space, and the data. If several blank spaces are to be entered between the first group of data and the next group, enter the first group hit XMIT and use the R, column number command to enter the second group. For example, to enter card 3 with sample data type:

I 4249ØØØ7849ØØ (XMIT)

R,39 ØØØØØ1

This will enter 42°49'00" for the latitude, 78°49'ØØ" for the longitude, blanks for the star site and meteorological data, urban setting and one source at the facility.

* * *

Column 39 = Indicator as to whether the facility is located in an urban or rural setting. Ø = urban; 1 = rural

Columns 40-44 = Total number of sources to be modeled at this facility (right justified). These columns must be filled and must be accurate or the program will not run.

Finally a set of cards, one card for each source at the facility identified in columns 40 - 44 in card 3, is entered. These cards give the emission characteristics of each source as follows:

Column 1 = Indicator as to emission type, P = process vent,
S = storage vent, F = fugitive emissions,
H = stack.

Columns 2-13 = Emission rate in kg/year <u>including decimal point.</u>

Columns 14-17 = Release height (Stack, vent or height of fugitive release) in meters with decimal point.

Columns 18-21 = For P, S or H, this is the vertical building (off vent or stack) cross-sectional area (m^2) perpendicular to the mean wind flow, including decimal point. For F, this is the area of release. This should be right justified or contain a decimal point. (The area should never exceed 2000 m^2.)

Column 22 = Indicator as to vent type, Ø = vertical stack, 1 = non-vertical stack or vent.

Columns 23-26 = Inside stack or vent diameter in meters including decimal point. (For fugitive leave blank)

Columns 27-31 = Gas exit velocity from vent or stack in m/sec including decimal point. (If this is unknown, use at least 0.1 m/sec.)

Columns 32-35 = Gas exit temperature in degrees K including decimal point. (If unknown, use 293-298 K.)

Figure 2-6 gives a good summary of all the above data. A xeroxed copy of that figure and Appendix C (or this manual) should always be available while adding data to a file.

You should now look at your file. The commands

```
T     XMIT
0 9   XMIT
```

will allow you to see the first 9 lines of your file. Please compare this to Figure 2-7, a typical program file. Using the delete, change and SC commands correct your file so that it will contain the information you want.

You should now exit the file. To do this type "Exit" while you are in the edit mode. If you are running a chemical with no chemical reactivity, you are finished entering data and may skip to "Running the Program." If your chemical has chemical decay, you must follow additional instructions below.

In order to run a program with chemical decay, a separate file must be opened. A good suggestion to remember which decay file coincides with which source file is to add -DK to the title of the source file to entitle the decay file. So, to open the file (again using the Maryland editor), type:

@EDM File Name. Element-DK

Only one card is entered into this file which contains the following information in the following format:

CONTROL CARDS FOR PROGRAM SHED

SUBMIT ONE CARD OF THIS FORM PER RUN

NUMBER OF PLANTS	MP	RC	Unit Risk No

NUMBER OF PLANTS IS THE NUMBER OF DIFFERENT LOCATIONS FOR THIS RUN
MP - ARE MAPS DESIRED AS OUTPUT FROM THE EXPOSURE PROGRAM T = YES F = NO
RC - IS IT DESIRED TO DO THE EXPOSURE ANALYSIS OUT TO EACH RING DISTANCE T = YES F = NO

SUBMIT ONE SET OF THE FOLLOWING THREE (3) CARDS PER FACILITY

CHEMICAL NAME

FACILITY IDENTIFICATION

LATITUDE DEG MIN SEC	LONGITUDE DEG MIN SEC	STAR SITE	AMBIENT TEMP (K)	LAPSE RATE STAB D	LAPSE RATE STAB E	LAPSE RATE STAB F	U	NUMBER SOURCES

MISSING STAR SITE CAUSES AUTOMATIC SELECTION OF THE NEAREST SITE
U (COLUMN 39) CODE ZERO (0) FOR URBAN OR ONE (1) FOR RURAL

SUBMIT ONE OF THE FOLLOWING FOR EACH SOURCE AT THE FACILITY

ET	EMISSION RATE (KG / YEAR)	STACK METERS	AREA M**2	VT	DIA METERS	VELOCITY M/SEC	TEMP (K)

ET (COLUMN 1) EMISSION TYPE
P - PROCESS VENT
S - STORAGE VENT
F - FUGITIVE EMISSIONS
H - STACK

VT (COLUMN 22) VENT TYPE
0 - VERTICAL STACK
1 - NON-VERTICAL STACK OR A VENT

Figure 2-6. Summary of SHED Data Entry Format

Figure 2-7. Typical SHED Data File

```
00004      FF    .0076
ASBESTOS
PLANT NAME      NEW YORK CITY
4043000740100                                  0      1
F144.          10.0100.110.0.0009293.
PLANT NAME      RALEIGH, NC
3547000783900                                  0      1
F6.80          10.0100.110.0.0009293.
ASBESTOS
PLANT NAME      MONTPELIER, VT
4416000723500                                  0      1
F 150          10.0100.110.0.0009293.
ASBESTOS
PLANT NAME      PHEONIX, AZ
4244560734145                                  000003
H301.9         4.50613.0.21615.46297.
H8003          7.50613.0.21611 85297
H214 50        12 6613 0.79014 54297
```

Columns 1-10: Daytime Decay rate (/minute)

Columns 11- 20: Nighttime Decay rate (/minute)

To convert half-lives to decay rates, you may use the following formula:

Decay Rate = $0.693/T_{1/2}$

where $T_{1/2}$ is the half-life in minutes.

Running the Program

Entering data into the program file stores the data for future use. The contents of the program file must be entered into the data file in order to run the program.

Adding the program file to the data file consists of three simple steps: 1) open the file, 2) delete any previously stored data, and 3) copy the program file into the data file. These steps can be easily performed using any text editor. The Maryland Editor would use the following commands:

@EDM (Qualifier)*Gauss-In.	XMIT [Hit XMIT a second time if not in edit mode.]
D *	XMIT [This step deletes all previously stored data.]
Add (Filename).(Element)	XMIT

This places the data from the source parameter program file into the Gauss-In data file. If decay rates are to be included, this data must also be entered into a data file. To do this, using the Maryland editor, type:

@EDM (Qualifier)*Decay.	XMIT
D *	XMIT
Add (Filename).(Element-DK)	XMIT

Once the data is added to the file, the file should be exited and a start card entered. The start card for the HEM without chemical decay

should be entered as below:

@Start SASD*Start.Xposure/Point-50,/(Site ID),,,(Qualifier)

The start card for the HEM with chemical decay should be entered as follows:

@Start SASD*Start.Xposure/Decay-50,/(Site ID),,,(Qualifier)

The site ID is the code which indicates where the results will be printed. If the site ID is omitted the results will be printed at Research Triangle Park. A site ID of FDØ5CR will cause the results to be printed on the 6th floor of the Mutual Building. Most regional offices have a printer dedicated to the UNIVAC that will have a Site ID. If there is not a UNIVAC printer available to you, please see the information below. The Qualifier is the same as the Qualifier in Qualifier*Gauss-In and Qualifier*Decay. Once XMIT is hit, the computer will print out a line of information. This information states the run ID, the category and whether the project was accepted or rejected. If it is accepted, the program is queued for execution and it is a matter of time before the results will be printed.

The run ID is the value printed after *TM*. If you would like to know if the program has finished, you may use the run ID in one of two commands. The first is:

@@CONS RC (run id)

This will tell you how many pages have been finished or if the program has "finned." The second:

@SASD*WAIT.WAIT (run id)

will give you the same information but will continue to update the information every 60 seconds or when the XMIT key is pressed. Typing any other command cancels the @WAIT.WAIT command.

Users who are using a remote terminal and who do not wish the results of the SHED run to go to the National Computer Center (NCC) and do not have

access to another site ID should use a different run card. This is typed as as follows for the 50 Km run:

@ START SASD*START.XPOSURE/USER-50,,,(Filename)

The 50 may be replaced with 20 or 80 for 20 Km or 80 Km analyses. Once executed, the file will not print out but will be saved until you type in:

@@SEND, U

This down loads the files to your PC. Before typing this, however, check on the file to see if it has been completed and is in the queue for being printed. To do this type:

@@CONS SQ (user id) *U

or

@@CONS SQ (run id) *R

Once the file is in the queue, type @FIN. This will scroll up information on the screen. When it finishes scrolling, type the @@SEND, U. It is important that you do not hit XMIT until this is typed in. Immediately you will see the file on the screen. Once you have downloaded the file and have the printout you want, you need to delete the file from the queue.

To do this, simply type:

@@CONS SX (run id)

Additional Miscellaneous Information

If the program is accepted but does not complete running, the most common error is in the entering of the data. To check the data in the file, reopen the file with the @EDM Filename.Element command and type:

NSITE X Y RM95PR

The symbols "X" and "Y" here represent the the beginning line number and ending line number. The RM95PR indicates where the data will be printed. This specific code is for the Mutual Building 6th floor printer. Other codes should be printed if another location is desired.

When the printout is available make sure all the data was entered exactly as the cards indicate. The most common error is inconsistency between the number of point sources indicated in the third card and the number of emission point source data listed. This will prevent the program from running.

Another common problem occurs when large amounts of data are being run. If the run takes longer than 10 minutes to run, the system will "time out". This can be resolved by adding a comma and the number of minutes needed to run the program to the end of the start statement. For example, if 30 minutes were needed, the start card would appear as below:

```
@Start  SASD*Start.Xposure/Point-5Ø,/(site id),,,(Qualifier),30
```

Printouts of programs which exceed 200 pages are not allowed to be printed on the Mutual Building printer. A simple addition to the start card will cause only the summary pages to be printed at the Mutual Building or other Site ID while the bulk of the material is laser printed at Research Triangle Park. The simple addition is "-L" and is inserted after xposure as below:

```
@Start  SASD*Start.Xposure-L/Point-5Ø,/(site id),,,(Qualifier),3Ø
```

This manual cannot cover all possible errors and you will probably find newer and more exciting ways to make mistakes. Therefore, please use References 2 and 3 to help find your errors, correct them and maybe learn a few short cuts.

