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DEVELOPMENT OF COMPUTERIZED EMISSION PROJECTION AND ALLOCATION SYSTEM

PHASE II: COMPARISON OF EXISTING SYSTEMS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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PHASE II: COMPARISON OF EXISTING SYSTEMS

by

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1 INTRODUCTION

This report documents the second phase of a feasibility study to determine the need for a computerized emission projection and allocation (CEPA) system to assist state and local air pollution control agencies in conducting air quality analyses.

The possible need for a CEPA system came as a result of informal discussions with agencies and individuals conducting analyses required to conform to air quality maintenance planning regulations. It appeared that the calculation procedures, although relatively straightforward, were long and tedious and might be consuming an inordinate amount of resources to perform. At the same time, it was evident that such a system would have possible applications in other types of air quality analyses.

The determination of need for a CEPA system is being carried out in a 3-phase feasibility study. The Phase I effort[1] focused on the potential demand for a CEPA system based on a series of interviews with control agency staff. The results were somewhat mixed in that there was no clear cut and definitive demand on the part of the agencies for such a system. At the same time, all of the agencies surveyed expressed some interest in the system and indicated they would consider using it to assist in their analyses. On the basis of these inconclusive results, it was decided to proceed to the Phase II effort to review existing systems to determine if any or all of the CEPA requirements could be met without the need for an entirely new system development. The results of Phase II are reported here.

The Phase II evaluation procedure is carried out on four existing air quality analysis systems: the Air Quality for Urban and Industrial Planning system (AQUIP), the Computer-Assisted Area Source Emission Gridding Procedure (CAASE), the Engineering-Science Air Quality system (ESAQ), and the Metropolitan Washington Council of Governments model (MWCOG). The methodology involves a description of the CEPA requirements without reference to any existing systems, a comparison of existing packages to those requirements, an identification of deficiencies, an estimate of effort required to remove those deficiencies, an evaluation of the effort needed to develop an entirely new system, and an assessment of the potential savings to be realized by employing a CEPA system in place of manual procedures.

Upon a decision to proceed with the acquisition of a CEPA system, the Phase III effort will concentrate on the preparation of a system specification document for procurement purposes.

2 ANALYTICAL REQUIREMENTS OF A CEPA SYSTEM

The CEPA system must be designed to function in the analysis of a variety of air quality management problems. The situations in which CEPA will be operated include the following:

1. Periodic analyses of areas to determine whether air quality standards will be violated in the future due to growth in emissions and hence whether revisions are needed to the state air quality implementation plans. These periodic analyses are required under 40 CFR 51.12(h)(2).
2. Evaluation of the impact on air pollutant emissions of strategies that are designed to control the magnitude, timing, or location of new emissions. The results of this evaluation can be used in air quality dispersion models to estimate air pollutant concentrations and thus determine whether a strategy is adequate to attain and maintain a national ambient air quality standard.
3. Analysis of the air quality effect of different land use plans and system level transportation plans.
4. Assessment of the direct air quality impact of large scale projects such as the provision of sewers or highways.
5. Evaluation of the effect of new sources of air pollutant concentrations to determine whether the new sources will violate an air quality standard or a significant deterioration increment.
6. Development of environmental impact statement assessments.
7. Assistance in the implementation of an emission offset policy in non-attainment areas.
8. Evaluation of air quality impact of alternative economic and energy policies.
9. Incorporation of air quality considerations in to other long-term planning efforts such as EPA's Section 208 waste water management planning, HUD's Section 701 comprehensive planning, and Coastal Zone Management planning.

Despite the rather large set of applications, the CEPA system will perform a relatively limited set of tasks that are crucial to each of the analyses but are far from complete in terms of the entire scope of each effort. CEPA will be limited to three basic tasks: (1) receiving current information on emission sources, population and housing, economic activity and employment, land use, transportation and other planning data and translating this into gridded point and area source emissions for use in a dispersion model, (2) applying the results of a growth analysis to the above information and generating gridded point and area source emission for future years, (3) applying control strategies and generating emissions subject to the various control scenarios. Figure 2.1 illustrates the extent of the CEPA system.

It is evident from this structure that there are several things CEPA is not. These include the following considerations:

1. CEPA is not a growth analysis package. Studies and projections of growth are done externally. CEPA only applies these projections to the existing information base.

2. CEPA is not a data management system although it will, of necessity, have to be designed for ease of data manipulation. Long-term storage and access to data is externally provided.

3. CEPA is not an air pollutant dispersion model. It only generates output in a format compatible with input requirements of models.

With these considerations, it is possible to outline the kinds of computations CEPA must be able to perform. For convenience, these are discussed in terms of the emission source categories affected using the National Emissions Report (NER) format shown on Table 2-1.

2.1 FUEL COMBUSTION SOURCES

Fuel combustion sources to be handled by the CEPA system can be grouped into 5 basic categories: residential, commercial/institutional, industrial, electric generation, and internal combustion. All of these categories can be made up of both point and area sources, each of which is handled differently in both the computational and data handling routines. Point sources will all

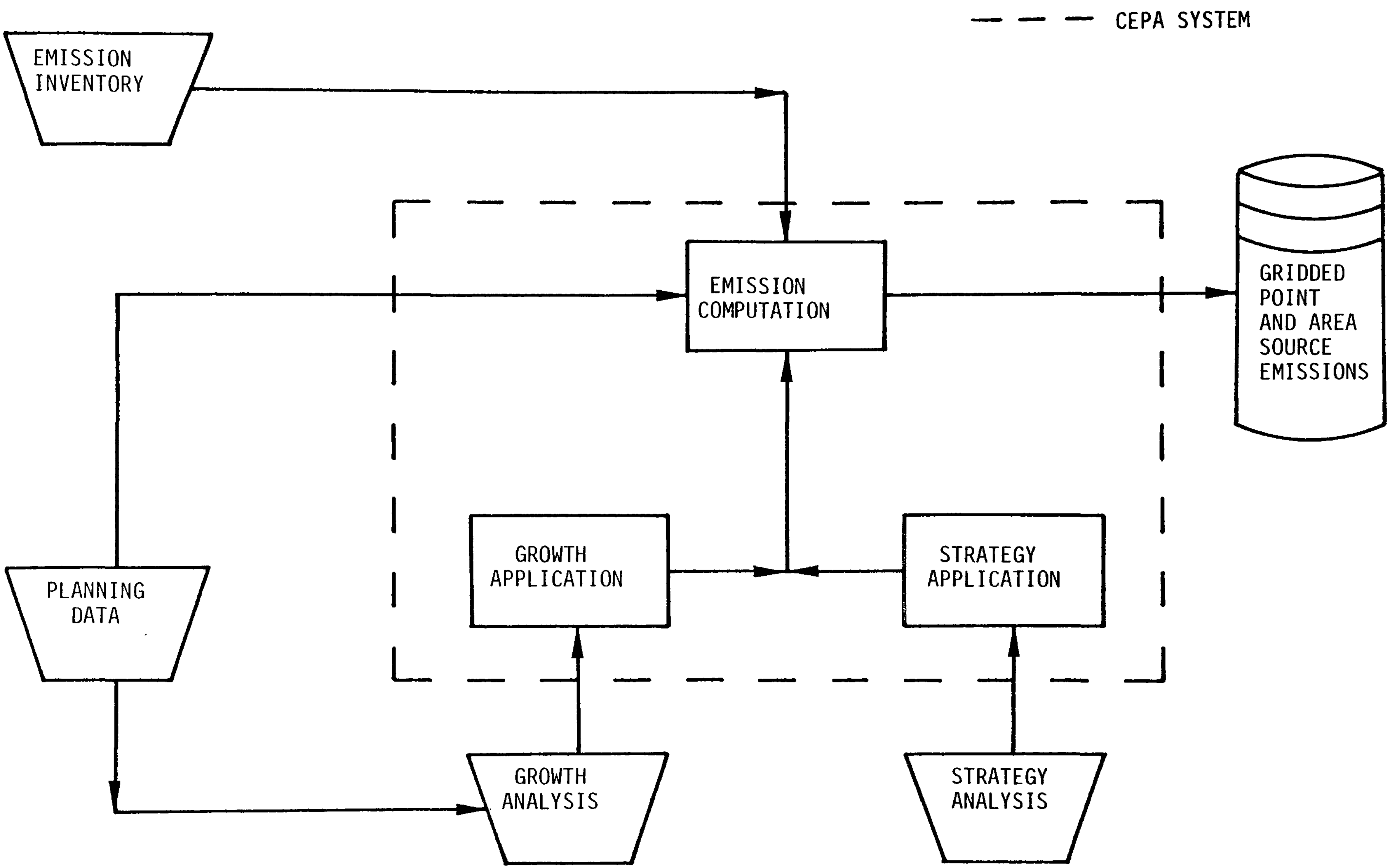

Fig. 2.1. Limits of CEPA System

Table 2-1. National Emissions Report Format

Category	Subcategory	
Fuel Combustion: External		Residential Fuel Commercial/Institutional Industrial Electric Generation
Fuel Combustion: Internal		Commercial/Institutional Industrial Electric Generation Aircraft Engine Testing
Industrial Process		Chemical Manufacturing Food/Agriculture Primary Metals Secondary Metals Mineral Products Petroleum Industry Wood Products Process Evaporation Metal Fabrication Leather Products Textile Manufacturing Inprocess Fuel Other/Not Classified
Solid Waste Disposal	Government	Municipal Incineration Open Burning Other
	Residential	On-Site Incineration Open Burning
	Commercial/Institutional	On-Site Incineration Open Burning Apartment Other
	Industrial	On-Site Incineration Open Burning Auto Body Incineration
Transportation		Highway Vehicles - gasoline, diesel Off-Highway Vehicles - gasoline, diesel Aircraft Vessels - railroad, ship Gasoline Handling Evaporation Loss
Miscellaneous	Solvent Evaporation	Industrial Sources Dry Cleaning
	Fires	Structural Frost control Slash Bruning Wild Forest Agricultural
	Dust Caused By Human Agitation Of The Air	Unpaved Roads Unpaved Airstrips Paved Roads Mineral Processing Tilling Activities Loading Crushed Rock, Sand, Gravel Construction
	Airborne Dust Caused By Natural Winds	Storage Piles Tilled Land Untilled Land

be handled through an interface with the emission inventory be it in National Emission Data System (NEDS) or other format. Area source information is much more diverse and requires a greater range of computational alternatives.

2.1.1 Residential Fuel Combustion

Figures 2.2a and 2.2b show the flow of the calculations necessary to compute emissions from residential fuel combustion sources. Table 2-2 lists the potential sources of data available. The two different approaches shown result from two basically different types of information used as the starting point. The CEPA system must be able to handle both procedures.

The Level 1,2 analyses (these are the same level designations used in Ref. 2) of Fig. 2.2a start with two basic pieces of information: state or county fuel consumption in the residential sector and a distribution of population or dwelling units by state, county, and subcounty areas (e.g., census tracts, municipalities, planning districts, etc.). This distribution should be a resident data file since it will be used for other portions of the analysis. The first step of the computation is to distribute the fuel consumption to the subareas using the population or dwelling unit distribution. The fuel consumption is also calculated as a total heat energy (Btu) consumed for use in growth and strategy analyses later. Next, the fuel consumed by point sources in the emission inventory is extracted since these sources are handled separately. The result of these steps is a data file containing residential area source fuel consumption by subarea and by fuel type and heat energy total. The next step is to map the fuel consumption by subarea into fuel consumption by master grid (i.e., the grid network that is used as input into a dispersion model). For the basic CEPA system, it is only necessary to have the areal fraction of the subarea in the master grid cell; that is, the master grid is developed externally and only the mapping of subareas into grid cells is necessary as input. The implications of this are discussed later. The master grid fuel consumption file and a data file containing emission factors are used to compute master grid residential fuel combustion emissions. These calculations, combined with other emissions in the master grids, are used as dispersion model input.

There are two ancillary sets of calculational procedures that a CEPA system must have available in addition to the basic calculational stream just

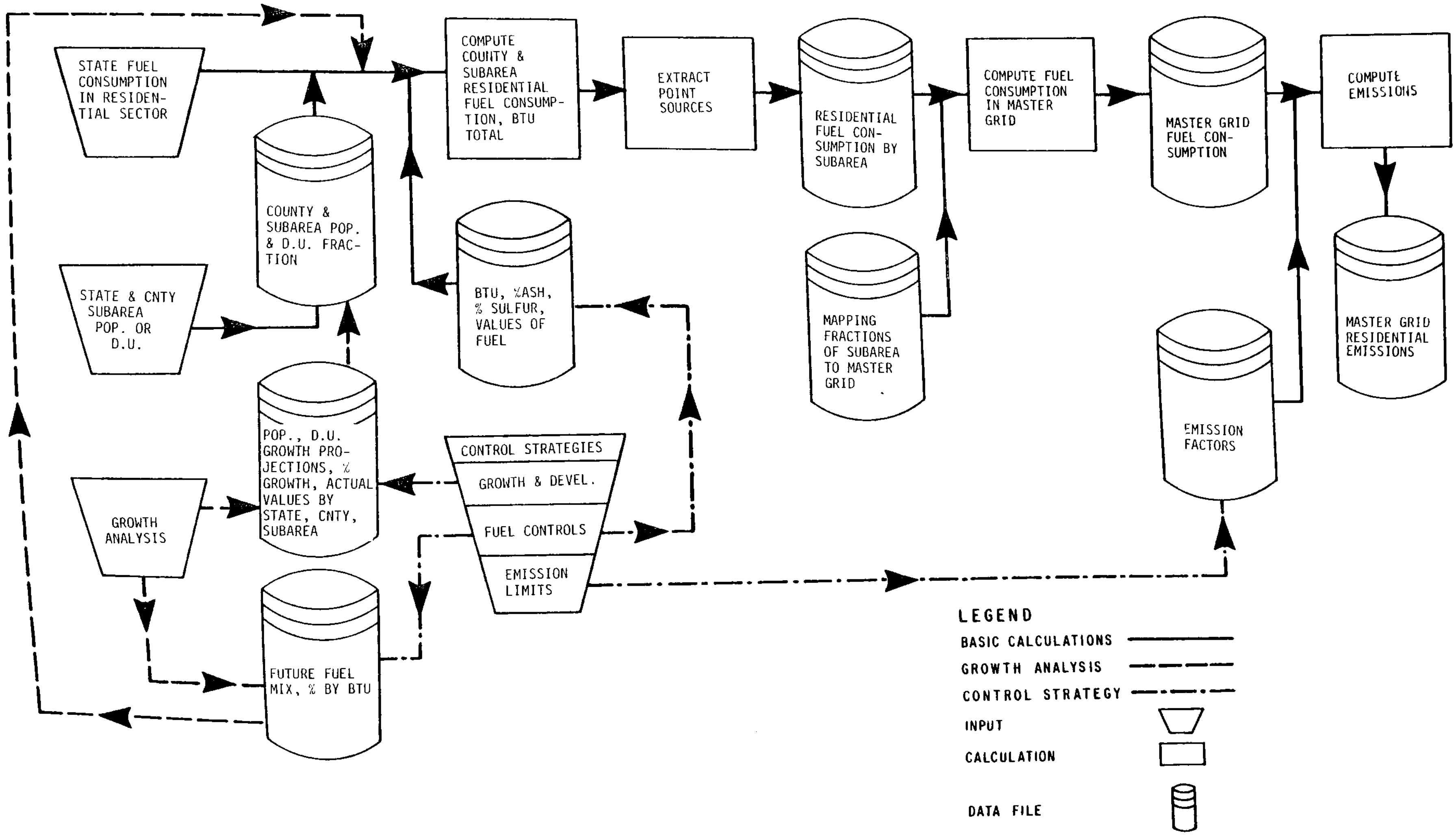

Fig. 2.2a. Computational Flow for Residential Fuel Combustion Sources (Levels 1 & 2)

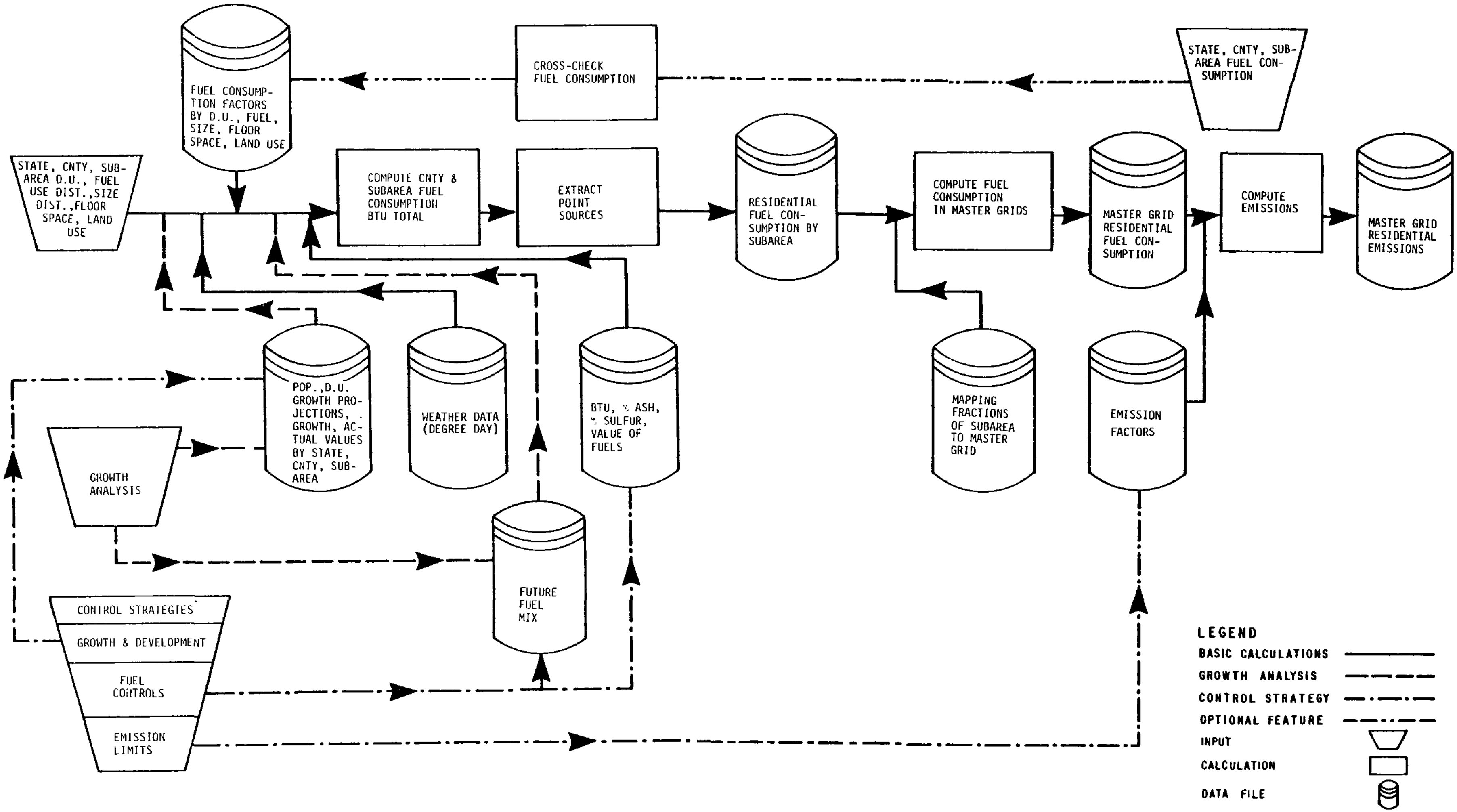

Fig. 2.2b. Computational Flow for Residential Fuel Combustion Sources (Level 3)

Table 2-2. Data Available for Residential Fuel Combustion Sources

Source	Data	Spatial Disaggregation	Form Available	Date of Information	General Availability
Census Bureau	Population Number of dwelling units (d.u.) Number of d.u. using Utility gas Fuel oil or kerosene Coal or coke Wood Electricity Bottled gas Other fuel No fuel for space heating water heating cooking Number of d.u. in structure 1, 2, 3 and 4, 5-49, 50+	All data: census tract, county, state, and other miscellaneous aggregations of the tract data	Computer tape, hard copy	Every 10 years for full set of data. Latest is 1970. Interim updates of selected data or areas sometimes available.	Virtually entire U.S. with some exceptions
Regional or Local Planning Agency	All or some of the above information Floor space (sq. ft.) of residential buildings Land area devoted to residential use Growth projections population dwelling units land use	Regional planning districts. May or may not be coincident with tracts, size range highly variable	Dependent on agency. May or may not be machine readable.	Latest planning cycle.	Variable. Most likely in major metropolitan areas.
Fuel Dealers	All or some of the above information Actual fuel consumed by residential customers	Variable with dealer.	Generally hard copy but occasionally machine-readable.	Latest data collection cycle	Variable
State Agencies	Fuel consumed by residential customers	Generally by county or for entire state	Hard copy	Latest year of statewide data collection plus possibly projections	Generally available
Federal Agencies	Fuel consumed by residential users	By state	Hard copy	Latest year of data collection (usually 1-2 year lag)	Entire U.S.

described. These are a growth routine and a strategy analysis. The growth routines must be able to take input in the form of % growth or real growth values of population and/or dwelling units from an exogenously performed growth analysis. This information will then be used to modify the data files on state, county, and subarea population and dwelling unit distributions to generate future distributions. The future fuel mix must also be included as part of the data the growth package must handle. With the new distribution and new fuel mix, the basic calculational stream can be repeated to generate master grid emissions for a future year.

The control strategy routines must be able to handle three types of control options. The traditional emission limit regulations are modeled by changing the emission factors just prior to the master grid emission computation. Fuel controls (such as sulfur content limitations or prohibition of certain fuel types) are simulated by changing the fuel characteristics and /or the future fuel mix. Growth and development controls are modeled by changing the population or dwelling unit distributions.

The Level 3 analysis differs from Level 1,2 with respect to the information used in the initial calculations. Instead of beginning with a state or county fuel consumption that is distributed to subareas, a set of surrogate variables such as dwelling units, floor space, residential land use, or others is combined with fuel consumption factors in related units (e.g., fuel consumed per dwelling unit, per acre of land used, etc.), and weather data to compute fuel use by subarea. The state or county totals computed this way can be cross-checked against actual data and the fuel consumption factors adjusted appropriately. The remainder of the calculations including the growth and strategy analyses are identical to Levels 1,2. In this level of analysis, provision should also be made to input subarea fuel consumption totals directly (collected, for example, from interviews with local fuel dealers). The use of the surrogate variables is, in this case, for growth and control strategy use only.

The need for the CEPA system to handle the Level 1, 2 and the Level 3 analyses illustrates an important design philosophy for the entire package. The simplified as well as the more sophisticated procedures must be built into the system to enable a wide variety of users to operate it. Likewise, the possibility of using more than one type of surrogate variable (e.g., population, dwelling units, land use, etc.) is necessary to cover the range of data availability.

2.1.2 Commercial/Institutional and Industrial Fuel Combustion

Figures 2.3a and b illustrate the computational scheme for commercial/institutional and industrial fuel combustion. Table 2-3 shows the sources of input information. The calculations are entirely analagous to those that are performed for residential fuel combustion with some small differences. In the Level 1,2 analyses the statewide fuel consumption must be disaggregated into commercial/institutional and industrial fuel use. This information may already be available from the basic information or some estimate may have to be made. Also, the distribution function whereby the statewide fuel use is mapped into subarea fuel use is made up of employment, land use, or other data as opposed to population and dwelling units in the case of residential fuel combustion. In the Level 3 analysis the different surrogate variables are the only point of difference from the residential calculations.

Because of the high degree of similarity between residential and commercial/institutional and industrial sources, it is entirely possible that the same computational modules can be used for all three source categories.

2.1.3 Electric Generation

For the most part, emissions from the generation of electricity are traceable to large centralized power plants. These facilities are treated as point sources and would be handled by the CEPA system in a manner entirely analagous to the Industrial Process emissions discussed in the next section. In the case of power plants, information on new facilities and on plant retirements is available from numerous sources including the utilities, the Electric Reliability Council, the National Coal Association, and others. The CEPA system should be able to process this data in the same way as data on industrial facilities.

There is one aspect of the electric generation that is slightly different and that a CEPA system should be designed to handle: that is, the projection of the demand for electricity. This information may be available from federal, state, or utility energy planning studies. The demand for electricity must be translated into the load factors of the various power plants serving the study region. It might also be useful to have the CEPA system check the demand against the available capacity. Excess demand will have to be met by the purchase of power from interconnected utility grids. The CEPA system

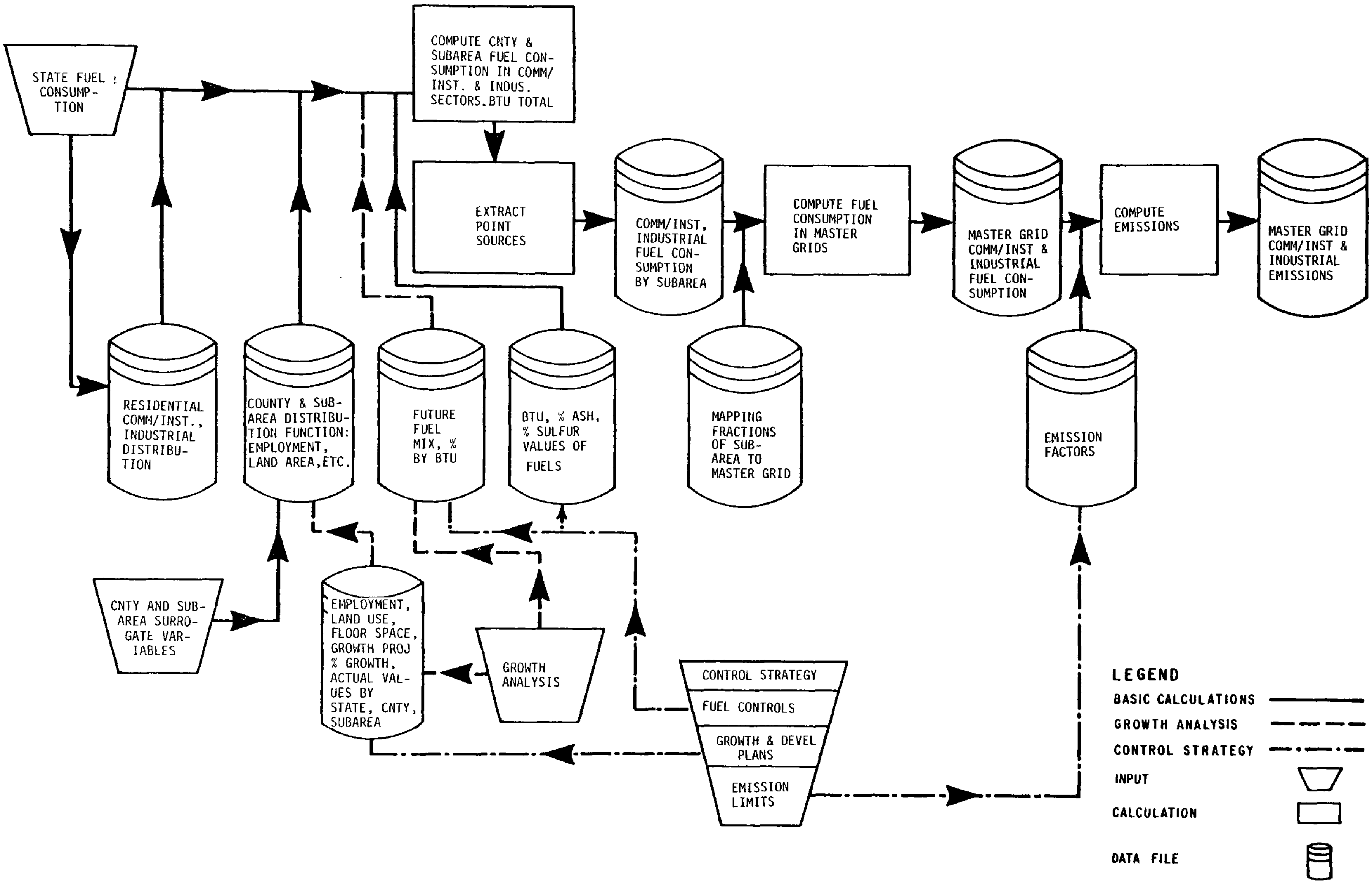

Fig. 2.3a. Computational Flow for Commercial/Institutional and Industrial Fuel Combustion Sources (Levels 1 & 2)

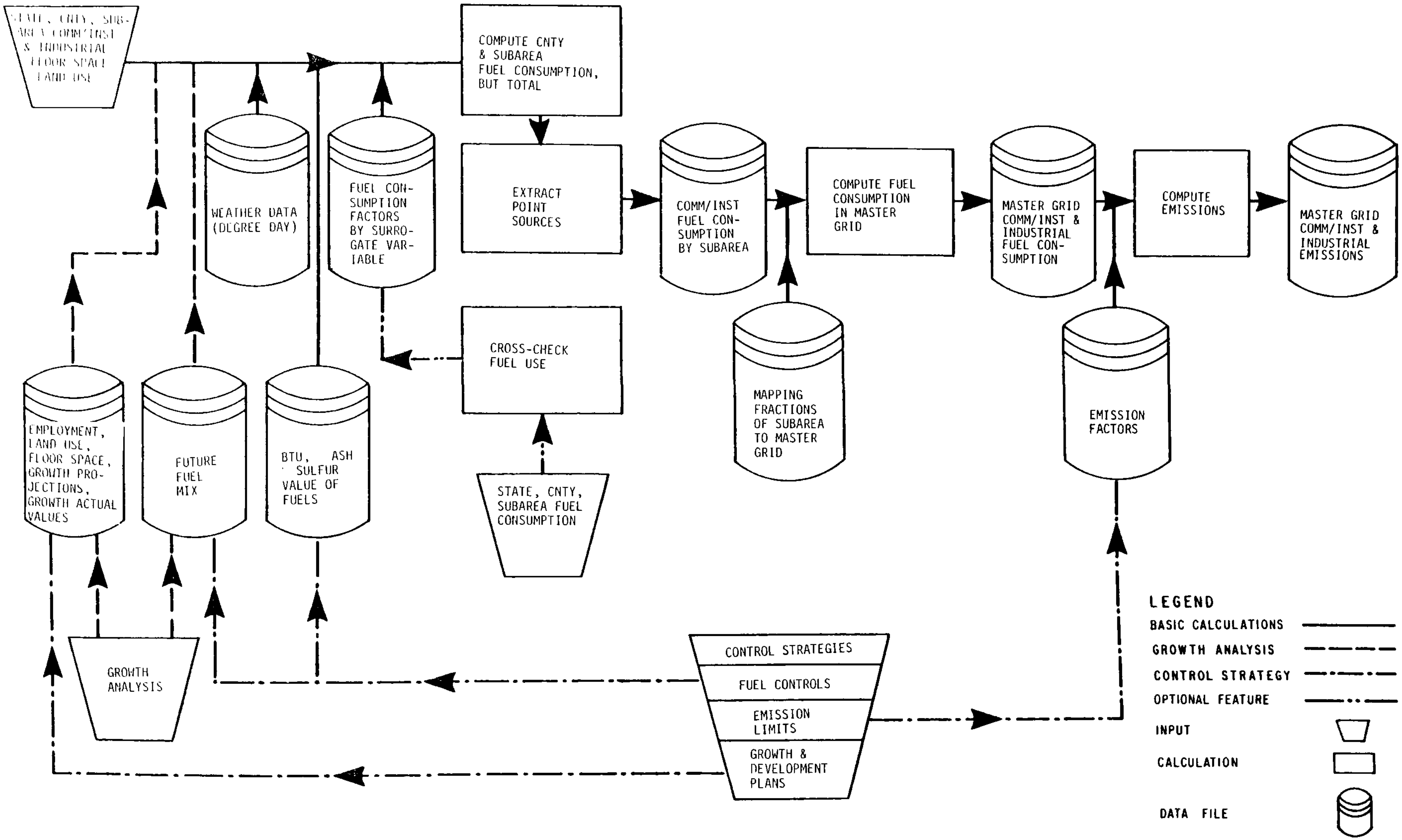

Fig. 2.3b. Computation Flow for Commercial/Institutional and Industrial Fuel Combustion Sources (Level 3)

Table 2-3. Data Available for Commercial/Institutional and Industrial Fuel Combustion Sources

Source	Data	Spatial Disaggregation	Form Available	Date of Information	General Availability
Census Bureau	Employment Number of establishments Industry type (SIC) distribution Economic data for manufacturing	County Some cities, SMSAs	Computer tape, hard copy	Annual	Entire U.S.
Regional or Local Planning Agency	All or some of the above information Floor space (sq. ft.) of comm/inst and industrial buildings Land area devoted to comm/inst and industrial uses Projection parameters to convert population to comm/inst uses Growth projections	Regional planning districts. May or may not be coincident with other areas Size range highly variable	Dependent on agency. May or may not be machine readable.	Latest planning cycle.	Variable. Most likely in major metropolitan areas.
Fuel Dealers	All or some of the above information Actual fuel consumed by commercial/institutional and industrial customers	Variable with dealer.	Generally hard copy but occasionally machine readable.	Latest data collection cycle.	Variable
State Agencies	Fuel consumed by commercial/institutional and industrial users.	Generally by county or for entire state.	Hard copy.	Latest year of statewise data collection plus possibly projections.	Generally available.
Federal Agencies	Fuel consumed by commercial/institutional and industrial users.	By state	Hard copy.	Latest year of data collection (usually 1-2 yr lag)	Entire U.S.

should not be designed as an electrical load management program but should be able to supply some rudimentary information in this area.

2.1.4 Internal Combustion

Emissions from stationary internal combustion sources (e.g., gas turbines, diesels, gasoline generators, etc.) are generally only small contributors to emission levels. Large electrical peaking units can be treated along with power plants while the smaller units at industrial facilities and aircraft engine testing facilities should be handled as individual sources in a point source inventory. The CEPA system handling of these facilities is analagous to the Industrial Process emission sources described next.

2.2 PROCESS EMISSIONS

The treatment of industrial process emissions primarily involves the handling of point source data; that is, the specific location and operational characteristics of individual facilities are identified. In some cases the nature of a particular process activity is such that for air quality modeling purposes it will be treated as an area source (e.g., large open pit mining activities) but the specific operation is still handled as an individual facility in the calculation. In other cases, the small and dispersive nature of a process activity may require treatment as an area source but this is not usually encountered with great frequency.

Figure 2.4 shows the flow of computations and Table 2-4 shows the available sources of information. Despite the relatively simple appearance of the basic calculation (solid lines in Fig. 2.4), this part of the CEPA system requires the greatest flexibility since it must be able to process information on a facility-by-facility basis.

The initial source of information is the point source file obtained as part of an emission inventory process. Current state files of this nature are in a variety of formats, the most frequent of which parallels EPA's National Emission Data System (NEDS), the form of which is shown on Fig. 2.5. The basic operations that a CEPA system must be able to perform on this file include the retrieval of certain key items of information (e.g., the process weight rates of all sources of a given type), the modification of the file with new information on such things as new plant additions, plant retirements, equipment

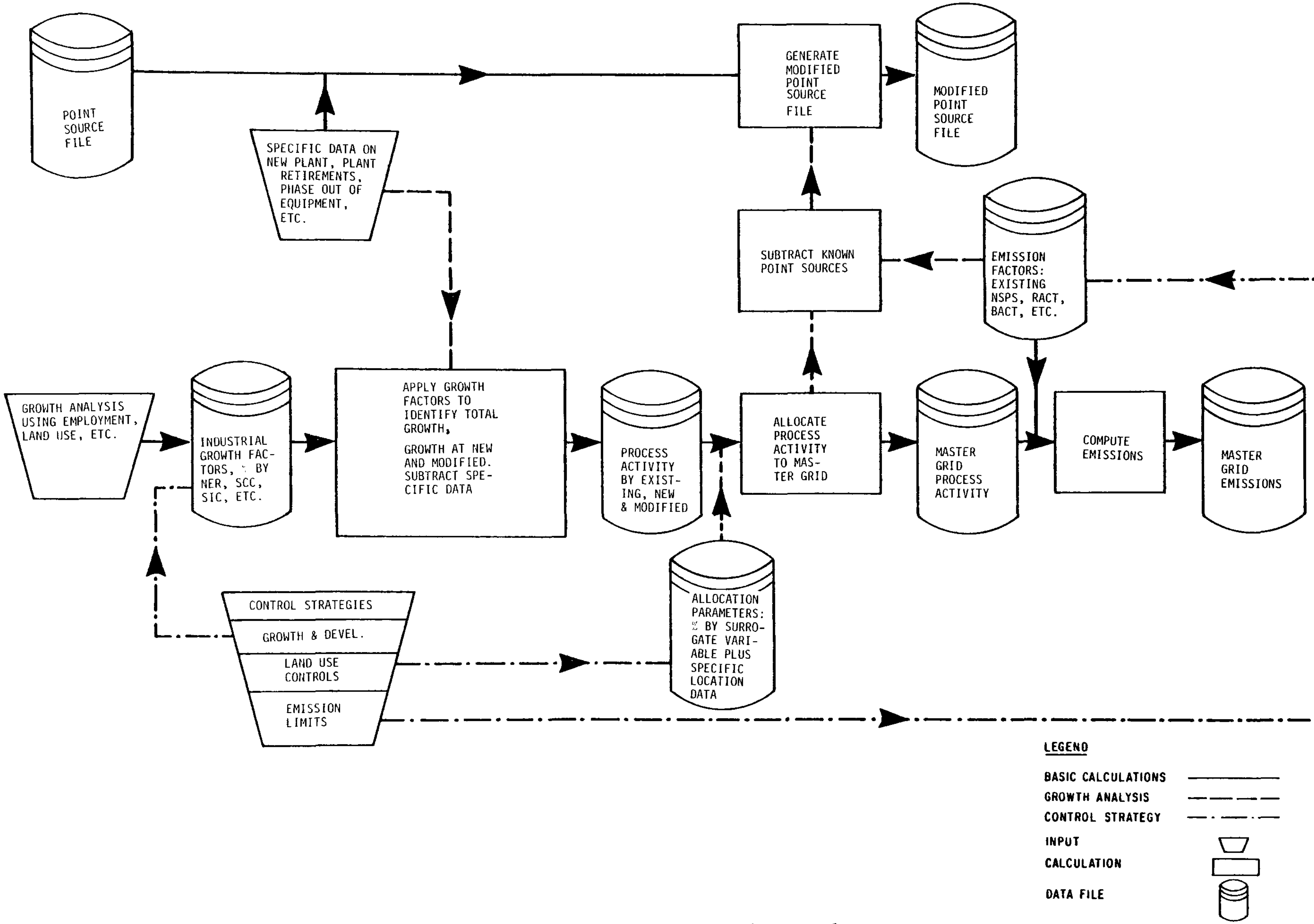

Fig. 2.4. Computational Flow for Industrial Process Sources

Table 2-4. Data Available for Industrial Process Sources

Source	Data	Spatial Disaggregation	Form Available	Date of Information	General Availability
State Air Pollution Control Agency	Point source inventory Interview results for new plants, retirements, etc.	Specific point sources	Machine-readable: either on state system or NEDS. Hard copy of new plants, retirements, etc.	Latest inventory cycle. Generally 2-3 year lag.	Inventory for entire U.S. Interview results varied.
Regional or Local Planning Agency	Growth projections: Population Land Use Industrial Output	Regional planning districts. May or may not be coincident with other subareas.	Dependent on agency. May or may not be machine readable.	Latest planning cycle.	Variable.
Federal Agencies	Generalized growth projections (e.g., OBERS)	Generally state level or industry level.	Most hard copy.	Latest year of planning cycle.	Entire U.S.

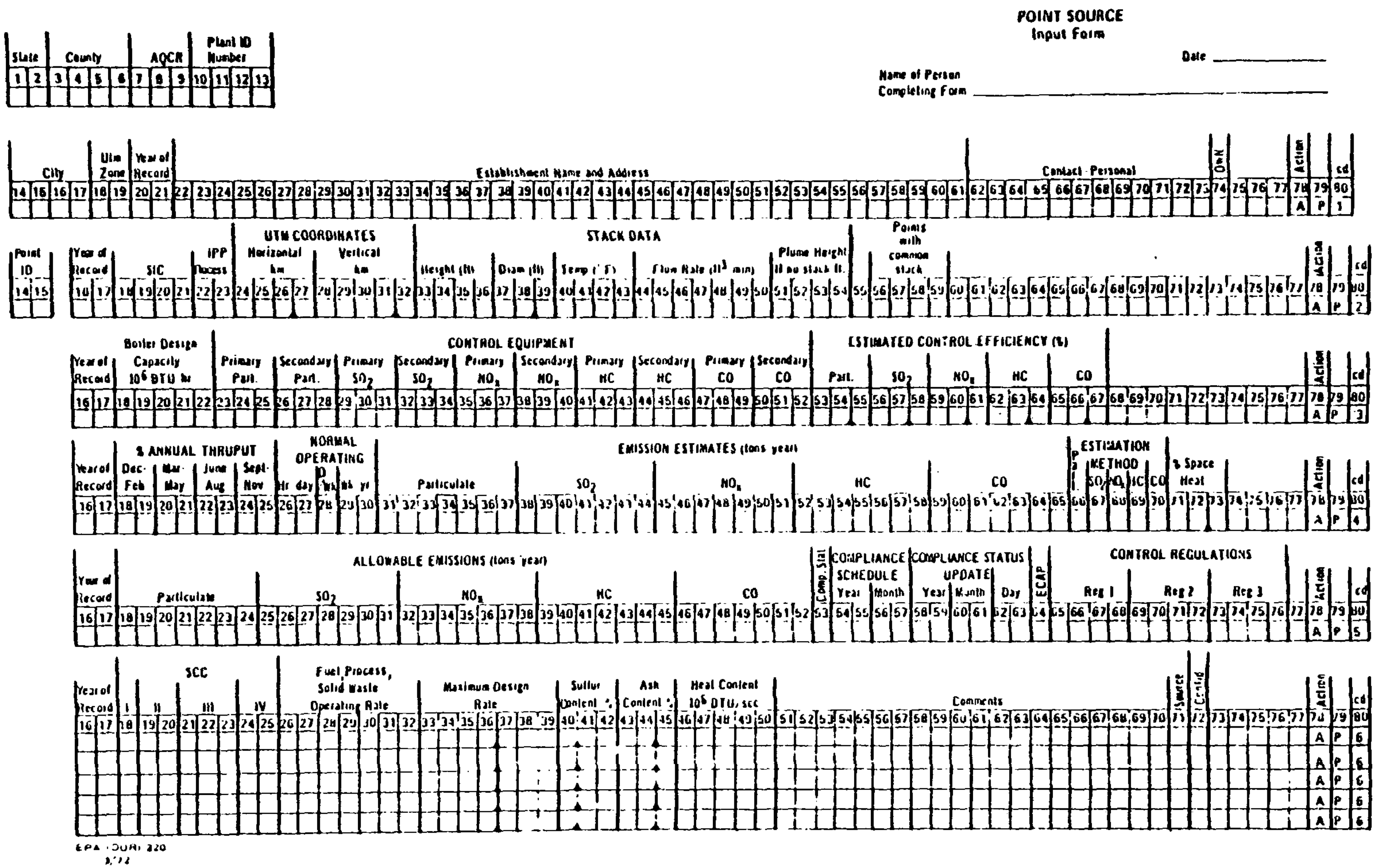

Fig. 2.5. NEDS Point Source Coding Form

replacement, process modifications, etc., and the compiling of the file information in summary formats to allow for dispersion modeling, strategy analysis, and the like. The system should be able to perform internal consistency checks on the information stored in the file (e.g., apply standard emission factors to see if the recorded emissions are of the right order of magnitude) and be able to call out information that appears out of order.

In this context the CEPA system is functioning like a data base management system more than like a computational system. There are some valid arguments to be made that this type of operation does not fit into the already defined concept of a CEPA system but should be performed externally. In any case, if these operations become an integral part of CEPA or if CEPA is designed to exclude these operations, some interface must be built so that these types of data handling can be done as part of the air quality analysis.

In handling growth projections, the CEPA system must be able to process both the plant specific information and the generalized growth projections. Generalized growth projections are usually generated by a state or local planning agency and would usually come in a form that specifies a percent growth in a given industry (e.g., output in secondary metals industry will grow by 2% between 1975 and 1980). This information must be applied to the industrial activity already recorded in the point source file and the resulting process activity must be disaggregated into growth that will occur at new sources, existing sources, and at sources whose location is presently unknown. Any available information on industry expansion plans must be included to separate the growth that has very definite locations identified and the growth that must be distributed to the most likely areas for industrial expansion. The CEPA system must then be able to make this distribution on the basis of some allocation parameter (e.g., employment, land use, etc.). The end product of these calculations is a projected point source inventory and a projected industrial process area source inventory made up of activity for which no specific locational information is available.

Again, despite the relative ease with which the calculational procedure can be described, the manipulation of a significant amount of specific data related to individual sources and the meshing of this information with generalized growth data is not a trivial task. The CEPA system must provide the user with enough flexibility to cover the most frequently encountered situations (e.g., knowledge of the startup or retirement of a specific facility) and be capable of easy modification to handle the unusual situations.

For control strategy testing the CEPA system must be able to treat three basic types of procedures. Emission limits are the most frequently used control techniques and are simulated by changing the emission factors applied to the process activity. In addition to the application of uncontrolled emission factors (e.g., from Ref. 3) and the application of the regulatory emission limits under consideration, the CEPA system should be able to perform calculations assuming other basic emission limits: for example, New Source Performance Standards (NSPS), Resonably Available Control Technology (RACT), Best Available Control Technology (BACT), etc. To do this, the CEPA system would need a catalogue of emission factors representing each control level and would apply the user-selected emission rate.

Control strategies involving growth and development plans would be simulated by the CEPA system by changing the growth rates or by regulating the source-specific data. Land use controls would be simulated by changing the allocation parameters to allow or deny a desired level of growth in a given location and then reapplying the emission factors.

2.3 SOLID WASTE DISPOSAL

Emissions from solid waste disposal occur in several ways. Large centralized municipal incinerators are the most obvious source but a significant amount of refuse is incinerated on-site at large industrial facilities and some is still incinerated in older apartment buildings. Open burning of refuse is prohibited in many areas although it still is practiced. Refuse disposal by land fill is not an emission source.

The CEPA system should be able to treat solid waste data in two forms. Figure 2.6 shows the flow of the computations. At the simplest level of analysis a surrogate variable (e.g., population) is input along with solid waste generation factors. The manner in which the refuse is disposed of (i.e., municipal incineration, on-site incineration, open burning, landfill) is also input and the quantity of solid waste is distributed accordingly. Point sources of waste disposal such as the municipal and large industrial or residential incinerators are separated from the totals and the remaining waste volume and disposal technique is allocated to subareas. This is mapped into master grids and emission factors are applied.

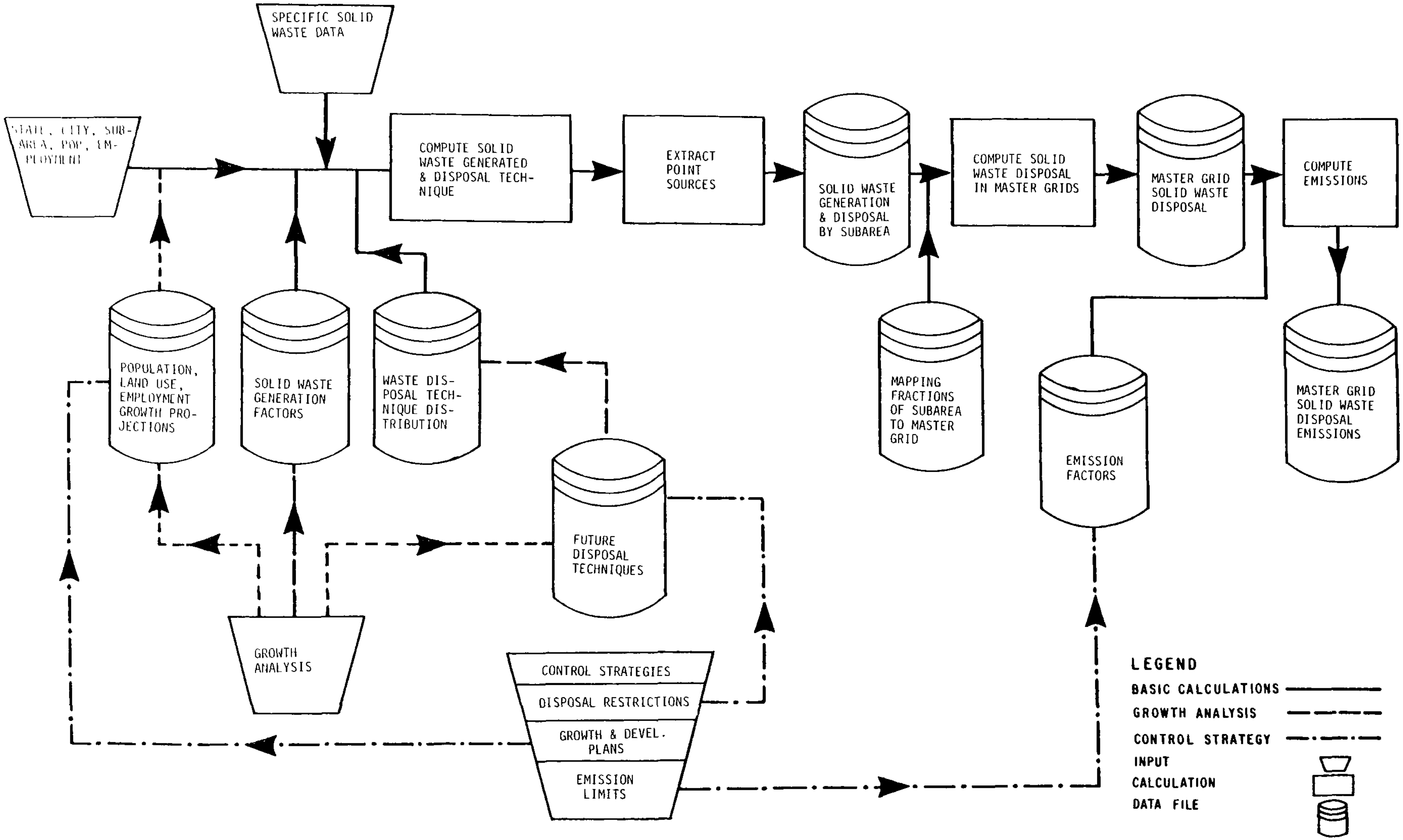

Fig. 2.6. Computational Flow for Solid Waste Disposal Sources

The second form of treatment involves the handling of specific solid waste data obtained from local scavengers, incinerator operators, or industrial facilities. This data can then replace the computation of waste volume using the surrogate variables and the remainder of the calculation is the same.

The growth analysis provides input into three basic parameters. It first identifies the growth rate of the surrogate variable. It also provides an indication of the solid waste generation rate; that is, a determination of whether the per capita generation rate will increase or decrease over time. Finally, it identifies the future distribution of disposal techniques.

Control strategies that CEPA must treat involve the application of emission limits to the centralized incinerators, changes in growth and development rates, and restrictions on disposal techniques.

2.4 TRANSPORTATION EMISSIONS

Emissions from transportation sources can be grouped into 6 basic categories: highway vehicles, off-highway vehicles, aircraft, railroads, vessels, and gasoline handling evaporation losses.

2.4.1 Highway Vehicles

Highway vehicles generally represent the largest fraction of transportation-generated emissions. For the purposes of air quality modeling the information will be handled as line sources (for major highway links) and area sources. The line source formulation is needed only if a model that specifically simulates line emissions (e.g., HIWAY) is to be used. In other cases the CEPA system must be capable of mapping the line segments into appropriate area sources for use with non-line-source models (e.g., CDM).

Figure 2.7 shows the flow of the highway vehicle computations and Table 2-5 gives the principal data sources. The basic calculations can proceed in one of two ways or in a combination of the two. At the simplest level of detail, the CEPA system takes countywide gasoline and diesel fuel sold from tax records, transforms these to vehicle-miles-travelled (VMT) using an average fuel economy (miles per gallon), and then maps these to a finer spatial resolution using the population distribution. For the more sophisticated levels

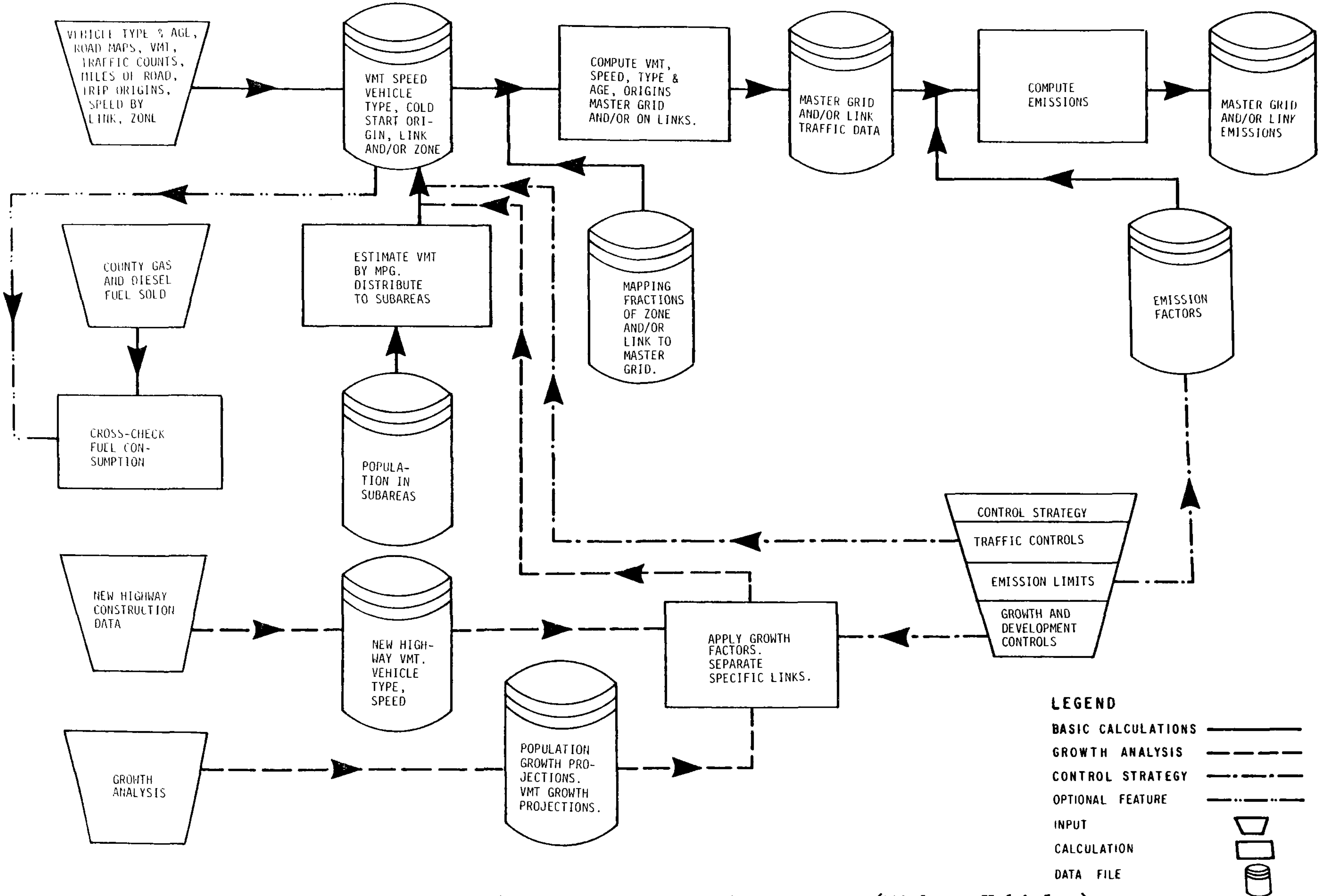

Fig. 2.7. Computational Flow for Transportation Sources (Highway Vehicles)

Table 2-5. Data Available for Transportation (Highway Vehicles) Sources

Source	Data	Spatial Disaggregation	Form Available	Date of Information	General Availability
State Highway Dept.	· Road Maps · Traffic Counts · Vehicle Speeds · Vehicle Type and Age Distribution · New Highway Plans	Generally by link for expressways, highways, major arterials.	Hard copy or machine readable.	Latest year of data collection. (Usually every two years.)	Some of this information is available throughout the U.S. Detail level varies with State.
Regional or Local Planning Agency	· All or some of the above information · Origin-Destination studies · Traffic growth projections	Generally by zone and including local streets.	Hard copy or machine readable.	Latest year of planning plus projections.	

of analysis, the CEPA system must be capable of handling specific data from regional planning, transportation, or highway agencies and process this information into a format that is suitable for the application of emission factors. For example, a highway department may supply a road map showing road segment lengths and traffic counts on major highways. The CEPA system should be able to convert this into VMT; CEPA should also be able to read in the VMT directly if the data is supplied in that format. Other parameters that the CEPA system must be able to deal with are vehicle speed, vehicle type (i.e., the five classes in Ref. 3) and age distribution, and vehicle trip origins (for cold start calculations). The system should be able to read this information as direct input as well as compute these parameters based on average or default values.

The highway vehicle data may be presented in either roadway link format or in traffic zone format and CEPA should be capable of processing both forms. The process of mapping the parameters from zone and/or link into the master grids and then applying emission factors is entirely analagous to the steps carried out for the other source categories.

Growth projections for highway vehicle activities must be handled by CEPA in two ways. First, specific data on new highway construction and projected traffic levels must be one form of standard input. Second, a generalized VMT growth projection based on population or other surrogate variable growth projection must also be treated. The two formats must be handled in a consistent manner to avoid double counting.

Control strategies for highway vehicles fall in three basic categories. Emission limits, such as those achieved through the Federal Motor Vehicle Pollution Control Program or state inspection and maintenance programs, are treated through changes in the emission factors. Traffic controls, such as improved traffic flow through intersections, are treated by changing vehicle speeds, trip origins, or VMT in the controlled zone. Growth and development controls are simulated by changing the growth rates and/or the operational dates of new roadway segments.

2.4.2 Other Vehicles

Emissions from other mobile sources generally represent a small portion of an emission inventory but they must be included nevertheless in the interest of accounting for localized problems. Off-highway vehicles (e.g., farm tractors, construction equipment, etc.), aircraft, railroads, and vessels are specialized both in terms of their operating characteristics and their spatial distribution. To treat these situations, the CEPA system must be able to handle two different types of input. First, it must be able to handle a basic surrogate parameter to which an emission factor is applied. For example, in the case of aircraft, CEPA must be able to read in the number of landing-takeoff (LTO) cycles and convert this to emissions by applying an LTO-based emission factor. Second, CEPA must be able to have as direct input the emissions from each of vehicle sources. This option would allow the user to do a much more detailed emission computation (of an entire airport, for example), input the results directly into CEPA, and have the emissions remain as an identifiable contribution from the specific source.

The spatial distribution of emissions from other vehicles is highly specific and does not lend itself to allocation by surrogate variables. Instead, the CEPA system must allow for the input of specific locational information about each source (e.g., the location of an airport, railroad yard, or port facility).

In a similar vein, growth projections and control strategies for these sources are highly specific and would be difficult to simulate for all the possible contingencies. It is, therefore, more reasonable to require the user to make the computations for these sources externally to the CEPA system and input the final results for the application of emission factors and the allocation to the master grids.

2.4.3 Gasoline Handling Evaporation Losses

Emissions from gasoline handling lend themselves to relatively straightforward computation on the basis of either direct gasoline consumption data (e.g., from tax records) or by using a per capita consumption rate. The CEPA system should be able to handle both of these contingencies relatively easily if it is structured to do the calculations for other sources as previously discussed.

2.5 MISCELLANEOUS SOURCES

There are a number of miscellaneous sources that CEPA must handle whose emission activity is not easy to compute but which may make sizeable contributions to the overall emission burden on the region under study. From the compilation of Table 2-1 these can be grouped into 3 basic areas: solvent evaporation, fires, and fugitive dust. A fourth area can be included that treats all other sources that do not fall into any other category.

2.5.1 Solvent Evaporation

The emissions from solvent use in industrial processes (such as degreasing) and in commercial operations (such as dry cleaning) come from a large number of relatively small sources. These sources are too small to be included as point sources under the Industrial Process category but their aggregate contribution to the emissions can be significant. These emissions can be estimated in two basic ways. If data on actual solvent use is available then it is possible to allocate this to master grid cells and compute emissions using an emission factor. If this information is not available then estimates of solvent consumption are made using, for example, national average per capita useage. Growth is handled as with other sources by applying growth factors to the surrogate variable (e.g., population) and applying the appropriate consumption rates. Control strategies in the form of emission limits are handled by CEPA by changing the emission factors; growth and development controls are handled by changing the growth factors; solvent use restrictions are handled by changing the consumption rates.

2.5.2 Fires

Emissions from natural as well as man-set fires are extremely difficult to estimate since the emission factors are not very well known. In terms of CEPA requirements, the system only need have provision for inputting a basic activity parameter, inputting an allocation parameter (e.g., acres of forest land), and applying an emission factor.

2.5.3 Fugitive Dust

Recent studies have indicated that fugitive dust from both natural and manmade sources represents a substantial portion of the particulate burden in some areas. The CEPA system must make provision for these calculations to be carried out but only in the simplest of forms. An input activity parameter (e.g., miles of unpaved roads), an allocation parameter, and an emission factor are all that is needed. Control strategies will operate on these basic variables.

2.5.4 Other Sources

The possibility always exists that an emission source that cannot be classified elsewhere will need to be addressed in the air quality analysis and the CEPA system will have to make provision for dealing with this situation. The simplest way to treat this is to develop a generalized format for these sources that specifies source activity, emission factor, allocation parameter, growth rate, and control level. The CEPA system should permit the user to input this data in point, area, or line source formulation. It should also allow an abbreviation of all the needed information so that the user need only input emissions.

2.6 GRIDDING

All of the previous discussions of how the CEPA system should handle emissions from the various source categories have followed a calculational procedure that eventually led to the distribution of an activity from its basic spatial resolution (e.g., census tracts, planning districts, highway line segments, etc.) to a master grid network. It is important to reemphasize at this point some significant concepts of what a CEPA system should and should not do with respect to this gridding procedure.

2.6.1 Calculational Procedure

The master grid network, as defined in previous guidelines, [4] is designed to display the emission data in a format that is compatible with dispersion models. In most cases, although certainly not all, the master grid network is chosen once and all future modeling runs are made with this network. Under these conditions, the transformation from one set of data (e.g., on census tracts) to the master grid is made only once and the fractional part of each district that resides in each master grid can become a fixed data set to be used in a variety of situations. For example, if it is desired to distribute county wide fuel consumption on the basis of population, the distribution is first made from county to census tracts using the population and then from census tracts to master grid using the fixed mapping fractions. Likewise, anything else that is to be allocated on the basis of population is first distributed to the census tracts and then from tracts to master grid.

The situation may also arise where several different data sets with different spatial resolutions may be available. For example, population may be available on census tracts, employment on regional planning districts, and VMT on traffic zones, and none of these areas are coincidental. The CEPA system should be able to handle all of these data sets individually and bring them together in the master grid by mapping each separately. In this way the user can retain the identity of his basic data set until such time as it is necessary to bring all together for a modeling run.

Another important point to emphasize in this procedure is that the mapping should be done on the basis of process activity and not on the basis of emissions. For example, for residential fuel combustion, the fuel consumption and not the emissions are transformed from the basic data set to the master grid. Emission factors are applied only after the master grid fuel consumption is computed. The reason for this procedure is to minimize the errors encountered by a mechanical transformation exercise with no interpretation of the reasonability of the results on the part of the user. By displaying the process activity in each of the master grids, rather than just an emission value, the CEPA system would give the user the opportunity to evaluate if the mapping is reasonable. The problems with the mechanical procedure was pointed out in the Phase I feasibility study where one EPA Regional Office felt it necessary to stipulate in its contractural agreements that prior knowledge of a given type of process activity in a given master grid cell was mandatory before any allocation of emissions from that activity could be made to that cell.

This method, despite its obvious advantages, does present some problems with regard to mapping certain parameters. For example, it is easily understood how fuel consumption instead of emissions can be allocated from the basic data set to the master grid, but it is not obvious how an ancillary parameter, such as fuel sulfur content, can be allocated. Careful weighting of the sulfur content of fuels used in all data cells contributing to a given master grid sell is necessary. This procedure requires somewhat careful book-keeping but the CEPA system should be able to handle this routinely.

In some instances, the master grid network may not remain fixed for all the calculations. It may be desireable, for example, to have a fairly coarse grid network for use in early analysis years and a more refined network when growth and development make it necessary to have better spatial resolution. Also, a changing land use plan may require a changing master grid network. In any case, the CEPA system should be able to process these varying grids in a very simple fashion since only the mapping fractions changes; the calculation procedure remains the same. This feature need not consume excessive machine core space since the mapping fractions can be stored off-line or read in as part of the input stream.

2.6.2 Master Grid Development

With regard to the development of the master grid, the CEPA system plays no role. This is done entirely external to CEPA and all that is needed by the system is the set of mapping fractions that transforms the basic data set into the master grid.

The reason for this limitation on CEPA is that there already exists a computerized procedure to develop master grids on the basis of population[11] and there are numerous manual techniques to develop grids on the basis of other considerations (e.g., land use, existing data bases, and others). CEPA need not duplicate these efforts but rather can make use of the grids developed by these other procedures and enable the user to more efficiently distribute activity to these grids.

2.7 GROWTH

An important component of the air quality analysis to be assisted by the CEPA system is the projection of growth in emission source activity. It has already been indicated that the CEPA system is not a growth analysis; that is, it is not intended to be a tool for analyzing socioeconomic data and developing growth forecasts. Rather, it is intended to take growth forecasts developed externally and translate those into emission forecasts. To do this, the CEPA system must be able to handle two types of growth projections. First, it must be able to process information or specific growth plans. If, for example, it is known that a new manufacturing facility or a new highway link is scheduled to open on a specific date, the CEPA system should be able to develop an emission forecast that accounts for that new activity. Second, the CEPA must be able to translate this into an emission growth rate. In addition to handling these two types of growth separately, the CEPA system must be able to coordinate the two to avoid double counting. It must be able to identify and separate growth at specific facilities from generalized growth.

The growth routine should be able to accomodate linkages between growth in different activities. It should, for example, allow the user to couple employment growth and population growth, VMT growth with residential land use growth, and others. In the purest sense, all of these linkages should be made by the planning agency doing the overall growth analysis and the resulting projections should be entirely consistent. In reality, the projections for various activities will come from different agencies and the air quality analysis agency will have to make some attempts to coordinate and consolidate the data. CEPA should provide an easy mechanism for doing this by allowing the agency to input the linkages between the various activities and by cross-checking for internal consistency. An example of how this might work would be the following: consider an agency receiving population growth projections on a census tract basis from a local planning agency and VMT projections from the state highway department on a traffic zone basis. The CEPA system would take both of these projections, process them to get growth projections on the master grid network, and print out the population and VMT for each cell as well as the growth rates. Wide discrepancies between these two would be immediately obvious and alert the user to investigate for possible inconsistencies in the data. If it were desired to estimate VMT growth strictly on the basis of population growth, the CEPA system should allow the user to input this link with a minimum of effort.

Another feature of the growth analysis that would greatly enhance the utility of the CEPA system is the capability to process more than one growth scenario in the same computer run. It should be possible for the user to input a number of scenarios and have them for ready comparison.

Although not essential for a basic CEPA system, there is an operational feature that could prove especially helpful to air quality analysts using the system. This feature would provide the user with information on what growth is tolerable. Under normal CEPA operation, growth is an input function and if the user seeks to know, for example, how much growth can be absorbed under certain constraints, he must proceed on a trial-and-error basis by inputting a variety of scenarios. To proceed in the opposite direction and have the user specify a desired emission level with the CEPA system back-calculating the allowable growth pattern, would involve non-trivial optimization routines, constraint specifications, and objective identification. While this type of computation is well beyond the design specifications of CEPA, the system can, nevertheless, provide outputs that would allow the user to make a "better educated guess" on the next scenario to be tested. These outputs would include, for example, a summary table identifying the source categories experiencing the most rapid growth, areas having greatest (and least) emission growth, and the sources within each category and area that are making the biggest contributions to emission growth.

2.8 CONTROL STRATEGIES

The application of control strategies is a common item for all of the calculations for the various emission sources. In a sense it represents the most significant procedure of the CEPA system in that it allows the user to identify the effectiveness of various steps taken to minimize air quality impacts. There are several features of a control strategy routine that would make CEPA a useful analytical tool.

For the most part, many of the control strategies for the various emission source categories can be simulated by changing the basic data. For example, emission limits can be modeled by changing the catalogued emission factors. To operate CEPA in this mode could easily become a tedious chore and could minimize the utility of CEPA. Instead, the strategy calculation should be done as part of an individual routine that allows the user to specify the control regulation and have the system change the emission factor for affected sources. This mode of operation gives the user the sense of inputing the control regulations in one place rather than attempting to pick out all the appropriate data values to change.

The CEPA strategy package should allow the user to test more than one regulation at a time to minimize the time required to conduct the analysis. For example, the user should be able to specify an emission limit, a fuel sulfur content restriction, and a coal ban strategy in the same run and have the CEPA system display them in the same run.

In applying control strategies, the CEPA system should address only the source categories that are affected. It should be capable of preserving the calculations for the base data sets that are not affected by the regulation constraints. The CEPA system should also provide the user with feedback information to assist in the evaluation of the effectiveness of the regulation tested and to help select the next regulation to be tested. This information would include the number of sources affected, location of regulation's greatest impact, percent emission reduction achieved, and others. The extrapolation of this feedback process to its ultimate conclusion would be equivalent to having the CEPA system back-calculate what regulations would be necessary to achieve a emission reduction. This, however, runs into the same problems as the growth analysis in that specification of objectives, constraints, and optimization procedures that are well beyond the scope of a CEPA system, are needed. Nevertheless, the feedback of information from the strategy calculation should be as extensive as possible to minimize the effort required to evaluate alternative strategy effectiveness and identify the best options.

2.9 GROWTH TRACKING SYSTEM COMPATIBILITY

As part of the air quality analysis requirements issued by EPA under Section 301(a) of the Clean Air Act, the states are required to assemble data on growth in all areas of the state and conduct an analysis to identify those portions that have indications of potential National Ambient Air Quality Standard violations. These areas would then be subject to more detailed analysis for possible Implementation Plan revisions.