2-6. Using Output from other Dispersion Models

The exposure portion of SHED model can be run using concentration inputs from other dispersion models. To do this, the concentration file must be in a compatible format. The Model Application Section of the Monitoring and Data Analysis Division in the OAQPS ((919) 541-5690 or FTS 629-5690) has succeeded in causing the Industrial Source Complex Long-Term Dispersion Model (ISCLT) to yield compatible output. Once the ISCLT output is stored, you need only the filename and element (if there is one) to access the concentrations.

Entering Data

Similar to running SHED without concentration input data you must set up a file. The following information describes what data must be entered and the proper format.

The first card is entered once for each run and contains the following information:

Columns 2-3	= Number of radial rings you wish to analyze, right justified (generally 10).
Column 4	= Indicator as to whether maps are to be supplied as part of the output, (maps - table of estimated BG/ED and population at centroid by 16 wind directions and 10 distances), T = Yes, F = No.
Column 5	= Indicator as to whether the exposure analysis should be performed out to each ring distance separately, T = Yes, F = No.
Columns 6-10	= Number of sources to be analyzed.
Columns 11-20	= Conversion factor. (This number will be multiplied times the concentration points to yield a converted

concentration. Since the emission rate is proportional to the concentration points, this factor may be used to analyze various possible emission rates with only one ISCLT run. Enter 1.0 if you wish the concentration points to remain the same).

Columns 21-30 = Unit Risk Number for lifetime risk; right justified.

The second, third, and fourth cards are entered only once for each run and depend on the number entered above as the number of radial rings. If the number is ten or less, only card 2 needs to be completed. If the number is twenty or less, cards 2 and 3 must be filled. If the number is thirty or less, cards 2, 3 and 4 must be used. The program is prepared to handle only up to 30 radial distances. The format for each of the cards is identical. Eight digits are allowed for each distance, ten distances are allowed per card. For example, the first three distances would be entered as below on card 1:

Columns 1-8 = radial distance closest to the plant (Km)

Columns 9-16 = radial distance second closest to the plant (Km)

Columns 17-24 = radial distance third closes to the plant (Km)

The next group of cards is entered for each plant or each chemical analyzed and contain the following information:

Card 1, Columns 1-80 = Title of the concentration chart that will be output. Generally, we enter, "Concentration in Micrograms per Cubic Meter."

Card 2, Columns 1-80 = The name of the chemical being modeled.

Card 3, Columns 1-80 = Name of the facility.

Card 4, Columns 2-7	= Latitude of the facility in degrees, minutes, seconds (two digits each).
Columns 9-15	= Longitude of the facility in degrees (three digits), minutes (two digits) and seconds (two digits).

Now the concentration information must be added to the file. If you are analyzing only one plant and have only one concentration group, you may add the entire file with the following command:

ADD concentration filename.element

If you have concentration results for several plants, you may add blocks of data with the following command:

NUMADD concentration filename.element x y

where x is the starting line number and y is the ending line number of the section you want to copy.

The process of entering plant data and copying the concentration file for that chemical must be repeated until all plants have been entered.

Running the Program

Once the program file is complete, it must be entered into the data file in order to run the program. This process is identical to running SHED without concentration inputs except that the data file is called GAUSS-OUT. rather than GAUSS-IN.. Using the Maryland editor, you would type the following commands:

```
@EDM (Qualifier)*GAUSS-OUT.        XMIT
D *                                XMIT
ADD Filename.Element               XMIT
```

Once the data has been entered into the data file, you may type the following start card to execute the program:

@START SASD*START.XPOSURE/XQT,/(Site id),,,(Qualifier)

Now you may follow the instructions in Section 2-5 to check on the status of the run and obtain the printout.

2-7. Output from SHED

SHED produces two sets of output. The first set included the input data and the concentration grid table for each plant and the cummlulative risk summary and the overall plant summary. This set also contains maps of population centroids if this option was selected. The second set contains only the cummulative risk summary and the individual plant summary.

This summary of the input data for one plant is shown in Figure 2-8. Some of the values are rounded off but can be used to proof the input data.

The concentration grid, as shown in Figure 2-9, presents the modeled concentration at each grid point. For example, the figure shows that the concentration 1.00 kilometers south of the plant is predicted to be 8.8588 x 10-6 g/m3. The column labeled wind direction is actual direction from the plant, not wind direction.

The optional maps show the population distribution about the source as a polar grid displayed rectangularly. The four plots differ in the orientation of their grids relative to the input concentration grid. Again, direction refers to actual direction from the plant, not wind direction.

The first plot, seen in Figure 2-10, shows both the number of BG/ED centroids and the number of people in each cell of the input concentration grid. The labels of the wind directions refer to the line directly above them and the radius label refers to the line directly to the right.

The second plot, seen in Figure 2-11, gives the same type of plot as the first except that the spaces shown are patches rather than grid cells.

Figure 2-8. Summary of the Input Data

```
SHED/GAUSS -- SUMMARY OF THE INPUT DATA

          BETHLEHEM STEEL  LACKAWANNA, NY
               LATITUDE: 424900, LONGITUDE:  784900
               STAR STATION:      0
               FOR AN    URBAN SOURCE
               AMBIENT TEMPERATURE: 293. DEGREES KELVIN
               CHEMICAL COMPOUND NAME: IRON AND STEEL
               NUMBER OF EMISSION TYPES:  2

               THE LAPSE RATES USED ARE
                        .00000 DEGREES K PER METER FOR STABILITY CLASS D
                        .00000 DEGREES K PER METER FOR STABILITY CLASS E
                        .00000 DEGREES K PER METER FOR STABILITY CLASS F

          THE NEAREST STAR SITE WAS CHOSEN
               STAR SITE USED
                    STATION NUMBER 14747  AT DUNKIRK          , NY
                    STARTED 49/01    ENDED 53/12 46
                    LATITUDE  423000 LONGITUDE   791659
                    DISTANCE   51.89 KM  BEARING 227


            EMISSION TYPE INDEX = (P) PROCESS VENT
               EMISSION RATE:        .003196 GRAMS/SECOND
                                   100.800000 KILOGRAMS/YEAR
               STACK HEIGHT:  68. METERS
               BUILDING CROSS SECTION:      1000. SQUARE METERS
               EMISSIONS ARE FROM A     VERTICAL STACK
               STACK DIAMETER:  6.10 METERS
               EXIT VELOCITY:  15.8 METERS/SECOND
               EXIT TEMPERATURE:  478. DEGREES KELVIN


            EMISSION TYPE INDEX = (F) FUGITIVE EMISSION
               EMISSION RATE:        .000105 GRAMS/SECOND
                                     3.300000 KILOGRAMS/YEAR
               STACK HEIGHT:  31. METERS
               BUILDING CROSS SECTION:      1000. SQUARE METERS
               EMISSIONS ARE FROM A     VERTICAL STACK
               STACK DIAMETER:  2.40 METERS
               EXIT VELOCITY:  20.9 METERS/SECOND
               EXIT TEMPERATURE:  339. DEGREES KELVIN
```

Figure 2-9. Individual Plant Concentration Grid

BETHLEHEM STEEL LACKAWANNA, NY

IRON AND STEEL

(CONCENTRATION (MICRO GRAMS/CUBIC METER))

WIND DIRECTION	DOWNWIND DISTANCE (KM) .200	.500	1.000	2.000	5.000	10.000	20.000	30.000	40.000	50.000
S	3.1248-007	4.8022-006	8.8588-006	7.7022-006	5.0673-006	2.6651-006	1.2593-006	8.1918-007	6.0946-007	4.8641-007
SSW	2.3631-006	2.8354-005	4.7424-005	3.6502-005	1.6587-005	7.8681-006	3.6893-006	2.3653-006	1.7217-006	1.3430-006
SW	9.2678-007	1.2581-005	2.1710-005	1.6840-005	7.7781-006	4.0595-006	2.1311-006	1.4487-006	1.0995-006	8.8675-007
WSW	1.3930-006	1.7671-005	3.0300-005	2.3339-005	1.0221-005	5.4812-006	3.0744-006	2.1707-006	1.6845-006	1.3773-006
W	1.6492-007	2.3099-006	4.2179-006	3.6072-006	2.1037-006	1.3779-006	8.8997-007	6.9326-007	5.8401-007	5.1045-007
WNW	4.5032-007	5.1345-006	8.8190-006	7.0336-006	3.5560-006	2.0301-006	1.1900-006	8.9060-007	7.3241-007	6.2978-007
NW	4.6912-007	4.4500-006	7.6494-006	6.1773-006	3.2511-006	1.9048-006	1.1445-006	8.7824-007	7.3842-007	6.4634-007
NNW	7.4701-006	5.0217-005	8.0205-005	5.8567-005	2.2946-005	1.0184-005	4.6058-006	2.9705-006	2.2163-006	1.7827-006
N	6.1570-006	4.8889-005	7.9423-005	5.8579-005	2.3518-005	1.0838-005	5.1378-006	3.3883-006	2.5606-006	2.0769-006
NNE	1.6300-005	1.5788-004	2.6054-004	1.9243-004	7.5911-005	3.4853-005	1.6567-005	1.0755-005	7.9056-006	6.2173-006
NE	3.4986-006	3.5345-005	5.8425-005	4.3456-005	1.7846-005	8.3118-006	3.9381-006	2.5548-006	1.8827-006	1.4862-006
ENE	1.9528-005	1.6507-004	2.6330-004	1.9224-004	7.5407-005	3.2475-005	1.3846-005	8.3712-006	5.8425-006	4.4137-006
E	2.4914-006	2.2872-005	3.7148-005	2.7945-005	1.2083-005	5.4017-006	2.3501-006	1.4417-006	1.0223-006	7.8501-007
ESE	1.2367-005	1.1828-004	1.9415-004	1.4480-004	5.9437-005	2.5948-005	1.1104-005	6.7265-006	4.7003-006	3.5531-006
SE	1.1515-006	1.4731-005	2.5381-005	1.9845-005	9.4195-006	4.5800-006	2.1831-006	1.4088-006	1.0299-006	8.0629-007
SSE	1.2144-006	1.8820-005	3.3463-005	2.7572-005	1.5341-005	7.6519-006	3.6334-006	2.3557-006	1.7323-006	1.3631-006