EPA has recently issued a report[5] providing guidelines on tracking this growth. One of the principal concerns with CEPA system development is that it be compatible with these guidelines. The guidelines prescribe procedures for four types of analysis conditions: (1) areas with existing detailed projection of emissions and simulation of air quality, (2) areas with a less detailed or condensed analysis of projected air quality, (3) areas with no current analysis of projected air quality but with air quality monitoring data, and (4) areas without an analysis and without monitoring data. The guidelines outline a set of procedures to be followed in each of the four area types. In the first type of situation (i.e. with a detailed analysis already available) the procedure calls for a collection of growth information and a comparison to the growth projections used in the analysis. If any of the growth parameters exceeds the information used in the analysis, then a rough estimate of emissions growth is made to determine the potential for NAAQS violations. In the second type of situation the process is basically the same only the parameter comparisons are made on a much less detailed basis.

In the third type of situation the guidelines call for a linear "roll-forward" of air quality data based on rates of growth in several basic parameters (e.g. population, employment). The fourth type of situation calls for an emission projection and an air quality estimate based on some very rough approximations.

It is evident that these guidelines are suggesting analyses that could easily be handled by a CEPA system. The suggestions generally amount to a Level 1 analysis; the CEPA design calls for this capability to be built into the system. It must be pointed out though, that while the CEPA design as described here could do the growth tracking, it would be unlikely that a control agency would install the CEPA system for that purpose alone. The CEPA would provide much more capability than is necessary. The conclusion is that a state agency that had a CEPA system operational would definitely use it in the growth tracking analysis but a state would not proceed to install a CEPA to do that task only.

3 COMPUTER CONFIGURATION OF THE CEPA SYSTEM

The computer configuration to be used when implementing the CEPA system consists of two distinct yet totally dependent parts. First is the hardware, namely the main computer memory, intermediate storage and the input-output devices. Second is the software which is the set of programs at both the support and applications levels. These two parts must be integrated in such a fashion that it will provide a feasible tool for a maximum number of users and yet be simple to use. The applications software is more flexible in its development than the hardware, hence the hardware requirements are more definitive.

3.1 CONSTRAINTS ON HARDWARE AND SOFTWARE

As a direct consequence of the Phase I Feasibility Study,[1] a set of objectives and constraints pertaining to the hardware and software configuration of a CEPA system has been established. These are as follows:

1. The CEPA system must be designed for operation on both UNIVAC and IBM equipment. Users with other machines may have to modify their version of CEPA to use it on their facilities. The system should be designed to facilitate conversion to other machines.

2. The system must be capable of installation on EPA's UNIVAC 1110 machine in Research Triangle Park, N.C.

3. The system software must use only FORTRAN and/or COBOL.

4. The system software, in either card, tape, or other format, must be in a form that is easily duplicated for transmission to potential users.

5. The system must not operate exclusively in the interactive mode. Batch mode or a combination of batch and interactive should be employed.

6. The system must be capable of accepting machine readable input from EPA's National Emission Data System (NEDS) and Emission Inventory/Permits and Registration Subsystem

(EIS/P&R). The only other existing machine-readable format that the CEPA system should be designed to accept (to the extent practicable) is the Bureau of the Census data tape format.

7. Users with only limited familiarity with automatic data processing should be able to use the CEPA system with the help of a user's manual. Extensive machine job control language should be avoided for normal operation.

8. The system should provide output that is machine-readable for direct input into the AQDM, CDM, IPP, and Valley models; that is suitable for input into isopleth plotting routines; and that is in hard copy (printed output) for the entire area or for individual subareas.

9. The system should be modular in structure so that a user may choose to run a portion of the system or the entire system.

10. The system should be designed for possible inclusion into EPA's Aerometric and Emissions Reporting System(AEROS).

3.2 HARDWARE ALTERNATIVES

As was stated above, the UNIVAC 1110 in Research Triangle Park satisfies part of the hardware restrictions. The IBM portion can be satisfied by a moderate-to-large size computer in the range of an IBM 370/160 to 370/195. The final choice is dependent on how much software is required and whether or not the CEPA system will function independently of other systems.

An intermediate storage capability must be available to the user for the transient files that will be created during an analysis. (Transient files contain results of intermediate computations and require too much main memory to be permitted to reside there, hence the name transient.) The varied forms of intermediate storage can be magnetic tape, high volume disk, data cell, high speed drum or cards. No permanent files can be allocated by the user because of the prohibitive cost required to provide enough hardware to support the large number of potential users. (Put simply, if each user were to have files reside ad infinitum, there would be no more available space for new files.) The magnetic tape then is the only cost effective and portable form of intermediate storage for large permanent files. Smaller files can be stored on cards if necessary. The remaining forms of data storage can be used for the transient files. Since CEPA must function as a viable user oriented computer system, then these transient files can and should be purged from the system automatically after being retained for a finite period of time. This retention period should be sufficiently long to allow analysis to be performed without the extra cost in time and effort of recreating the transient files.

Input and output (I/O) options must also be considered. For input, magnetic tape and cards are the only reasonable choices. Cost and portability are the key factors governing these choices. These two modes of input would then contain the machine-readable raw data necessary to begin the analysis. The output can be in the form of magnetic tapes, punched cards, or printed output. These formats will not require extensive control language to manipulate.

The only other form of I/O that can be considered is an interactive terminal; namely, a device by which communication with the central computing facilities is made possible. With this device and the proper software support, the user can communicate with the central facilities via the telephone lines. However, the interactive mode must not be the sole form of I/O available under the restrictions stated above.

3.3 SOFTWARE CONSIDERATIONS

The software requirements to handle the potentially large volumes of data immediately indicate that some form of Data Base System (DBS) and Data Base Management System (DBMS) be employed. The DBS and DBMS required is the Emissions Inventory/Permits and Registration Subsystem (EIS/P&R) for point and area sources. This system will permit NEDS data to be input and output. Retrieval and updates of existing data as well as addition of new data is made efficient and simple by this system.

The CEPA system may become part of the EPA's Aerometric and Emissions Reporting System (AEROS), which further heightens the desire to maintain compatability with the NEDS format. The AEROS system is used to provide multileveled reports of air quality and emissions for states, AQCRs and counties. Other systems can be developed to handle the more general user input but this would require a great deal of time and effort to implement. An alternative to the development would be to purchase a proprietary package for DBS and DBMS such as the DMS 1100 created by Sperry Univac Company or IMS created by IBM. Such packages can perform general DBMS functions but can represent a considerable cost factor.

The final output of the CEPA system will be in the form of gridded emissions and have formats which are compatable with the AQDM, CDM, IPP, Valley and isopleth plotting programs. Intermediate output can be the transient files discussed earlier, tabulated printout for each module of the analysis, magnetic tape or cards containing either the tabulated results or the transient files for future analysis.

Some problems can always be expected when transportability of computer systems software or programs is required. To relieve some of these difficulties the following restrictions are made: only ANSI (American National Standards Institute) FORTRAN IV and ANSI COBOL will be used in applications programs. Whenever possible, the primary language should be FORTRAN IV and only where absolutely necessary should COBOL be used. A minimum of interaction between these two languages is desired since the interfacing will vary from computer installation to computer installation. The FORTRAN language has good computational capability while COBOL is good for file manipulation.

The prime mode of operation is to be batch, namely, an entry of data into the CEPA system and execution of CEPA modules without further interaction by the user until the results are compiled. A secondary mode of operation can be the interactive mode whereby the user is in constant communication with the CEPA system, which would provide intermediate results for the capability of on-line supervision of the procedures used in producing the results. Since this mode of operation, in the general case, is not required by the average user, this system should be developed only if it does not degrade the operation of the batch mode and if it can be developed in such a fashion that it is separable from the batch system. The interactive mode should be used only if intermediate results can change the path of a given strategy and the compilation of the intermediate results is relatively short. If these two conditions prevail, it is to the user's advantage to use the interactive mode since it will shorten the time required for the analysis.

3.4 DOCUMENTATION

The documentation of the CEPA system should be developed at two levels and in accordance with some predefined guidelines. The first level is the user guide and must contain at the very least a description of the theoretical methods used in applications programs, a detailed description of how to use each of the applications programs, and a set of comprehensive sample problems. In addition, any control procedures necessary to facilitate data handling and linking one module of CEPA to another should appear as sample problems. The second level is a programmer's manual on the details involved with applications program, so that the user may develop modifications of his version of the system. Flow charts, discussion of primary variables, input parameters and formats, output parameters and formats, and linking of one module to another are just a sample of the items to be discussed in the programmer's manual.

In addition to these basic requirements, one other documentation consideration must be addressed. If the CEPA system is to be included as part of EPA's AEROS system and is to be maintained and supported by EPA, it must meet certain documentation requirements that would not ordinarily be required. These requirements are based on the concept that an EPA staff member who was not involved in system development would be able to learn the structure and operation of the system quickly and would be in a position to make updates and changes that could be transmitted to all users. The meeting of these requirements could amount to a significant effort above and beyond that required to meet ordinary user needs.

4 COMPARISON PROCEDURE FOR ALTERNATIVE CEPA SYSTEMS

With the basic analytical and computer requirements laid out for the CEPA system, it is now necessary to define a comparison procedure to determine if any existing computerized air quality analysis packages are capable of meeting most of these needs. The systems reviewed here are the following:

1. Air Quality for Urban and Industrial Planning (AQUIP)
2. Computer-Assisted Area Source Emission Gridding procedure (CAASE)
3. Engineering Science Air Quality System (ESAQ)
4. Metropolitan Washington Council of Governments Air Quality Analysis (MWCOG) Models

In addition to matching each of these systems against the requirements, a comparison will be made with two other calculational procedures that can be used. These are:

5. Manual calculations
6. Newly developed CEPA system.

These last two can, by definition, be made to meet the requirements and they will serve to bound the evaluation by estimating the costs of doing the calculation by hand or developing an entirely new system to do the required calculations.

The comparison procedure to be followed here involves the steps shown on Fig. 4.1. First, each of the existing systems will be briefly described to give an overview of how each is designed and the major computational philosophies of each system. Next, each system will be compared to the analytical requirements spelled out in Section 2. If the system does not meet the analytical requirements, then the significance of the lack will be identified and an estimate of the modifications necessary will be made. If the system is capable of performing the required calculations, then a review of the data required and the validity of the approach will be made. This is to identify potential problem areas where a system will perform a certain calculation but use difficult to obtain data or use a procedure that is of uncertain validity. Despite the answer to the analytical evaluation questions, each system will be reviewed to determine if there are extra features that are not required as a part of CEPA but which are especially useful to an air quality analysis.

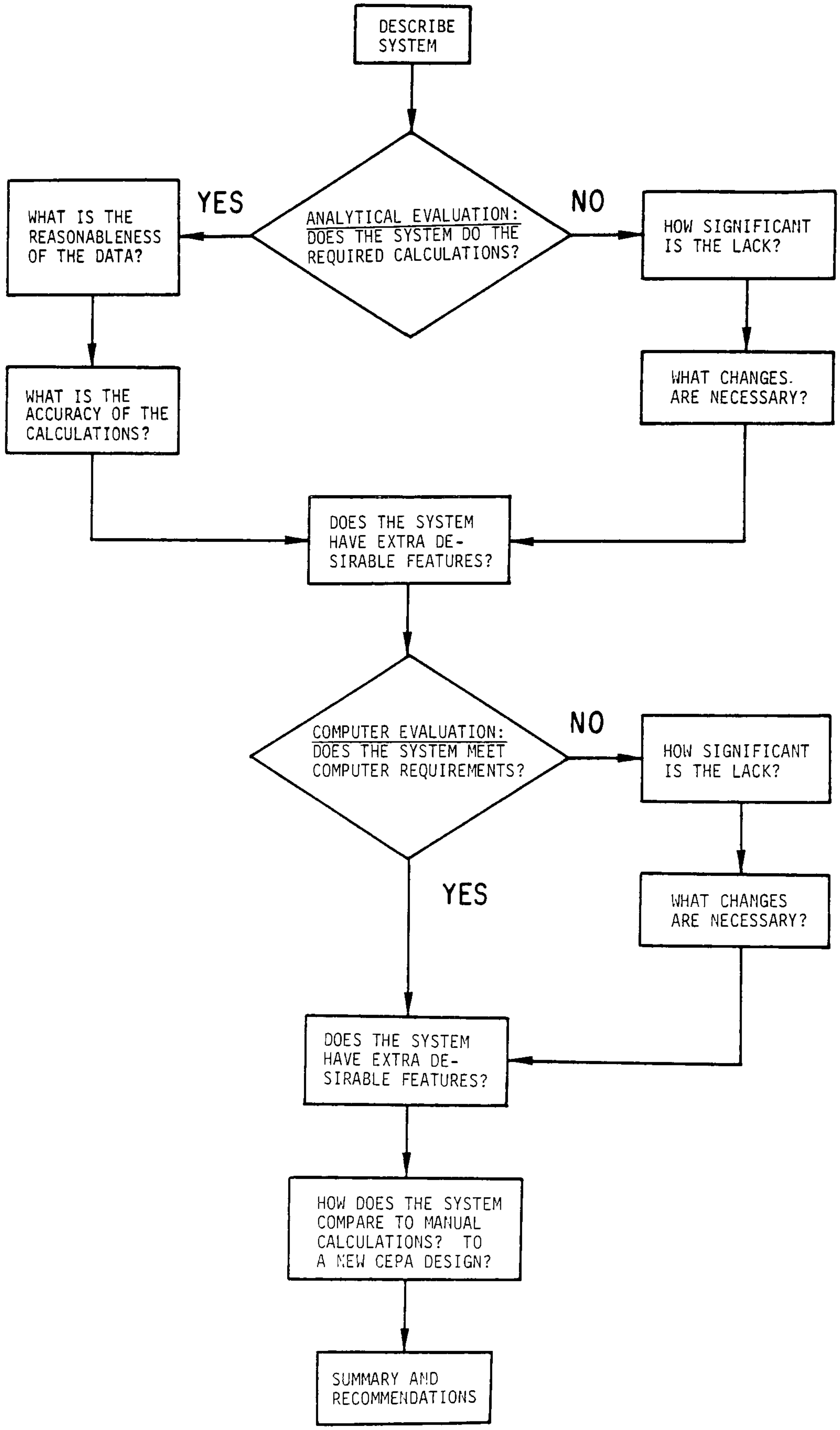

Fig. 4.1. Comparison Procedure for Existing Computer Systems

The next step in the comparison procedure is to review each system to determine if the computer requirements are satisfied. If the answer is negative, then the significance of the lack and the modifications required will be evaluated. Again, any desirable extra features will be highlighted.

Next, each system under consideration will be compared to a set of criteria that will measure the capability of that system against a manual calculation procedure and against a new CEPA system developed from the ground up. The criteria used for this evaluation are the following: (1) effort required to use the system - including getting the system operational, preparing the data for input, and operating the system, (2) Level of expertise needed to operate the system, and (3) cost of using the system - including cost to get it operational, cost of preparing the data, and cost of operating the system.

The final step in the evaluation will be to summarize the assessments and develop a set of recommendations for future action. No attempt will be made to reduce this summary to a single number for comparison as this would tend to obscure the details of the problem areas.

The following section presents the descriptions of the existing systems and the evaluations.

5 COMPARISON OF EXISTING SYSTEMS

In this section four existing computerized air quality analysis systems are described and evaluated against the CEPA system requirements. System descriptions are drawn primarily from documentation available, sometimes verbatim. Detailed evaluations against CEPA requirements are presented in the appendices; only summary conclusions are discussed here.

5.1 THE AQUIP SYSTEM

The evaluation of AQUIP was made on the basis of the documentation contained in References 6-10 and on discussions with EPA staff using the system.

5.1.1 System Description

The Air Quality for Urban and Industrial Planning (AQUIP) System was developed as a joint venture between the New Jersey Department of Environmental Protection and the U.S. Environmental Protection Agency. Environmental Research and Technology, Inc. (ERT) of Lexington, Massachusetts was selected as the contractor to build the system.

The objective of the ERT work was to develop a methodology to assess the air pollution impact of land use plans and to apply this methodology to a test case in the New Jersey Hackensack Meadowlands. Because of this objective, the system carries a distinct orientation toward use by planners. Much of the input and output is structured around the variables and parameters normally used by planners (as opposed to those used by air pollution control engineers). As such, it is the only one of the systems evaluated as CEPA candidates that allows for direct and straightforward treatment of land use plans.

The AQUIP software system makes use of input data sets and model parameter data sets, performs computations using four basic computer programs, and provides tabular and graphical outputs of the results. The logical relationships among these elements of the software system are shown in Fig. 5.1. Data sets are shown as rectangles, computation steps as circles, and printed output as document symbols. In addition, each element is identified by a code made up of a generic letter followed by a number. The letter prefixes and their meanings are:

I - Input data set, prepared by the system user.

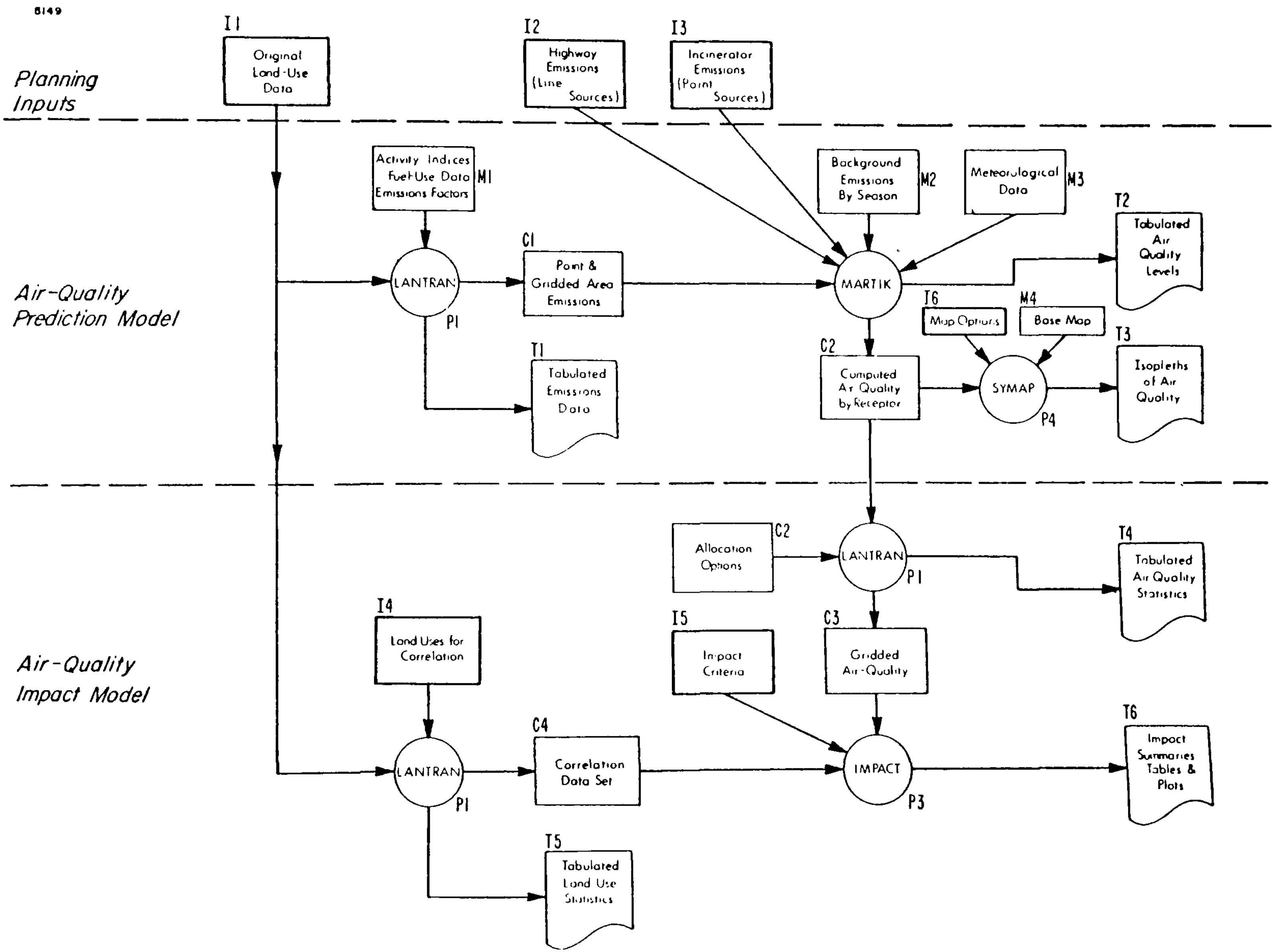

Fig. 5.1. Flowchart of AQUIP System

M - Model parameter data set, established initially for the study conditions, and modified only as necessary for updates to the model.

P - Computation step involving one of the four basic computer programs.

C - Computed data set formed as an output of one computation step and used as an input to another.

T - Tabulated outputs (or line printer graphics) delivered to the system user.

Table 5-1 gives a summary of the elements of the system.

Of the four computer programs that comprise the AQUIP system, only the LANTRAN routine is of direct relevance to the needs of a CEPA system. The MARTIK program is a dispersion model and, by definition, is excluded from the CEPA consideration. The SYMAP routine is a standard plotting package which can be incorporated into a CEPA system, but its location in the AQUIP structure (i.e., receiving output from the dispersion model) puts it beyond the bounds of CEPA. The IMPACT program is designed to determine various land use and population exposures to air pollutant concentrations and it also is beyond CEPA bounds.

The purpose of the LANTRAN program is to convert land use data to a rectangular grid system; to provide land use statistics; to provide certain commonly used preprocessing procedures for land-use data; and to establish data sets for use by other programs. The program is organized around two basic forms of data: that related to land use activities and represented by a set of geographically defined "figures," and that related to a grid system with its associated "cells." In LANTRAN the "figures" are the input and the grid system the output, i.e., the result of an allocation of activities defined on the figures to cells of the grid system. Internally, the two forms of data are represented by two large arrays. The first enables up to 18 different sets of data to be defined on up to 400 different figures, with each figure consisting of either: (1) a single point, (2) a broken line of up to 50 vertices, or (3) a polygon area of up to 50 vertices. The 18 "variables" are assigned symbolic names by the user at run time, making possible the manipulation of data by reference to the symbolic name. Examples of symbolic names which might be useful in land use applications are "POP-DENS" for population density or "DU/ACRE" for density of dwelling units.

Table 5-1 AQUIP System Elements

Element Designation	Element	Description
Input Data Sets		
I1.	Original Land-Use Data	This data set is specified as a set of point, line or polygon "figures" to which "values" representing planning variables are assigned.
I2.	Highway Emissions Data	This data set is specified as a set of "line" sources, to which emission densities have been assigned by the application of emission factors to traffic data.
I3.	Point Source Emissions Data	This data set is specified as a set of "point" sources to which emission rates have been assigned.
I4.	Land Uses for Correlation	Specified as a set of "figures" representing land uses to be correlated with air quality predictions.
I5.	Impact Criteria Data	This data set is a set of operations to be performed upon gridded air quality data for comparison with standards or correlation with various land uses.
I6.	Map Options	Which select variables for isopleth plotting and specify characteristics of output maps.
Model Parameter Data Sets		
M1.	Activity Indices	To relate activities specified in the given land use data to fuel demand.
	Fuel Use Data	To specify overall fuel availability data.
	Emission Factors	To relate fuel use or process rate by activity to emissions by pollutant.
	LANTRAN Program Parameters	To specify the grid properties, program options and computation parameters.
M2.	Background Emissions, by Season	A previously generated data set to account for the contribution of all point, line and area emissions sources outside the study area to computed concentrations at the receptor sites.

Table 5-1 AQUIP System Elements (Cont'd)

Element Designation	Element	Description
Model Parameter Data Sets (Cont'd)		
M3.	Meteorological Data	The set of normalized weighting factors to be assigned to each of the 480 meteorological conditions, based on the relative frequency of occurrence of these conditions.
	Meteorological Parameters	To determine such model characteristics as plume dispersion coefficients, mixing layer depth and vertical wind-velocity profile.
	MARTIK Program Parameters	To specify receptor properties, program options and computation parameters.
M4.	SYMAP Base Map	The set of SYMAP input packages which define the study region and the coordinates of the data points.
M5.	Allocation Options	The set of LANTRAN control options required for allocation of computed concentrations by receptor to the chosen grid system.
Computer Programs		
P1.	LANTRAN - Land Use Data Transformation Program	The fundamental purpose of this program is to convert data defined on point, line, or irregular polygon "figures" to a regular grid system.
P2.	MARTIK - Martin-Tikvart Diffusion Modeling Program	Computes the arithmetic mean air quality levels at designated receptor locations for a given distribution of emission sources with meteorological data specified for the averaging period of interest and the climatology of the study region.
P3.	IMPACT - Impact Analysis and Display Program	This program performs arithmetic and logical operations as specified at run-time by a "user hyper-language" on each element of a gridded system of data, allowing cell-by-cell comparison with user-specified criteria.

Table 5-1 AQUIP System Elements (Cont'd)

Element Designation	Element	Description
Computer Programs (Cont'd)		
P4.	SYMAP - Synagraphic Computer Mapping Program	A general-purpose graphics display program presently implemented for the display of isopleths of air quality as computed by MARTIK.
Computed Data Sets		
C1.	Point and Gridded Area Source Emissions	Allocated by pollutants to the specified grid system. The point sources in the data set represent discrete sources with emissions in excess of a given threshold. The area sources represent the remaining activities distributed to grid cell on the basis of area overlap or "extent".
C2.	Computed Air Quality	By pollutant for each of the specified receptors.
C3.	Gridded Air Quality	By pollutant converted to mean concentration for each grid cell.
C4.	Correlation Data Set	A gridded data set representing allocation of specified land-uses or their derivatives (e.g., population density) selected for correlation with air-quality levels.
System Outputs		
T1.	Tabulated Emissions	Projected emissions as computed by LANTRAN for the given ensemble of input data and model parameters, given as a summary for each constituent land use "figure", with tables and plots of resultant emissions presented for the specified grid system.
T2.	Tabulated Air Quality Predictions	For the given ensemble of planning inputs, model parameters and meteorological conditions. Tabulated by pollutant for each of a specified set of "receptor" locations within the study region.

Table 5-1 AQUIP System elements (Cont'd)

Element Designation	Element	Description
System Outputs (Cont'd)		
T3.	Isopleths of Predicted Air Quality	A graphical display of isopleths of pollutant concentrations generated by the line printer using an over-print technique to produce "shading".
T4.	Tables and Plots of Predicted Total Air Quality	Expressed in absolute units of con-centration for each cell of the study region grid system
T5.	Tables and Plots of Land Use Data	To be used for correlation with gridded air quality data.
T6.	Tables and Plots Pre-senting the Results of Impact Analyses	e.g., (1) statistics of compliance with standards; (2) integrated dosage by land use; and (3) overall land use compatibility.

The second array corresponds to the same 18 variables defined on a grid system of up to 400 cells. The grid system is specified by the horizontal and vertical coordinates of its "origin," the cell count in the horizontal and vertical directions, and the dimension of the grid cell in the horizontal and vertical directions. In addition, a scale parameter is specified to enable a convenient set of units such as kilometers or miles to be used for the coordinate system; the physical height of the grid system is specified in meters.

In summary, the use of LANTRAN consists of (1) defining the set of FIGURES, (2) defining the variables associated with the figures and assigning VALUES for these variables to the figures, (3) performing an ALLOCATION which distributes selected variables among cells of the grid system, and (4) creating an OUTPUT data set defined on the grid system, and putting this data set out either in punched-card form or as card images on a specified file. In addition, the two basic forms of data represented by the figure-values or "FV" array and the grid-values or "GV" array may be manipulated before or after allocation using an application-specific subroutine (COMP) written by the user.

5.1.2 System Use

The AQUIP system has not been widely used. Apart from the original application to the New Jersey Hackensack Meadowlands, there have been only limited attempts to use the system in air quality analyses. The system has not been used as part of any required air quality control plan (e.g. SIP revision, AQMA analysis, etc.).

5.1.3 Comparison with CEPA Requirements

The details of the comparison of the AQUIP system against the CEPA requirements are given in Appendix A.

The strong point of the system is its ability to map emissions from sub-area to master grids. The LANTRAN routine allows the user to easily change from one subarea set to another and have the program determine the appropriate transformation from subarea to grid. The routine is generalized enough to handle areas, points, and lines and treats them all as generic "figures."

The procedure whereby the figure is transformed to the grid can be varied depending on the nature of the situation. Allocations can be made by extent (i.e. by the portion of a figure lying in a grid cell), by association (i.e. by choosing the dominant value of a parameter from among all the values on all the figures lying in a grid cell), by interpolation (i.e. by developing a weighted average of the parameter values of all the figures lying in the grid cell), or by proximity (i.e., by choosing the value of a parameter corresponding to the figure whose centroid lies closest to the centroid of the grid cell).

In making the transformation, the user also has the option of interspersing a subroutine to do additional manipulations on the variables before they are transformed. This is a very desirable feature in that it gives the user a great deal of flexibility with respect to the calculations that can be performed.

The structure of the LANTRAN routine meets the CEPA requirements of surrogate variable input for the residential and commercial/institutional fuel combustion, solid waste disposal, transportation, and miscellaneous sources. The surrogate parameter (e.g., population density, housing units per acre, etc.) can be defined as one of the 18 "variables" on each subarea or "figure." The translation from a surrogate variable to fuel consumption (or solid waste generated, or solvent used, or VMT, etc.) is made via a table look-up routine and the calculation of emissions is done using emission factors. The one weakness in this procedure is that the translation tables and the emission factors are strongly linked to land use parameters (e.g., acres of commercial land, emissions per acre of commercial land used, vehicle density, etc.) and are not readily adaptable to the use of direct information on fuel consumption, solid waste generated, etc. In this regard, AQUIP cannot handle the direct data input for either residential and commercial/institutional fuel combustion, solid waste disposal, or miscellaneous sources, and does not meet the CEPA requirements for these types of analysis. For highway vehicle transportation sources AQUIP can accept VMT data by link or traffic zone but cannot treat vehicle fuel consumption inputs.

AQUIP is especially weak with regard to its treatment of point sources (industrial process and electric generation). The system simply reads in point source data and cannot provide the user with any ability to manipulate, summarize, or evaluate the information. Because of its orientation towards land use planning applications this is not a serious problem with respect to these uses. It does, however, represent a significant deficiency with respect to CEPA requirements. The user would still need to process much of the point source data manually to get the information in the desired format.

The growth analysis for all source categories is handled by AQUIP by inputing an entirely new data set representing the projected information. This means that the system can technically treat a growth projection, but that the user must develop and apply the growth parameters externally. There is no provision for inputing a base data set and growth factors and having the system generate a new data set. This is a significant flaw in AQUIP used as a CEPA system since the user must still do a substantial amount of manual calculation.

Analysis of alternative control strategies is done in the same way as is the growth analysis; that is, the user must input a new data set representing the effects of the controls. The program has no provision for the user to input a base data set and a control strategy and have the system recompute the impact of that strategy on emissions. Here again, AQUIP has significant deficiencies relative to CEPA requirements. The significant exception to this is the application of land use control strategies. In this case the user will input an entirely new land use plan to represent the control and there is no need to have the program operate from a base data set. The ease with which AQUIP can treat land use plans makes it especially useful for these applications.

The CEPA computer requirements are only partially met by AQUIP. The code is written in FORTRAN, is modular in structure, does not have only interactive processing requirements, and uses standard data transfer procedures (i.e., tape, cards). The system has only been run on IBM equipment although the translation to UNIVAC equipment should not be a major problem since there are no highly unusual features to the code. The ease of portability is unknown since the system has not been widely used. There are two major deficiencies with respect to AQUIP's use as a CEPA system. First, the existing user's manual is not easily understandable and does not adequately describe the way in which the system can be used. The attempt was made to keep the program descriptions very general and to minimize the ties to specific examples. The result is that the average user cannot readily determine if the system can meet his calculational requirements and what information is needed to operate the system. Also, there is no programmer's manual and it is not possible to get into the details of the code very easily

The second, and perhaps more significant, deficiency in the computer area is the incompatibility of AQUIP with existing emission data systems. The program does not accept data in NEDS format and cannot at all interface with the EIS/P&R system. The reasons for this are obvious; EIS/P&R was not available at the time AQUIP was being developed and the orientation towards land use planning did not dictate any pressing need to interface with a large emission inventory system like

NEDS. In any case, this leaves AQUIP as being basically separate and incompatible with systems that are in wide use today.

5.1.4 Required Modifications

Based on the detailed evaluation of AQUIP in Appendix A, it is estimated that about 4-7 person-years (51-85 person-months based on the sum of the efforts for each task) of effort would be required to modify AQUIP to meet all the CEPA requirements. The largest single effort (14-23mm) would be spent on bringing AQUIP into compatibility with the computer requirements. Substantial effort would be needed on new coding to make the system compatible with EIS/P&R, NEDS, and Census data.

Significant effort would also be needed on developing a control strategy routine that could be used to eliminate the need for the user to manually compute a new emission inventory reflecting the effects of each strategy.

5.2 THE CAASE SYSTEM

The evaluation of CAASE was made primarily on the basis of the documentation contained in References 8-9 and on discussions with EPA staff responsible for system development.

5.2.1 System Description

The Computer Assisted Area Source Emissions (CAASE) system is designed to provide a method for allocating county area source emission data to grid squares selected on the basis of demographic features and sized to give appropriate detail for input into air quality modeling programs. The Research Triangle Institute (RTI) of Research Triangle Park, N.C. was selected by EPA to do the original development of CAASE. RTI is currently under contract to do some additional modifications on and upgrading of the capability of CAASE.

The principal objective of the development of CAASE is to improve the characterization of emissions from area sources. The development program is based on the premise that substantial amounts of data needed for determination of area source emission are available only on the countywide level. Since county sizes are generally too large for use in air pollutant dispersion models, some means of allocating these data to smaller areas or grids is needed. Population, housing units, and land use are among the many criteria that have been used to make this allocation. The development of the CAASE system was begun as an effort to reduce the subjectivity in selecting the appropriate grid sizes and to reduce the time and effort required to carry out the allocation.

The design of the CAASE system centers on the use of the Bureau of the Census information contained in the Master Enumeration District Listing extended with geographic coordinates (MED-X) tapes. These tapes contain all of the data compiled by the Bureau of the Census for each of the enumeration districts along with the geographic coordinates of the center of area of the district. This information is used to both develop an appropriate grid system and make the allocation of data to these grids.

Figure 5.2 gives a flow chart of the current version of the CAASE system. This is being modified by RTI but the basic flow through the system is not significantly altered. CAASE currently has five computer programs associated with it and various subroutines called by these programs. A sixth program (CAASEO) has been developed to generate the data file titled "'Fuels' Totals from Stripped NEDS Files Area Source Category" and this will be incorporated when the revised version of CAASE is issued. Off-line gridding is now done in the procedure steps between the execution of the second and third programs. One of the modifications underway is to eliminate the need for manual gridding at this point. The programs have been numbered CAASE 1 through CAASE 5 and they perform the following functions:

CAASE1 strips the MED-X census tape files for all of the enumeration district population entries for all counties in the Air Quality Control Region (AQCR) being processed. CAASE1 also converts the coordinates of the center of each enumeration district from latitude and longitude (in degrees) to Universal Transverse Mercator (UTM) coordinates, which are used in dispersion modeling programs. CAASE1 also writes tape files to be used as input to the CAASE2 and the CAASE4 programs.

The current format of the CAASE2 program, using edited tape files written by CAASE1 and the line-drawing plotter (in this application a CALCOMP plotter), plots circles with their radii proportional to the population counts. When all counties for a particular AQCR have been processed through CAASE1 and CAASE2, a grid for the entire AQCR must be determined using partly subjective means. In order to make this determination a light-table is used; the population plots are overlayed onto a USGS map(s) containing all counties for the AQCR, and a grid is manually selected for the entire AQCR. Because determining the sizes of the grid squares and where they whould be placed is partially subjective, the technical personnel performing this step should have had some experience in gridding area source emissions using other techniques or should have been

CAASE SYSTEM DESCRIPTION

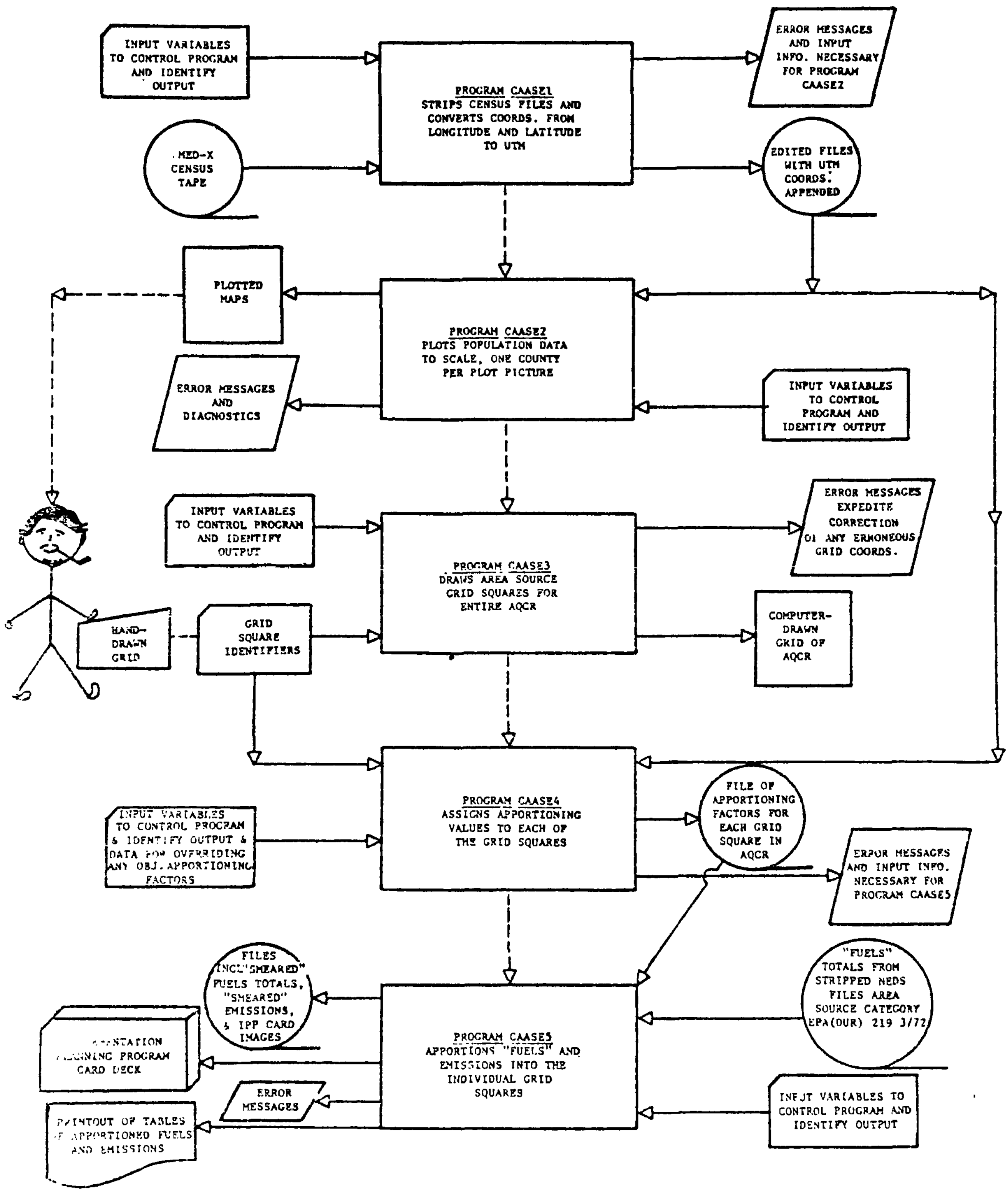

Fig. 5.2. Flowchart of CAASE System

trained to use this technique. The modifications to CAASE2 currently underway are designed to eliminate the manual gridding step and generate the grid system entirely by computer.

The CAASE3 program uses the input grid description cards and draws, to scale, a map of the entire AQCR. The map drawn by CAASE3 portrays the grid, and it is helpful in isolating any errors which may have been introduced when preparing the load sheets or in keypunching and verifying the cards. All grid elements must be square and errors of omission or the incorrect recording of a coordinate(s) are quite obvious when this map is visually checked. A symbol, in this application an "X," is optionally plotted at the center of each grid square to help in the location of errors.

After the grid description cards have been corrected, if necessary, for any errors found by using the CAASE3 program, the next step in the procedure is to use the CAASE4 program which assigns apportioning values to each of the grid squares. For each area source emission category included on the area source input form, an apportioning factor has been assigned using objective data when possible. Bureau of the Census MED-X data tapes contain a population count, a housing count, and a rural/urban classification for each enumeration district. Each grid description card includes the side length of the grid square from which the area is calculated. County totals for most of the area source emissions categories can be objectively apportioned using population, housing, area, or a combination of these three measurements. One obvious exception is the apportioning of emissions from aircraft operations which would require a knowledge of airport locations and, if more than one airport was located within a county, their relative operations activity. Table 5-2 illustrates the apportioning factors used in the current CAASE system and Table 5-3 illustrates those factors that have been decided on for the new NEDS area source format.

The CAASE4 program logic has been written to permit the user to subjectively override any of the objective apportioning factors. The actual apportioning factor for each source category used within the program is the product of a weighting factor and the assigned objective factor. This allows the user to override the programmed (or objective) apportioning factor within any particular county (or counties) if information to do so is available. The output of the CAASE4 program includes binary tape files which are used as input files to the CAASE5 program. CAASE4 output files contain, for each grid square and source category combination for each county, a number which can be used to

Table 5-2. Objective Apportioning Factors Current Area Source

Category Number	Major Classification	Minor Classification	Objective Apportioning Factor[a]
1	Residential Fuel	Anth. Coal	Housing Units
2	Residential Fuel	Bitum. Coal	Housing Units
3	Residential Fuel	Dist. Oil	Housing Units
4	Residential Fuel	Resid. Oil	Housing Units
5	Residential Fuel	Nat. Gas	Housing Units
6	Residential Fuel	Wood	Housing Units
7	Comm'l & Institl Fuel	Anth. Coal	Population
8	Comm'l & Institl Fuel	Bitum. Coal	Population
9	Comm'l & Institl Fuel	Dist. Oil	Population
10	Comm'l & Institl Fuel	Resid. Oil	Population
11	Comm'l & Institl Fuel	Nat. Gas	Population
12	Comm'l & Institl Fuel	Wood	Population
13	Industrial Fuel	Anth. Coal	Population
14	Industrial Fuel	Bitum. Coal	Population
15	Industrial Fuel	Coke	Population
16	Industrial Fuel	Dist. Oil	Population
17	Industrial Fuel	Resid. Oil	Population
18	Industrial Fuel	Nat. Gas	Population
19	Industrial Fuel	Wood	Population
20	Industrial Fuel	Process Gas	Population
21	On-Site Incineration	Residential	Housing Units
22	On-Site Incineration	Industrial	Population
23	On-Site Incineration	Comm'l & Institl	Population
24	Open Burning	Residential	Housing Units
25	Open Burning	Industrial	Population
26	Open Burning	Comm'l & Institl	Population
27	Gasoline Fuel	Light Vehicle	Population
28	Gasoline Fuel	Heavy Vehicle	Population
29	Gasoline Fuel	Off Highway	1/Population Density
30	Diesel Fuel	Heavy Vehicle	Population
31	Diesel Fuel	Off Highway	1/Population Density
32	Diesel Fuel	Rail Locomotive	Grid Sq. Side Length
33	Aircraft	Military	Area
34	Aircraft	Civil	Area
35	Aircraft	Commercial	Area
36	Vessels	Anth. Coal	Grid Sq. Side Length
37	Vessels	Diesel Oil	Grid Sq. Side Length
38	Vessels	Resid. Oil	Grid Sq. Side Length
39	Vessels	Gasoline	Grid Sq. Side Length
40	Evaporation	Solvent Purchased	Population
41	Evaporation	Gasoline Marketed	Population
42	Measured Veh Miles	Limited Access Rds	1/Population Density
43	Measured Veh Miles	Rural Roads	1/Population Density
44	Measured Veh Miles	Suburban Rds	Population
45	Measured Veh Miles	Urban Roads	Population
46	Dirt Rds Traveled	...	1/Population Density
47	Dirt Airstrips	...	1/Population Density
48	Construct Land Area	...	Area
49	Rock Handlg & Storage	...	Area
50	Forest Fires	Area-Acres	1/Population Density
51	Slash Burning	Area-Acres	1/Population Density
52	Frost Control	Orchard Heaters	1/Population Density
53	Structure Fires	No. Year	Population
54	Coal Refuse Burning	Size of Bank	Area

[a]Each of the above apportioning factors is multiplied by a weighting factor where some are initialized as zero for all grid squares and some are initialized as 1.0 for all grid squares. These initial weighting factors can be overridden with input data if desired.

Table 5-3. Objective Apportioning Factors New Area Source

Category Number	Major Classification	Minor Classification	Objective Apportioning Factor[a]
1	Residential Fuel	Anth. Coal	Housing Units
2	Residential Fuel	Bitum. Coal	Housing Units
3	Residential Fuel	Dist. Oil	Housing Units
4	Residential Fuel	Resid. Oil	Housing Units
5	Residential Fuel	Nat. Gas	Housing Units
6	Residential Fuel	Wood	Housing Units
7	Comm'l & Institl Fuel	Anth. Coal	Population
8	Comm'l & Institl Fuel	Bitum. Coal	Population
9	Comm'l & Institl Fuel	Dist. Oil	Population
10	Comm'l & Institl Fuel	Resid. Oil	Population
11	Comm'l & Institl Fuel	Nat. Gas	Population
12	Comm'l & Institl Fuel	Wood	Population
13	Industrial Fuel	Anth. Coal	Population
14	Industrial Fuel	Bitum. Coal	Population
15	Industrial Fuel	Coke	Population
16	Industrial Fuel	Dist. Oil	Population
17	Industrial Fuel	Resid. Oil	Population
18	Industrial Fuel	Nat. Gas	Population
19	Industrial Fuel	Wood	Population
20	Industrial Fuel	Process Gas	Population
21	On-site Incineration	Residential	Housing Units
22	On-site Incineration	Industrial	Population
23	On-site Incineration	Comm'l & Institl	Population
24	Open Burning	Residential	Housing Units
25	Open Burning	Industrial	Population
26	Open Burning	Comm'l & Institl	Population
27	Gasoline Fuel	Light Vehicle	Population
28	Gasoline Fuel	Light Truck	?
29	Gasoline Fuel	Heavy Vehicle	Population
30	Gasoline Fuel	Off Highway	1/Population Density
31	Diesel Fuel	Heavy Vehicle	Population
32	Diesel Fuel	Off Highway	1/Population Density
33	Diesel Fuel	Rail Locomotive	Grid Sq. Side Length
34	Aircraft	Military	Area
35	Aircraft	Civil	Area
36	Aircraft	Commercial	Area
37	Vessels	Coal	Grid Sq. Side Length
38	Vessels	Diesel Oil	Grid Sq. Side Length
39	Vessels	Resid. Oil	Grid Sq. Side Length
40	Vessels	Gasoline	Grid Sq. Side Length
41	Evaporation	Solvent Purchased	Population
42	Evaporation	Gasoline Marketed	Population
43	Measured Veh Miles	Limited Access Rds	1/Population Density
44	Measured Veh Miles	Rural Roads	1/Population Density
45	Measured Veh Miles	Suburban Rds	Population
46	Measured Veh Miles	Urban Roads	Population
47	Dirt Rds Traveled	...	1/Population Density
48	Dirt Airstrips	...	1/Population Density
49	Construct Land Area	...	Area
50	Misc. Wind Erosion	...	?
51	Land Tilling	...	?
52	Forest Wildfires	Area-Acres	1/Population Density
53	Managed Burning	Area-Acres	?
54	Agri. Field Burning	Area-Acres	?
55	Frost Control	Orchard Heaters	1/Population Density
56	Structure Fires	No. Year	Population

[a]Each of the above apportioning factors is multiplied by a weighting factor where some are initialized as zero for all grid squares and some are initialized as 1.0 for all grid squares. These initial weighting factors can be overridden with input data if desired.

apportion a fraction of the county total into each grid square within the county. Each county within the AQCR is processed separately through the CAASE4 program using the grid squares associated with the county, the MED-X census data, and any overriding weighting factors provided as additional input data.

The CAASE5 program, using "fuel" totals for each of the emission source categories for area sources, apportions these "fuels" into the individual grid squares. CAASE5 uses the same methods as those used in standard EPA programs to calculate the emissions using fuel totals and emission factors for each of the source emissions categories. The term "smear" has generally been used when describing the process of apportioning the total emissions for a county into the grid squares within a county. The CAASE5 program does the "smearing" by using apportioning factors assigned by CAASE4. CAASE5 first "smears" the "fuel" for each of the categories into each of the grid squares and outputs (prints) a tabular listing (and writes a binary magnetic tape) for all grid squares within the county for each emissions source category. For each area source emissions category, each grid square receives a fraction of the county total - that fraction being the number associated with that particular grid square and "fuel" category divided by the sum of all apportioning numbers for that "fuel" category within the county. For any area source category, the apportioning fractions summed over all grid squares for that county equals unity.

Procedurely, the pollutant emissions are calculated for the county totals and then "smeared." This procedure is used, rather than calculating emissions for each grid square using "smeared" fuels, because the calculations for "smearing" do not require as much computer time as the calculations of the emissions. For each source category, emissions are calculated for the five pollutants: suspended particles (SP), sulfur dioxide (SO_2), oxides of nitrogen (NO_x), hydrocarbons (HC), and carbon monoxide (CO). As emissions of each pollutant are calculated and "smeared," a tabular listing is output (printed) of the "smeared" emissions for each pollutant as was done with the fuels. The county totals for each emissions source category are output to indicate the contribution of each of them to the total emissions for each pollutant. For each grid square the "smeared" emissions from all source categories are summed for each pollutant for output in the Implementation Planning Program (IPP) expanded card format for area source inputs. A binary magnetic tape is also written containing all data items in the tabular listings and card decks. The output from CAASE5, then, includes tables of "smeared" fuel totals and "smeared" emissions for each of the five pollutants of interest, where for each grid square a separate value is printed for each source category. Also, a card deck is punched in the IPP format, containing, for each grid square, the total suspended particles, sulfur dioxide, oxides of nitrogen, hydrocarbon and carbon monoxide emissions "smeared" into each grid square for all source categories.

5.2.2 System Use

The CAASE system has been used in a number of applications. The documentation for CAASE[11] was issued as part of the guidelines on air quailty maintenance planning and as a result, the applications of CAASE have focused on its use as part of an AQMA analysis. Of the seven state agencies surveyed in Phase I of this feasibility study, three had used CAASE, at least in part, for their AQMA analysis. A comprehensive survey of CAASE users was not conducted, but informal contacts with state and local agencies indicates that the system is widely recognized as an available tool for air quality analyses and has been used in a number of situations.

The Phase I report indicated that experience with the system was mixed. The system was presenting more problems in its implementation than the standard dispersion models had, but this is to be expected since the system is much more complex. The current modifications to CAASE designed to eliminate the manual gridding process may eliminate some of this complexity.

Also, some questions were raised as to the accuracy of the CAASE procedure of allocating the countywide totals to the grids on the basis of the population, housing unit, or area allocation parameters. As is shown in the detailed evaluation of CAASE against the CEPA requirements, this procedure corresponds to the Level 1 and 2 analysis; there is no provision for surrogate variable inputs to do the more detailed calculations.

5.2.3 Comparison with CEPA Requirements

The details of the comparison of the CAASE system against the CEPA requirements are given in Appendix B.

The strong point of the CAASE system is its ability to generate a master grid system on the basis of an objective measure of population distribution. In all of the other systemsthe user must define the master grid manually, often on the basis of subjective judgements. This concept may be open to challenge using the argument that a population based grid system will not necessarily accurately reflect the emission distribution. That is, emissions are not always distributed in the same ways as the population. Nevertheless, the majority of air quality analyses that have been done use a grid that is population-oriented. This is accepted practice and also provides a method for focusing on population exposures to air pollutants. With regard to the CEPA requirements of being able to process several subarea sets into the master grid and of being able to map activity into a changing master grid, CAASE cannot meet either. CAASE starts with the Census Master Enumeration Districts and maps into a population-based master grid only.

Another strong point of the CAASE system is its ability to process Bureau of the Census tapes. This is not a trivial problem because of the large amount of information to be handled and because of the geographical idiosyncrasies of the county and subcounty boundaries. This capability is a very strong analytical tool for the air quality analyst in that it makes available to him the full extent of the Census data.

The CAASE system meets the CEPA requirements for inputing fuel consumption in the residential, commercial/institutional, industrial, and transportation sectors, solid waste disposal, solvent use, and futive-dust-generating activity. All of these are input in standard NEDS countywide format and allocated to the grid squares on the basis of the allocation parameter shown on Table 5-2. The system does not, however, have any provision for dealing with surrogate variables and calculating the emission distribution from them. (The surrogate parameters of population and housing units on the Census tapes are used to determine the allocation proportions only and are not used for direct emission computations.)

This situation illustrates the basic design philosophy of CAASE as it relates to CEPA requirements. CAASE was designed to assist in the development of a grid and the allocation of emissions to that grid. It was not intended to provide substantial assistance in emission computations. In this light, the majority of the CAASE system is meant to be run only once. Programs CAASE1 through CAASE3 need not be used after the master grid is set up. CAASE4 will be used only infrequently after the initial run and serves the function of changing any of the apportioning factors. CAASE5 is the only program that needs to be run more than once as it operates on the emission inventory, which will change as growth scenarios and control strategies are applied. The entire CAASE system is, therefore, a tool that is used to initiate an air quality analysis (by developing the grid) but is not used to continue the analysis to study various management and control options.

This is further evidenced by the way in which growth and control strategies are handled by CAASE. The system treats these scenarios as inputs in the form of NEDS area source data. It does not provide a means for computing what the effect of a particular growth or control strategy is, but only computes emissions from a specified strategy. In essence, the user must externally determine how an emission-producing activity is affected by growth or controls, input these into CAASE in the NEDS area source format, and then the system will take over to allocate these to the grid cells. Therefore, although CAASE technically meets the CEPA requirements of being able to process data indicating the effect of growth and controls, it still requires a great deal of user manual calculation to prepare the input data appropriately.

The CAASE system does not treat point sources at all. Its design was intended to be oriented exclusively to area sources. To meet CEPA requirements, entirely new coding would be needed. This is tantamount to developing the entire CEPA system for point sources anew.

The CAASE system meets virtually all of the CEPA computer requirements. The only significant requirement that the current version does not meet is its ability to operate on the EPA UNIVAC 1110 computer, but the current modifications underway call for the UNIVAC conversion to be made.

5.2.4 Required Modifications

From the detailed evaluation of CAASE in Appendix B, it is estimated that to modify CAASE to meet all of the CEPA requirements would take 5-7.5 person-years (60-89 person-months using the sum of all the tasks) of effort. The largest efforts involve the development of point source, growth, and control strategy routines, the upgrading of the gridding routines to handle other than Census Districts and population-oriented grids, and the development of surrogate variable input routines. A number of small tasks needed to upgrade the transportation sources also add up to a significant effort in this sector.

It is evident by reviewing the extent of the modifications needed for CAASE that the efforts amount to almost an entirely new system development. This is because CAASE was designed to do a very specific job and there was never any need to generalize the routines for other applications. This is not a criticism of CAASE for it serves a useful function in performing its design tasks but it casts significant doubt on the reasonability of attempting to modify it to fit CEPA requirements.

5.3 THE ESAQ SYSTEM

The evaluation of ESAQ was made on the basis of the information contained in Refs. 13-14. These materials do not constitute formal documentation of the system but are only general descriptions used for overview information; formal documentation does not now exist on the ESAQ system. To further identify the performance of ESAQ, discussions with Engineering-Science representatives were held. Most of the details of the evaluations were made on the basis of these discussions. For this reason, the comments made about the ESAQ system must be offered with a caveat. The information is based on the interpretation of verbal communications and may be subject to inaccuracies typical of this type of procedure. Every effort was made to clarify any points of uncertainty; nevertheless, it is possible that the results of some of these evaluations may be erroneous or incomplete because of the unavailability of written documentation.

5.3.1 System Description

The Engineering-Science Air Quality (ESAQ) system was developed as a result of air quality analyses performed by Engineering-Science (ES) of McLean, Virginia. The original impetus for the development of the system came from some studies that ES performed in Fairfax County, Virginia. Later studies resulted in modifications and upgrading of the system.

The ESAQ system consists of a number of computer programs, some of which were developed by ES and some of which were modified from codes developed by EPA and the National Climatic Center (NCC). Figure 5.3 illustrates the structure of the code. The system has five major subsystems: (1) a "Land Use" subsystem that processes data on residential and commercial/institutional fuel combustion and allocates area source data to subcounty areas, (2) a "Traffic" subsystem that handles all motor vehicle sources, (3) a "New Industry" subsystem that processes point source information, (4) an air quality and meteorological data subsystem, and (5) an air quality dispersion model subsystem. These subsystems are not entirely discrete entities in that there is some overlap and sharing of functions. Also, the titles of each subsystem do not completely reflect the functions performed.

The air quality dispersion model subsystem consists of the Air Quality Display Model (AQDM), the APMAX model for short term, point source analyses and the AQHIWAY model for line source analyses. AQDM and AQHIWAY are modifications of EPA programs. These functions are outside the range of CEPA

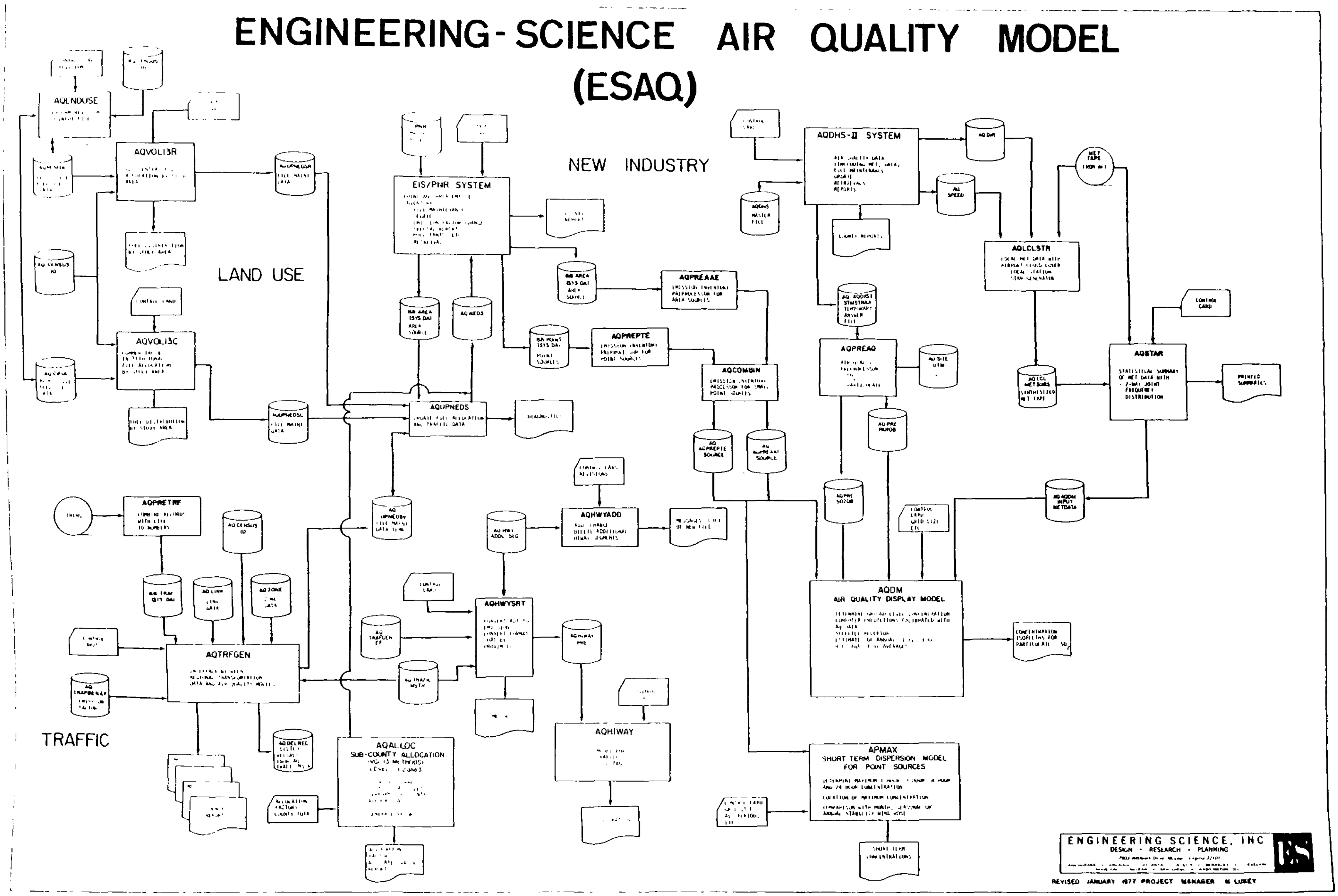

Fig. 5.3. Flowchart of ESAQ System

requirements and the only important point to emphasize is that the structure of the ESAQ system allows for these to be easily replaced with other models simply by changing the preprocessing programs to generate input decks in the desired format.

The air quality and meteorological data subsystem includes the AQDHS system for storing and maintaining air quality data, the AQSTAR program for generating statistical summaries of meteorological data, the AQPREAQ program that preprocesses air quality data into the appropriate format for the dispersion models, and the AQLCLSTR that generates the statistical meteorological summaries for locally generated data. The AQDHS system is an EPA code and the AQSTAR program was developed by NCC. This entire subsystem is also outside the scope of a CEPA system and will not be discussed further.

One of the most significant components of the ESAQ system is the "New Industry" subsystem. The title is somewhat of a misnomer since the subsystem handles all sources. The core of the subsystem is the Emissions Inventory System/ Permits & Registration (EIS/P&R). EIS/P&R consists of approximately 15 programs and was developed by EPA. It is a data management program designed to edit, update, and calculate emissions for point and area source inventories; select and retrieve specific information; prepare emission reports; and process data for creation of emission scenarios. To the full capability of EIS/P&R, ES has added several preprocessor programs AQPREPTE, AQPREAAE and AQCOMBIN to translate EIS/P&R output into model-compatible form and another module, AQUPNEDS, to update residential, commercial/institutional fuel, and VMT data in the EIS/P&R files.

The "Land Use" subsystem contains four important codes: AQVOL13R, AQVOL13C, AQLNDUSE, and AQALLOC. The first two compute residential and commercial/institutional, respectively, fuel use by means of the surrogate variable procedure. That is, number of housing units in a subarea (for residential) or floor space (for commercial/institutional), building size distribution, fuel use distribution, fuel consumption factors, and degree-days are input and the fuel consumption for each subarea is computed. This corresponds to the Level 3 analysis described in Section 2. The third is an updating code to change the building size distribution used in the first two. The fourth program, AQALLOC allocates area source emissions in NEDS format to subareas on the basis of input allocation parameters. This program is almost identical in operation to the CAASE 4 and CAASE5 routines operated in the full override mode (i.e., where the user specifies the allocation parameters rather than using the population-based parameters generated by the program). The AQALLOC program corresponds to the Level 1 and 2 of Section 2 and processes the emissions from all area sources included in the NEDS structure.

The "Traffic" subsystem centers around the AQTRFGEN program. One function of AQTRFGEN is to calculate emissions of carbon monoxide and hydrocarbons from each link, after considering such factors as type of road, speed, and vehicle mix. The emission information is reported on a link-by-link basis. In addition, carbon monoxide emissions are written to a file named AQ.TRAFIC. MSTR, where data concerning the link's location and configuration are stored. This file is converted to HIWAY format by AQHWYSRT for subsequent analysis of carbon monoxide concentration. Another basic function is to read estimated traffic counts on each segment of the highway network and assign vehicle miles traveled to the proper subcounty area. The totals for each subcounty area are sent to the EIS/P&R system for calculation of emissions, and subsequently to AQDM for an area-wide analysis of particulate and sulfur dioxide concentrations.

The purpose of the AQHWYADD program is to modify a file containing data concerning highway links or segments that are not maintained by TRIMS (typical traffic model). The format for this file is the same as that for AQ.TRAFIC. MSTR, which is updated with information supplied by TRIMS (or other traffic models) each time that AQTRFGEN is run. The AQHWYADD file, AQ.HWY.AQDL.SEG, is used in conjunction with AQ.TRAFIC.MSTR by the AQHIWAY preprocessor AQHYWSRT. The outputs are a modified file, and a formatted listing of the file after all modifications have been performed.

The AQHWYSRT program accesses the highway link files maintained by AQTRFGEN and AQHWYADD, selects those within a certain radius from a selected center point, converts average daily traffic to 1-hour or 8-hour carbon monoxide emissions using emission factors, and reformats the data for use by AQHIWAY. The output consists of a file containing those highway links within the selected area with emissions greater than zero, and printed messages indicating how many links were selected. The file may be used directly by AQHIWAY.

5.3.2 System Use

The ESAQ system has been used for air quality analyses in 5 areas. The system is currently operational only on ES in-house computer (an IBM 370/165) and has not been used outside the company. The lack of formal documentation and the general unavailability of the code have precluded its use elsewhere. In its current state, the system must be viewed as an in-house program that is not available for use by air pollution control agencies except through Engineering-Science.

5.3.3 Comparison with CEPA Requirements

The details of the comparison of the ESAQ system against the CEPA requirements are given in Appendix C.

The ESAQ system comes closest, of all the systems evaluated, to meeting the CEPA requirements. Its structure, designed to meet air quality maintenance planning needs, parallels very closely the general analytical capability required of CEPA. One of its strongest features is its focus on the EIS/P&R system as the core of its data management. This makes the system very attractive in that it is entirely compatible with the emission inventory routines that are being more widely accepted for use in the states.

The major weakness of the system is its lack of documentation, its general unavailability for use in the states, and the lack of experience with it outside of Engineering-Science. These are not significant problems to overcome but they are important in that the entire evaluation of the system must be qualified by these considerations.

The ESAQ system can meet virtually all of the CEPA requirements for residential, commercial/institutional, and industrial fuel combustion sources. The lack of the ability to extract point source fuel use from input fuel use totals is relatively minor and would require only small programming changes. Likewise the transportation source requirements are almost entirely met. New coding to allow a user to input generalized growth factors would not be difficult to develop. The treatment of solid waste disposal sources requires a little extra effort to allow the waste generation to be calculated on the basis of a surrogate variable. Miscellaneous source treatment also requires only small modifications. For industrial process sources, the system does not disaggregate growth among existing, new, and unknown sources. This would require some more extensive effort to program but would still not be difficult to achieve.

In dealing with the mapping of emissions from subareas to master grids, the system can only deal with one subarea set and one master grid network. As this is primarily a bookeeping problem, the development of new code to handle several subarea sets and/or master grids would be straightforward.

The manner in which the system deals with growth and control strategies is one of its weak points. This is a function of how the EIS/P&R system is used. The in-line COBOL retrieval system is used to extract those sources for which a growth rate or control strategy is to be applied. The user must then program, in COBOL, the application of each scenario to each source category separately. While this process does, in fact, allow the user to deal with a wide variety of growth and control scenarios, there are two major problems with it. First, the coding must be done in COBOL. This language was not designed to handle extensive or complex computations and may prove difficult to use in complicated conditions. Also, Phase I of this feasibility study indicated that COBOL was not as widely used in the state agencies as FORTRAN. Of the seven states surveyed, one did not have COBOL capability at all and two others had only limited experience with it. It may be argued that any agency using the EIS/P&R system would, of necessity, have to have COBOL capability and this problem would not arise. This a valid point but the use of the COBOL language in a computational mode to apply growth or control strategies may be beyond the capabilities of an agency or, at best, many not be the most efficient way to do this type of analysis.

The second problem with the ESAQ system's growth and control strategy procedure is that the scenario must be programmed for each source category separately. Where only a few source categories are affected this is not a problem, but when a large number of categories are involved this may be a tedious and time-consuming chore. Also, this process does not aid the user in doing standard types of analyses with minimum effort. Every scenario must be programmed anew as opposed to just inputing data representing the desired conditions.

With regard to the CEPA computer requirements, the ESAQ system satisfies most of the needs with the exception of the availability of documentation and the use on other computers, especially the UNIVAC. These problems have already been addressed.

5.3.4 Required Modifications

From the detailed evaluations of ESAQ in Appendix C, it is estimated that the modifications necessary to meet all of the CEPA requirements would take about 3-5 person-years (36-61 person-months using the sum of all the tasks) of effort. The largest efforts would involve the development of better growth and control strategy routines, the preparation of documentation, and the testing of the code on other computers.

Review of the detailed evaluations also shows that a good deal of this cost is taken up by making a large number of relatively small modifications. Also, these small modifications, in many cases, represent desirable although not essential features. Significant cost savings could be effected by reducing the CEPA requirements to the minimum acceptable level.

5.4 THE MWCOG SYSTEM

The evaluation of the MWCOG system was made primarily on the basis of the information contained in Refs. 15-17. The materials do not constitute formal documentation of the system and were supplemented with discussions with MWCOG staff. The comments made regarding the MWCOG system must be tempered with the qualification that there is no documentation and the possibility of misinterpretation of verbal communications is present.

5.4.1 System Description

The Metropolitan Washington Council of Governments (MWCOG) system was developed to assist the air quality planning efforts of the Council. Its design was based on making use of existing data and systems, particularly transportation-oriented, that were available to the COG. It was intended primarily as an in-house analytical tool but has seen some applications outside the Council. It was developed entirely by MWCOG staff.

The MWCOG system can only loosely be described as a "system." More accurately, it is a set of computer programs, each of which generates a specific output. These outputs can be fed into other programs to obtain additional results. Figure 5.4 illustrates the relationships between the different codes; Table 5-4 gives a brief summary of the programs.

The system begins with the calculation of fuel combustion emissions. The input data consists of a 1972 demographic data base (primarily Census information aggregated to planning districts) and 1980 and 1985 projections of this data base. The GROWTH routine uses this information to compute growth factors for households (H), employment (E), and a parameter called "activity" (A=H+E). It was discovered by some statistical analyses that the activity parameter sometimes gave a better growth projection than either households or employment alone.

The growth factors, a 1972 fuel use survey, and assumptions about future fuel use patterns are used in FUELGR to develop growth factors for fuel consumption. The GROW routine then proceeds to compute future emissions from fuel combustion and tabulates this information by planning district. GROW also receives input in the form of an area source emission inventory and applies growth factors to generate an updated inventory. The update is computed by applying either the household, employment, activity, or fuel growth factors to the current emissions. The user can input non-demographic growth rates to handle special sources (e.g., airports).

The GROW routine is also used to compute the effect of changes in emission rates due to regulations, changes in emission factors, etc. This is done by developing an effective growth rate that reflects both growth and changes in emission rate.

The output of GROW is emissions by planning district. The CONVRT routine maps these into grid emissions using a table look-up procedure. The mapping can be made on the basis of area, population, employment, or any other desired parameter. CONVRT prepares the emissions for input into any one of a number of dispersion models.

The EMSUM routine takes the district emissions and generates a summary by ring, political jurisdiction, and region.