Figure 2-10. Map of Population Centroids and Population of Grid Cell

MAP OF POPULATION BY CONCENTRATION RADIUS

CONCENTRATIONS ARE IN UNITS OF MICRO-GRAMS PER CUBIC METER
ASARCO EL PASO, TX

DIR	RADIUS	.200	.500	1.000	2.000	5.000	10.000	20.000	30.000	40.000	50.000
S	# CNTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0
SSW	# CNTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0
SW	# CNTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0
WSW	# CNTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0
W	# CNTRDS	0	0	0	0	0	1	0	1	0	0
	POP	0	0	0	0	0	3377	0	405	0	0
WNW	# CNTRDS	0	0	0	0	1	5	2	1	0	0
	POP	0	0	0	0	932	6037	230	681	0	0
NW	# CNTRDS	0	0	0	0	0	6	13	1	3	2
	POP	0	0	0	0	0	13442	8218	774	1946	1201
NNW	# CNTRDS	0	0	2	0	1	4	2	7	3	3
	POP	0	0	818	0	375	11535	1071	4308	1998	3390
N	# CNTRDS	0	0	0	0	0	0	1	2	0	1
	POP	0	0	0	0	0	0	2	1417	0	0
NNE	# CNTRDS	0	0	0	0	4	3	33	4	1	1
	POP	0	0	0	0	10738	5691	55117	765	205	0
NE	# CNTRDS	0	0	0	1	1	18	20	1	0	0
	POP	0	0	0	577	1727	16771	37217	0	0	0
ENE	# CNTRDS	0	0	0	0	2	29	18	1	0	1
	POP	0	0	0	0	3175	28857	29072	1688	0	0
E	# CNTRDS	0	0	0	1	9	43	62	8	3	0
	POP	0	0	0	2347	8007	33481	103274	10228	1956	0
ESE	# CNTRDS	0	0	0	0	22	11	9	31	4	4
	POP	0	0	0	0	15861	5490	19038	31877	3709	2498
SE	# CNTRDS	0	0	0	0	2	1	0	0	0	0
	POP	0	0	0	0	1259	266	0	0	0	0
SSE	# CNTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0

Figure 2-11. Map of Population Centroids and Population by Patch

MAP OF POPULATION BY PATCH RADIUS

CONCENTRATIONS ARE IN UNITS OF MICRO-GRAMS PER CUBIC METER
ASARCO EL PASO, TX

DIR	RADIUS	.200	.500	1.000	2.000	5.000	10.000	20.000	30.000	40.000	50.000
S	# CHTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0
SSW	# CHTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0
SW	# CHTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0
WSW	# CHTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0
W	# CHTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0
WNW	# CHTRDS	0	0	0	0	1	0	0	1	0	0
	POP	0	0	0	0	3377	0	0	405	0	0
NW	# CHTRDS	0	0	0	0	5	9	2	1	0	0
	POP	0	0	0	0	5834	10160	808	1083	0	0
NNW	# CHTRDS	0	0	2	0	5	7	9	4	4	3
	POP	0	0	818	0	9815	3428	8369	2294	3673	2012
N	# CHTRDS	0	0	0	0	3	0	2	1	0	1
	POP	0	0	0	0	8593	0	2	69	0	0
NNE	# CHTRDS	0	0	0	2	0	1	13	4	0	1
	POP	0	0	0	5003	0	0	17278	1879	0	0
NE	# CHTRDS	0	0	1	0	5	32	14	1	0	0
	POP	0	0	577	0	5801	43857	26965	330	0	0
ENE	# CHTRDS	0	0	0	2	10	17	1	0	0	1
	POP	0	0	0	3028	12956	25862	0	0	0	0
E	# CHTRDS	0	0	0	2	30	41	30	0	0	0
	POP	0	0	0	1588	23547	42987	65461	0	0	0
ESE	# CHTRDS	0	0	0	6	22	18	45	15	1	0
	POP	0	0	0	5667	18926	23122	74422	8514	482	0
SE	# CHTRDS	0	0	0	5	16	0	0	9	3	2
	POP	0	0	0	5274	8745	0	0	7164	2511	362
SSE	# CHTRDS	0	0	0	0	0	0	0	0	0	0
	POP	0	0	0	0	0	0	0	0	0	0

Patches are defined by the midpoint between cell radii and the midpoint between wind directions. These patches form an area surrounding a receptor site rather than each corner being a receptor site as in the case of the grid cell.

The last two plots, not shown here, are versions of the first plot, with each input grid subdivided into quadrants. For each quadrant, the number of BG/ED centroids (third plot) or the population (fourth plot) is shown.

The cummulative summary is shown in Figure 2-12. This table starts at the highest concentration to which an individual is exposed. It then reports how many people are predicted to be exposed to that concentration and the resulting exposure. The exposure is the product of the population and concentration. The next level is a certain increment lower concentration (about 1/2 of the previous concentration) with the number of people exposed to that concentration or higher. The exposure in this instance is the cummulative exposure from the level 2 concentration and those higher. The following levels are similarly calculated until the concentration level reaches the miniumum predicted.

The overall plant summary is shown in Figure 2-13. Three such summaries are usually produced. The first is ordered according to the order of the data file. The second is ordered highest to lowest by the maximum lifetime risk number. The third is ordered highest to lowest by the annual incidence.

The first half of the overall plant summary deals with the risk to the maximum concentration. The first column reports the maximum concentration to which a person is predicted to be exposed. The second column reports the number of people predicted to be exposed to that concentration. The third column reports the exposure (people x concentration) due to that concentration. The fourth column reports the predicted lifetime incidence (exposure x unit

Figure 2-12. Cummulative Summary

SUMMARY FOR IRON AND STEEL
MAXIMUM RADIUS = 50.0 KM

LEVEL	CONCENTRATION	POPULATION	EXPOSURE
1	1.64E-03	7	1.19E-02
2	1.00E-03	32	4.24E-02
3	5.00E-04	422	3.17E-01
4	2.50E-04	7,230	2.72E+00
5	1.00E-04	66,700	1.10E+01
6	5.00E-05	240,000	2.27E+01
7	2.50E-05	733,000	3.95E+01
8	1.00E-05	2,810,000	7.00E+01
9	5.00E-06	8,000,000	1.04E+02
10	2.50E-06	22,500,000	1.57E+02
11	1.00E-06	28,000,000	1.67E+02
12	5.00E-07	31,500,000	1.69E+02
13	2.50E-07	33,500,000	1.70E+02
14	1.00E-07	33,600,000	1.70E+02
15	5.00E-08	33,600,000	1.70E+02
16	4.61E-08	33,600,000	1.70E+02

Figure 2-13. Overall Summary Chart

SUMMARY FOR IRON AND STEEL
WITH A UNIT RISK OF 2.30E-03

-MAXIMUM-					--MINIMUM--					
CONC	PEOPLE	EXPOSURE	LIFETIME INCIDENCE	MAX RISK	CONC	PEOPLE	EXPOSURE	ANNUAL INCIDENCE	REPEAT INTERVAL	SOURCE
2.63E-04	605	1.59E-01	3.66E-04	6.06E-07	1.65E-07	1,270,000	1.53E+01	0.0005	2,000.	BETHLEHEM STEEL LACKAWANNA, N
7.41E-05	399	2.96E-02	6.80E-05	1.70E-07	4.61E-08	1,270,000	5.98E+00	0.0002	5,100.	REPUBLIC STEEL BUFFALO, NY
2.89E-04	1	1.69E-04	3.88E-07	6.65E-07	9.35E-07	1,140,000	5.71E+00	0.0002	5,300.	CRUCIBLE, INC. SYRACUSE, NY
4.37E-04	20	8.63E-03	1.99E-05	1.00E-06	2.99E-07	237,000	1.03E+00	<0.0001	30,000.	ROBLIN STEEL DUNKIRK, NY
1.19E-04	25	2.98E-03	6.84E-06	2.74E-07	4.99E-07	8,000,000	3.42E+01	0.0011	890.	NEW JERSEY STEEL & STRUCTURE
1.64E-03	7	1.19E-02	2.73E-05	3.78E-06	6.91E-07	904,000	1.94E+01	0.0006	1,600.	AL TECH SPECIALTY STEEL WATER
1.19E-04	50	5.96E-03	1.37E-05	2.74E-07	5.43E-07	10,800,000	4.95E+01	0.0016	620.	RARITAN RIVER STEEL PERTH AMB
2.01E-04	59	1.20E-02	2.75E-05	4.63E-07	1.89E-07	739,000	2.30E+00	0.0001	13,000.	AUBURN STEEL CO AUBURN, NY
2.37E-04	7	1.74E-03	4.00E-06	5.45E-07	1.92E-07	707,000	5.91E+00	0.0002	5,100.	COLT INDUSTRIES SYRACUSE, NY
2.10E-04	91	1.98E-02	4.54E-05	5.02E-07	1.49E-07	1,240,000	1.81E+00	0.0001	17,000.	GUTERL SPECIAL STEEL CORP. LOC
6.88E-05	4	2.82E-04	6.48E-07	1.58E-07	2.89E-07	4,530,000	4.76E+00	0.0002	6,400.	JARSCO ROEBLING, NY
1.15E-03	4	4.20E-03	9.67E-06	2.64E-06	9.91E-07	2,750,000	2.43E+01	0.0008	1,300.	CARPENTER TECHNOLOGY CORP. BR
						33,600,000	1.70E+02	0.0056	180.	OVERALL

risk) due to the maximum concentration. The fifth column is one of the values EPA uses to report risk. This is the maximum individual lifetime risk and is calculated by multiplying the maximum concentration by the unit risk number.

The next part of the summary deals with the minimum and overall concentrations and exposures. The first column of this half (the sixth column overall) reports the minimum predicted concentration within 50Km of the plant. The next column reports the total number of people exposed to any concentration of the chemical within 50Km of the plant. The next column reports the cummulative exposure. This is calculated by summing the exposure from each modeled receptor site. The next column reports annual incidence and is calculated by multiplying the cummulative exposure by the unit risk number which yields lifetime risk and dividing by seventy (the estimated life span) to yield an average annual incidence. This number is also frequently used to describe risk. The next column, labeled repeat interval, is simply the inverse of the annual incidence column. This is used to describe how many years elapse before one death is predicted to occur. The last column reports the source name.

Chapter 3

3-1. Introduction to SHEAR

The Systems Applications Human Expsoure and Risk (SHEAR) model is based on code and concepts developed in SHED. In contrast to SHED, which was developed for a national estimation of risk, SHEAR was developed for regional analysis. SHEAR is also more complicated to run as it has more options and input files than does SHED.