Transportation emissions are handled by using a travel demand model that operates from data on the present transportation system and on projected

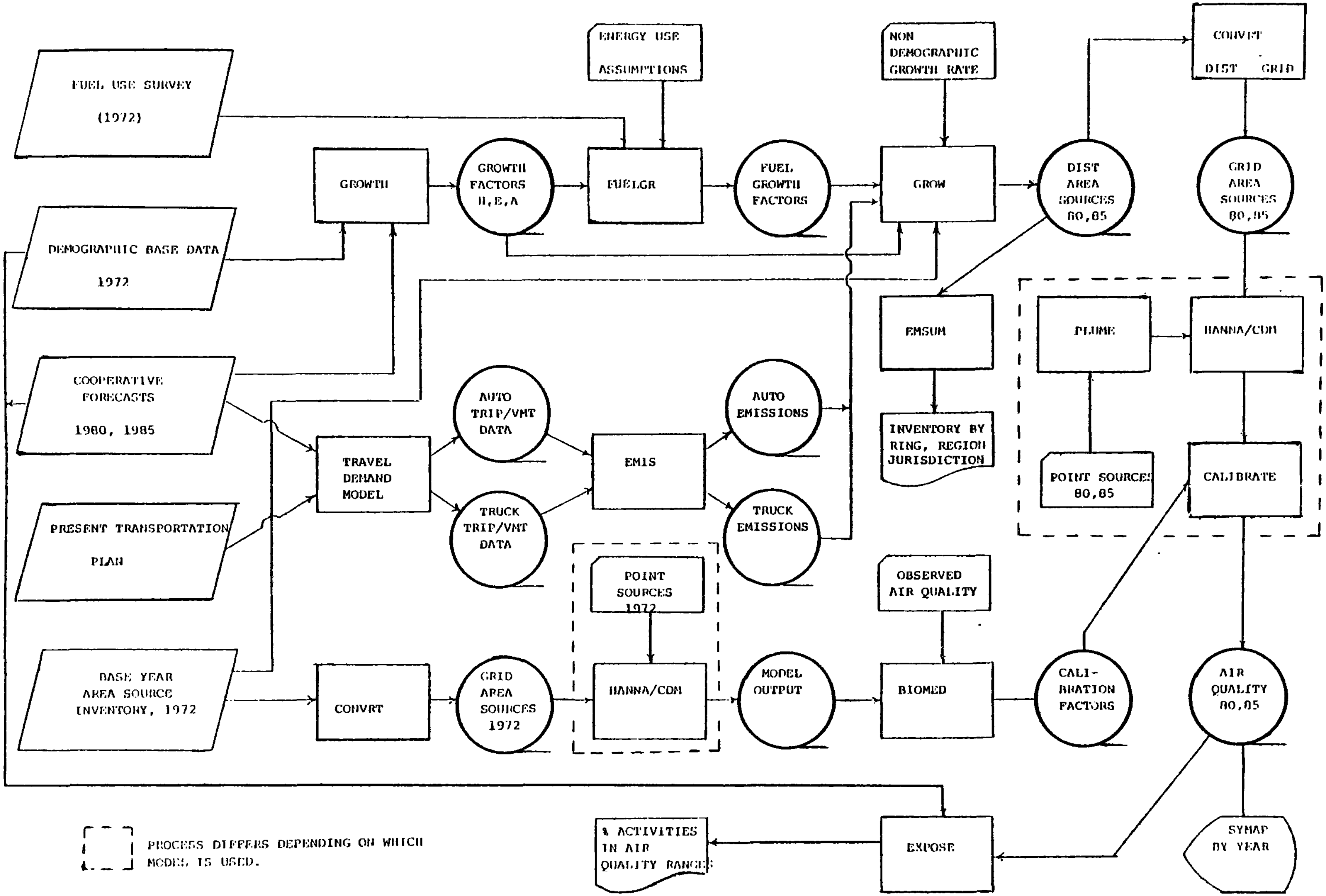

Fig. 5.4. Flowchart of MWCOG System

Table 5-4. Components of the MWCOG System

Program Name	Description
1. ALLOK[a]	Version of the HANNA Model which iterates for point and area sources until air quality standard is violated.
2. BIOMED	Statistical Package
3. CALIBRATE	Applies calibration factors.
4. CDM	The Climatological Dispersion Model estimates long-term concentrations of non-reactive pollutants due to emissions from area and point sources in an urban area.
5. COMPCO[a]	Converts Hanna CO concentrations in 16 x 15 grid matrix to a 12 x 12 grid matrix for input to ICOM.
6. CONVRT[a]	Converts district emissions to grid emissions for a 5 km. and/or 2.5 km. grid system.
7. EGAMA	Numerical simulation model for non-reactive pollutant analysis.
8. EMIS[a]	Computes auto emissions per AP-42 Supplement #5 for years 1974 through 1992 by district given the number of trip starts and ends along with VMT and average speed per district.
9. EMSUM[a]	Program compiles district area source inventory by jurisdiction and ring.
10. EXPOSE[a]	Computes percent household, employment and activities over the primary and secondary standards.
11. FUELGR[a]	Program will project fuel use by district given energy use assumptions and growth factors from GROWTH.
12. GROW[a]	Program will project area source emissions inventory by district given future fuel inventory from FUELGR, growth factors from GROWTH, nondemographic growth factors (airports, etc.), and projected auto and truck inventories along with the base year inventory.
13. GROWTH[a]	Computes growth factors given base and future year projections of housing, employment and activities by district.
14. HANNA[a]	Box model used to estimate long-term concentrations of non-reactive pollutants due to emissions from area and Gaussian model for point sources.
15. HIWAY (batch & interactive)	Line source model used to simulate short term CO concentration near a roadway. The model assumes Gaussian plume dispersion.
16. HIWEMF[a]	Computes CO emission rates (g/sec-m) using techniques described in AP-42, Supplement 5. Results are used as input to HIWAY.
17. ICOM[a]	Program incorporates the EPA-HIWAY model, Urban Street Canyon subroutine of APRAC-1A and the Hanna-Gifford area source model used to calculate the CO urban background.
18. INTRANS	Interactive program performs many statistical manipulations to data sets then visually displays the results as graphs, maps or list of statistics on CRT terminal.
19. LOADEM[a]	Converts output from the Travel Demand Model for autos in 168 districts to trip end VMT data (by special categories) for 134 districts for input to EMIS.
20. LOADTRK[a]	Same as LOADEM except for trucks.
21. MDXY[a]	Program converts the longitude and latitude coordinates of a geographical point to the X and Y coordinates of the Maryland Plane System.
22. PLUME[a]	Program calculates both the Briggs and Holland plume rise in meters at several downwind distances.
23. PSMAP[a]	Program draws the outline of the region and plots data points on a graph plotter.

[a]MWCOG-developed. Available on request.

demographic forecasts. The output of this model is a set of trips and VMT on the traffic planning zones. The model itself is not part of the MWCOG system and is a standard transportation planning tool. The EMIS routine computes motor vehicle emissions and feeds this information into the GROW program for assignment to the appropriate district.

All of the other programs in the MWCOG system (HANNA, CDM, BIOMED, PLUME, CALIBRATE, SYMAP, EXPOSE) are out of the scope of the CEPA system.

Point sources are handled in the MWCOG system as input data only. No attempt is made to do any calculations on these data other than air quality computations. Growth in point source activity is handled manually.

5.4.2 System Use

The MWCOG system has been used extensively by the Council in its air quality analysis programs. Approximately 20-30 different growth scenarios for the metropolitan Washington area have been tested with the system.

The COG has offered to give the programs to any interested party. To date, the EMIS routine has been most in demand since it handles the complexity of applying motor vehicle emission factors. The system as a whole has not been used outside of the agency.

5.4.3 Comparison with CEPA Requirements

The details of the comparison of the MWCOG system with CEPA requirements are given in Appendix D.

The MWCOG system is attractive as a CEPA candidate from the standpoint of its simplicity and ease of operation. A number of simplifying assumptions are made that reduce the generality of the system but also make it much easier to understand and operate.

The system meets the fuel combustion requirements for residential and commercial/institutional sources reasonably well. The GROWTH routine that allows the user input a base and projected scenario and computes growth factors in especially useful. Likewise, the highway vehicle emission computations are handled reasonably well, with the exception that the user cannot easily input specific link data; all information is handled through the travel demand model.

The system is weak in the manner in which it handles area source emissions other than fuel combustion and highway vehicles. The data is input to the GROW routine where growth factors are applied. These growth factors account for both the increase in activity and the change in emission rates. This approach is a simplification that enables the user to avoid getting into the details of each source category. At the same time it reduces the accuracy of the calculation and does not allow the user to simulate growth and/or control strategies that cannot be represented by a simple growth rate. If the user does wish to do a more detailed calculation he must manually compute an "effective" growth rate for input into the system.

A second area where the system does not meet the CEPA requirements is in the handling of point sources. The system was never designed to treat point sources other than as input to the dispersion models. This leaves a significant gap in the needs as outlined for CEPA.

In terms of computer requirements, the system's simplicity assures that it can function under most of the requirements. The lack of documentation is the most severe limitation at this point.

5.4.4 Required Modifications

From the detailed evaluations of Appendix D, it is estimated that modifications to the MWCOG system to meet CEPA requirements would thake about 4-6 person-years (51-79 person-months using the sum of all the tasks) effort. The largest efforts would be in developing routines to handle the point sources and adding more detailed treatments of some of the area source categories. A significant effort would also be spent on making modifications to the transportation routines to handle other than highway vehicles in more detail and in allowing user input of specific highway link data. The development of a control strategy routine to replace the "effective" growth rate procedure would also be an extensive task.

6 COST ANALYSIS OF THE CEPA SYSTEM

The CEPA system concept is based on the consideration that the availability of such a system will save time, effort, and money in the conducting of an air quality analysis. This section will summarize the evaluation of the existing systems as well as the development of a new system on this basis.

6.1 SYSTEM DEVELOPMENT COSTS

There are two basic procedures that can be followed in developing the CEPA system. One of the existing systems just described can be modified to meet the CEPA requirements or an entirely new system can be developed. The comparison of these two approaches must be made on the basis of several criteria. First, the effort required to either modify an existing system or develop a new system must be estimated. This effort must be described in terms of skills required, extent of effort (in person-months), and personnel required on the part of EPA staff and assisting contractors. Second, the time required to perform the modifications or develop the new system must be considered. Third, the cost of modifications or development must be estimated.

6.1.1 Modification and Development Resource Requirements

The estimates of the effort required to make the modifications on each of the existing systems has already been described (Appendices A-D). Appendix E gives the estimates for the development of an entirely new CEPA system. These effort levels are consistent with those given on the modifications in that a major coding effort for modifying an existing system is assumed to be equivalent to developing that piece of the CEPA system anew.

Effort Table 6-1 summarizes the technical effort required to modify the existing systems and to develop a new CEPA system. It is important to note that these effort estimates vary by about a factor of two for the programming associated with each task category and for the entire modification or development. This is because past experience with the development of large scale computerized systems has indicated that integrating a number of independent programs into a unified whole and identifying and correcting coding errors can easily consume substantial amounts of time above and beyond that required to write the first version of the programs. The lower effort numbers should, therefore, be taken to represent that which is required if no substantial problems

Table 6-1 Summary of Modification and Development Efforts for CEPA System

Category	Effort, person-months				
	AQUIP	CAASE	ESAQ	MWCOG	New CEPA
Residential Fuel Combustion	5-10	6-10	1-2	3-5	13-23
Commercial/Institutional and Industrial Fuel Combustion	2-4	3-6	-	-	6-12
Electric Generation and Internal Combustion	2-3	2-3	2-3	2-3	2-3
Industrial Process	5-8	8-10	4-7	8-10	7-10
Transportation	4-6	11-15	3-4	11-18	17-27
Solid Waste Disposal	3-4	3-6	3-6	4-8	7-14
Miscellaneous	1-2	2-3	2-4	6-8	6-13
Gridding	5-9	5-7	2-4	2-4	5-10
Growth	4-6	7-11	5-9	-	7-11
Control Strategies	6-10	6-8	5-8	6-9	6-10
Computer Requirements	14-23	7-10	9-14	9-14	11-16
TOTAL	51-85	60-89	36-61	51-79	87-149

are encountered and the coding proceeds without the need for significant backtracking to trace down errors. The larger effort numbers reflect the resources required if there are substantial difficulties in integrating the various pieces of the system together and if errors that are difficult to find and correct appear regularly.

It is evident from the table that the effort required to either modify an existing system or develop a new system is substantial. Even the least effort (i.e., modification of the ESAQ system) still requires about three person-years of work to meet all of the CEPA requirements. The ESAQ system modification would require the least amount of effort since, as was indicated in the detailed evaluations, it already meets many of the requirements. The AQUIP and MWCOG systems require about equal effort to modify and the CAASE system requires slightly more effort. The low effort estimates for developing an entirely new CEPA system about match the high effort estimates of modifying AQUIP, CAASE, and the MWCOG routines. The indications are that if the modifications run into difficulties in integrating the codes and tracking down errors, they could end up consuming as much effort as developing a whole new system if the development were done efficiently and without many problems arising.

Personnel The personnel required to carry out the modifications or new system development would include both EPA and contractor staff. The magnitude of even the smallest effort indicates that EPA in-house staff would not be able to carry out these tasks without a significant readjustment in their current priorities. The staffing of the group to perform these tasks would depend on the path chosen. At a minimum, EPA would need to assign a project officer to monitor the work and to provide overall policy guidance. In addition, staff from several EPA divisions would have to participate in setting down specific needs and constraints that the system would have to meet. The project officer need not be intimately involved with systems development and would probably spend only 1/4 - 1/2 time on this program. The other EPA staff would be involved only intermimitently.

The contractor group would require a program manager to oversee the project and to coordinate the efforts of other personnel. An air quality analyst, either an engineer or a meteorologist, would be required to ensure that the proper analysis procedures are being used and that the system will provide the most useful outputs to the ultimate users. A senior systems programmer would be needed to lay the system out in the most efficient fashion from a computational standpoint. This is important in the design of a large and complex computer package that will be processing a significant amount of information.

It is possible that one individual can function in more than one of these roles. For example, the program manager and the air quality analyst could be the same individual and the senior programmer could do some of the basic coding and debugging. In any case, the two minimum skills required to effectively modify an existing system or develop a new system would be those of an experienced air quality analyst and a senior programmer.

For the purposes of this analysis it will be assumed that the contractor staff will be composed of the following personnel:

1 Program Manager/Air Quality Analyst - This individual will be responsible for coordinating the effort and for providing guidance on the air quality analysis procedures to be used. This person will be attached to the program on essentially a full-time basis.

1 Senior Programmer - This individual will have responsibility for the computational design and structure of the system. This person will also be assigned on a full time basis.

1-3 Junior Programmers - These people will have responsibility for the coding and debugging of various portions of the system. They will be assigned as needed.

There are obviously numerous perturbations to this scheme that could be considered. Nevertheless, this appears to be a reasonable structure possessing the necessary skills to do the job. The last requirement on the number of Junior Programmers is based on some practical considerations. The Senior Programmer should have at least one assistant, even in the shortest efforts, to avoid having to spend a great deal of time on simple coding and debugging. This assistance can be used to shorten the time required to get the system operational. The upper limit of three is based on the maximum number of people that could effectively contribute to the program without creating undue confusion and problems of coordination. System development or modification could probably not be broken into more than three discrete pieces and still have the end product remain a coherent whole. If this maximum group of five staff could not perform the required tasks in the desired time it will be assumed that the time frame will be extended rather than add additional staff.

With regard to the four existing systems, the AQUIP, CAASE, and ESAQ packages were developed by private contractors who could conceivably put together the appropriate technical staff to carry out the modifications without much difficulty. The MWCOG system was developed by a regional planning agency for its own needs and it is not clear that there would be any interest there in diverting resources away from their prime mission (i.e., planning for the Metropolitan Washington area) into the activity required for a major modification of the system. If the decision was made to use that system as the basis for CEPA, it might be necessary to bring in another contractor to assist in the work.

Time. The effort required for either modification of an existing system or development of a new system has already been shown to be substantial. Although all of the effort estimates are shown in person-months, there is a limit to how much time savings can be achieved by increasing the staffing.

For the smallest effort (i.e., modifying the ESAQ system) it appears reasonable to assume that the basic tasks will take at least 9 months to complete. A shorter period would probably not be reasonable in light of the fact that about 3 person-years of work are required to make the necessary changes. At the upper end of the spectrum, the development of an entirely new CEPA system that runs into significant difficulties could easily consume in excess of two years to complete. As an upper limit of time it will be assumed that a maximum of 24 months will be allowed for new CEPA system development.

It is evident from the Phase I feasibility study that time is a critical element in making the CEPA system a useful tool for on-going air quality analyses. On this basis, a decision to proceed with a modification of an existing system or a new system development would probably be made with the intent of keeping the developmental period as short as possible.

Costs. With the effort, skill, and time figures given above, it is now possible to estimate the cost of development of a CEPA system. For the purpose of this computation the following assumptions are made: (1) the contractor group will consist of one program manager/air quality analyst, one senior programmer, and one - three junior programmers, (2) in the interest of minimizing time for system development, three junior programmers will be used where needed, (3) development time will not be less than nine months nor greater than 24 months,

(4) the lower estimate on resource requirements will assume no major problems in programming, debugging, and testing the system while the upper estimate represents substantial difficulties and problems encountered.

Table 6-2 gives the cost figures to be used for each of the cost items to be considered. The personnel charges are averages taken from a review of a number of proposals submitted by contractors with skills similar to those required to do the CEPA development (no information from the four organizations with existing systems was used in developing these data). The monthly costs include all labor overhead and general administrative expenses.

The program manager is assumed to be a senior staff member of the organization but not a principal. The junior programmers are considered to be at a level higher than technicians. Secretarial time is computed on the basis of 1/5th of program manager and senior programmer time. Travel expenses are computed on the basis of program manager time only. Graphics and printing is a one time charge. Computer use is assumed to be at the rate of seven hours per month for each junior programmer. Finally, a 12% profit is added to the total cost.

Table 6-3 summarizes the resource requirements for each of the four modifications and for new system development. It is evident that any approach taken will involve the commitment of a significant amount of resources. The least cost option is the modification of the ESAQ system, which is expected given the evaluations of its performance as compared to CEPA requirements. The most expensive option is the development of an entirely new CEPA system, which is more than twice as costly as the ESAQ modification. The modifications to AQUIP, CAASE, and MWCOG are roughly comparable and are about 30-60% more expensive than the ESAQ modification.

All of the options can be completed within the established maximum of 24 months. For the new system development, however, encountering significant problems could extend the time for completion to 30 months.

One very important observation must be made from the data on the table. With the exception of the ESAQ modification, the upper estimates for modifying existing systems comes very close to the lower estimate of developing a new system. This same point was made with respect to the technical effort estimates on Table 6-1. The indication is that an attempt to modify an existing system that runs into substantial problems could conceivably end up costing as much as

Table 6-2 Summary of Staff Costs

Personnel	Charge
Program Manager/Air Quality Analyst	\$5000/month[a]
Senior Programmer	\$3900/month[a]
Junior Programmer	\$3100/month[a]
Secretary (Time computed as 1/5 of Program Manager and Senior Programmer time)	\$2500/month[a]
Materials and Services	
Travel (per person-year of program manager time)	\$1000
Graphics and Printing	\$1500
Computer (time computed as 7 hours per person-month of Junior Programmer time)	\$150/hour
Profit (computed on total cost)	12%

[a]Includes all overhead charges

Table 6-3. Summary of Resource Requirements

ITEM	AQUIP Modification		CAASE Modification		ESAQ Modification		MWCOG Modification		New CEPA Development	
	Effort (person-months)	Cost[a] (1000$)	Effort (person-months)	Cost[a] (1000$)	Effort (person-months)	Cost[a] (1000$)	Effort (person-months)	Cost[a] (1000$)	Effort (person-months)	Cost[a] (1000$)
Program Manager/Air Quality Analyst	10-17	50-85	12-18	60-90	9-12	45-60	10-16	50-80	17-30[b]	85-150
Senior Programmer	10-17	39-66	12-18	47-70	9-12	35-47	10-16	39-62	17-30[b]	66-117
Junior Programmers	31-51	96-158	36-53	112-164	18-37	56-115	31-47	96-146	53-89	164-275
Secretary	2.0-3.4	5.0-8.5	2.4-3.6	6.0-9.0	1.8-2.4	4.5-6.0	2.0-3.2	5.0-8.0	3.4-6.0	8.5-15.0
Travel		.8-1.4		1 -1.5		0.8-1.0		0.8-1.3		1.4-3.0
Graphics		1.5		1.5		1.5		1.5		1.5
Computer		33-54		38-56		19-39		33-49		56-93
TOTAL	53-88.4	225-374	62.4-92.6	265-392	37.8-63.4	162-269	53.0-82.2	224-348	90.4-155.0	383-656
TOTAL with 12% profit		$252-419		$296-439		$181-301		$252-390[c]		$429-735
Minimum Time for Completion		10 mons		12 mons		9 mons		10 mons		17 mons

[a]Cost figures may not add due to roundoff.

[b]Under the assumptions of effort, the 24-month maximum time for development may not be met if significant problems are encountered.

[c]Assuming private contractor called into assist.

a well-developed new system. It can reasonably be argued that a modification to an existing code is more prone to encounter problems since that code is being changed to do tasks that are outside its initial design considerations. The costs in this case are more likely to tend toward the higher side of the estimate. For a new system, substantial problems requiring significant effort to trace down are less likely to occur. The costs, therefore, will tend to the lower side of the estimate. This should be given careful consideration in the final decision on the best path to proceed.

Sensitivity Considerations. Given the range of estimates for CEPA development, it is important to consider the parameters of most significance in determining the total cost estimates.

Starting with the smaller items on Table 6-3, the travel and graphics charges are insignificant and make no impact on the relative merits of any option. The computer costs are significant but account for only 12-15% of the total cost. The assumed rate of computer useage of seven hours per month for each of the junior programmers would probably not vary by more than a factor of two and the assumed computer charge of $150 per hour might go as low as $100 per hour or as high as $300 per hour. Despite the fact that the computer cost could double or be halved, the resulting total cost would not change by more than about 15%. Thus the cost estimate is not especially sensitive to assumption about computer costs.

The effort component makes up about 85-90% of the total costs. The charge rates given on Table 6-2 were based on current figures quoted by contractors and as such, would not be expected to vary by more than 15-20%. Since the overall cost is almost directly related to the charge rates and since expected deviations from the assumptions used would not be more than 20%, it can be said that the charge rate assumptions are important but will not cause a change on the order of a factor of two in the total cost estimates.

The only other parameter that is of significance is the amount of effort required to carry out the tasks. These already have a factor of two variation in them and they strongly influence the total cost estimate. The distribution of effort among the skill types is not as important as the total effort since it would be difficult to conceive of a radically different project team (i.e. project manager, senior programmer, three junior programmers) that could accomplish the tasks in as efficient a manner. The total effort required is, therefore, the most sensitive variable in the estimate.

In reviewing the source of the effort estimates (task-by-task estimates in Appendices A-E) it must be emphasized that there is no way to precise in obtaining these data. They are based on considered judgement using past experience with computer system development. As such, they are open to question and revision.

6.2 SYSTEM INSTALLATION AND APPLICATION

After a CEPA system has been developed it will be important to provide the potential users (i.e., state and local agencies) with instructions in its use and with support to resolve any problems that might occur with its implementation. The question of what kind of savings can be expected from CEPA system use must also be addressed.

6.2.1 Training

One concept that has been successfully used in introducing a new computational system to potential users is that of periodic workshops. Users would be assembled for a one or two day session and given basic introductory information on system use and potential applications. The objective of the sessions would be to aid the users in getting started with the system and providing motivation for further study.

This procedure has been used extensively by computer manufacturers in getting people familiar with their hardware and software packages. Training sessions have been held by EPA on the use of the EIS/P&R system with a great deal of success. The number of these activities indicates that the process serves a useful function that cannot be met by providing users with written manuals only.

The cost of conducting such workshops should rightfully be considered as part of the overall CEPA costs. Table 6-4 summarizes the resources required to develop and conduct a series of such workshops. The first part of the table shows the cost of workshop development. It assumes that the same contractor who developed the CEPA system would also prepare the workshop materials. The instructional materials would include descriptions of the CEPA system, problems and test cases to be run for demonstration purposes, visual aids (e.g., slides,

Table 6-4 Resource Requirements for Training Workshops

	Effort (Person-Months)	Cost (1000$)
Workshop Development		
Period of Performance: 3 months		
Contractor Requirements:		
Program Manager/Air Quality Analyst	3	15,000
Senior Programmer	3	11,700
Secretary	1	2,500
Materials and Services		
Travel		300
Graphics and Printing		3,000
Computer		1,000
Total		29,900
Total with 12% Profit		$33,500
EPA Requirements:		
Project Officer -	1/2 time for 3 months	
Workshop Presentation		
Duration: 2 days		
Contractor Requirements:		
Program Manager/Air Quality Analyst	0.15	750
Senior Programmer	0.15	585
Materials and Services		
Travel		500
Computer		500
Total		2,335
Total with 12% Profit		$2,615
EPA Requirements:		
Project Officer to attend each workshop -	.15 person-months per workshop	

overheads), and the use of remote terminal demonstrations of CEPA capabilities. The workshop could be prepared in a three month period and would require about $33,500 of contractor assistance and about 1/2 time of an EPA project officer to monitor the work and arrange for the logistics of conducting the workshops themselves.

The second part of the table indicates the cost of presenting each workshop. It assumes a two-day session and would involve two staff from the contractor and the EPA project officer to attend. It could reasonably be expected that 5-10 of these workshops would be held around the country shortly after CEPA becomes available. Thereafter, additional workshops could be held every three-six months for new users. These follow-up sessions are necessary because the personnel turnover rate in control agencies requires that new staff be trained in the basic tasks that the agency performs.

6.2.2 System Support

In addition to the basic training program presented through the workshop program, it would be desirable to provide the users of the CEPA system with technical support and advice on any problems that arise with applications of the package. This activity serves two useful functions that will affect the ultimate success of the system. First, it provides users with expert capability to quickly resolve any problems that might otherwise discourage them from fully exploiting the capabilities of the system. Second, it provides a mechanism to identify and correct problems with the system that were not uncovered in development and only show up in the course of wide application. The issuance of updates and modifications will help keep the CEPA system viable.

Table 6-5 indicates the resource requirements for system support. It assumes that the contractor will provide staff to visit the state and local agencies that experience difficulties with the system and that these staff members will assist the agency to correct the problems. These staff will also prepare updates to the system reflecting deficiencies corrected and/or caution to be exercised when using the system for unusual applications. The EPA project officer will need to monitor the work and to arrange for publication of the updates.

Table 6-5 Resource Requirements for System Support

Contractor Requirements:	Effort (Person-Months/Year)	Cost ($/year)
Program Manager/Air Quality Analyst	2	10,000
Senior Programmer	3	11,700
Secretary	1	2,500
Materials and Services		
Travel		5,000
Computer		1,000
Total		30,200
Total with 12% Profit		$33,800 per year

EPA Requirements:

Project Officer - 1/4 time per year.

6.2.3 Potential System Use

Table 6-6 summarizes the resource requirements for making a CEPA system available to state and local control agencies. With this considerable resource investment it is imperative to ask what the potential savings might be to state and local control agencies that use a CEPA system instead of a manual procedure to do their air quality analyses.

To make this type of assessment it is necessary to specify the tasks in a typical air quality analysis and to identify those areas where the availability of a CEPA system would enable a savings in time and effort to be realized. Table 6-7 is a tabulation of those parts of an air quality analysis that relate to emission projections and allocations. Tasks involving dispersion modeling, processing of air quality and meteorological data, and the like are not included since, by definition, they are outside the scope of a CEPA system.

To make a meaningful comparison of the merits of a CEPA system vs. a manual calculation procedure it is necessary to have a basis for comparing the two methods. Given the wide variety of circumstances for which an air quality analysis must be performed, it appears reasonable to postulate three scenarios to which each method may be applied. These are:

1. Small data analysis - Under this scenario there are only a few point sources (less than about 50), a relatively small number of subareas and master grid cells (less than about 100), only one or two growth scenarios that will be evaluated, and only one or two control strategies to be considered.

2. Moderate data analysis - In this instance the number of sources would number 100-200, the number of subareas and grid cells would be in the range of 200-400, and about 4 or 5 growth scenarios and 5-10 control strategies would be evaluated.

3. Large data analysis - This situation would involve in excess of 400-500 sources, 800 or more subareas and master grid cells, more than 8-10 growth scenarios, and more than 15-20 control strategies.

Six people were asked to independently estimate the effort required on the part of a control agency doing each of the three types of analyses using a manual procedure and an automated CEPA system. Two of the six were EPA staff who have served as project officers on programs dealing with air quality analyses, three were Argonne staff, and one was a private contractor. These people

Table 6-6 CEPA System Cost Summary

<table>
<tr><th></th><th>AQUIP Modification</th><th>CAASE Modification</th><th>ESAQ Modification</th><th>MWCOG Modification</th><th>New System Development</th></tr>
<tr><td><u>System Development</u></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Time (months)</td><td>10-17</td><td>12-18</td><td>9-12</td><td>10-16</td><td>17-30</td></tr>
<tr><td>EPA Staff (person-months)</td><td>2.5-8.5</td><td>3.0-9.0</td><td>2.3-6.0</td><td>2.5-8.0</td><td>4.3-15</td></tr>
<tr><td>Contractor Funds (1000$)</td><td>252-419</td><td>296-439</td><td>181-301</td><td>252-390</td><td>429-735</td></tr>
<tr><td><u>Training Workshops</u>[a]</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Time (months)</td><td colspan="5">4</td></tr>
<tr><td>EPA Staff (person-months)</td><td colspan="5">2.7</td></tr>
<tr><td>Contractor Funds (1000$)</td><td colspan="5">54</td></tr>
<tr><td><u>Total Investment</u></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Time (months)</td><td>14-21</td><td>16-22</td><td>13-16</td><td>14-20</td><td>21-34</td></tr>
<tr><td>EPA Staff (person-months)</td><td>5.2-11.2</td><td>5.7-11.7</td><td>5.0-8.7</td><td>5.2-16.7</td><td>7.0-17.7</td></tr>
<tr><td>Contractor Funds (1000$)</td><td>306-473</td><td>350-493</td><td>235-355</td><td>306-444</td><td>483-789</td></tr>
<tr><td><u>System Support</u> (annual)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Time (months)</td><td colspan="5">12</td></tr>
<tr><td>EPA Staff (person-months)</td><td colspan="5">3</td></tr>
<tr><td>Contractor Funds (1000$)</td><td colspan="5">34</td></tr>
</table>

[a] Assumes three months of preparation and one month of presentations.

Table 6-7. Activities Required for Emission Projection and Allocation

1. Mount and operate system

   Obtaining copy of code.

   Loading on computer.

   Identifying computer bugs - i.e., incompatibilities between received version of code and computer installation.

   Resolving hardware and software problems.

   Testing of system with simple test cases.

2. Assemble basic data - all systems must have this step. It is almost independent of system used although the availability of a given type of system (e.g., CAASE) might require getting data that would ordinarily not be used (e.g., Census tapes).

3. Prepara data for analysis - some information must be processed manually; other may be processed by machine, either as part of a CEPA system or externally.

   Develop grid system.

   Select sources to be considered as points, areas, lines.

   Identify source characteristics needed - e.g., stack height, VMT on link, etc.

   Select calculation procedure to be used - Level 1, 2, 3, or Order 1, 2, 3.

   Determine variables needed - surrogate parameters, fuel characteristics, etc.

   Assemble or estimate needed variables.

4. Process data - perform the calculations with an eventual output of a point, area, and line source emission inventory suitable for use in a model.

   Identify and/or calculate activity parameters.

   Apply emission factors to activity parameters.

   Apply control efficiencies based on existing regulations, compliance information, etc.

   Allocate activity and emissions to grid cells.

   Review and correct anomalous data.

   Generate input file for dispersion model.

5. Assemble growth data - all systems must have this step. Again, depending on the system used, certain types of data would be used that would ordinarily not be.

6. Develop growth factors - using the assembled growth information, transform these into growth factors, specific levels of growth, etc. (This is not a growth analysis, but a conversion from the planning version of growth to the version that can be applied to the basic data set.)

7. Apply growth factors

   Apply the growth factors to the base data set.

   Determine growth at new, modified, existing sources.

   Distribute growth to known sites, projected growth sites.

   Apply emission factors representing NSPS, SIP and other regulations.

   Allocate activity and emissions to grid cells.

   Generate projected input file for dispersion model.

8. Assemble control strategy information - Parts of this step are common to all systems, but the availability of a CEPA system might encourage the use of more detailed information.

   Identify types of control strategies - emission limits, fuel controls, land use controls, traffic controls, etc.

   Determine control level (i.e., the controlled emission factor) - NSPS, LAFR, etc.

   Determine sources to be affected.

9. Apply control strategies

   Calculate controlled growth and development rate.

   Calculate controlled emission rates for affected sources.

   Distribute controlled activity and emissions to known sites, projected sites.

   Allocate activity and emissions to grid cells.

   Review and correct anomalous data.

   Generate controlled input file for dispersion model.

   Repeat for additional strategies based on modeling results.

were asked to estimate effort of a senior engineer, junior engineer, junior engineer/programmer, programmer, and data clerk(s) required to do each of the nine tasks on Table 6-7 in each of the three scenarios given above. The Phase I feasibility study indicated that some or all of these personnel types would be responsible in a control agency for doing the air quality analyses.

The effort estimated by each of the six people was converted to a cost estimate using a salary survey of air pollution control agencies plus an average 82% overhead charge. Table 6-8 gives the cost used for each of the skill categories. The cost difference between using the manual procedure and the CEPA system was then computed. The estimates varied widely, most probably because of differing interpretations on what constituted each of the nine tasks. For this reason, and because of the small sample size, it was decided to reject data that was more than one standard deviation from the mean of the six estimates and to recompute the mean on the basis of the remaining data. In virtually all cases this led to the rejection of only one or two very high or very low estimates, which would have reasonably been considered out of line. Table 6-9 summarizes the cost estimates and Table 6-10 shows the cost savings of the CEPA system. Figure 6.1 shows the range of estimates of the cost savings.

The data show that some of the tasks will result in a cost penalty if a CEPA system is used. The cost of mounting and operating the system is an obvious one, but some of the data collection tasks might also incur a cost penalty since additional information might have to be collected and coded into appropriate formats for CEPA use. The biggest cost savings are in the data processing, application of growth factors, and application of control strategies tasks. Overall, the use of a CEPA system is estimated to save the control agencies money under all three scenarios. In the case of the large data analysis the savings are in excess of $40,000 for each analysis done.

These cost savings results must be interpreted cautiously in light of the wide range of estimates shown in Figure 6.1. In all three scenarios it was estimated by at least two of the six people that the use of a CEPA system could actually cost more. This resulted from a change in the distribution of skills and not from increased total effort. CEPA would, as estimated by these people, require more skilled people and the time and effort savings would not be enough offset the higher charge rate.

Table 6-8. Control Agency Personnel Costs

Skill Classification	Cost[a] ($/person-months)
Senior Enginner	3185
Junior Engineer	2584
Junior Engineer/Programmer	2584
Programmer	1984
Data Clerk	1456

[a]Includes average salary plus 82% overhead charge for fringe benefits and administrative expenses.

Table 6-9. Cost of Emission Projection and Allocation

Task	Cost[a], $1000					
	Small Analysis		Moderate Analysis		Large Analysis	
	Manual	With CEPA	Manual	With CEPA	Manual	With CEPA
1. Mount and operate system	2.1	8.2	2.1	8.2	2.1	8.2
2. Assemble basic data	14.7	14.9	33.5	33.8	52.6	53.7
3. Prepare data for analysis	7.3	7.9	10.6	10.7	18.5	18.7
4. Process data	7.2	2.8	10.0	2.5	25.3	7.5
5. Assemble growth data	8.1	8.1	9.7	9.7	20.1	21.0
6. Develop growth factors	3.1	2.4	4.8	2.8	9.9	4.2
7. Apply growth factors	6.8	2.2	11.8	3.7	21.1	6.2
8. Assemble control strategy information	7.5	7.5	13.2	13.2	16.7	16.6
9. Apply control strategies	9.3	4.4	18.4	8.4	28.8	14.9
TOTAL	66.1	58.4	114.1	93.0	195.1	151.0

[a]Computed as the mean of six estimates with data $>1\sigma$ discarded.

Table 6-10. Summary of CEPA Cost Savings

Task	Cost Savings[a,b] of CEPA System, 1000$		
	Small Analysis	Moderate Analysis	Large Analysis
1. Mount and operate system	-6.1	-6.1	-6.1
2. Assemble basic data	-0.2	-0.3	-1.2
3. Prepare data for analysis	-0.6	-0.1	-0.2
4. Process data	4.4	7.5	17.8
5. Assemble growth data	0.	0.	-0.9
6. Develop growth factors	0.7	2.0	5.7
7. Apply growth factors	4.6	8.1	14.9
8. Assemble control strategy information	0.	0.	0.1
9. Apply control strategies	4.9	10.0	13.9
TOTAL	7.7	21.0	44.0

[a]Negative numbers indicate use of CEPA would be more costly.

[b]Numbers may not add due to rounding.

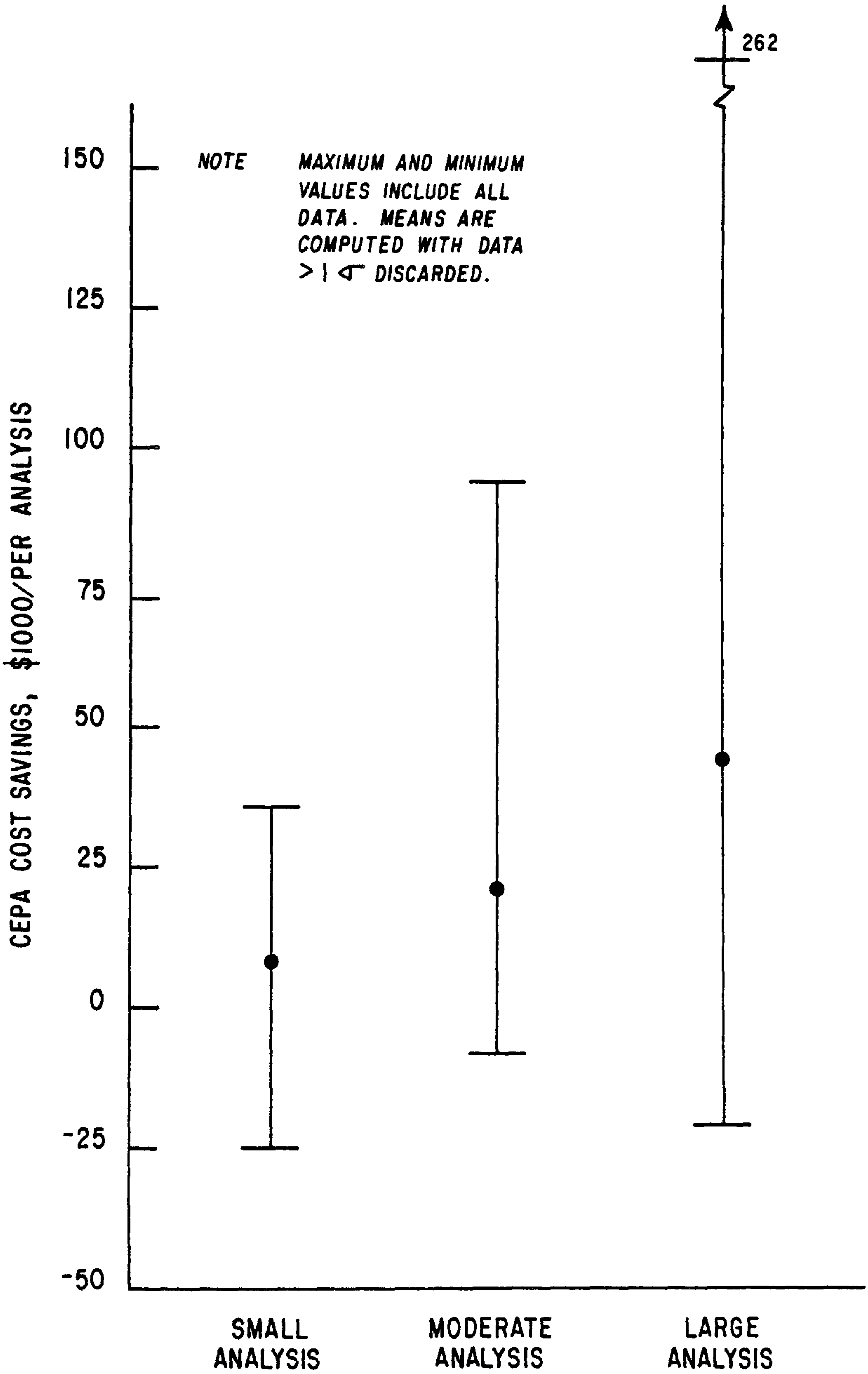

Fig. 6.1. Range of CEPA Cost Savings Estimates.

The final point of comparison is the question of whether these anticipated cost savings are sufficient to offset the investment required to make the CEPA system available. To make this assessment it would be necessary to project the extent of CEPA system use in air quality analyses. This is highly speculative in that it would require estimating the decisions that would be made on an agency by agency basis to use CEPA or a manual procedure. The indications from the Phase I study are that a CEPA system would at least be given consideration in many agencies (all agencies surveyed indicated they would consider it) and that it would be used in-house. Nevertheless, for the purposes of this study it will be more instructive to estimate how many applications the system would need to have in order for the investment costs to be recovered.

Figure 6.2 shows the total investment cost plotted against the number of analyses that the CEPA system would be required to be applied to in order to recover the cost. The three bounding lines correspond to the cost savings from Table 6-9 realized when doing small, moderate, and large analyses. The horizontal lines indicate the range of costs for the modification of the ESAQ, AQUIP, CAASE, and MWCOG systems and for new system development.

Using the moderate analysis line as an average indicator, it can be seen that the investment in modifying ESAQ could be recovered if the system were used on 10-15 applications. In the worst case of maximum cost to develop a new system, the investment would be recovered in about 38 moderate applications. These values appear entirely reasonable when it is considered that there are 161 designated Air Quality Maintenance Areas all of which will have to have some analysis done on them. When the number of potential other applications of CEPA, as outlined in Section 2, is considered it appears reasonable to expect that the investment in CEPA could be recovered through the cost savings to the states. The potential for cost savings in large analyses lends further weight to this conclusion. Considering the highest investment cost, a use in only 18 applications would still recover the investment.

For small analyses, the lower limit for investment recovery is about 30 applications; the upper limit is about 102. Although this is still less than the total number of AQMAs needing analysis it may represent an unreasonably high expectation for system use. It appears that the cost savings must be accrued through some combination of small, moderate, and large analyses.

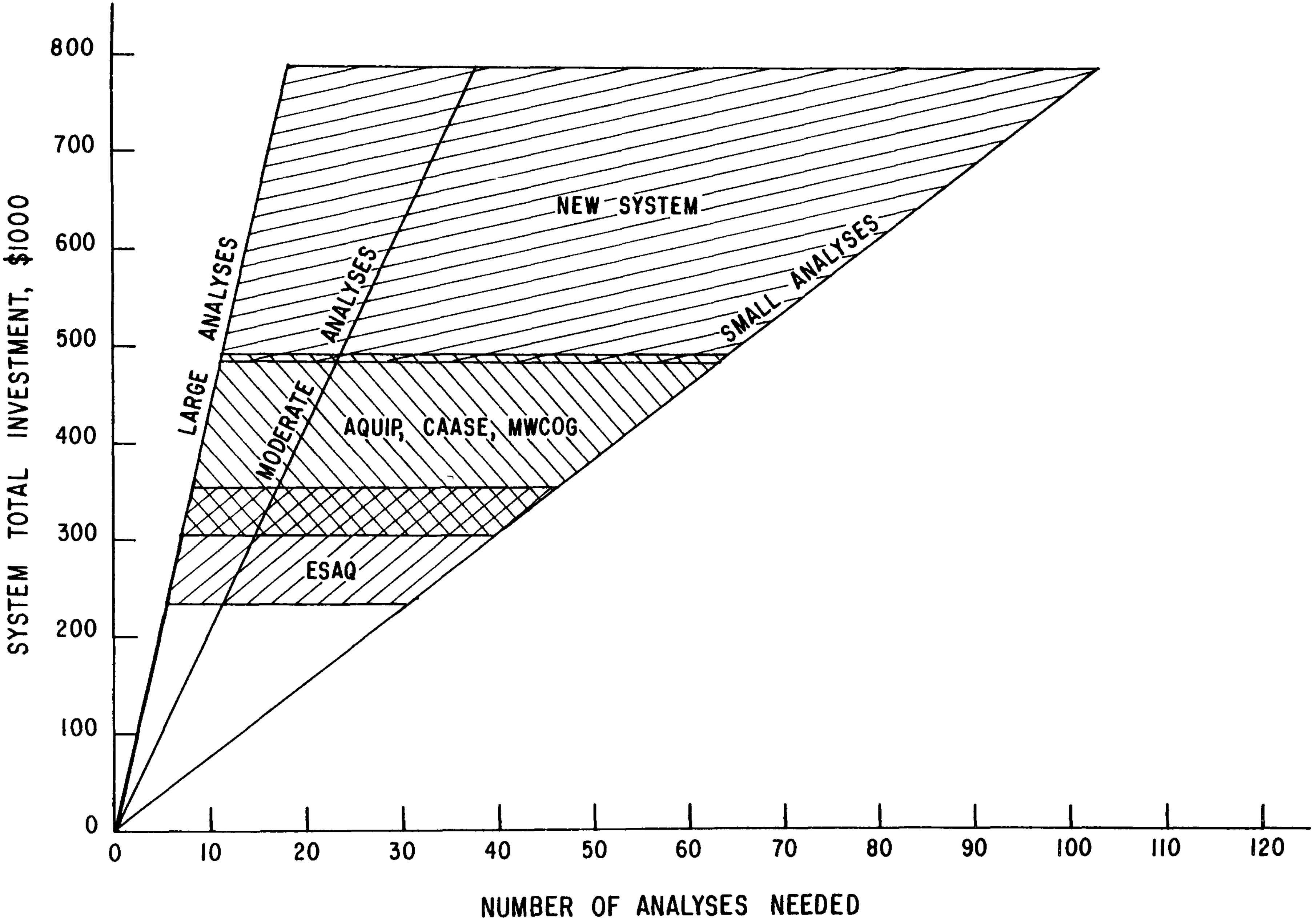

Fig. 6.2. Analyses Required to Recover Investment

For the annual cost of system support ($34,000 from Table 6-6) only 1-4 analyses per year would be needed to recover that investment. It appears that this would be easily attainable.

7 CONCLUSIONS AND RECOMMENDATIONS

This Phase II feasibility study on the development of a computerized emission projection and allocation system has focused on an evaluation of existing computer systems in an attempt to determine if any of them could be used to satisfy the CEPA requirements. The evaluation methodology consisted of (1) the definition of the CEPA requirements in general, without reference to any existing system, (3) the comparison of each existing system to those requirements, (3) an identification of deficiencies in existing systems, (4) an estimation of the effort and cost required to remove those deficiences, (5) an estimation of the effort and cost of developing an entirely new CEPA system, and (6) an estimation of the expected cost savings that would be realized through use of a CEPA system. The results of applying this methodology are given in this section.

7.1 SYSTEM EVALUATION

Four existing computer systems were evaluated as part of this study along with an evaluation of the development of a new CEPA system.

7.1.1 AQUIP

The AQUIP system does not now satisfy many of the CEPA requirements. It was designed primarily as a tool to evaluate land use plans and, as such, it has an orientation that does not cover all of the aspects of an air quality analysis that would be required of CEPA.

The principal component of AQUIP that is of interest is the LANTRAN routine. This program provides a method of mapping arbitrarily shaped areas into a rectangular grid. Apart from any application as part of a CEPA system, this routine has value in and of itself. This mapping process can be extremely tedious and prone to error if done manually. LANTRAN has the potential for providing the air quality analyst with an easier way of carrying this out.

The primary weaknesses in the AQUIP system are its treatment of point sources, which are handled as input with little opportunity for processing new information, and its land use orientation. The latter problem makes it difficult to treat non-land-use-related problems, which constitute the majority of air quality analysis situations being dealt with today.

The cost of modifying the AQUIP system to meet CEPA requirements was estimated to be between $306,000 - $473,000. Considering the extent of the changes necessary, it is quite possible that the modification could encounter substantial difficulties and the overall cost could approach that of developing an entirely new CEPA system. On this basis it is recommended that AQUIP not be considered as the foundation of the CEPA system. However, some consideration may be given to improving the documentation on the LANTRAN routine and providing it to the states as an analytical tool to assist in the gridding process.

7.1.2 CAASE

The CAASE program also does not now satisfy many of the CEPA requirements. It was designed to perform the specific task of developing a master grid based on population distribution and mapping countywide area source data into these grids. As such, it serves a valuable function and experience shows that some states are attempting to take advantage of its capability.

The principal deficiences of CAASE with regard to CEPA requirements are its lack of treatment of point sources and its focus on the Level 1 and 2 types of analyses in distributing emissions. Its strong points are the ability to handle Bureau of the Census information and the capacity to generate a master grid network.

The cost of modifying CAASE to meet CEPA requirements was estimated to be $350,000 - $493,000. As with the AQUIP system, the upper end of this estimate approaches the cost of developing an entirely new system. This, combined with the fact that the bulk of the CAASE system centers around developing the master grid, which is only peripheral to the CEPA requirements, leads to the recommendation that CAASE not be considered as the basis for a CEPA system. CAASE appears to have benefits by itself that do not entirely overlap CEPA requirements and there is little need to force-fit it into CEPA needs.

7.1.3 ESAQ

The ESAQ system comes the closest to meeting the CEPA requirements. It is built around the EIS/P&R system and can perform many of the CEPA tasks. It was originally designed to handle a general air quality analysis and so does not suffer from the limited objectives of AQUIP and CAASE.

The principal deficiencies of the ESAQ system are in two areas. First, there is no formal documentation available. The remarks made about the system must be qualified by this consideration. The system has never been used outside of Engineering-Science and must, therefore, be considered as an in-house program that is not generally available. Although this is not a serious problem to resolve, it does cast a measure of uncertainty on the potential utility of the system.

Second, the system treats growth and control strategies through the use of the in-line COBOL retrieval portion of the EIS/P&R system. While the use of the COBOL retrieval program is desireable from a data handling perspective, it may become cumbersome in the application of complex growth and control strategy scenarios. What would be more desireable is to couple the retrieval code with a user-oriented growth and control strategy package. This would greatly enhance the potential for system use.

The cost of modifying ESAQ to meet all the CEPA requirements was estimated to be $235,000-355,000. This is the lowest cost of all the options considered. Reviewing the areas on which the effort would be spent indicates that many of the tasks are related to CEPA requirements that may not be absolutely essential. A reduction of these cost estimates may be achieved through a scaling down of CEPA requirements.

On this basis it is recommended that the ESAQ system be given serious consideration as the basic component of a CEPA system.

7.1.4 MWCOG

The MWCOG system is actually a set of individual programs, each of which generates a data set that is input to another program. The principal advantage of the system is its relative simplicity and ease of operation. There is little reason to suspect that most of the control agencies would have difficulty using it.

This ease of use, however, has also lead to the biggest deficiency of the system. The program makes several simplifying assumptions in the course of the analysis. These assumptions are well within the requirements of EPA guidelines but the resulting computer codes do not allow the user to do a more sophisticated analysis. Also the system does not treat point sources with any detail.

It was estimated that $306,000-$444,000 would be required to modify the MWCOG system to bring it up to CEPA requirements. As with AQUIP and CAASE, the upper limit is about equal to that required to develop an entirely new system. It is, therefore, recommended that the MWCOG system not be used as the foundation for CEPA.

7.1.5 New CEPA System

The development of an entirely new CEPA system was the most expensive option of the five considered. It could cost from $483,000-$789,000. The lower end of this cost is about the same as that required to do major modifications on AQUIP, CAASE, or MWCOG.

In the light of the fact that the ESAQ system already meets most of the CEPA requirements, it is recommended that the development of an entirely new CEPA system not be considered as it would be duplicating existing capability. However, should the ESAQ system be ruled as inappropriate either through the discovery of system problems through documentation and field use or through the consideration of its general unavailability, then the development of a new CEPA system would be the only reasonable choice to provide the states with the desired analytical tools. As with ESAQ, a reduction in the CEPA requirements might also be used to cut the overall cost of system development.

7.2 SYSTEM USE

For the sake of determining the extent to which a CEPA system would have to be used to recover the investment of making the system available, the cost savings of using a CEPA were estimated. These estimates can also be used to evaluate the option of not pursuing the development of any CEPA system.

The estimates of cost savings varied widely and it must be emphasized that these are estimates. There is little hard data that can be used to firmly determine the time and money to be saved in using a CEPA system as compared to a manual procedure. Nevertheless, the assessments do indicate that the potential for cost savings is significant, ranging from over $7000 per study for small analyses to $44,000 per study for large analyses. At this rate it appears that even the highest cost investment in a CEPA system (i.e., development of an entirely new system that runs into significant problems and overruns) has a reasonable chance of being recovered through savings in state and local control agency use.

It can reasonably be argued that the indications of savings, although admittedly of a high-risk nature, are significant enough to warrant consideration of making some type of CEPA system available to the states. The savings in cost to the states might, in reality, be a savings in cost to EPA because of the extensive Federal support given to air quality analyses. The benefits that may be accrued in improving the quality of the analyses are not included in this assessment.

7.3 ALTERNATIVE COURSES OF ACTION

The development of a CEPA system will involve the commitment of a significant level of resources both in time, effort, and money. The nature of the information presented here indicates that this is a high-risk situation in which the actual effort required to do the job may vary considerably (nominally by a factor of two in all cases) and the actual savings to be realized are based on considered judgements rather than hard data. Nevertheless, there are indications of considerable savings in making a CEPA system, in some form, available. The following options are presented as alternatives for consideration along with the authors' recommendations on each.

7.3.1 No Further Action

This option would cease any further consideration of developing a CEPA system and would rely on the states and their contractors to make their own provisions. This is not recommended because of the potential for savings and because the Phase I feasibility study indicated that the states would, in fact, consider using a federally-developed system.

7.3.2 Modify AQUIP, CAASE, or MWCOG

This option is not recommended because of the aforementioned consideration that problems may be encountered that will drive the cost to that of new system development. Also, these systems serve purposes unique to their specific design and need not become part of a CEPA system to see further use.

7.3.3 Initiate New System Development

This option is not recommended at this time because of the potentially high cost involved and because of the availability of an existing system that meets many CEPA requirements. This option may be the recommended course of action at a later date.

7.3.4 Modify ESAQ

This option would involve the initiation of ESAQ modifications to meet all of the CEPA requirements. This option is not recommended at this time because of the uncertainty of the availability and ease of use of ESAQ (i.e., resulting from the lack of documentation). It is the authors' feeling that, although the system looks extremely promising, these are too many unknowns to commit a significant amount of resources to system development. This option may become the recommended course of action at some later date.

7.3.5 Proceed with Stepwise Modification of ESAQ

This option would proceed to modify the ESAQ system in a stepwise fashion with decision points at various milestones to determine if the system use justifies continuing further. Based on the review of the system in Section 5 it is felt that the system has a sufficient amount of capability in its current form to warrant issuance of it for general use by the states. The first step in this option would, therefore, be to prepare adequate documentation for it to be used by a control agency. This step could also include the funding of several test applications of the system on various types of air quality analyses. These applications would be carried out by control agency staff.

The second step would be to develop growth and control strategy routines. As these routines will interact with the EIS/P&R system, their development could be considered as part of an EIS/P&R update and could be initiated before the first step is completed. Subsequent steps would add successively more of the CEPA requirements to the system as need demands.

This option is recommended since it allows significant decision points to be incorporated into system development and also makes a useful tool available to the states in the shortest time period. The incremental improvement of the system should not be anymore costly than the modifications made all at once because of the modular nature of the system.

7.4 SUMMARY

The results of this Phase II feasibility study has made some very distinct points. The development of a CEPA system will be expensive. There are no low cost options apart from discarding some of the requirements. The potential cost savings also appear to be substantial, but this is based on estimates of effort and is not easily substantiated by actual data. The resulting decision on how to proceed from this point must be made with careful consideration of all the possible outcomes. For this reason it is recommended that CEPA system development proceed in a stepwise fashion with adequate decision points built into the process.

APPENDIX A

Detailed Evaluation of the AQUIP System

The tables included in this Appendix compare the AQUIP system with the CEPA requirements described in Sections 2 and 3. The evaluation is based on whether the system will do the required calculation. If it does not, the significance of the lack of this capability is given along with the changes that would be necessary to enable the system to perform as desired. An estimate of the effort, in man-months (mm), of making the modification is also given. If the system does the required calculation, the reasonability of the data requirements and the accuracy of the calculation are evaluated. Finally, any extra features of the system are identified.

Table A-1. Computation Comparison for Residential Fuel Combustion Sources - AQUIP

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update						
A. Fuel Use Input (Level 1, 2)	No	Would be difficult for an agency seeking to do a simplified analysis.	Modification of code to accept data on a wide area (e.g., county) and distribute it to "figures" 2-4 mm			
1. Input state/county fuel consumption in residential sector						
2. Distribute fuel to county/subarea by surrogate variable (e.g., d.u., population) distribution						
3. Extract point sources						
4. Go to C.						
B. Surrogate Variable Input (Level 3)						
1. Input state, county, subarea, surrogate variable (e.g., population, d.u., floor area, land use)	Yes. Uses du/acre only as surrogate			Keyed almost exclusively to data obtained from a land use plan. Difficult to use other types of data.	Basically the same as Level 3.	
2. Input fuel consumption factors	Yes. Factors based on Btu/d.u.-hr. Seasonally variable.			Yes.	More detailed since factors vary by season.	
3. Compute subarea fuel use	Yes. Need to know residential acreage.			Yes. Linked to land use plan as above but program computes area of "figures"	Same as Level 3.	
4. Extract point sources	No. Must start with separate point and area source totals.	A small inconvenience. User must manually separate point and area source totals.	Modification of code to scan point source inventory to determine if any large sources need to be extracted from area source totals 1-2 mm			
5. Go to C.						
C. Emission Computation and Mapping						
1. Map fuel consumption to master grids	Yes.			Yes. Must specify "figures" and master grid	Probably much less prone to error than manual system.	Can deal with arbitrary and changing subareas easily. Very desirable.
2. Apply emission factors	Yes			Yes.	Standard procedure.	
3. Generate output in model-compatable form	Yes, but for MARTIK model only. Slight change for use with other models.			Yes.	Standard.	

Table A-1. Computation Comparison for Residential Fuel Combustion Sources - AQUIP (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
II. Growth Analysis						
A. Input Growth Data						
1. % growth or actual values	Yes.			Yes. Input new actual values.	Standard	
2. Future fuel mix	Yes.			Yes. Input future fuel mix.	Standard	
B. Apply Growth Factors	No. Must input new actual values.	Inconvenience to user who must generate new growth values by hand. May limit the number of growth scenarios that can be considered.	Modification of code and input data set to permit growth factor to be applied to base data. 2-4 mm			
III. Strategy Analysis						
A. Emission Limits						
1. Change emission factors	Yes.			Yes, but must change input data set.	Standard	
B. Fuel Controls						
1. Change fuel mix	Yes.			Yes, but must change input data set.	Standard.	
2. Change fuel characteristics	Yes.			Yes, but must change input data set.	Standard	
C. Growth and Development Plans						
1. Change surrogate variable distribution	Yes.			Can change population densities and dwelling unit densities. Again keyed almost exclusively to a land use plan.	Basically the same as Level 3.	

Table A-2. Computation Comparison for Commercial/Institutional and Industrial Sources - AQUIP

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update						
A. Fuel Use Input (Level 1, 2)	No	Would be difficult for an agency seeking to do a simplified analysis.	Modification of code to accept data on a wide area (e.g., county), separate residential and commercial/institutional/industrial, and distribute to figures. 1-2 mm			
1. Input state/county fuel consumption in comm/inst/indus sector						
2. Distribute fuel to county/subarea by surrogate variable (e.g., employment, land area) distribution for C/I, I sector						
3. Extract point sources						
4. Go to C.						
B. Surrogate Variable Input (Level 3)						
1. Input state, county, subarea surrogate variable (e.g., population, d.u. floor area, land use)	Yes. Uses % sq. ft., and % coverage, pupils/class.			Keys almost exclusively to data obtained from a land use plan. Difficult to use other types of data.	Basically the same as Level 3.	
2. Input fuel consumption factors	Yes. Factors based on Btu/sq.ft-hr, Btu/classroom. Seasonally variable.			Some area and classroom fuel requirements may be difficult to obtain.	More detailed since factors vary by season.	
3. Compute subarea fuel use	Yes. Need to know total sq. footage, coverage, number of classrooms.			Yes. Linked to land use plan as above but program computes area of "figures"	Same as Level 3.	
4. Extract point sources	No. Must start with separate point and area source totals.	An inconvenience. User must manually separate point and area source totals. May be a significant effort for industrial sources.	Modification of code to scan point source inventory to determine if any large sources need to be extracted from area source totals. 1-2 mm			
C. Emission Computation and Mapping						
1. Map fuel consumption to master grids	Yes.			Yes. Must specify "figures" and master grid.	Probably much less prone to error than manual system.	Can deal with arbitrary and changing subareas easily. Very desirable
2. Apply emission factors	Yes.			Yes.	Standard procedure.	
3. Generate output in model-compatable form	Yes, but for MARTIK model only. Slight change for use with other models.			Yes.	Standard.	

Table A-2. Computation Comparison for Commercial/Institutional and Industrial Sources - AQUIP (Contd.)

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
II. Growth Analysis						
A. Input Growth Data						
1. % growth or actual values	Yes			Yes. Input new actual values.	Standard.	
2. Future fuel mix	Yes			Yes. Input new actual values.	Standard.	
B. Apply Growth Factors	No. Must input new actual values.	Inconvenience to user who must generate new growth values by hand. May limit the number of growth scenarios that can be considered.	Modification of code and input data set to permit growth factor to be applied to base data.			
III. Strategy Analysis						
A. Emission Limits						
1. Change emission factors.	Yes.			Yes, but must change input data set.	Standard.	
B. Fuel Controls						
1. Change fuel mix	Yes			Yes, but must change input data set.	Standard.	
2. Change fuel characteristics.	Yes.			Yes, but must change input data set.	Standard.	
C. Growth and Development Plans						
1. Change surrogate variable distribution	Yes			Can change population densities, % sq. ft., % coverage, pupils/classroom. Again, keyed almost exclusively to a land use plan.	Basically the same as Level 3.	

Table A-3. Computation Comparison for Electric Generation and Internal Combustion Sources - AQUIP

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Electric Generation						
I. Treat power plants similar to industrial process sources.	Yes.			See comments on Industrial Process sources.	See comments on Industrial Process sources.	
II. Project electrical demand and load factors.	No.	Does not give the user information on electrical requirements.	Modification to code to determine electrical demand from surrogate variable (e.g., population) 2-3 mm			
Internal Combustion						
I. Treat similar to industrial process sources	Yes.			See comments on Industrial Process sources.	See comments on Industrial Process sources.	

Table A-4. Computation Comparison for Industrial Process Sources - AQUIP

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. <u>Emission Update</u>						
A. Receive emission inventory input.						
1. NEDS	No. Cannot read NEDS point source data.	Problem for user who must convert his input into NEDS format.	Straight-forward pre-processor to convert format or modification of code input requirements. ½-1 mm			
2. Other systems.	Yes. Point sources input in generalized form.			Yes.	Standard	
B. Retrieve and summarize inventory data.	No.	Major inconvenience.	Write entirely separate data manipulation routines or tie in with existing system (e.g., EIS/P&R). 2-3 mm			
C. Modify inventory with source specific data.	No. Must input entire data file.	Major inconvenience.	Same comment as B.			
D. Perform internal consistency checks.	No.	Inconvenience to user who must check data separately.	Same comment as B.			
E. Generate output in model-compatable form.						
1. Point sources	Yes, but for MARTIK model only. Slight change for use with other models.			Yes.	Standard	
2. Area sources	Same comment as 1.			Yes.	Standard	
II. <u>Growth Analysis</u>						
A. Input source specific information.	Yes			Yes, but must input entire new data set.	Standard	
B. Apply generalized growth factors.	No.	Inconvenience to user who must generate new growth manually. May limit the number of growth scenarios considered.	Modification of code and input data set to permit growth factor to be applied to base data. (Same as residential and commercial/institutional).			

Table A-4. Computation Comparison for Industrial Process Sources - AQUIP (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
C. Disaggregate growth to existing, new, and unknown sources.	No.	Significant inconvenience to user who must make this disaggregation manually. Could present major problems for large inventories.	Write new code to make this disaggregation. 2-3 mm			
D. Allocate growth at unknown sources by surrogate parameter.	No. Allocation must be defined off-line and input. Several modes are available.	Inconvenience to user who must do the allocation manually.	Some modification of code. ½-1 mm			Several methods of allocation are available.
III. Strategy Analysis						
A. Apply emission limits.	Yes.			Yes, but must change emission factors on input stream.	Standard	
B. Apply growth and development controls.	Yes.			Yes, but must change input data set.	Standard	
C. Apply land use controls.	Yes.			Yes. Closely tied to land use plans.	Better than other procedures because of direct connection to land use plans.	

Table A-5. Computation Comparison for Transportation Sources - AQUIP

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Highway Vehicles						
I. Emission Update						
A. Fuel Consumption Input (Level 1)	No	Some inconvenience to an agency seeking to do a simplified analysis although this procedure is not used very frequently.	Modification of code to accept data on a wide area (e.g., county) and distribute to "figures". (Similar to residential sources.) 1-2 mm			
1. Input state/county fuel sold.						
2. Estimate VMT.						
3. Distribute VMT to subareas by surrogate variable (e.g., population)						
4. Go to C.						
B. Specific Data Input (Level 2, 3)						
1. Input VMT, vehicle type distribution, speed, etc. data.						
a. Link	Yes			Yes. Inputs major highway links and traffic volume.	Standard.	
b. Traffic zone	Yes			Yes, although required input of vehicle density in zones may make it difficult to use other types of data.	Vehicle density approach may not be as accurate as direct zone VMT estimates.	
2. Go to C.						
C. Emission Computation and Mapping						
1. Map traffic data to master grid and/or links.	Yes			Yes. Must specify "figures", links and master grid.	Probably much less prone to error than manual system.	Can deal with arbitrary and changing subareas easily. Very desireable.
2. Apply emission factors.	Yes			Yes. Uses standard emission factors.	Standard.	
3. Generate output in model-compatable form.						
a. Line sources	No	Line source format is not generated but data is available in code.	Minor change to output format. ½-1 mm			
b. Area sources	Yes, but for MARTIK model only. Slight change for use with other models.			Yes.	Standard.	

Table A-5. Computation Comparison for Transportation Sources - AQUIP (Contd.)

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
II. Growth Analysis						
A. Input new highway construction data.	Yes.			Yes. Must input as part of a new data set.	Standard.	
B. Input generalized growth projections.	No. Must input entirely new data set.	Inconvenience to user who must develop VMT due to growth externally. May limit the number of growth scenarios considered.	Modification of code and input data set to allow growth factors to be applied to base data sets. (Similar to residential sources.) 2-3 mm			
III. Strategy Analysis						
A. Apply emission limits.	Yes			Yes, but must change input data set.	Standard.	
B. Apply traffic controls.	Yes.			Yes, but must change input data set.	Simulation of traffic controls is not very detailed because of data formats in vehicle density terms.	
C. Apply growth and development controls.	Yes.			Yes, but must input entirely new data set representing controls.	Standard.	Can simulate land use changes very easily.
Other Vehicles						
I. Activity Parameter Input						
A. Input vehicle activity.	Yes			Yes, but may need to tie input data to land use through some density function.	Some loss of detail because of land use tie.	
B. Apply emission factors.	Yes.			Yes.	Standard.	
II. Emission Input						
A. Input emissions directly.	Yes.			Some careful manipulation of input data is required to have the code treat the data as emissions and not activity.	Standard.	
Gasoline Handling Evaporation Losses						
I. Gasoline Marketed Input						
A. Input gasoline sold.	Yes.			Yes.	Standard.	
B. Apply emission factors.	Yes.			Yes, but requires some manipulation of input data.	Standard.	
II. Surrogate Variable Input						
A. Input per capita gasoline consumption rate.	Yes.			Yes.	Standard.	
B. Compute gasoline marketed.	Yes.			Yes.	Standard.	
C. Apply emission factors.	Yes.			Yes.	Standard.	

Table A-6. Computation Comparison for Solid Waste Disposal Sources - AQUIP

Calculation	Does the system do the calculation?	No		Yes		Extra Features
		Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	
I. Emission Update						
A. Surrogate Variable Input (Level 1,2)						
1. Input surrogate variable to be used.	Yes.			Yes. Uses standard input to LANTRAN routine.	Standard.	
2. Input solid waste generation factors.	Yes.			Yes.	Standard.	
3. Input disposal technique distribution.	Yes.			Yes, but must treat each disposal technique as a separate variable.	Standard.	
4. Compute solid waste generation and disposal technique in subareas.	Yes.			Yes.	Yes.	
5. Extract point sources.	No, must start with separate point and area source totals.	A small inconvenience. User must manually separate point and area sources.	Modification of code to scan point source inventory to determine if any large point sources need to be extracted from area source totals. (Similar to residential sources). ½-1 mm			
6. Go to C.						
B. Solid Waste Data Input (Level 3)	No.	Inconvenience to user. May not be many users who exercise this option except for point source municipal incinerators.	Modification of code. 2-3 mm			
1. Input solid waste generation and disposal data from local sources.						
2. Extract point sources.						
3. Go to C.						
C. Emission Computation and Mapping						
1. Map solid waste generation and disposal technique to master grids.	Yes.			Yes. Must specify "figures" and master grid.	Probably much less prone to error than manual method.	Can deal with arbitrary and changing subareas easily. Very desireable.
2. Apply emission factors.	Yes.			Yes.	Standard.	
3. Generate output in model-compatable form.	Yes, but for MARTIK model only. Slight change for use with other models.			Yes.	Standard.	

Table A-6. Computation Comparison for Solid Waste Disposal Sources - AQUIP (Contd.)

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
II. Growth Analysis						
A. Input Growth Data						
1. Surrogate variable projections.	Yes.			Yes. Input new actual values.	Standard.	
2. Solid waste generation rates.	Yes.			Yes. Input new generation rates.	Standard.	
3. Accept local solid waste projections.	No.	Same comment as I, B above.	Same modification as I, B.			
4. Disposal techniques.	Yes.			Yes, but must treat each disposal technique as a separate variable.	Standard.	
III. Strategy Analysis						
A. Emission limits.	Yes.			Yes, but must change input data set.	Standard.	
B. Growth and development controls.	Yes.			Yes, but must change input data set.	Standard.	
C. Disposal restriction.	Yes.			Yes, but must make the distribution to new disposal processes prior to input.	Standard.	