There are four basic instances where SHEAR should be used: 1) If there are two major point sources very close (within 5 km) to each other and the additive concentration needs to be determined, 2) multiple pollutants from one source need to be analyzed, 3) there are a large number of sources within an area which cannot feasibly be located individually, or 4) when the sources are so numerous and widespread that they act as an area source rather than several point sources. In the first instance, SHEAR holds the population constant within the study area and sums the risk. So, if a person were exposed to a concentration X from source A and a concentration Y from source B, SHEAR would report a single person exposed to a concentration (X+Y). In contrast, SHED would report 2 people, one exposed to concentration X and the other to concentration Y. Both models yield the same exposure results but SHED double counts some of the people. Unfortunately, the same mechanism which allows SHEAR to prevent double counting often causes the model to underpredict the maximum lifetime risk. Even though SHEAR sums the risk, it only sums these risks at population centroids. This eliminates the area closer to the plant where people actually may be residing and where the concentrations are much higher. For this reason, SHED, which spreads the population out, almost always predicts a higher maximum lifetime risk than SHEAR. Hence, SHEAR is generally not used to determine maximum lifetime risk.

In the second instance, SHEAR merely allows many chemicals to be run at once. The same results could be obtained manually with SHED by adding results of each run. SHEAR automates this procedure and, again, holds the population constant.

The last two instances in which SHEAR would be used provide a means of analyses not available through SHED. SHEAR allows modeling of sources too numerous to model individually through its prototype and area source models. Therefore, such sources as service stations, dry cleaners, etc. are more appropriately modeled with SHEAR rather than SHED.

In addition, SHEAR allows areas to be specified within the study region. For instance, you can define each neighborhood in a county in order to model residential emissions for that county, rather including downtown areas, farmland and lakes. These capabilities make SHEAR a very useful model for sources which cannot be modeled with SHED.

3-2. Input Data

SHEAR requires several pieces of information in order to run properly.

Although SHEAR requires somewhat different input data than SHED, the information still falls into the four major categories:

> Location Data

> Emissions Data

> Vent Parameter Data

> Atmospheric Reactivities

In addition, SHEAR requires input of the STAR station code number to identify which meteorological data should be used. The following section describes the input information needed for SHEAR and possible sources of this information. Much of this additional information can be derived from the same sources as those indicated in Section 2-2. In those instances,

the appropriate earlier section will be referenced. Placement of the data into the various files for use by the SHEAR program is discussed in Section 3-5.

As in SHED, SHEAR requires input of the unit risk estimate to link the exposure to health risk. These estimates for cancer risk are generally generated by the Carcinogen Assessment Group in a Health Assessment Document for the chemical. A unit risk estimate is the estimated risk to an individual of contracting cancer if the individual is exposed to one $\mu g/m^3$ of the chemical for their entire lifetime. Hence it is expressed in units of $(\mu g/m^3)^{-1}$. If the unit risk is not included, the concentrations and exposure results are calculated with no calculations of health risk. Insertion of zero for the unit risk will prevent the program from running properly. So, insert one or leave blank if the unit risk is unknown.

Location Data

The location data for the major point source portion of SHEAR can be determined by the means discussed in Section 2-2. It is important with SHEAR, as with SHED, to locate the plants accurately, as the additive concentrations will not be representative of the actual situation.

The location of area and prototype sources is different from major point sources. These sources are not located specifically, but a box is defined around them. First, you must determine the general area you wish to study. (The area should be about the size of a county or a few counties.) Then you must determine the specific coordinates of the southwest corner of the box and the length and width of the box. This information can be determined from:

> United States Geological Survey maps (7 1/2 and 15 minute series).

> U.S. atlas which has county breakdowns in state maps.

The southwest corner must be in UTM coordinates. To translate geodetic coordinates to UTM use the program described in Appendix B.

Often you will wish to model only a specific county(s) or part of a county(s) within the box. The program has the areas of all the counties in the U.S. defined. You still must box in the county and define the grid cells but if you enter the Federal Information Processing System (FIPS) code of the county(s), only the area both inside the county and inside the box will be modeled. The FIPS codes for the counties can be obtained from the most recent copy of Worldwide Geographic Location Codes produced by the U.S. General Service Administration, Office of Finance or from the National Bureau of Standards FIPS Publication 55.

Emissions Data

Again, for major point sources, the emissions data can be obtained as discussed in Section 2-2.

The emissions data for prototype sources can also be obtained by using methods in Section 2-2. The emission rate used, however, should be an average or prototypical emission rate because all sources will be modeled to emit at the same rate.

The area emission rate may be obtained from a number of published sources which include:

> Statistical Abstracts of the United States.

> Chemical Engineering Progress and other journals.

> Government publications of emissions and/or material consumption.

From these, the emission rate may determine as emissions/area or emissions/person. Consumption rates can yield emission rates if an emission factor is applied as earlier discussed.

Vent Parameter Data

Vent parameter data are necessary for the major point and prototype dispersion modeling. These data can be obtained in the manner discussed in

section 2-2. The parameters include the number of vents, vent height, vent diameter, gas discharge temperature, gas velocity, fugitive discharge area and building cross-sectional area. The area source analysis does not require these data.

Atmospheric Reactivities

At present, chemical reactivity input is not available with the SHEAR model. Although the card is structured to accept the data input, a separate runstream initiating the program to use the data has not been implemented. The need has not yet risen to develop this portion of the program because very few chemicals are reactive enough to demonstrate changes within the 50 km radius.

Meteorological Data

Unlike SHED, SHEAR requires input of the desired STAR station code number. The station selected should normally be the station closest to the region currently being analyzed. A more remote station can be selected if it is judged that its climate is more representative of conditions in the analysis region. This might occur because of the relative proximity of the region and each weather station to coastlines or major topographical features. Selection of a station other than the closest should be made only upon expert advice. (See Section 1-2 for additional information.)

To obtain STAR station code numbers for the area of interest, a program available on UNIVAC may be used. This program is called STAR-PICK and is described in detail in Appendix A.

3-3. Dispersion Modeling

This section describes the algorithms used to process the input data into the resulting exposures to populations. Each of the three types of sources, major point, prototype and area, must be discussed individually as each uses its own method to reach the end result.

Major Point Source

The major point source for SHEAR is analyzed almost exactly the same as for SHED (see Section 2-3). Therefore, the complete discussion will not be repeated here. Two differences exist between the SHEAR point source and the SHED point source. First, the two-level scheme adopted by SHED for pairing concentrations to populations is not used in SHEAR. SHEAR uses the method of interpolating the concentration receptors to the BG/EDs from the source out to the maximum radius. This is the same method SHED uses outside the 3.5 km radius. Secondly, SHEAR is capable of storing all the concentrations and their locations. In the event that another plant emits the pollutant within the same area, the new concentrations at each location (BG/ED centroid) will be added to the stored concentrations at that same location. SHEAR handles exposure to several chemicals from the same plant in a similar manner. SHED does not have this capability.

Prototype Sources

Prototype sources are treated exactly as specific point sources except for an algorithm for selecting sites for the required samples of each prototype. PROTO code is the POINT code with the addition of the siting algorithm and the provision of a single source characterization (the prototype) to be used for every source that is sited.

The siting algorithm provides for a random selection of L centroids where L is the number of locations to be selected. If it is desired that some sites serve multiple samples--as, for example, a fraction of gasoline service stations are sited in pairs, triplets, etc.--then the number of locations is determined by $L = S + 2(D) + 3(T) + 4(Q)$:

where

L = number of locations,

S = number of singles (single source),

D = number of doubles (two sources),

T = number of triplets (group of three sources),

Q = number of quadruplets (group of four sources)

The actual sites are placed at randomly perturbed locations within each selected district. That is, each site location is at the population centroid map coordinates + (-) a random fraction of the district mean radius to the east (west) + (-) a random fraction to the north (south).

This procedure approximately distributes sources by population density. However, there is a rural/urban bias to BG/ED population because some rural BG/EDs can be very small; urban BG/EDs almost never are. This bias would tend to over-represent rural districts since the small rural BG/EDs would have an equal probability of being selected; a counter-bias is provided whereby BG/EDs of less than 1,000 population are randomly rejected and replaced with another selection.

Area Source Analysis

The area source is used for those sources which cannot be specified in detail. Such emissions must be inferred by relating them to population, motor vehicles, etc. For these sources, it is necessary to use a simple dispersion algorithm to estimate concentration patterns. The Gifford urban area dispersion algorithm (Hanna and Gifford, 1973) has proved to be a simple but physically realistic model capable of estimating atmospheric

pollutant concentrations caused by area source emissions in cities. The basic Hanna-Gifford Equation is given as:

$$X = CQ_0/U \quad ,$$

where X is the air pollutant concentration, Q_0 is the effective emissions rate per unit area, and U is the wind speed. The parameter C, generally referred to as the Gifford coefficient, is a weak function of the city size; it may be taken to be approximately constant. Theoretically, the parameter C is given by:

$$C = (2)^{1/2} \cdot X^{1-b}/[a(1 - b)]^{-1} \quad ,$$

where X is the distance from a receptor point to the upwind edge of the area source. The constants a and b are defined by the vertical atmospheric diffusion length, $\sigma_z = ax^b$. Values of a and b for different atmospheric dispersion conditions have been discussed by Pasquill (1970, 1971). The parameter C can be estimated for various combinations of the stability factors a and b and by assuming that X equals half the city size (Hanna, 1978). For example, 213 would be an appropriate value of C for a city with a land area of 400 km^2 under Pasquill Class D stability (while a = 0.15 and b = 0.75). Specific values of the parameter C have been empirically estimated by Hanna and Gifford (1973) for a large number of U.S. cities based on a large quantity of air quality data, average annual emissions, and meteorological conditions. The mean value of C has been found to equal 225, with a standard deviation roughly half that magnitude. This value of the parameter C has been recommended for use in evaluating an area source by the EPA (1977a, b) if removal and decay processes may be neglected. Estimates of the parameter C were calculated by using Equation 11 and by

assuming Pasquill Class D stability as the average long-term meteorological condition.

The application of the Gifford approach within SHEAR has been modified to provide variation of atmospheric concentration across a modeling region in proportion to the local emission rate per unit area. This approach provides a higher degree of resolution of concentration patterns than does the single urban box approach, but does not address the details of pollutant advection and dispersion that are treated by grid dispersion models.

In the present approach, box model (Gifford model) dispersion results are simply scaled at each BG/ED by the ratio of the density of emissions per surface area at the BG/ED to the regional mean emission density.