Table A-7. Computation Comparison for Miscellaneous Sources - AQUIP

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Solvent Evaporation						
I. Emission Update						
A. Direct Data Input						
1. Input actual solvent use.	No.	Would prevent use of actual data.	Modification of code to accept this data. 1-2 mm			
B. Surrogate Data Input						
1. Input solvent consumption factors	Yes.			Yes. Standard input.	Standard.	
C. Emission Computation and Mapping						
1. Map solvent use to master grids.	Yes.			Yes. Must specify "figures" and master grid.	Probably much less prone to error than manual system.	
2. Apply emission factors.	Yes.			Yes. Standard procedure.	Standard.	
3. Generate output in model-compatable form.	Yes, but for MARTIK model only. Slight change for use with other models.			Yes.		
II. Growth Analysis						
A. Apply growth factors.	No.	User must apply growth factors externally. May limit the number of growth scenarios considered.	Modification of code (similar to residential sources).			
III. Strategy Analysis						
A. Emission limits.	Yes.			Yes, but must change input data set.	Standard.	
B. Solvent use restrictions.	Yes.			Yes, but must specify this through input data set.	Standard.	
C. Growth and development controls.	Yes.			Yes, but must change input data set.	Standard.	
Fires						
I. Input basic activity factor.	Yes.			Yes, can use standard information.	Standard.	
II. Input allocation parameter.	No.	Must distribute to the "figures" manually.	Modification to code. Similar to residential sources, Fuel Use Input.			

Table A-7. Computation Comparison for Miscellaneous Sources - AQUIP (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
III. Apply emission factor.	Yes.			Yes.	Standard.	
<u>Fugitive Dust</u>						
I. Input basic activity factor.	Yes.			Yes. Can use standard information.	Standard.	
II. Input allocation parameter.	No.	Must distribute to "figures" manually.	Modification to code. Similar to residential sources, Fuel Use Input.			
III. Apply emission factor.	Yes.			Yes. Can use standard information.	Standard.	
IV. Apply Control Strategy.	Yes.			Yes, but must change input data set.	Standard.	
<u>Other Sources</u>						
I. Generalized Format	Yes.			Depends on the source. Keyed heavily to land use information.	Standard.	
II. Emission Input	Yes.			Yes, but must manipulate the input data carefully.	Standard.	

Table A-8. Computation Comparison for Gridding - AQUIP

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
A. Map from subarea to master grid using previously determined fractions.	No. Computes the mapping fractions on every run.	No inconvenience to user but results in extra machine time if the "figures" and grids do not change from one run to another.	Modification of code to store mapping fractions from one run to another. May not be a simple task. 2-4 mm			One of the biggest benefits of LANTRAN is the ability to deal with arbitrary land use configurations.
B. Map several subareas to master grid.	Yes.			Yes, but must be done with care.	Probably less prone to error than manual system.	
C. Map process activity instead of emissions.	No. Converts activity to emissions on "figures" and then maps emissions on to grid.	Can generate problems of irrelevant distribution of activity (see Sec. 2.6)	Significant rewrite of code to map the activity first. 3-5 mm			
D. Map into changing master grid.	Yes.			Yes. Easy to do since grid is input on each run. Grid flexibility is one of the strongest points of model.	Probably less prone to error than manual system.	

Table A-9. Computation Comparison for Growth - AQUIP

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
I. Determine growth from specific data.	Yes.			Yes, but must input an entirely new set of data for each run.	Standard.	
II. Determine growth from generalized growth factors.	No.	Inconvenience to user who must apply growth factors externally. May limit the number of growth scenarios considered.	Modification of code. Discussed under source categories.			
III. Link growth between activities.						
A. Provide linkages	Yes.			Yes. Can do with user-generated subroutines.	As accurate as user provides in new subroutines.	
B. Provide output for data consistency checks.	No.	Does not supply user with interpretive information.	Major change to code to identify growth in the data set rather than as a separate input on each run. 3-5 mm			
IV. Process more than one growth scenario per run.	No. Each scenario is treated separately.	Requires user to run each scenario separately.	Small change to code to begin reading new data input. < 1 mm			
V. Provide summary tables of emission and activity growth.	No. Result of treatment of growth separately.	Does not supply user with interpretive information.	Same as III, B above.			

Table A-10. Computation Comparison for Control Strategies - AQUIP

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
I. Separate control strategy routine.	No.	Inconvenience to user who must identify controls on each source in the input stream separately. May limit the number of strategies considered.	Major rework of the code to have input control strategies applied to input data set. 3-5 mm			
II. Process more than one control strategy per computer run.	No.	Requires user to run each control strategy separately.	Small change to code to begin reading new data set. < 1 mm			
III. Apply regulations only to affected sources.	Yes.			Yes, but must input entire data set reflecting control.	Standard.	
IV. Provide summary tables for regulation evaluation.	No.	Does not provide user with interpretive information.	Major change to code to identify base case and regulated case. 3-5 mm			

Table A-11. Evaluation of Computer Requirements - AQUIP

Requirement	Does the System Meet the requirement?	No: Significance of the Lack	No: Modifications Necessary	Extra Features
I. Computer System				
A. UNIVAC 1110	No.	Cannot be run on EPA facility.	Must be converted to UNIVAC form. 1-2 mm	
B. IBM	Yes. Was developed on IBM OS facilities.			
II. Programming Language				
A. FORTRAN and/or COBOL	Yes.			
B. ANSI standard	Unknown.			
III. Mode of Operation				
A. Batch and interactive	Yes.			
B. Interactive only.	No. There is no interactive component.			
IV. Program Structure				
A. Modular	Yes, but major component of interest to CEPA (LANTRAN) is a single routine.			Has option to call user-prepared subroutine.
B. Complete or single module run capability.	Yes.			
V. Off-Line Storage				
A. Permanent-tape, cards.	Yes.			
B. Transient - tape, disk, data cell, drum.	Yes.			
VI. Input Format				
A. NEDS compatible.	No. Must input point and area sources in specified form.	Cannot use NEDS data directly.	Must prepare a preprocessing routine to convert NEDS format to AQUIP format.	
B. EIS/P&R compatible.	No.	Does not allow user to take advantage of EIS/P&R features.	Rewrite input format to accept EIS/P&R information. 2-3 mm	
C. Census tapes.	No. Does not handle census at all.	Census information must be processed manually.	Major new code to process census data. 3-4 mm	

Table A-11. Evaluation of Computer Requirements - AQUIP (Contd.)

Requirement	Does the System Meet the requirement?	No		Extra Features
		Significance of the Lack	Modifications Necessary	
VII. Output Format				
A. Models	Compatible with MARTIK model only.	Cannot use other models directly.	Relatively small change to output. 1-3 mm	
1. AQDM				
2. CDM				
3. IPP				
4. VALLEY				
B. Isopleth programs	Yes. Available for a variety of plotting uses.			
C. Hard copy by area or subarea.	Yes.			
VII. Documentation				
A. User's guide	Yes, but is difficult to interpret.			
B. Programmer's manual	No.	Difficult to make programming changes.	Manual must be prepared. 2-4 mm	
IX. Portability				
A. Easily transferable.	Uncertain. Has not been widely used.			
B. Transferred by cards, tape (binary or source form batch process).	Yes. Cards and tape.			
X. Compatibility				
A. AEROS	No. Does not have proper documentation.	Cannot be supported by AEROS system.	Documentation must be prepared. 4-6 mm	

APPENDIX B

Detailed Evaluation of the CAASE System

The tables included in this Appendix compare the CAASE System with the CEPA requirements described in Sections 2 and 3. The evaluation is based on whether the system will do the required calculation. If it does not, the significance of the lack of this capability is given along with the changes that would be necessary to enable the system to perform as desired. An estimate of the effort, in man-months (mm), of making the modification is also given. If the system does the required calculation, the reasonability of the data requirements and the accuracy of the calculation are evaluated. Finally, any extra features of the system are identified.

Table B-1. Computation Comparison for Residential Fuel Combustion Sources - CAASE

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update						
A. Fuel Use Input (Level 1, 2)						
1. Input state/county fuel consumption in residential sector.	Yes.			Yes. Takes countywide input from NEDS.	Standard.	
2. Distribute fuel to county/subarea by surrogate variable (e.g., d.u., population) distribution.	Yes. Does this simultaneously with step C.1. (CAASE 4 & 5)			Yes	Allocation much less prone to error than manual method but must start with countywide data. Cannot start with more detailed information.	
3. Extract point sources	No. Must start with area source totals.	A small inconvenience. User must manually separate point and area source totals.	Major new coding effort. Program does not treat point sources at all. (See Industrial Process sources.)			
4. Go to C.						
B. Surrogate Variable Input (Level 3)	No. There is no provision for inputing any surrogate variables and making emission calculations.	Significant. Does not allow user to make use of more detailed data.	Moderate modifications and new coding. Must write new emission computation subroutines. 3-4 mm			
1. Input state, county, subarea surrogate variable (e.g., population, d.u., floor area, land use)						
2. Input fuel consumption factors						
3. Compute subarea fuel use						
4. Extract point sources						
5. Go to C.						
C. Emission Computation and Mapping						
1. Map fuel consumption to master grids	Yes. Does this simultaneously with step A.2.			Yes.	Much less prone to error than manual system.	
2. Apply emission factors	Yes			Yes.	Standard.	
3. Generate output in model-compatable form.	Yes. In IPP format.			Yes.	Standard.	
II. Growth Analysis						
A. Input Growth Data						
1. % growth or actual values	Yes.			Yes. Must input new actual values in NEDS format.	Standard.	

Table B-1. Computation Comparison for Residential Fuel Combustion Sources - CAASE (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
2. Future fuel mix	Yes.			Yes. Must input new fuel mix in NEDS format.	Standard.	
B. Apply Growth Factors	No. Must input new actual values.	Inconvenience to user. Must do growth projections manually. May limit the number of growth scenarios considered.	Modification of code and input data set to apply growth factors to base data. 2-4 mm			
III. Strategy Analysis						
A. Emission Limits						
1. Change emission factors	Yes.			Yes. Must change DATA statements in code.	Somewhat prone to error since appropriate factor to change must be located.	
B. Fuel Controls						
1. Change fuel mix	Yes.			Yes. Must change input data set.	Standard.	
2. Change fuel characteristics.	Yes			Yes. Must change input data set.	Standard.	
C. Growth and Development Controls						
1. Change surrogate variable distribution	No, since there is not provision for surrogate variable manipulation.	User must determine effect of controls externally. May limit the number of controls considered.	Modification of code to handle surrogate variables. Similar to modifications needed in steps I, B and II, B above. 1-2 mm			

Table B-2. Computation Comparison for Commercial/Institutional and Industrial Fuel Combustion Sources - CAASE

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
I. Emission Update						
A. Fuel Use Input (Level 1, 2)						
1. Input state/county fuel consumption in comm/inst/indus sector	Yes			Yes. Takes countywide input from NEDS.	Standard	
2. Distribute fuel to county/subarea by surrogate variable (e.g., employment, land area) distribution for comm/inst/indus sector.	Yes. Does this simultaneously with step C.1. (CAASE 4 & 5).			Yes. Uses surrogate of population only.	Not as good as other possible variables (e.g. employment, land use).	
3. Extract point sources	No. Must start with area source totals.	A small inconvenience. User must manually separate point and area source totals.	Major new coding effort. Program does not treat point sources at all. (See Industrial Process sources).			
4. Go to C.						
B. Surrogate Variable Input (Level 3)	No. There is no provision for imputing any surrogate variables and computing emissions.	Significant. Does not allow user to make use of more detailed data.	Moderate modifications and new coding. (Similar to residential sources). 1-2 mm			
1. Input state, county, subarea surrogate variable (e.g., population, d.u., floor area, land use)						
2. Input fuel consumption factors						
3. Compute subarea fuel use						
4. Extract point sources						
5. Go to C.						
C. Emission Computation and Mapping						
1. Map fuel consumption to master grids	Yes. Does this simultaneously with step A.2.			Yes	Much less prone to error than manual system.	
2. Apply emission factors	Yes			Yes	Standard.	
3. Generate output in model-compatable form	Yes. In IPP format.			Yes	Standard.	
II. Growth Analysis						
A. Input Growth Data						
1. % growth or actual values	Yes			Yes. Must input new actual values in NEDS format.	Standard.	
2. Future fuel mix	Yes			Yes. Must input new fuel mix in NEDS format.	Standard.	

Table B-2. Computation Comparison for Commercial/Institutional and Industrial Fuel Combustion Sources - CAASE (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
B. Apply Growth Factors	No. Must input new actual values.	Inconvenience to user Must do growth projections manually. May limit the number of growth scenarios considered.	Modification of code and input data set to apply growth factors to basic data. (Similar to residential sources). 1-2mm.			
III. Strategy Analysis						
A. Emission Limits						
1. Change emission factors	Yes			Yes. Must change DATA statements in code.	Somewhat prone to error since appropriate factor to change must be located	
B. Fuel Controls						
1. Change fuel mix	Yes			Yes. Must change input data set	Standard	
2. Change fuel characteristics	Yes			Yes. Must change input data set.	Standard	
C. Growth and Development Plans						
1. Change surrogate variable distribution	No, since there is no provision for surrogate variable manipulation.	User must determine effect of controls externally. May limit the number of controls considered.	Modification of code to handle surrogate variables. Similar to modifications needed in steps I, B and II, B above. 1-2 mm.			

Table B-3. Computation Comparison for Electric Generation and Internal Combustion Sources - CAASE

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Electric Generation						
I. Treat power plants similar to industrial process sources.	No.	See comments on Industrial Process Sources.				
II. Project electrical demand and load factors.	No.	Does not give the user information on electrical requirements.	Major modification of code to handle surrogate variables and point sources (see Residential and Industrial Process) and determine electrical demand. 2-3 mm			
Internal Combustion						
I. Treat similar to industrial process sources	No.	See comments on Industrial Process Sources.				

Table B-4. Computation Comparison for Industrial Process Sources - CAASE

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update						
A. Receive emission inventory input.	No.	CAASE was never designed to handle point sources. It is strictly an area source computation procedure. Modification for it to handle point sources would be equivalent to writing an entirely new code in the form of a new CEPA system.	8-10 mm			
1. NEDS						
2. Other Systems						
B. Retrieve and summarize inventory data.						
C. Modify inventory with source specific data.						
D. Perform internal consistency checks.						
E. Generate output in model-compatable form.						
1. Point sources.						
2. Area sources						
II. Growth Analysis						
A. Input source specific growth information.						
B. Apply generalized growth factors.						
C. Disaggregate growth to existing, new, and unknown sources.						
D. Allocate growth at unknown sources by surrogate parameter.						
III. Strategy Analysis						
A. Apply emission limits.						
B. Apply growth and development controls.						
C. Apply land use controls.						

Table B-5. Computation Comparison for Transportation Sources - CAASE

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Highway Vehicles						
I. Emission Update						
A. Fuel Consumption Input (Level)						
1. Input state/county fuel sold.	Yes.			Yes. Takes county-wide input from NEDS.	Standard.	
2. Estimate VMT.	Yes.			Yes. Takes county-wide input from NEDS.	Standard.	
3. Distribute VMT to subareas by surrogate variable (e.g., population).	Yes. Does this simultaneously with Step C.1.			Yes. Uses surrogate of population or population density.	Standard at this level of analysis.	
4. Go to C.						
B. Specific Data Input (Level 2,3)						
1. Input VMT, vehicle type distribution, speed, etc. data.	No.	Significant lack. Precludes the use of local VMT data.	Significant new code development to handle other than countywide data. 4-6 mm			
a. Link						
b. Traffic zone						
2. Go to C.						
C. Emission Computation and Mapping						
1. Map traffic data to master grid and/or links.	Yes. Does this simultaneously with Step A.3.			Yes.	Standard.	
2. Apply emission factors.	Yes.			Yes.	Standard.	
3. Generate output in model-compatible form.						
a. Line sources	No. Does not treat line sources at all.	Cannot run certain models (e.g. HIWAY).	Significant new code development in connection with I.B.			
b. Area sources	Yes. In IPP format.			Yes.	Standard.	
II. Growth Analysis						
A. Input new highway construction data.	Yes, but can only deal with county totals.			Yes. Must input new county total VMT.	Loss of spatial resolution of new facilities.	
B. Input generalized growth projections.	No.	Inconvenience to user. Must do the growth projection externally. May limit the number of growth scenarios considered.	Modification of code and input variables to apply growth factors to base data set. (Similar to residential sources), - 2 mm			

Table B-5. Computation Comparison for Transportation Sources - CAASE (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
III. Strategy Analysis						
A. Apply emission limits.	Yes.			Yes. Must change DATA statements in code.	Standard.	
B. Apply traffic controls.	No. Not sensitive to these controls since data is on county level.	Eliminates a significant class of control strategies that could be considered.	Major rework of code to handle other than countywide data. (Similar to I,B,1) 2-3 mm			
C. Apply growth and development controls	Yes.			Yes. Must input new data set in NEDS format.	Standard.	
OTHER VEHICLES						
I. Activity Parameter Input						
A. Input vehicle activity.	Yes.			Yes. Input data in NEDS format.	Standard.	
B. Apply emission factors.	Yes.			Yes.	Standard.	
II. Emission Input						
A. Input emissions directly.	No.	User cannot do a refined calculation and input the results. Eliminates special cases.	Modification of code to handle a direct emissions input. 2-3 mm			
GASOLINE HANDLING EVAPORATION LOSSES						
I. Gasoline Marketed Input						
A. Input gasoline sold.	Yes.			Yes. Input countywide data in NEDS format.	Standard.	
B. Apply emission factors.	Yes.			Yes.	Standard.	
II. Surrogate Variable Input						
A. Input per capita gasoline consumption rate.	No.	Inconvenience to user.	Minor modification since population is already treated. 1 mm			
B. Compute gasoline marketed.	No.	Inconvenience to user.	Same as above.			
C. Apply emission factors.	Yes.			Yes.	Standard.	

Table B-6. Computation for Solid Waste Disposal Sources - CAASE

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update						
A. Surrogate Variable Input (Level 1,2)						
1. Input surrogate variable to be used.	No. There is no provision for inputting any surrogate variables and making emission calculations.	Significant. Does not allow user to make use of different estimating procedures.	Moderate modifications and new coding. (Similar to residential sources.) 1-2 mm			
2. Input solid waste generation factors.						
3. Input disposal technique distribution.						
4. Compute solid waste generated and disposal technique in subareas.						
5. Extract point sources.						
6. Go to C.						
B. Solid Waste Data Input (Level 3)						
1. Input solid waste generation and disposal data from local sources.	Yes.			Yes. Extracts data from NEDS.	Standard.	
2. Extract point sources.	No. Must start with area source totals.	Major new coding effort. Program does not treat point sources at all. (See Industrial Process Sources.)				
3. Go to C.						
C. Emission Computation and Mapping						
1. Map solid waste generation and disposal technique to master grids.	Yes. Does this simultaneously with Step B.1.			Yes.	Much less prone to error than manual system.	
2. Apply emission factors.	Yes.			Yes.	Standard.	
3. Generate output in model-compatible form.	Yes. In IPP, AQDM format.			Yes.	Standard.	
II. Growth Analysis						
A. Input Growth Data						
1. Surrogate variable projections.	No. Must input new actual values.	Inconvenience to user. Must do growth projections manually. May limit the number of growth scenarios considered.	Modification of code to accept surrogate variables and apply growth factors. 2-4 mm			

Table B-6. Computation for Solid Waste Disposal Emissions - CAASE (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
2. Solid waste generation rates.	No.	Modification of code in conjunction with II,A,1 above.				
3. Accept local solid waste projections.	Yes.			Yes. Must input new actual data in NEDS format.	Standard.	
4. Disposal techniques.	Yes.			Yes. Each technique must be identified in NEDS format.	Standard.	
III. <u>Strategy Analysis</u>						
A. Emission limits.	Yes.			Yes. Must change DATA statements in code.	Somewhat prone to error since appropriate factor to change must be located.	
B. Growth and development controls.	Yes.			Yes. Must change input data set.	Standard.	
C. Disposal restrictions.	Yes.			Yes. Must change input data set.	Standard.	

Table B-7. Computation Comparison for Miscellaneous Sources - CAASE

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Solvent Evaporation						
I. Emission Update						
A. Direct Data Input						
1. Input actual solvent use.	Yes.			Yes. Standard NEDS format.	Standard.	
B. Surrogate Data Input						
1. Input solvent consumption factors.	No.	Inconvenience to user. Inability to manipulate this type of data.	Modification of code and input data. 1-2 mm			
C. Emission Computation and Mapping.						
1. Map solvent use to master grids.	Yes.			Yes.	Probably much less prone to error than manual system.	
2. Apply emission factors.	Yes.			Yes. Standard procedure.	Standard.	
3. Generate output in model-compatible form.	Yes for IPP, AQDM models. Slight change for use with other models.			Yes.	Standard.	
II. Growth Analysis						
A. Apply growth factors.	No.	User must apply growth factors externally. May limit the number of growth scenarios considered.	Modification of code. (Similar to residential sources.)			
III. Strategy Analysis						
A. / Emission limits.	Yes.			Yes, but must change factors in DATA statement.	May be prone to some error since appropriate data to change must be located.	
B. Solvent use restrictions.	Yes			Yes, but must specify this through input data set.	Standard.	
C. Growth and development controls.	Yes			Yes, but must change input data set.	Standard.	

Table B-7. Computation Comparison for Miscellaneous Sources - CAASE (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
<u>Fires</u>						
I. Input basic activity factor.	Yes.			Yes. Can use standard NEDS information.	Standard.	
II. Input allocation parameter.	Yes.			Yes. Can use standard allocation parameters or input an overriding parameter.	Standard.	
III. Appy emission factor.	Yes.			Yes.	Standard.	
<u>Fugitive Dust</u>						
I. Input basic activity factor.	Yes.			Yes. Can use standard NEDS information.	Standard.	
II. Input allocation parameter.	Yes.			Yes. Can use standard allocation parameters or input an overriding parameter.	Standard.	
III. Apply emission factor.	Yes.			Yes. Can use standard information.	Standard.	
IV. Apply control strategy.	Yes.			Yes, but must change input data set.	Standard.	
<u>Other Sources</u>						
I. Generalized format.	No. Uses NEDS format only.	Inconvenient to user.	Minor modification of code to accept additional input.			
II. Emission input.	No. Uses NEDS format only.	Inconvenient to user.	Minor modification as above.			

Table B-8. Computation Comparison for Gridding - CAASE

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
A. Map from subarea to master grid using previously determined fractions.	Yes.			Yes. Uses geocoded census data from standard tapes.	Much less prone to error than manual system.	Helps develop the master grid based on population density. A powerful feature but somewhat external to CEPA.
B. Map several subareas to master grid.	No. Uses census data only.	Significant. Limits the user to one data source.	Major new coding effort to treat other data sources. Equivalent to writing new package. 2-3 mm			
C. Map process activity instead of emissions.	Yes.			Yes.	Standard.	
D. Map into changing master grid.	No. Uses one master grid based on population density.	Limits the user to one grid system. Cannot use any other than population oriented grid.	Major new coding effort. 3-4 mm			

Table B-9. Computation Comparison for Growth - CAASE

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Determine growth from specific data.	Yes.			Yes. Must input entire new data set.	Standard.	
II. Determine growth from generalized growth factors.	No.	Inconvenience to user. Must do growth projections manually. May limit the number of growth scenarios considered.	Modification of code and input. (See Residential sources.)			
III. Link growth between activities						
A. Provide linkages.	No. Data input in NEDS format only.	Inconvenience to user. Must make the linkages manually.	Modification of input format and coding. 2-3 mm			
B. Provide output for data consistency checks.	No.	Inconvenience to user.	Modification of code to treat baseline and growth data and print changes. 3-4 mm			
IV. Process more than one growth scenario per run.	No.	Inconvenience to user.	Minor modification of code to read in successive data sets. 1 mm			
V. Provide summary tables of emission and activity growth	No.	Inconvenience to user.	Modification of code. Related to III,B above. 1-2 mm			

Table B-10. Computation Comparison for Control Strategies - CAASE

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I Separate control strategy routine.	No.	Inconvenience to user. Must apply strategies separately.	Modification to code to change input data reflecting control. 3-4 mm			
II. Process more than one control strategy per computer run.	No.	Inconvenience to user.	Minor modification to code to read in successive data sets. 1 mm			
III. Apply regulations only to affected sources.	Yes.			Yes. Done by inputting entire data set.	Standard.	
IV. Provide summary tables for regulation evaluation.	No.	Inconvenient to user. Does not supply interpretive information.	Modification to code to treat regulated and unregulated data sets. 2-3 mm			

Table B-11. Evaluation of Computer Requirements - CAASE

Requirement	Does the System Meet the requirement?	No: Significance of the Lack	No: Modifications Necessary	Extra Features
I. Computer System				
A. UNIVAC 1110	No.		Is currently undergoing modifications for use on UNIVAC 1110.	
B. IBM	Yes. Was developed on IBM OS System.			
II. Programming Language				
A. FORTRAN and/or COBOL	Yes.			
B. ANSI standard	Yes.			
III. Mode of Operation				
A. Batch and interactive.	Yes.			
B. Interactive only.	No. There is no interactive component.			
IV. Program Structure				
A. Modular	Yes, but output of some modules have relevance to other modules only.			
B. Complete or single module run capability	No. Must run in 5 steps. (See Growth)	Not significant for CAASE 1-3 since these are generally run only once. An inconvenience to user for CAASE 4 and 5.	Major effort for CAASE 1 - 3 since an intermediate step of hand-plotted grids is necessary. Minor coding change, or JCL change, for CAASE 4 and 5. Currently under extensive modification to eliminate hand-plotted grids.	

Table B-11. Evaluation of Computer Requirements - CAASE (Contd.)

Requirement	Does the System Meet the requirement?	No		Extra Features
		Significance of the Lack	Modifications Necessary	
V. Office Storage				
A. Permanent - tape, cards.	Yes. Everything is tape.			
B. Transient - tape, disk, data cell, drum.	Yes. Everything is tape.			
VI. Input Format				
A. NEDS compatible.	Yes. Takes input from NEDS.			
B. EIS/P&R compatible.	No.	Does not allow user to take advantage of EIS/P&R capabilities.	Moderate effort to change input format to accept EIS/P&R information. 2-3 mm	
C. Census tapes.	Yes. Takes input from Census tapes.			Significant capability to process Census tapes.
VII. Output Format				
A. Models				
1. AQDM	Yes.			
2. CDM	Yes.			
3. IPP	Yes.			
4. VALLEY	Yes.			
B. Isopleth programs	No.	Does not allow user to map emission densities.	Relatively minor modification to add standard plotting package. 1 mm	
C. Hard copy by area or subarea	Yes. Whole area comes out broken down by grid.			

Table B-11. Evaluation of Computer Requirements - CAASE (Contd.)

Requirement	Does the System Meet the requirement?	No: Significance of the Lack	No: Modifications Necessary·	Extra Features
VIII. Documentation				
A. User's guide	Yes. New one being prepared.			
B. Programmer's manual	Yes. Only in Air Quality Maintenance Guideline (Vol. 8).			
IX. Portability				
A. Easily transferable	Yes, but some plotting CALLS are specific to University of N.C. (system developer), and not easy to get.		Is being changed to identify IBM plotting packages.	
B. Transferred by cards, tape (binary or source form, batch process).	Yes. Cards and tape.			
X. Compatibility				
A. AEROS	No. Does not have proper documentation.	Cannot be supported by AEROS system.	Documentation must be prepared. 4-6 mm	

APPENDIX C

Detailed Evaluation of the ESAQ System

The tables included in this Appendix compare the ESAQ system with the CEPA requirements described in Sections 2 and 3. The evaluation is based on whether the system will do the required calculation. If it does not, the significance of the lack of this capability is given along with the changes that would be necessary to enable the system to perform as desired. An estimate of the effort, in man-months (mm), of making the modification is also given. If the system does the required calculation, the reasonability of the data requirements and the accuracy of the calculation are evaluated. Finally, any extra features of the system are identified.

Table C-1. Computation Comparison for Residential Fuel Combustion Sources - ESAQ

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update						
A. Fuel Use Input (Level 1,2)						
1. Input state/county fuel consumption in residential sector.	Yes.			Yes. Input in NEDS format.	Standard.	
2. Distribute fuel to county/subarea by surrogate variable (e.g., d.u, population) distribution.	Yes.			Yes. Can input allocation factors.	Standard.	
3. Extract point sources	No. Must start with area source totals.	A small inconvenience. User must manually separate point and area source totals.	Moderate coding effort to process point source data and retrieve fuel combustion. 1-2 mm			
4. Go to C.						
B. Surrogate Variable Input (Level 3)						
1. Input state, county, subarea surrogate variable (e.g., population, d.u., floor area, land use)	Yes.			Yes. Uses building size and fuel use distribution.	Standard.	
2. Input fuel consumption factors	Yes.			Yes. Uses standard factors of Btu/deg-day/housing unit.	Standard.	
3. Compute subarea fuel use.	Yes.			Yes.	Standard.	
4. Extract point sources	No.	Same as A.3 above.				
5. Go to C.						
C. Emission Computation and Mapping						
1. Map fuel consumption to master grids	Yes.			Yes. Must input portion of each subarea in grid.	Standard.	
2. Apply emission factors	Yes.			Yes.	Standard.	
3. Generate output in model-compatible form.	Yes. Currently set up for AQDM and HIWAY.					
II. Growth Analysis						
A. Input Growth Data						
1. % growth or actual values	Yes. Uses EIS/P&R in-line COBOL retrieval.			Yes, but must program (in COBOL) source category separately. Complex growth scenarios not easily handled.	Standard.	

Table C-1. Computation Comparison for Residential Fuel Combustion Sources - ESAQ (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
2. Future fuel mix	Yes. Uses EIS/P&R in-line COBOL retrieval.			Yes, but must program (in COBOL) each source category separately.	Standard.	
B. Apply Growth Factors	Yes. Uses EIS/P&R.			Yes, but must program each source separately.	Standard.	
III. Strategy Analysis						
A. Emission Limits						
1. Change emission factors	Yes. Uses EIS/P&R.			Yes.	Standard.	
B. Fuel Controls						
1. Change fuel mix	Yes. Uses EIS/P&R.			Yes.	Standard.	
2. Change fuel characteristics.	Yes. Uses EIS/P&R.			Yes.	Standard.	
C. Growth and Development Controls						
1. Change surrogate variable distribution.	Yes.			Yes, but must change input data set.	Standard.	

Table C-2. Computation Comparison for Commercial/Institutional and Industrial Fuel Combustion Sources - ESAQ

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update						
A. Fuel Use Input (Level 1, 2)						
1. Input state/county fuel consumption in comm/inst/indus sector.	Yes.			Yes. Input in NEDS format.	Standard.	
2. Distribute fuel to county/subarea by surrogate variable (e.g., employment, land area) distribution for comm/inst/indus sector.	Yes.			Yes. Can input allocation factors.	Standard.	
3. Extract point sources	No. Must start with area source totals.	A small inconvenience. User must manually separate point and area source totals.	Moderate coding effort to process point source data and retrieve fuel combustion. (Similar to residential sources.)			
4. Go to C.						
B. Surrogate Variable Input (Level 3)						
1. Input state, county, subarea surrogate variable (e.g., population, d.u. floor area, land use).	Yes.			Yes. Can use floor space or other parameter.	Standard.	
2. Input fuel consumption factors.	Yes.			Yes. Can input standard factors.	Standard.	
3. Compute subarea fuel use	Yes.			Yes.	Standard.	
4. Extract point sources.	No. See I.A.3 above.					
5. Go to C.						
C. Emission Computation and Mapping						
1. Map fuel consumption to master grids.	Yes.			Yes. Must input portion of each subarea in grid.	Standard.	
2. Apply emission factor	Yes.			Yes.	Standard.	
3. Generate output in model-compatible form.	Yes. Currently set up for AQDM and HIWAY.					
II. Growth Analysis						
A. Input Growth Data						
1. % growth or actual values	Yes. Uses EIS/P&R in-line COBOL retrieval.			Yes, but must program (in COBOL) each source category separately. Complex growth scenarios not easily handled.	Standard.	

Table C-2. Computation Comparison for Commercial/Institutional and Industrial Fuel Combustion Sources - ESAQ (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
2. Future fuel mix	Yes. Uses EIS/P&R in-line COBOL retrieval.			Yes, but must program (in COBOL) each source category separately.	Standard.	
B. Apply Growth Factors	Yes. Uses EIS/P&R.			Yes, but must program each source category separately.	Standard.	
III. Strategy Analysis						
A. Emission Limits						
1. Change emission factors	Yes. Uses EIS/P&R.			Yes.	Standard.	
B. Fuel Controls						
1. Change fuel mix	Yes. Uses EIS/P&R.			Yes.	Standard.	
2. Change fuel characteristics.	Yes. Uses EIS/P&R.			Yes.	Standard.	
C. Growth and Development Plans						
1. Change surrogate variable distribution	Yes.			Yes, but must change input data set.	Standard.	

Table C-3. Computation Comparison for Electric Generation and Internal Combustion Sources - ESAQ

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
<u>Electric Generation</u>						
I. Treat power plants similar to industrial process sources.	Yes.			See comments on Industrial Process sources.		
II. Project electrical demand and load factors.	No.	Does not give user information on electrical requirements.	Modification to code to determine electrical demand from surrogate variable (e.g. population) 2-3 mm			
<u>Internal Combustion</u>						
I. Treat similar to industrial process sources	Yes.			See comments on Industrial Process sources.		