Options in the AREA code provide for varying or non-varying (from district to district) emission rates. Emissions that vary with BG/ED are scaled by the population density of the BG/ED. This is to address pollutant emitting activities that uniform fractions of the population are expected to be engaged in at any given time. Examples of such activities are motor vehicle usage and operation of home furnaces.

Either uniform or nonuniform emission rates may be restricted to specified portion of the modeling region. This feature is provided so that the user may address such source types as crop spraying, tillage dust, area burning, or other activities for which specified areas may be identified.

Equation 11 shows that the concentration is inversely proportional to the wind speed. In SHEAR, each wind speed in the STAR set is used. The STAR matrix is summed over wind direction and stability class to give the frequency of occurrence of each speed. The concentration is computed as the sum of the frequency-weighted concentrations for each wind speed.

3-4. Assumptions

Similar to SHED, SHEAR makes certain assumptions in order to run with limited data. This section describes the necessary assumptions to provide the user with an understanding of the limitations of SHEAR and the need to consider such limitations in the use of the output data. The assumptions for SHEAR include both those listed here and those covered in Section 2-4.

The SHEAR model uses census data to the BG/ED level. Although this is the smallest defined population unit, it still places approximately 800 people at one point. This is not a realistic depiction of their residence. Some of the people may actually be located closer to the plant and receive greater exposure than modeled or vice versa. Unlike SHED, this is especially true closer into the plant. Where SHED spreads the population out to all the concentration points within the 3.5 km range, SHEAR simply uses the interpolation method (which SHED uses from 3.5 - 50 km radius) for all distances from the source so that all exposure occurs only at the population centroid. This can result in concentration receptors close to the plant being ignored because no people are assigned to them, even though people counted in a nearby population centroid may actually be living in such areas. This would result in an under estimation of the maximum concentration to which people are exposed. Thus, even though the major point source portion of SHEAR can add concentrations from several plants and risks of different chemicals, the modeled maximum risk may not be as high as that modeled by SHED. One advantage of the SHEAR methodology for using the interpolation of concentration to people rather than people to concentration, is that this method never locates people over large bodies of water, provided population centroids are not so located (a circumstance the Census Bureau strives to avoid).

The prototype algorithm of SHEAR with the random location of sources obviously cannot be assumed to correctly represent the actual source locations. The results of the prototype model depend strongly on the population density of the county being modeled.

The area source model requires more fundamental assumptions concerning population and concentrations than do the other two types of sources. Unless the area is well known and defined, portions of the study area such as parks or lakes which contain no sources may be included into the area over which the emissions are spread. Since area is contained in the denominator of the Hanna Gifford Equation, the resulting concentration may be somewhat lower than the actual. In addition, unless rural areas are deleted from models of urban sources, people in the rural area who may not be exposed to the pollutant will be included with those exposed. This model should be used only to determine a rough estimate of what public exposure might be, unless the study is restricted to urban areas.

3-5. Using the SHEAR Model

The SHEAR model is more complex to run than the SHED model. It is designed to handle the various modeling techniques (area, prototype and point), as well as, multiple chemicals. This flexibility requires the use of several files and each file has its own format. Some of the data entered in each file may seem redundant but must be entered in order for the program to identify the appropriate files and to execute properly.

The number of files and means of accessing the appropriate files requires a brief explanation of how files are identified before you can effectively use SHEAR. In order for a file to be identified, the qualifier and the filename must be provided. If you type only the filename, the

project ID is assumed as the qualifier. If you type *filename, the program searches for the last @QUAL statement. That statement becomes the qualifier. If no @QUAL exists, the project ID again becomes the default. If these methods cannot define the appropriate file, you must type qualifier*filename to identify the file.

* * *

NOTE: For all the instructions below, all information within commands which are specific to your file or run will be typed in small letters and contained in parentheses. For example, @@CONS RC (run id) means type @@CONS RC Ø8PT if Ø8PT is the run id of the run you needed to check. Do not type the parentheses.

* * *

SHEAR groups its files into two categories; area specific and chemical specific. This allows several chemicals to be analyzed for the same study area, using the same study area file. Both groups of files must be cataloged before entering the data.

To name the area specific files, type:

@QUAL (Study Area)

The study area name may be any alpha numeric name with 1-12 characters. This name is now the qualifier for all the area specific files. To catalog the files type:

@ADD SASD*HEP-RUN.SHEAR-CAT/NON-QUALED

Several lines of symbols will be printed when you push XMIT. When the computer responds with "READY" the area specific files are cataloged. You may enter data now or catalog the second group of files.

To name the chemical specific files, type:

@QUAL (Chemical Name)

The chemical name may be any alpha numeric name with 1-12 characters. This chemical name is now the qualifier for all the chemical specific files. To catalog these files type:

@ADD SASD*HEP-RUN.SHEAR-CAT/QUALED

Again, the computer will print several lines of symbols until it responds with "READY." At this point the chemical specific files are cataloged and you are ready to enter data.

Entering the Data

You are now ready to enter data into each data file. To do this, some sort of text editor must be called. Several text editors are avilable but for this example, we will use the Maryland text editor. Specific editing commands for the Maryland editor are available in Hagerty and Sibbald's "Text Editor User's Guide." A few commands are also provided in Appendix C of this manual.

The first file to be entered is an area specific file which identifies to the program the name of the chemical-specific files. This is the only area-specific file which must be changed when running an additional chemical with the same study area.

To open the file type:

@EDM (Study-Area)*QUAL.

Enter the following information:

@QUAL (Chemical Name)

In order to have the output printout alligned correctly, the format should follow figure 3-1.

To open the first data file type:

@EDM (Studyarea)*SHR-XTRACT.

The data you enter into this file defines the area of the country which will be modeled. Each line of data, referred to as a card, has a specific

@QUAL CARD FOR SHEAR FILE QUAL

THE QUAL CARD ALLOWS THE USER TO SELECT DIFFERENT SETS OF DATA FOR THE SAME REGION

1	15 26
@QUAL	THE QUALIFIER

Figure 3-1

function and format. If data is not entered in the correct columns and rows, the data will be misinterpreted by the program. Therefore, you should enter the data exactly as described below (see also Figure 3-2):

Card 1, Columns 1-80 = An identifying name of the region, to be selected by user. This name is used in subsequent output headings generated by any module using this data. The name may be up to 80 alpha characters.

Card 2, Columns 1-10 = The UTM easting of the SW corner of a rectangle sufficiently large to include the desired modeling region. UTM coordinates are expressed in meters on all USG maps. The 7 1/2- and 15-minute series maps are likely to be most appropriate sources of this data. Because UTM coordinates are numerically large, trailing zeros may be suppressed on some map displays. Care should be taken to acquire and input coordinates in kilometers. Up to 10 digits are allowed.

Columns 10-20 = The UTM northing of the SW corner referred to above.

Columns 21-25 = The UTM zone number. Since UTM coordinates are plane approximations to a spherical surface, they are defined for zones, each of which is limited in size to limit the approximation error. UGS maps note zones used. Coordinates are entered as up to 5-digit integers.

Columns 26-34 = The size of cell to be used in Cartesian grid resolution of BG/ED areas. Small cells lead to fine resolution on the plotter, but, since actual BG/ED perimeters are

POPULATION EXTRACTION DATA FOR SHEAR FILE SHR-XTRACT.

CARD 1

1 – 80
REGION NAME

CARD 2 - DEFINES BASIC RECTANGLE

1	11	21	26	36	41 – 45
MINIMUM X (KILOMETERS)	MINIMUM Y (KILOMETERS)	UTM ZONE	GRID SIZE (KILOMETERS)	NUMBER X CELLS	NUMBER Y CELLS

CARD 3

1	5 – 9
POP YEAR	NUMBER OF COUNTIES

CARD 4 FIPS CODES OF COUNTIES TO BE SELECTED - AS MANY CARDS AS REQUESTED ON CARD 3

1 – 5
ST CNT

Figure 3-2

not known, finer resolution does not necessarily produce more accurate definition of BG/ED areas. Hence, larger grid cells produce the same risk results as small grid cells but the smaller cells produce better plotted output. Larger cells also require less computer time to run. The number of grid cells used may be limited by available space or computing time on the computer used. This XTRACT code limits the grid to 10,000 cells. This limitation may be changed at the user's discretion by recompiling the programs. The cells will be square, so this datum serves as both as X and a Y cell dimension.

Columns 35-40 = The number of grid cells desired in the X (E-W) direction.

Columns 41-45 = The number of grid cells desired in the Y (N-S) direction.

Card 3, Columns 1-4 = The year for which population is desired (used for extrapolation from 1980).

Columns 5-9 = The number of counties for which the populations is desired. (optional)

Card 4, Columns 15 = The FIPS codes of the counties to be selected. The number of codes listed must be the same number of counties stated in Card 3. (optional) If this option is exercised, the analysis will be restricted to the county(s) specified. The study area then consists of the portions of the specified counties that are within the box defined above.

Card 5 = The region within the defined analysis area to be excluded from the analysis (optional). The region is defined in the card by the minimum and maximum rows (y coordinates) of any cluster of cells to be deleted followed by the minimum and maximum columns (x coordinates) in each affected row, in sequence. Coordinates are expressed in units of cell number (five digits). Cell number (1, 1) is the lower left corner of the defined rectangle. (See Figure 3-3.)

This is all the data needed for the XTRACT file. The next data file requires information concerning the weather (STAR) data. To open the file type:

@EDM (chemical)*SHR-STAR.

The data should then be entered in the following format (see also Figure 3-4):

Card 1, Columns 1-80 = The name of the chemical addressed in the present run. This is to be used in subsequent headings.

Card 2, Columns 1-10 = The hazard factor (unit risk) for the chemical, if available. This is required if hazard or risk or other multi-species computations are desired. The factor has units of cases (of health effect) per person.$\mu g/m^3$.year. Hazard factors are based on extensive analysis of clinical and/or epidemic toxicology.

Card 3, Column 1 = A flag, zero or one, to indicate if rural (1) or urban (0) dispersion conditions prevail. This flag should be

EXCLUSION DATA FOR SHEAR FILE SHR-XTRACT.

CARD 5 (EXCLUSION CARDS USING FILE COUNTS) OPTIONAL

1	6	11	16	21	26	31	36	41	46	51	56	61	66	71	76	80
MIN BOX	MAX BOX	MIN 1 COLUMN	MAX 1 COLUMN	MIN 2 COLUMN	MAX 2 COLUMN	MIN 3 COLUMN	MAX 3 COLUMN	MIN 4 COLUMN	MAX 4 COLUMN	MIN 5 COLUMN	MAX 5 COLUMN	MIN 6 COLUMN	MAX 6 COLUMN	MIN 7 COLUMN	MAX 7 COLUMN	

Figure 3-3

CHEMICAL & STAR DATA FOR SHLAR FILE *SHR-STAR.

CARD 1

CHEMICAL NAME

CARD 2

UNIT RISK

CARD 3

R U	STAR SITE	EXCLUDED STABILITIES	EXCLUDED WIND SPEEDS	EXCLUDED WIND DIRECTIONS

COLUMN ONE EQUAL 1 IMPLIES THE AREA IS RURAL. USE ALL STABILITY CLASSES
COLUMN ONE EQUAL 0 IMPLIES THE AREA IS URBAN. COMBINE STABILITY CLASSES D, E, & F TO GIVE REVISED CLASS D

ITEMS CODED 1 ARE EXCLUDED

CARD 4

AMBIENT TEMP DEGREES K	LAPSE RATE FOR STABILITY CLASS D	LAPSE RATE FOR STABILITY CLASS E	LAPSE RATE FOR STABILITY CLASS F

Figure 3-4

set by a person familiar with EPA dispersion modeling practices.

Columns 11-15 = The station number of the United States Weather Service reporting station from which STAR dispersion data is desired for the present run. The station selected will normally be the station closest to the region currrently being analyzed. A more remote station might be selected if it is judged that its climate is more representative of conditions in the analysis region. This might occur because of the relative proximity of the region and each weather station to coast lines or major topographic features. Selection of a station other than the closest should be only upon expert advice. (See Section 1-2)

Columns 21-27, Columns 31-36 and Columns 41-56 = Specification of portions of the selected STAR data matrix to be deleted. The STAR matrix consists of a three-dimensional array. The array variables are wind speed, direction, and atmospheric stability. The set of standard values of one or more of these variables may be diminished if it is assumed that correlations between source operation and occurrence of meteorological conditions are such that the emissions and the variable values are mutually exclusive. This data should only be entered upon expert advice. These data entries are in flag style (zeros and ones). Each parameter is addressed by a string of flags, one for each

standard value, in sequence. There are six wind speeds, so there is a string of six flags for this parameter; there are seven stabilities and 16 directions with corresponding flag strings. If these columns are left blank, all of the STAR data is used.

Card 4, Columns 1-40 = Ambient temperature (in °K) and lapse rate (in °K/m). Since the computation is an annual average computation, only representative values can be used. Depending on the application, mean or extreme values might be used. If these cards are left blank, default values are used. It is important, however, that a blank card actually be inserted here. One way to do this is to type:

```
I Y    (XMIT)
  C / Y /  /    (XMIT)
```

This will insert a blank card.

This completes the STAR data. The next set of commands demonstrates what to enter for point, prototype and area sources. For major point source model, enter the following (see also Figure 3-5):

@EDM (chemical)*SHR-POINT.

The data to be entered for this file is very similar to that entered for SHED with a few exceptions. In fact, a SHED file can be added and edited to create this file. The three cards should be entered for each plant and each chemical. The data is entered in the following format:

Card 1, Columns 1-80 = The facility identification in alpha numeric characters.

Card 2, Columns 1-6 = Latitude of the facility in degrees, minutes and seconds.

POINT SOURCE & PROTOTYPE DATA FOR SHEAR

FILES *SHR-POINT. & *SHR-PROTO.

CARD 8

1	80
FACILITY IDENTIFICATION	

CARD 9

1	7		40	45	50	55	60	64
LATITUDE DEG MIN SEC	LONGITUDE DEG MIN SEC		NUMBER SOURCES	PROTOS SINGLE	PROTOS DOUBLE	PROTOS TRIPLE	PROTOS QUADRUPLE	

CARD 10

SUBMIT ONE OF THE FOLLOWING FOR EACH SOURCE AT THE FACILITY

1		14	18	22		27	32	35
E I	EMISSION RATE (KG / YEAR)	STACK METERS	HRLA Mo=2	V I	DIA METERS	VELOCITY M/SEC	TEMP (K)	

ET (COLUMN 1) EMISSION TYPE
- P = PROCESS VENT
- S = STORAGE VENT
- F = FUGITIVE EMISSIONS
- H = STACK

VT (COLUMN 22) VENT TYPE
- 0 = VERTICAL STACK
- 1 = NON-VERTICAL STACK OR A VENT

Figure 3-5

Columns 7-13 = Longitude of the facility in degrees, minutes and seconds.

(This is all that is entered in Card 2 for major point sources)

Card 3, Column 1 = Indicator as the emission type.

P = process vent; S = storage vent

F = fugitive emissions; H = stack

Columns 2-13 = Emission rate in Kg/year including decimal point.

Columns 14-17 = Stack or vent height in meters with decimal point.

Columns 18-21 = Building (of vent or stack) cross sectional area (M^2) perpendicular to the mean wind flow, including demical point.

Column 22 = Indicator as to vent type.

Ø = vertical stack, 1 = nonvertical stack or vent.

Columns 23-26 = Inside stack or vent diameter in meters, including decimal point.

Columns 27-31 = Gas exit velocity from vent or stack in m/sec including decimal point.

Columns 32-35 = Gas exit temperature in degrees K including decimal point.

In order to use the prototype portion of the SHEAR model you must open the following file:

@EDM (chemical)*SHR-PROTO.

The data entered for the prototype source is identical to the data entered for the major point source described above except for Card 2. This card should be filled out exactly as follows (see also Figure 3-5):

Card 2, Columns 1-39 = Blank

Columns 40-44	= The number of prototype sources to be located within the specified area.
Columns 45-49	= The number of sources which will not be located in the same cell as another prototype (protosingle).
Columns 50-54	= The number of times that sources which will be colocated with only one other prototype.
Columns 55-59	= The number of times three prototype sources will be colocated.
Columns 60-64	= The number of times four prototype sources will be colocated.

(The sum of columns 45-49 plus 2X columns 50-54 plus 3X columns 55-59 plus 4X columns 60-64 must equal the number entered in columns 40-44.)

In order to use the area source portion of the SHEAR program type in the following:

@EDM (chemical)*SHR-AREA.

The data should be entered into this file as indicated below (see also Figure 3-6):

Card 1, Columns 1-80	= The area source identification name.
Card 2, Columns 1-10	= The emission rate per year per unit population or per square kilometer. The units are Kg/yr.
Columns 11-20	= The number of people which you use as the unit population above. If this number is zero, the model assumes the emission rate to be Kg/yr/Km^2.
Card 3, Columns 1-5	= Indicator as to whether the whole area is to be used or whether additional areas are to be added or subtracted. If the number of areas is positive, then the areas are included; if

AREA SOURCE DATA FOR SHEAR FILE *SHR-AREA

CARDS 1-4 COME FROM FILE *SHR-STAR CARD 4 IS IGNORED CARD TYPES 5 & 6 ARE REPEATED AS OFTEN AS NEEDED

CARD 5

1 ... 80
AREA SOURCE IDENTIFICATION

CARD 6

1 ... 10	11 ... 20
EMISSION RATE (KG/YR/Z)	UNIT POPULATION

IF UNIT POPULATION = 0. EMISSIONS ARE IN KG/YR/SQ KM
IF UNIT POPULATION > 0. EMISSIONS ARE IN KG/YR/UNIT POPULATION

CARD 7

1 ... 6
NUMBER OF AREAS

IF NUMBER OF AREAS > 0. THEN THE AREAS ARE INCLUDED
IF NUMBER OF AREAS < 0. THEN THE AREAS ARE EXCLUDED
IF NUMBER OF AREAS = 0. THEN THE WHOLE AREA IS USED

CARD 8 (THE AREAS)

1 ... 10	11 ... 20	21 ... 30	31 ... 40
MIN X	MAX X	MIN Y	MAX Y

Figure 3-6

negative, the areas are excluded and if the number of areas is zero, the whole area is used.

Card 4, Columns 1-40 = These cards define the area to be included or excluded from the defined analysis region (optional). The area is defined by the minimum and maximum UTM x coordinates (10 digits each in kilometers) and the minimum and maximum y coordinates (10 digits each in kilometers). This could be used to look at only crop areas in a county (inclusion) or deleting a city park from the analysis area (exclusion).

The last data file, called the Summarization Data File, must be filled out for any SHEAR run. This file enters the unit risk number for the final calculation. To open this file type:

@EDM (studyarea)*SHR-REPORT.

Enter the data as follows (see also Figure 3-7):

Card 1, Columns 1-80 = Enter the chemical name as previously entered.

Card 2, Columns 1-10 = Unit risk number for lifetime risk.

Columns 11-42 = Filename. (chemical name*CONC-FILE.)

Cards 1 and 2 should be filled out for each chemical to be analyzed. This allows separate reports to be printed for each chemical when running multiple chemicals.

Figures 3-1 through 3-7 gives a summary of the data to be entered for each file described above. It is strongly recommended that these summary sheets be used when entering data into the data files.

SUMMARIZTION DATA FOR SHEAR FILE SHR-REPORT.

REPEAT THE SETS OF TWO CARDS

CARD 1

CHEMICAL NAME (1–80)

CARD 2

UNIT RISK (1–10)	FILE NAME (11–42)

CARD 1

CHEMICAL NAME (1–80)

CARD 2

UNIT RISK (1–10)	FILE NAME (11–42)

Figure 3-7

Running the Program

Once the files have been filled as described above, the program is ready to run. Unlike SHED, you have entered data into data files not program files. Therefore, the files are ready to use by the model and do not need to be copied.

Also unlike SHED, SHEAR has several options for being run. The following set of commands demonstrate a good way to run the prototype and area sources. To begin, type:

@START START.SHR-PROTO-A,/(Site id),,,(Filename)

Once the program has finished running for prototype sources, you must empty the XTRACT file of all concentrations. This is accomplished by entering:

@Copy (Filename)*BGED-FILE., (Filename)*CONC-FILE.

This allows the program to use the data derived from EXTRACT without rerunning that portion of the program. It also blanks out the prototype data to prevent its addition to any subsequent runs.

To run area sources, type:

@START START.SHR-AREA,/(Site id),,,(Filename)

If you want to run area first, just substitute the word "area" for "proto" and vice versa. The same applies to point source.