Table C-4. Computation Comparison for Industrial Process Sources - ESAQ

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. <u>Emission Update</u>						
A. Receive emission inventory input.						
1. NEDS	Yes			Yes	Standard	
2. Other Systems	Yes. EIS/P&R			Yes	Standard	
B. Retrieve and summarize	Yes. Uses full EIS/P&R			Yes	Standard	
C. Modify inventory with source specific data.	Yes. Uses EIS/P&R file management.			Yes	Standard	
D. Perform internal consistency checks.	Yes. Uses EIS/P&R checks			Yes	Standard	
E. Generate output in model-compatible form.						
1. Point sources.	Yes. Set up for AQDM.			Yes	Standard	
2. Area sources	Yes. Set up for AQDM			Yes	Standard	
II. <u>Growth Analysis</u>						
A. Input source specific growth information.	Yes. Uses EIS/P&R file management.			Yes	Standard	
B. Apply generalized growth factors.	Yes. Uses EIS/P&R in-line COBOL retrieval.			Yes, but must program (in COBOL) each source category separately.	Standard	
C. Disaggregate growth to existing, new, and unknown sources.	No.	Significant inconvenience to user who must make disaggregation manually. Could present major problems for large inventory.	Write new code to make this disaggregation. 2-3mm			
D. Allocate growth at unknown sources by surrogate parameter.	No. Allocation must be defined off-line and input.	Inconvenience to user who must do the allocation manually.	Some modification of code. 1 mm			

Table C-4. Computation Comparison for Industrial Process Sources - ESAQ (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
III. Strategy Analysis						
A. Apply emission limits.	Yes. Uses EIS/P&R			Yes	Standard	
B. Apply growth and development controls	Yes. Uses EIS/P&R			Yes, but must program (in COBOL) each source category separately. Complex controls may be difficult to model.	Standard	
C. Apply land use controls.	No. Has no routine to interface with a land use plan.	User cannot simulate a land use control directly.	Write new code. 2-3mm			

Table C-5. Computation Comparison for Transportation Sources - ESAQ

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Highway Vehicles						
I. Emission Update						
A. Fuel Consumption Input (Level 1)						
1. Input state/county fuel sold.	Yes.			Yes.	Standard. Level 1 analysis.	
2. Estimate VMT.	No.		Minor coding change.			
3. Distribute VMT to subareas by surrogate variable. (e.g. population)	Yes. Allocation parameters are input.			Yes.	Standard.	
4. Go to C.						
B. Specific Data Input (Level 2,3)						
1. Input VMT, vehicle type distribution, speed, etc., data.						
a. Link	Yes.			Yes, although system is currently tied to TRIMS traffic model. Some generalization may be necessary.	Not as good resolution on vehicle speed and class distribution as could be.	
b. Traffic zone	Yes.			Yes. Same comment as above.	Same comment as above.	
2. Go to C.						
C. Emission Computation and Mapping						
1. Map traffic data to master grid and/or links.	Yes. Maintains link file for CO, area file for TSP, SO_2.			Yes, but may need some modification to do all pollutants on link or zone.	Standard.	
2. Apply emission factors.	Yes.			Yes.	Standard.	
3. Generate output in model-compatible form.						
a. Line sources	Yes.			Yes. Uses HIWAY.	Standard.	Has separate routine to generate model-formatted data. Easy to modify.
b. Area sources	Yes.			Yes. Uses AQDM.	Standard	
II. Growth Analysis						
A. Input new highway construction data.	Yes. Has separate routine for this.			Yes. Need input only changes.	Standard	

Table C-5. Computation Comparison for Transportation Sources - ESAQ (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
B. Input generalized growth projections.	No. Must input entirely new data set.	Inconvenience to user who must develop VMT due to growth externally. Current system uses TRIMS model to do this.	Modification of code to allow growth factor to be applied to base data set. 2-3 mm			
III. Strategy Analysis						
A. Apply emission limits.	Yes.			Yes.	Standard.	
B. Apply traffic controls.	Yes.			Yes, but must input new data set.	Standard.	
C. Apply growth and development controls.	Yes.			Yes, but must input new data set.	Standard.	
Other Vehicles						
I. Activity Parameter Input						
A. Input vehicle activity.	Yes.			Yes. Must input activity in NEDS format.	Standard.	
B. Apply emission factors.	Yes			Yes.	Standard.	
II. Emission Input						
A. Input emissions directly.	Yes			Yes, but some careful manipulation of EIS/P&R required.	Standard.	
Gasoline Handling Evaporation Losses						
I. Gasoline Marketed Input						
A. Input gasoline sold.	Yes			Yes. Input county data in NEDS format.	Standard.	
B. Apply emission factors.	Yes.			Yes.	Standard.	
II. Surrogate Variable Input						
A. Input per capita gasoline consumption rate.	No.	Inconvenience to user.	Minor modification since population is already treated. 1 mm			
B. Compute gasoline marketed.	No.	Inconvenience to user.	Same as above.			
C. Apply emission factors.	Yes.			Yes.	Standard.	

Table C-6. Computation Comparison for Solid Waste Disposal Sources - ESAQ

Calculation	Does the system do the calculation?	No		Yes		Extra Features
		Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	
I. Emission Update						
A. Surrogate Variable Input (Level 1,2)						
1. Input surrogate variable to be used.	No. There is no provision for inputting surrogate variables for solid waste disposal.	Significant. Does not allow user to make use of different estimating procedures.	Moderate modifications and new coding. 1-2 mm			
2. Input solid waste generation factors.						
3. Input disposal technique distribution.						
4. Compute solid waste generated and disposal technique in subareas.						
5. Extract point sources.						
6. Go to C.						
B. Solid Waste Data Input (Level 3)						
1. Input solid waste generation and disposal data from local sources.	Yes.			Yes. Inputs data in NEDS format.	Standard.	
2. Extract point sources.	No. Must start with area source totals.	Inconvenience to user who must separate point and area source totals manually.	Moderate coding effort to process point source data and retrieve solid waste disposed of. 1-2 mm.			
3. Go to C.						
C. Emission Computation and Mapping						
1. Map solid waste generation and disposal technique to master grids.	Yes.			Yes. Allocation done along with other variables.	Standard.	
2. Apply emission factors.	Yes.			Yes.	Standard.	
3. Generate output in model-compatible form.	Yes. Currently set up for AQDM.			Yes.	Standard.	
II. Growth Analysis						
A. Input Growth Data						
1. Surrogate variable projections.	No. Same as I.A.1 above.					

Table C-6. Computation Comparison for Solid Waste Disposal Sources - ESAQ (Contd.)

Calculation	Does the system do the calculation?	No		Yes		Extra Features
		Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	
2. Solid waste generation rates.	No. Same as above.					
3. Accept local solid waste projections.	Yes.			Yes. Input in NEDS format.	Standard.	
4. Disposal techniques.	Yes.			Yes. Input in NEDS format.	Standard.	
III. <u>Strategy Analysis</u>						
A. Emission limits.	Yes.			Yes.	Standard.	
B. Growth and development controls.	No. Because of lack of surrogate variable.	User cannot easily simulate the effect of this type of strategy.	Moderate new coding effort. 1-2 mm.			
C. Disposal restrictions.	Yes.			Yes, but must change input data in NEDS format.	Standard.	

Table C-7. Computation Comparison for Miscellaneous Sources - ESAQ

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Solvent Evaporation						
I. Emission Update						
A. Direct Data Input						
1. Input actual solvent use.	Yes.			Yes. Standard NEDS format.	Standard	
B. Surrogate Data Input						
1. Input solvent consumption factors.	No.	Inconvenience to user. Inability to manipulate this type of data.	Moderate modification of code since basic surrogate data can already be input. 1-2 mm.			
C. Emission Computation and Mapping.						
1. Map solvent use to master grids.	Yes.			Yes. Using NEDS data to start from.	Standard	
2. Apply emission factors.	Yes.			Yes.	Standard	
3. Generate output in model-compatible form.	Yes. Currently set up for AQDM.			Yes.	Standard	
II. Growth Analysis						
A. Apply growth factors.	Yes. Using EIS/P&R.			Yes.	Standard	
III. Strategy Analysis						
A. Emission limits	Yes.			Yes.	Standard	
B. Solvent use restrictions.	Yes			Yes, but must manipulate EIS/P&R data carefully.	Standard	
C. Growth and development controls.	No. There is no tie to a surrogate variable.	User cannot simulate this strategy easily.	Moderate coding change and new code. 1-2 mm.			

Table C-7. Computation Comparison for Miscellaneous Sources - ESAQ (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Fires						
I. Input basic activity factor	Yes.			Yes. Can use standard NEDS information.	Standard	
II. Input allocation parameter	Yes.			Yes. Can use standard allocation parameter or input overriding parameter.	Standard	
III. Apply emission factor	Yes.			Yes.	Standard	
Fugitive Dust						
I. Input basic activity factor.	Yes.			Yes. Can use standard NEDS information.	Standard	
II. Input allocation parameter.	Yes.			Yes. Can use standard allocation parameter or input overriding parameter.	Standard	
III. Apply emission factor.	Yes.			Yes.	Standard	
IV. Apply control strategy.	Yes.			Yes, but must change input data set.	Standard	
Other Sources						
I. Generalized format.	Yes.			Yes, but must manipulate EIS/P&R carefully.	Standard	
II. Emission input.	Yes.			Yes, but must manipulate EIS/P&R carefully.	Standard	

Table C-8. Computation Comparison for Gridding - ESAQ

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
A. Map from subarea to master grid using previously determined fractions.	Yes.			Yes.	Standard	
B. Map several subareas to master grid.	No. Can use only one grid system.	Inconvenience to user. Limits the different data files that can be used.	Some reprograming to keep accurate bookkeeping of various subareas to grids. 1-2 mm.			
C. Map process activity instead of emissions.	Yes.			Yes.	Standard	
D. Map into changing master grid.	No. Use one master grid only.	Inconvenience to user.	Some reprogramming as above. 1-2 mm.			

Table C-9. Computation Comparison for Growth - ESAQ

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. *Determine growth from specific data.*	Yes			Yes, but must input new data set.	Standard	
II. Determine growth from generalized growth factors.	Yes. Uses ETS/P&R			Yes, but must program (in COBOL) for each source category.	Standard	
III. Link growth between activities						
A. Provide linkages	No.	Inconvenience to user who must make the linkages manually	Modification of code 2-3mm.			
B. Provide output for data consistency checks.	No.	Does not supply user with interpretive information.	Modification of output formats. 1-2mm			
IV. Process more than one growth scenario per run.	No. Each scenario is treated separately.	Inconvenience to user.	Minor modification of code. 1-2mm.			
V. Provide summary tables of emission and activity growth	No.	Inconvenience to user.	Modification of output formats 1-2mm			

Table C-10. Computation Comparison for Control Strategies - ESAQ

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
I. Separate control strategy routine.	No. Uses EIS/P&R	Inconvenience to user who must program (in COBOL) the particular control strategies for each source category.	New code to handle the most common strategies. 3-5 mm			
II. Process more than one control strategy per computer run.	No.	Requires user to run each control strategy separately.	Small change to code. 1 mm			
III. Apply regulations only to affected sources.	Yes.			Yes. Uses EIS/P&R.	Much more convenient and less prone to error than inputing entirely new data set.	
IV. Provide summary tables for regulation evaluation.	No.	Does not provide user with interpretive information.	Moderate output changes. 1-2 mm.			

Table C-11. Evaluation of Computer Requirements - ESAQ

Requirement	Does the system meet the requirement?	No: Significance of the Lack	No: Changes Necessary	Extra Features
I. Computer System				
A. UNIVAC 1110	No. Has never been run on other than ES System.	Cannot be run on EPA facility.	Must be converted to UNIVAC form. 1-2 mm	
B. IBM	Yes. Was developed on IBM OS System.			
II. Programming Language				
A. FORTRAN and/or COBOL	Yes.			
B. ANSI standard	Yes.			
III. Mode of Operation				
A. Batch and interactive.	Yes.			
B. Interactive only.	No. There is no interactive component.			
IV. Program Structure				
A. Modular	Yes.			
B. Complete or single module run capability	Yes, but package is not likely to be run straight through.			
V. Off-Line Storage				
A. Permanent - tape, cards.	Yes.			
B. Transient - tape, disk, data cell, drum.	Yes.			
VI. Input Format				
A. NEDS compatible.	Yes.			
B. EIS/P&R compatible.	Yes. Built around EIS/P&R.			
C. Census tapes	No. Processes census information input on cards.	User must manually load census data. Can be significant effort with a large data set.	Moderate modification of code to read census tapes. 1-2 mm.	

Table C-11. Evaluation of Computer Requirements - ESAQ (Contd.)

Requirement	Does the system meet the requirement?	No: Significance of the Lack	No: Changes Necessary	Extra Features
VII. Output Format				
A. Models				
1. AQDM	Yes.			
2. CDM	No.		Minor modification. < 1 mm.	
3. IPP	No.		Minor modification. < 1 mm.	
4. VALLEY	No.		Minor modification. < 1 mm.	
B. Isopleth programs	Yes. Isopleths used in air quality packages. May need some generalization.			
C. Hard copy by area or subarea	Yes.			
VIII. Documentation A. User's guide B. Programmer's manual	There is no documentation available for general use.	Currently not possible for anyone outside of ES to use system.	Significant effort to document work. 3-4 mm.	
IX. Portability				
A. Easily transferable	Uncertain. Has not been used outside ES.			
B. Transferred by cards, tape (binary or source form, batch process).	Yes.			
X. Compatibility				
A. AEROS	No. Does not have proper documentation.	Cannot be supported by AEROS systems.	Documentation must be prepared. 4-6 mm.	

APPENDIX D

Detailed Evaluation of the MWCOG System

The tables included in this Appendix compare the MWCOG system with the CEPA requirements described in Sections 2 and 3. The evaluation is based on whether the system will do the required calculation. If it does not, the significance of the lack of this capability is given along with the changes that would be necessary to enable the system to perform as desired. An estimate of the effort, in man-months (mm), of making the modification is also given. If the system does the required calculation, the reasonability of the data requirements and the accuracy of the calculation are evaluated. Finally, any extra features of the system are identified.

Table D-1. Computation Comparison for Residential Fuel Combustion Sources - MWCOG

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
1. <u>Emission Update</u>						
A. Fuel Use Input (Level 1,2)						
1. Input state/county fuel consumption in residential sector.	Yes, but data is input on a subarea basis.			Yes. Uses fuel use survey.	Standard.	
2. Distribute fuel to county/subarea by surrogate variable (e.g., d.u., population) distribution.	No. Must input data already disaggregated to subareas.	Inconvenience to user seeking to do a simplified analysis.	Minor coding change since all necessary information is there. 1 mm			
3. Extract point sources	No. Must start with area source totals.	A small inconvenience. User must manually separate point and area source totals.	Moderate coding effort in addition to new code required to handle point sources (see Industrial Process Sources). 1-2 mm			
4. Go to C.						
B. <u>Surrogate Variable Input (Level 3)</u>						
1. Input state, county, subarea surrogate variable (e.g., population, d.u., floor area, land use).	Yes.			Yes. Entire Census information is input.	Standard.	
2. Input fuel consumption factors.	No. Baseline fuel consumption by subarea is an input data set.	User is confined to one baseline data set. New updated data for baseline must be computed manually and input.	Moderate coding effort. All the basic information, except the fuel consumption factors, are available. 1-2 mm			
3. Compute subarea fuel use.	No.	Same as above.				
4. Extract point sources.	No.	Same as 1.A.3 above.				
5. Go to C.						
C. <u>Emission Computation and Mapping</u>						
1. Map fuel consumption to master grids.	Yes, but applies emission factors (step 2) first.			Yes. Can specify allocation on the basis of area, population, employment or other parameter.	Less desirable than mapping activity first. Could lead to unusual results.	
2. Apply emission factors	Yes. Does this before step 1.			Yes.	Standard.	
3. Generate output in model-compatible form.	Yes. Can modify for use with several models.					

Table D-1. Computation Comparison for Residential Fuel Combustion Sources - MWCOG (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
II. Growth Analysis						
A. Input Growth Data						
1. % growth or actual values	Yes. Can input actual values.			Yes. Operates from planning data.	Standard.	
2. Future fuel mix	Yes.			Yes.	Standard.	
B. Apply Growth Factors	Yes. GROWTH routine calculates growth factors. Can override these with input to GROW.			Yes.	Standard.	
III. Strategy Analysis						
A. Emission Limits						
1. Change emission factors	Yes.			Yes, but must apply data carefully as emission factor change is interpreted as a change in the effective growth rate.	Not as accurate a procedure as could be done. Prone to some clerical errors.	
B. Fuel Controls						
1. Change fuel mix	Yes.			Yes.	Standard.	
2. Change fuel characteristics.	Yes.			Yes, but the change is interpreted as an effective growth change as above.	Same problem as III.A.1 above.	
C. Growth and Development Controls						
1. Change surrogate variable distribution.	Yes.			Yes. Easily done since growth scenario is a direct input.	Standard.	

Table D-2. Computation Comparison for Commercial/Institutional and Industrial Fuel Combustion - MWCOG

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update						
A. Fuel Use Input (Level 1, 2)						
1. Input state/county fuel consumption in comm/inst/indus sector	Yes. But data is input on a subarea basis.			Yes. Uses fuel use survey.	Standard	
2. Distribute fuel to county/subarea by surrogate variable (e.g., employment, land area) distribution for comm/inst/indus sector.	No. Must input data already disaggregated to subareas.	Inconvenience to user seeking to do a simplified analysis	Minor coding change. Similar to residential sources.			
3. Extract point sources	No. Must start with area source totals.	A small inconvenience. User must manually separate point and area source totals.	Moderate coding effort in addition to new code required to handle point sources. Similar to residential sources.			
4. Go to C.						
B. Surrogate Variable Input (Level 3)						
1. Input state, county, subarea surrogate variable (e.g., population, d.u., floor area, land use).	Yes.			Yes. Entire census information is input.	Standard	
2. Input fuel consumption factors.	No. Baseline fuel consumption by subarea is an input data set.	User is confined to one baseline data set. New updated data for baseline must be computed manually and input.	Moderate coding effort. All the basic information, except the fuel consumption factors, are available. Same as residential sources.			
3. Compute subarea fuel use	No.	Same as above.				
4. Extract point sources.	No.	Same as I.A. 3 above.				
5. Go to C.						

Table D-2 Computation Comparison for Commercial/Institutional and Industrial Fuel Combustion - MWCOG (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update (Cont'd)						
C. Emission Computation and Mapping						
1. Map fuel consumption to master grids.	Yes, but applies emission factors (step 2) first.			Yes. Can specify allocation on the basis of area, population, employment or other parameter.	Less desirable than mapping activity first. Could lead to unusual results.	
2. Apply emission factor	Yes. Does this before step 1.			Yes.	Standard	
3. Generate output in model-compatible form.	Yes. Can modify for use with several models.					
II. Growth Analysis						
A. Input Growth Data						
1. % growth or actual values	Yes. Can input actual values.			Yes. Operates from planning data.	Standard.	
2. Future fuel mix	Yes.			Yes.	Standard.	
B. Apply Growth Factors	Yes. GROWTH routine calculates growth factors. Can override these with input to GROW.			Yes.	Standard.	
III. Strategy Analysis						
A. Emission Limits						
1. Change emission factors	Yes			Yes, but must apply data carefully as emission factor change is interpreted as a change in the effective growth rate.	Not as accurate a procedure as should be done. Prone to some clerical errors.	
B. Fuel Controls						
1. Change fuel mix	Yes			Yes.	Standard.	
2. Change fuel characteristics	Yes			Yes, but the change is interpreted as an effective growth change as above.	Same problem as III, A, 1 above.	
C. Growth and Development Plans						
1. Change surrogate variable distribution	Yes			Yes. Easily done since growth scenario is a direct input.	Standard.	

Table D-3. Computation Comparison for Electric Generation and Internal Combustion Sources - MWCOG

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
<u>Electric Generation</u>						
I. Treat power plants similar to industrial process sources.	Yes.			See comments on Industrial Process Sources.		
II. Project electrical demand and load factors.	No.	Does not give user information on electrical requirements.	Modification to code to determine electrical demand from surrogate variable (e.g. population). 2-3 mm			
<u>Internal Combustion</u>						
I. Treat similar to industrial process sources.	Yes.			See comments on Industial Process Sources.		

Table D-4. Computation Comparison for Industrial Process Sources - MWCOG

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. <u>Emission Update</u>	No.	The MWCOG system was not designed to do any computations with point sources. The point source information is all handled manually and is used only as input into the dispersion models.	8-10 mm			
A. Receive emission inventory input.						
1. NEDS						
2. Other systems						
B. Retrieve and summarize inventory data.						
C. Modify inventory with source specific data.						
D. Perform internal consistency checks.						
E. Generate output in model-compatible form.						
1. Point sources						
2. Area sources						
II. <u>Growth Analysis</u>						
A. Input source specific growth information.						
B. Apply generalized growth factors.						
C. Disaggregate growth to existing, new, and unknown sources.						
D. Allocate growth at unknown sources by surrogate parameter.						
III. <u>Strategy Analysis</u>						
A. Apply emission limits.						
B. Apply growth and development controls.						
C. Apply land use controls.						

Table D-5. Computation Comparison for Transportation Sources - MWCOG

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
Highway Vehicles						
I. Emission Update						
A. Fuel Consumption Input (Level 1) 1. Input state/county fuel sold. 2. Estimate VMT. 3. Distribute VMT to subareas by surrogate variable (e.g. population). 4. Go to C	No. System uses a transportation demand model.	User cannot do simplified analysis.	Moderate coding change since all necessary data is available. 1-2 mm.			
B. Specific Data Input (Level 2,3)						
1. Input VMT, vehicle type distribution, speed, etc., data.	Yes. Uses transportation demand model.			Yes. Runs from planning data.	Standard.	
a. Link	Yes.			Yes.	Standard.	
b. Traffic zone	Yes.			Yes.	Standard.	
C. Emission Computation and Mapping						
1. Map traffic data to master grid and/or links.	Yes, but applies emission factors (step 2) first.			Yes. Can specify allocation parameter.	Less desirable than mapping activity first. Could lead to unusual results.	
2. Apply emission factors.	Yes. Does this before step 1.			Yes.	Standard.	
3. Generate output in model-compatible form.						
a. Line sources.	No. Does not treat line sources.	User cannot model line sources.	Moderate modification of code since link data is available. 2-3 mm.			
b. Area sources	Yes			Yes	Standard.	
II. Growth Analysis						
A. Input new highway construction data.	No. There is no provision for handling specific highway data.	User cannot use any available data on new highways.	Modification to code and coordination of new highway data with output from demand model. 2-3 mm.			
B. Input generalized growth projections.	Yes.			Yes, but user must develop an entire growth scenario to operate the travel demand model. May require some modification to simplify the input of simple growth factors. 2-3 mm.	Standard.	

Table D-5. Computation Comparison for Transportation Sources - MWCOG (Contd.)

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
III. Strategy Analysis						
A. Apply emission limits.	Yes.			Yes, but must change basic data in EMIS code.	Standard.	
B. Apply traffic controls.	Yes.			Yes, but must modify output of demand model.	Standard.	
C. Apply growth and development controls.	Yes.			Yes, but must rerun demand model.	Standard.	
Other Vehicles						
I. Activity Parameter Input						
A. Input vehicle activity.	No. Must input data in area source emission inventory format.	User must manually calculate the emission rate for input.	Modification of input and addition of calculation routines. 2-3 mm.			
B. Apply emission factors.	No.	Same as above.				
II. Emission Input						
A. Input emissions directly	Yes.			Yes. Input as part of area source inventory	Less accurate than is possible when doing growth analysis.	
Gasoline Handling Evaporation Losses						
I. Gasoline Marketed Input						
A. Input gasoline sold.	No. Must input data in area source emission inventory format.	User must manually calculate the emission rate for input.	Modification of input and addition of calculation routines. 1-2 mm.			
B. Apply emission factors.	No.	Same as above.				
II. Surrogate Variable Input	No.	User must make the surrogate variable calculations externally.	New coding effort. 1-2 mm.			
A. Input per capita gasoline consumption rate.						
B. Compute gasoline marketed.						
C. Apply emission factors.						

Table D-6. Computation Comparison for Solid Waste Disposal Sources - MWCOG

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Emission Update						
A. Surrogate Variable Input (Level 1,2)						
1. Input surrogate variable to be used.	No. There is no provision for inputting surrogate variables for solid waste disposal.	Significant. Does not allow the user to make use of different estimating procedures.	Moderate modifications and new coding. 1-2 mm			
2. Input solid waste generation factors.						
3. Input disposal technique distribution.						
4. Compute solid waste generated and disposal technique in subareas.						
5. Extract point sources.						
6. Go to C.						
B. Solid Waste Data Input (Level 3)						
1. Input solid waste generation and disposal data from local sources.	No. Must input data in area source emission inventory format.	User must manually compute input emissions.	Modification of input and new coding 1-2 mm			
2. Extract point sources.	No. Must start with area source totals.	Inconvenience to user who must separate point and area source totals manually.	New coding effort in connection with additional point source routines. (See industrial process sources) 1-2 mm			
3. Go to C.						
C. Emission Computation and Mapping						
1. Map solid waste generation and disposal technique to master grids.	Yes, but maps emissions.			Yes. Can specify allocation parameter.	Less desirable than mapping activity first.	
2. Apply emission factors	No. Maps input emissions.	None. The mapping of activity can be done when the computation procedure (I.B.1 above) is changed.				
3. Generate output in model-compatible form.	Yes			Yes.	Standard.	

Table D-6. Computation Comparison for Solid Waste Disposal Sources - MWCOG (Contd.)

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
II. Growth Analysis						
A. Input Growth Data						
1. Surrogate variable projections.	No. Same as I.A. above.					
2. Solid waste generation rates.	No. Same as above.					
3. Accept local solid waste projections.	No. Same as I.B. above.					
4. Disposal restrictions.	No. Same as above.					
III. Strategy Analysis						
A. Emission limits.	Yes.			Yes, but must simulate as an effective growth rate.	Not an accurate procedure.	
B. Growth and development controls.	No. Because of lack of surrogate variable.	User cannot easily simulate the effect of this strategy.	New coding effort 1-2 mm			
C. Disposal restrictions.	No.	User must manually determine the effect of this strategy on emissions.	New coding effort (same as I.B.1)			

Table D-7. Computation Comparison for Miscellaneous Sources - MWCOG

Calculation	Does the system do the calculation?	No		Yes		
		Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
Solvent Evaporation						
I. Emission Update						
A. Direct Data Input						
1. Input actual solvent use.	No. User must input emissions.	User must manually compute emissions.	Modification to input and new code. 1 mm.			
B. Surrogate Data Input						
1. Input solvent consumption factors.	No. No provision for handling a surrogate variable for this source.	Inconvenience to user. Inability to manipulate this type of data.	Moderate modification of code in connection with I.A.1 above.			
C. Emission Computation and Mapping						
1. Map solvent use to master grid.	Yes, but maps emissions.			Yes. Can specify allocation parameter.	Less desirable than mapping activity first.	
2. Apply emission factors.	No. Maps input emissions.	None. The mapping of activity can be done when the computation procedure (I.A and B above) is changed.				
3. Generate output in model-compatible form.	Yes.			Yes.	Standard.	
II. Growth Analysis						
A. Apply growth factors.	Yes.			Yes. Can use either population or a non-demographic growth rate.	Not an accurate procedure to apply growth rate to emissions directly.	
III. Strategy Analysis						
A. Emission limits	Yes.			Yes, but must simulate as an effective growth rate.	Not an accurate procedure.	
B. Solvent use restrictions.	No.	User must manually determine the effect of this on emissions.	New coding effort (same as I.A and I.B above).			
C. Growth and development controls.	No.	User cannot easily simulate the effect of this type of strategy.	New coding effort. 1-2 mm.			

Table D-7. Computation Comparison for Miscellaneous Sources - MWCOG (Contd.)

Calculation	Does the system do the calculation?	No		Yes		Extra Features
		Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	
Fires						
I. Input basic activity factor.	No. User must input emissions.	User must manually compute emissions.	New coding. 1 mm.			
II. Input allocation parameter.	Yes.			Yes. Can use allocation routine in GROW.	Standard.	
III. Apply emission factor.	No.	Same as I above.				
Fugitive Dust						
I. Input basic activity factor.	No. User must input emissions.	User must manually compute emissions.	New coding. 1-2 mm.			
II. Input allocation parameter.	Yes.			Yes. Can use allocation routine in GROW.	Standard.	
III. Apply emission factor.	No.	Same as I above.				
IV. Apply control strategy.	No.	User must manually compute the effect of strategy on emissions.	New coding. 1 mm.			
Other Sources						
I. Generalized format.	No. User must input emissions.	User must manually compute emissions.	New coding. 1 mm.			
II. Emission input.	Yes.			Yes.	Standard.	

Table D-8. Computation Comparison for Gridding - MWCOG

		No		Yes		
Calculation	Does the system do the calculation?	Significance of the Lack	Changes Necessary	Reasonable Data Requirements	Accuracy of Calculation	Extra Features
A. Map from subarea to master grid using previously determined fractions.	Yes. Done in CONVRT.			Yes.	Standard.	
B. Map several subareas to master grid.	No. Use only one grid system.	Inconvenience to user. Limits the different data files that can be used.	Some reprogramming to keep accurate bookkeeping of various subareas to grids 1 - 2 mm.			
C. Map process activity instead of emissions.	No. Maps emissions.	Not as desirable a feature. Could lead to incorrect distributions.	Considered under individual source categories.			
D. Map into changing master grid.	No. Uses one master grid only.	Inconvenience to user.	Some reprogramming as in B above 1 - 2 mm.			

Table D-9. Computation Comparison for Growth - MWCOG

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Determine growth from specific data.	Yes. Done in GROWTH routine.			Yes.	Standard.	
II. Determine growth from generalized growth factors	Yes. Computes growth factors			Yes.	Standard.	
III. Link growth between activities						
A. Provide linkages	Yes. Can compute growth on the basis of combinations of parameters.			Yes.	Standard	
B. Provide output for data consistency checks.	Yes.			Yes.	Standard.	
IV. Process more than one growth scenario per run.	Yes.			Yes.	Standard.	
V. Provide summary tables of emission and activity growth.	Yes.			Yes	Standard.	

Table D-10. Computation Comparison for Control Strategies - MWCOG

Calculation	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Yes: Reasonable Data Requirements	Yes: Accuracy of Calculation	Extra Features
I. Separate control strategy routine.	No.	User must interpret control strategy manually or by using an effective growth rate.	New code. 3 - 5 mm			
II. Process more than one control strategy per computer run.	No.	Requires user to run each control strategy separately.	Change to code in connection with I above. 1 mm			
III. Apply regulations only to affected sources.	No.	User must apply regulations manually.	New code in connection with I above. 1 - 2 mm			
IV. Provide summary tables for regulation evaluation.	No.	Does not provide user with interpretive information.	Output change in connection with I above. 1 mm			

Table D-11. Evaluation of Computer Requirements - MWCOG

Requirement	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Extra Features
I. Computer System				
A. UNIVAC 1110	No. Has been run on IBM 370/168.	Cannot be run on EPA facility.	Must be converted to UNIVAC form. 1 mm	
B. IBM	Yes.			
II. Programming Language				
A. FORTRAN and/or COBOL	Yes. FORTRAN only.			
B. ANSI standard	Yes.			
III. Mode of Operation				
A. Batch and interactive	Yes.			
B. Interactive	No. The interactive component has been eliminated.			
IV. Program Structure				
A. Modular	Yes.			
B. Complete or single module run capability	Yes, but would require appropriate JCL to run straight through; not likely to be used in this manner.			
V. Off-Line Storage				
A. Permanent - tape, cards.	Yes.			
B. Transient - tape, disk, data cell, drum.	Yes.			
VI. Input Format				
A. NEDS compatible.	No. Receives point source information in state-supplied format.	User cannot use NEDS data directly.	Modification of input. 1-2 mm	
B. EIS/P&R compatible	No.	User cannot use EIS/P&R system.	Major new coding effort. (See industrial process sources).	
C. Census tapes	No. Processes aggregated Census information.	Inconvenience to user. Must create an aggregated census tape first.	Minor modification. 1 mm	

Table D-11. Evaluation of Computer Requirements - MWCOG (Contd.)

Requirement	Does the system do the calculation?	No: Significance of the Lack	No: Changes Necessary	Extra Features
VII. Output Format				
A. Models				
1. AQDM	No.		Minor modification < 1 mm	
2. CDM	Yes.			
3. IPP	No.		Minor modification < 1 mm	
4. VALLEY	No.		Minor modification < 1 mm	
B. Isopleth programs	Yes. SYMAP isopleths used in air quality packages. May need some generalization.			
C. Hard copy by area or subarea	Yes. Special routine (EMSUM).			
VIII. Documentation A. User's guide B. Programmer's manual	There is no documentation available for general use although the programs have extensive comments.	A user must interpret the programs himself. Not especially difficult since the codes are short and straightforward.	Prepare documentation 2-4 mm	
IX. Portability				
A. Easily transferable	Yes. Select programs have been used elsewhere.			
B. Transferred by cards, tape (binary or source form, batch process).	Yes. Cards.			
X. Compatability				
A. AEROS	No. Does not have proper documentation.	Cannot be supported by AEROS system.	Documentation must be prepared. 4-6 mm.	

APPENDIX E

Development Effort of a New CEPA System

The table contained in this Appendix gives an estimate of the effort required to develop an entirely new CEPA system. These estimates are given for each task involved in an air quality analysis. They are consistent with the estimates of modifications to the existing systems in that the effort required to make a major modification is assumed to be equivalent to developing that component of a CEPA system anew.

Table E-1. Development Effort of New CEPA System

Source Category	Effort Required to Program (man-months)	Total Effort For Source Category (man-months)
Residential Fuel Combustion		
I. Emission Update		
A. Fuel Use Input	2-4	
B. Surrogate Variable Input	3-4	
C. Emission Computation and Mapping	1-2	
II. Growth Analysis		
A. Input Growth Data	1-2	
B. Apply Growth Factors	2-4	
III. Strategy Analysis		
A. Emission Limits	2-3	
B. Fuel Controls	1-2	
C. Growth and Development	1-2	
		13-23
Commercial/Institutional and Industrial Fuel Combustion		
I. Emission Update		
A. Fuel Use Input	1-2	
B. Surrogate Variable Input	1-2	
C. Emission Computation and Mapping	(Same as Residential)	
II. Growth Analysis		
A. Input Growth Data	1-2	
B. Apply Growth Factors	1-2	
III. Strategy Analysis		
A. Emission Limits	1-2	
B. Surrogate Variable Input	(Same as Residential)	
C. Emission Computation and Mapping	1-2	
		6-12
Electric Generation		
I. Treat Power Plants	(See Industrial Process Sources)	
II. Project Electrical Demand	2-3	
		2-3
Internal Combustion	(See Industrial Process Sources)	
Industrial Process Sources		
I. Emission Update	3-4	
II. Growth Analysis	2-3	
III. Strategy Analysis	2-3	
Highway Vehicles		
I. Emission Update		
A. Fuel Consumption Input	1-2	
B. Specific Data Input	4-6	
C. Emission Computation and Mapping	2-3	
II. Growth Analysis	2-4	
III. Strategy Analysis	3-5	
		12-20
Other Vehicles	3-4	3-4
Gasoline Handling Evaporation Losses	2-3	2-3
Solid Waste Disposal		
I. Emission Update		
A. Surrogate Variable Input	1-2	
B. Solid Waste Data Input	2-4	
C. Emission Computation and Mapping	1-2	
II. Growth Analysis	2-4	
III. Strategy Analysis	1-2	
		7-14
Miscellaneous Sources		
Solvent Evaporation	2-5	
Fires	1-2	
Fugitive Dust	2-4	
Other Sources	1-2	
		6-13
Gridding	5-10	5-10
Growth	7-11	7-11
Control Strategies	6-10	6-10
Computer		
Census Tapes	3-4	
Documentation		
Users Guide	2-3	
Programmers Guide	2-3	
AEROS Requirements	4-6	
		11-16
TOTAL EFFORT		87-149

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15. SUPPLEMENTARY NOTES

Another report may follow if decision is made to continue study on the CEPA system. Phase III would cover the development of the detailed system specification.

16. ABSTRACT

This report documents the second phase of a feasibility study to determine the need for a computerized emission projection and allocation (CEPA) system to assist State and local air pollution control agencies in conducting air quality analyses. This phase entailed the review and evaluation of four existing emission analysis systems: the Air Quality for Urban and Industrial Planning (AQUIP) system, the Computer-Assisted Area Source Emission (CAASE) gridding procedure, the Engineering-Science Air Quality (ESAQ) system, and the Metropolitan Washington Council of Governments (MWCOG) model. The evaluation consisted of a description of the CEPA requirements without reference to any existing systems, a comparison of the existing packages to those requirements, an identification of deficiencies, an estimate of effort required to remove those deficiencies, an evaluation of the effort needed to develop an entirely new system, and an assessment of the potential savings to be realized by employing a CEPA system in place of manual procedures.

The report recommends that EPA proceed with stepwise modification of the Engineering-Science model by first documenting the model and making it available. After that, EPA could then begin to modify the model to correct deficiencies uncovered by the contractor. The contractor estimates that the cost of modifying the Engineering-Science model ranges from \$235,000 to \$355,000. This was the lowest cost of all the options considered.

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