Two points are important to remember:

1. The "-A" as typed in the first start command is only used in the start command for the first run of a chemical. (The "A" initiates the XTRACT portion of the program which is not necessary to run again.)

2. Before making the next run, you must always empty the CONC. file using the @copy command described above.

This method of running the program keeps the analyses separate. If you wish to know the cumulative risk from thee point prototype and area sources, simply omit the step in which you empty the conc. file.

Users who would like the results of the SHEAR run to go to their PC or user ID rather than be printed at the Mutual Building or other dedicated UNIVAC printer should replace the letters SHR in the start card with USR. Do not replace SHR with USR in the filenames. The file will then not print out until requested. Please see instructions in section 2-5 to obtain results at your PC. To receive a laser printout at the Research Triangle Park replace SHR with LAZ.

Plotting SHEAR Data

Each time SHEAR is run by the commands listed earlier, a plot of the study area is sent to the CALCOMP plotter. These plots include: 1) the BG/ED locations in the region analyzed, 2) the population density, 3) the locations of the sources, and 4) the concentrations around each source. These plots are large and use various colors to depict the variable plotted.

The TEKTRONICS plotter could also be used for the SHEAR output. This produces 8 1/2 x 11 plots that are not color. To send the SHEAR output to the TEKTRONICS plotter rather the calcomp plotter, type /TEK after the point, proto or area portion of the start command. To run a stripped down version (no legends) of the output, type/TEK-B in the same place. These commands are shown in Appendix D to demonstrate all the variations (e.g., different radial distances).

The specifications for the plots described above are initiated by the run stream and can only be changed by a programmer who is familiar with the Executive Control Language (ECL). The format for the information is shown in the top portion of Figure 3-8. Additional legends, however, can be added to the plot by the general user. This format is shown in the bottom portion of Figure 3-8 and is described below:

Columns 1-13 = location of legend in UTM coordinates (e.g., source locations that you need to label.

PLOT DATA FOR SHEAR

SPECIFICATIONS (VARIOUS DEFAULT DATA SUPPLIED FOR EACH MAP)

1	4	9	12
MAP SIZE	P L	PEOPLE SYMBOL	C L	SYM SIZE
. .		. . . .		. .

MAP SIZE OF 1.0 YIELDS A MAX SIZE MAP OF 31.0 BY 23.6 INCHES OTHER VALUES YIELD FRACTIONS OF 31.0 BY 23.6 INCHES

COLUMN 4 EQUAL TO 1 IMPLIES PLOT THE POPULATION CENTROIDS

COLUMN 9 IS THE COLOR FOR THE SYMBOL 1=BLACK 2=RED 3 BLUE 4=GREEN

LEGENDS FOR SHEAR FILE LEG-FILE.

FILE *PLOT-FILE CONTAINS THE LOCATION OF POINT SOURCES AND PROTOTYPES AND HAS THE SAME FORMAT

1	7	14	18	22	26	29	80
UTMX (KMS)	UTMY (KMS)	SYMBOL NUMBER	C S	SYMB SIZE	C T	TEXT SIZE	TEXT ANG	LEGEND TEXT
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .
. . . . .	. . . . .	. . .		. .		. .	. .	. . . . .

COLUMN 18 IS THE COLOR FOR THE SYMBOL
COLUMN 22 IS THE COLOR FOR THE TEXT

Figure 3-8

Columns 14-17	= symbol number (see Appendix E).
Column 18	= color of symbol. 1 = black, 2 = red, 3 = blue, 4 = green.
Column 19-21	= Height of symbol in inches.
Column 22	= Color of the text.
Columns 23-25	= Height of letters of text in inches.
Columns 26-28	= Angle at which the text should be printed in degrees.
Columns 29-80	= The text of the label (will be printed in Simplex Roman type).

Miscellaneous

As mentioned previously, SHEAR is much more complicated to run than SHED. You must complete a larger number of files and select the appropriate start card for the analysis. The available SHEAR start cards are listed in Appendix D.

Some of the start cards cause the SHEAR program to generate a concentration ranking from the center of the box. These start cards are noted in Appendix D. If these cards are used, it is also possible for the user to choose a location other than the center of the box. See Figure 3-9 for the appropriate format.

Figure 3-10 is provided for the programmer who has a good knowledge of ECL. The radial distances for SHEAR can be altered by changing the runstream. Figure 3-10 provides the appropriate format. The current defaults for 50 Km run are ten radii at .20, .50, 1.00, 2.00, 5.00, 10.00, 20.00, 30.00, 40.00 and 50.00 Km. The decay rate is assumed to be zero.

SELECTION OF CENTER FOR LISTING OF CONCENTRATIONS

FILE *SHR-CONCS.

LATITUDE DEG MIN SEC	LONGITUDE DEG MIN SEC	

Figure 3-9

POINT SOURCE & PROTOTYPE DATA FOR SHEAR NO FILE (DEFAULTS)

CARD 1

1 — 3
NUM RADII

CARDS 2A, 2B, 2C (RADII IN KM AS NEEDED)

1 — 8	9 — 16	17 — 24	25 — 32	33 — 40	41 — 48	49 — 56	57 — 64	65 — 72	73 — 80
RADIUS 1, 11, 21	RADIUS 2, 12, 22	RADIUS 3, 13, 23	RADIUS 4, 14, 24	RADIUS 5, 15, 25	RADIUS 6, 16, 26	RADIUS 7, 17, 27	RADIUS 8, 18, 28	RADIUS 9, 19, 29	RADIUS 10, 20, 30

CARD 3

1 — 10	11 — 20
DECAY RATE - DAY (PER HOUR)	DECAY RATE NIGHT (PER HOUR)

CARDS 4-7 COME FROM FILE *SHR-STAR

Figure 3-10

3-6. Using Output from other Dispersion Models

Similar to SHED, SHEAR can be executed using concentration inputs from other models for the point source portion of the model. It is currently capable of using ISCLT results. The ISCLT output must be created as tape file output on disk using options when the ISCLT model is run. You need then know only the filename(s) to access the concentrations.

Entering Data

To execute SHEAR using output concentrations, you must enter data into all the files as usual with one additional file. To open this file, type:

@EDM (chemical)*SHR-ISCLT.

Enter the data as follows (see also Figure 3-11):

Card 1,	Columns 1-6	= Latitude of the plant in degrees, minutes, and seconds (two digits each).
	Columns 7-13	= Longitude of the plant in degrees (three digits), minutes (two digits), and seconds (two digits).
	Columns 14-23	= Conversion factor. (This number will be multiplied by the concentration points to yield a converted concentration. Since the emission rate is proportional to the concentration points, this factor may be used to analyze various possible emission rates with only one ISCLT run. Enter 1.0 if you wish the concentration points to remain the same.)

SELECTION OF ISC OUTPUT FILES FILE *SHR-ISCLT.

1	7	14	24	56 80
LATITUDE DEG MIN SEC	LONGITUDE DEG MIN SEC	CONVERSION FACTOR	FILE NAME	ISCLT POINT SOURCES TO BE INCLUDED

Figure 3-11

Columns 24-25	= filename in which the ISCLT concentration values are listed.
Columns 56-80	= Point sources (individual stacks) at the plant to be included. Each digit represents each stack. If the stack is to be included, type 1; if excluded, type Ø. Leaving this part blank includes all the stacks.

This card should be completed for each plant and chemical analyzed.

Running the Program

There are several options for running the program depending upon your needs. If you have not yet executed a SHEAR run for these sources, the XTRACT program must be run. Hence the start card would be as follows:

@ START START*SHR-ISCLT-A,/(Site ID),,,(filename)

If XTRACT has been run previously for these sources, simply empty the conc. file as described in section 3-5 and type the start card as shown above deleting the "-A".

3-7. Output from SHEAR

The major output from SHEAR is very similar to SHED. It includes a listing of the input data and concentration grid for each point source. The output also includes the cummulative exposure summary similar to that discussed under SHED. The overall summary constitutes the major difference between SHEAR and SHED output. SHEAR output presents a chart similar to the cummulative exposure summary in lieu of the overall summary. This chart presents levels of hazard (concentration plus unit risk divided by seventy), the number of people exposed to that hazard or greater and the annual incidence (people x hazard).

In addition to these output, SHEAR also reports the location of each prototype source and each BG/ED used in the analysis. The area and prototype data output are cummulative for the area analyzed rather than presented for each individual source.

References

1. Anderson, G.E. and G.W. Lundberg, (May 1983) "User's Manual for SHEAR." (Prepared for the Environmental Protection Agency, Durham, North Carolina.) Publication Number SYSAPP-83/124, Systems Applications, Incorporated.

2. EPA (1977), "User's Manual for Single Source (CRSTER) Model," U.S. Environmental Protection Agency, U.S. Department of Commerce, NTIS PB-271360.

3. Hagerty, P.E. and K.E. Sibbald, (1975) "Text Editor User's Guide" Computer Science Center, University of Maryland, 1975.

4. Hanna, S.R. (1978), "Diurnal Variation of the Stability Factor in the Simple ATDL Urban Dispersion Model," J. Air Pollut. Control Assoc. Vol. 28, No. 2, pp. 147-150.

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6. Martin, D.O., and J.A. Tikvart (1968), "A General Atmospheric Diffusion Model for Estimating the Effects on Air Quality of One or More Sources, "APCA Paper, presented at the 61st Annual APCA Meeting, June 1968, St. Paul, Minnesota.

7. Pasquill, F. (1961), "The Estimation of the Dispersion of Windborne Material," Met. Mag., Vol 90, pp 33-49.

8. Systems Applications, Incorporated (March 1983) "Human Exposure to Atmospheric Concentrations of Selected Chemicals". (Prepared for the Environmental Protection Agency, Research Triangle Park, North Carolina.) Volume I, Publication Number EPA-2/250-1, and Volume II, Publication Number EPA-1/250-2.

9. Turner, D.B. (1964), "A Diffusion Model for an Urban Area, Atmospheric Dispersion Estimates," 6th Printing Rev., Government Printing Office, U.S. Environmental Protection Agency, Office of Air Programs, Publ. No. Ap-26, Washington, D.C.

Appendix A

STAR-PICK

To access STAR-PICK you must have access to the UNIVAC computer system (as described in Section 1-3) and be logged on (as described in Section 2-4). Once logged on type the following:

@ADD,PL HEP-RUN.STAR-PICK

and hit XMIT. The program will then respond with several strange lines of information. At the end of the information the computer types:

Enter the location's latitude (DEG, MIN, SEC) and longitude (DEG, MIN, SEC) and the number of sites to list (default of 20) Format (3I2, I4, 2I2, I4) or @ EOF if finished.

You should now type the following in exactly the format shown below:

DDMMSS DDDMMSSNNNN

where: D = degrees (latitude in first group of number, longitude in the second

M = minutes

S = seconds

N = Digits of the number of star stations you wish to be displayed (default is 20)

When you hit XMIT, the computer will respond with the STAR station code number, the city in which it is located, its distance from the source longitude and latitude, and other information. The listing will be in order of closest distance from the given longitude and latitude.

After you have obtained all the STAR station code numbers you need, type:

@EOF

and hit XMIT. This will exit you from the program.

Appendix B

Conversion of UTM Coordinates to Latitude/Longitude Coordinates

To use the program available on the UNIVAC system you must have access to the UNIVAC system (as described in Section 1-3) and be logged on (as described in Section 2-4). To access the program type the following:

@XQT EDS*RUN.UTM-CALC

and hit XMIT. You then must enter the UTM coordinates in the following format:

UEEE.EØNNNN.NØZZ

where: U = signals program that these are UTM coordinates

E = digits of the UTM easting

N = digits of the UTM northing

Z = zone of the UTM coordinates

Be careful to place exactly the indicated number of digits and to place the zeros or spaces in. Once you hit XMIT, the computer will respond with the latitude and longitude with both decimal units and degrees, minutes, seconds units. You are interested in the degrees, minutes, seconds reading for SHED.

You may also translate geoditic coordinates to UTM by using the following format:

LDDMMSSØDDDMMSS

where: L = signals program that these are geodetic coordinates

D = degrees (latitude in the first number; longitude in the second)

M = minutes

S = seconds

Be careful to enter all the digits indicated and the zero (or space). Once you hit XMIT, the computer will respond with the same format as the conversion of UTM to latitude and longitude.

It is also possible to translate longitude and latitude represented by a decimal figure into UTM coordinates or units of degrees, minutes and seconds. To do this, use the following format:

DXX.XXXXØYYY.YYYY

where: D = signals program that these are decimal coordinates

X = latitude digits

Y = longitude digits

Be careful to enter the digits and zero (or blank) as shown with the decimal points in the indicated positions. The computer will respond with the same format as with the previous conversions.

Appendix C

Helpful Hints With the Maryland Editor

The Maryland Editor operates in two modes, the input mode and the edit mode. In the input mode, every typed character is entered into the data file. In the edit mode, the user directs the Editor to change or scan the text in various ways. Data can also be input in the edit mode by typing I, a space, and the information to be inserted.

The Editor toggles between edit and input modes by pressing XMIT after an SOE (>). We suggest remaining in the edit mode at all times in order to make use of the editing commands.

The most used commands are listed below in brief summary form. Please refer to reference 2 to obtain a complete explanation of the Editor, a more extensive list of commands and a more complete definition. The numbers 9 and Ø used below are examples, any number may be used.

Maryland Editor Commands:

To move around in a file (Remember that moving the cursor may move you around on the screen but it does not move you around in the file.)

D - deletes the line you are on

D 9 - deletes the line you are on and the next eight lines

O 9 - prints the next 9 lines on the screen

P 9 - prints the line you are on & the next 8 lines

N - prints the next line on the screen

T - takes you to the top of the file (this also stores any changes that have been made in a backup data file)

LA - takes you to the last line of a file

9 - takes you to line number 9

-9 - moves you up 9 lines

+9 - moves you down 9 lines

To Change a file

C /old/new/ - changes the old (type whatever you want changed) to the new (type what you want it changed to) the first time it appears in the line

C /old/new/ G - changes the old to the new everytime it occurs in the line

C /old/new/ 9 - changes the old to the new the first time it occurs in the line for the line you are on and the next 8 lines

R (a space) new - replace the line you are on with new

R,9(a space) new - replace part of line starting in column 9 with new

To Copy a Part of a file

Ditto Ø 9 - copies lines Ø to 9 below the line you are on

BE - begins to copy (move to first line you want copied before typing)

CO - ends part to copy (move to the line below the last line you want copied before typing)

ADD - copies the data defined by BE and CO below the line you are on

CO Filename - used in place of CO and ADD to copy data to a separate file

For Help

HELPS[Procedure Name] - displays information on a particular procedure; use @EOF to exit

SC - prints column scale

Appendix D

Summary of SHEAR Run Cards

This Appendix lists parts of the SHEAR run card which can be inserted for slight variations of the SHEAR run. The general format for all the cards will be:

@START SASD*START. [part from below],/site ID ,,, filename

The following rules apply to the variations and may help in selecting the correct card:

1. If TEK is included as part of the card, the output will be plotted on the tektronics plotter. Otherwise the output goes to the calcomp plotter. The "-B" omits the legends on the plots.
2. If the point or proto run cards have no numbers, the analysis will be performed out to 20 Km. A number with the card indicates the distance to which the analysis will be performed. (e.g., 50 Km)
3. The "-A" commands the XTRACT portion of SHR to be executed.
4. The "All" commands all (point, proto and area) to be run.
5. The "-P" commands the concentration values to be added to those values already in the CONC. FILE (i.e., XTRACT must have been run previously). This is similar to running without "-A" except that -P also commands the output to be plotted.

The following inserts include as output the concentration levels surrounding the center of the city or other designated location:

SHR-ALL
SHR-ALL/TEK
SHR-ALL/TEK-B
SHR-AREA-A
SHR-AREA-A/TEK
SHR-AREA-A/TEK-B
SHR-ISCLT
SHR-ISCLT-A
SHR-ISCLT-A/TEK
SHR-ISCLT-A/TEK-B
SHR-ISCLT-P
SHR-ISCLT-P/TEK
SHR-ISCLT-P/TEK-B
SHR-POINT
SHR-POINT-A
SHR-POINT-A/TEK
SHR-POINT-A/TEK-B
SHR-POINT-P
SHR-POINT-P/TEK
SHR-POINT-P/TEK-B
SHR-PROTO
SHR-PROTO-A
SHR-PROTO-A/TEK
SHR-PROTO-A/TEK-B
SHR-POINT/50-KM
SHR-POINT-A/50-KM
SHR-POINT-A/TEK-50-KM
SHR-POINT-A/TEK-B-50-KM
SHR-POINT-P/50-KM
SHR-POINT-P/TEK-50-KM
SHR-POINT-P/TEK-B-50-KM
SHR-POINT/80-KM
SHR-POINT-A/80-KM
SHR-POINT-A/TEK-80-KM
SHR-POINT-A/TEK-B-80-KM
SHR-POINT-P/80-KM
SHR-POINT-P/TEK-80-KM
SHR-POINT-P/TEK-B-80-KM
SHR-POINT/100-KM
SHR-POINT-A/100-KM
SHR-POINT-A/TEK-100-KM
SHR-POINT-A/TEK-B-100-KM

The following inserts do not include the concentration ranking as output:

SHR-AREA
SHR-AREA-P
SHR-AREA-P/TEK
SHR-AREA-P/TEK-B
SHR-PROTO-P
SHR-PROTO-P/TEK
SHR-PROTO-P/TEK-B

To send the results of the SHEAR run to your specific location to be printed out from your PC substitute USR for SHR in any of the above start cards. The actual printout of the material requires that you type @@SEND, U after the program has finished running (see section 2 - 5). To print out on the laser printer substitute LAZ for SHR.

Appendix E

BG/ED	Block Group/Enumeration District
CDM	Climatological Dispersion Model
ECL	Executive Control Language
EIQ	Emission Inventory Questionnaires
FIPS	Federal Information Processing System
HAD	Health Assessment Document
HEM	Human Exposure Model
ISCLT	Industrial Source Complex Long-Term
MARF2	Master Area Reference File 2
NCC	National Climatic Center, National Computer Center
NEDS	National Emissions Data System
NTIS	National Technical Information Service
SAI	Systems Applications Incorporated
SHEAR	Systems Applications Human Exposure and Risk
SHED	Systems Applications Human Exposure and Dosage
STAR	Stability Array
U.S.G.S.	United States Geological Survey
UTM	Universal Transverse Mercator

INSTRUCTIONS

1. **REPORT NUMBER**
Insert the EPA report number as it appears on the cover of the publication.

2. **LEAVE BLANK**

3. **RECIPIENTS ACCESSION NUMBER**
Reserved for use by each report recipient.

TITLE AND SUBTITLE
Title should indicate clearly and briefly the subject coverage of the report, and be displayed prominently. Set subtitle, if used, in smaller type or otherwise subordinate it to main title. When a report is prepared in more than one volume, repeat the primary title, add volume number and include subtitle for the specific title.

5. **REPORT DATE**
Each report shall carry a date indicating at least month and year. Indicate the basis on which it was selected *(e.g., date of issue, date of approval, date of preparation, etc.)*.

6. **PERFORMING ORGANIZATION CODE**
Leave blank.

7. **AUTHOR(S)**
Give name(s) in conventional order *(John R. Doe, J. Robert Doe, etc.)*. List author's affiliation if it differs from the performing organization.

8. **PERFORMING ORGANIZATION REPORT NUMBER**
Insert if performing organization wishes to assign this number.

9. **PERFORMING ORGANIZATION NAME AND ADDRESS**
Give name, street, city, state, and ZIP code. List no more than two levels of an organizational hirearchy.

10. **PROGRAM ELEMENT NUMBER**
Use the program element number under which the report was prepared. Subordinate numbers may be included in parentheses.

11. **CONTRACT/GRANT NUMBER**
Insert contract or grant number under which report was prepared.

12. **SPONSORING AGENCY NAME AND ADDRESS**
Include ZIP code.

13. **TYPE OF REPORT AND PERIOD COVERED**
Indicate interim final, etc., and if applicable, dates covered.

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16. ABSTRACT

This document describes the Human Exposure Model, furnishes contact personnel to establish access to the UNIVAC System, and provides step-by-step instructions for operating both the SHED and SHEAR portions of the model. The manual also lists caveats which should be considered when using the HEM and criteria to distinguish situations which are appropriately modeled by each portion of HEM. The intended audience ranges from someone with limited knowledge of modeling to someone well-acquainted with the UNIVAC.

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