**Technical Documentation and
User's Guide for City-County
Allocation Model (CCAM)**

Version 1.0

L. T. Clark, Jr.

M. J. Scott

P. Hammer

May 1986

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

NTIS Price Codes
Microfiche A01

Printed Copy

Pages	Price Codes
001-025	A02
026-050	A03
051-075	A04
076-100	A05
101-125	A06
126-150	A07
151-175	A08
176-200	A09
201-225	A010
226-250	A011
251-275	A012
276-300	A013

TECHNICAL DOCUMENTATION AND
USER'S GUIDE FOR CITY-COUNTY
ALLOCATION MODEL (CCAM)

VERSION 1.0

L. T. Clark, Jr.
M. J. Scott
P. Hammer

May 1986

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RL0 1830

Pacific Northwest Laboratory
Richland, Washington 99352

PREFACE

The purpose of this manual is to assist the user in understanding and operating the City-County Allocation Model (CCAM). The manual explains the data sources for the model and code modifications as well as the operational procedures. The procedures explained are not optimal and can be improved. The user may forward his suggestions to M. J. Scott: 509-376-2458.

The CCAM model is resident on the U.S. Department of Energy, Energy Information Administration (EIA) main frame computer in the Forrestal Building in Washington, D.C. This manual assumes the user has knowledge of the following computer languages: SAS, TSO, SUPERWYLBER and JCL.

CONTENTS

TO USER	iii
1.0 INTRODUCTION	1.1
2.0 MODEL THEORY AND SPECIFICATION	2.1
POPULATION	2.1
COMMUNITY SERVICES	2.5
3.0 CCAM DATA AND MODEL DESCRIPTION	3.1
DATA SET CREATION	3.1
CITY DATA	3.2
STATE LEVEL DATA	3.11
NATIONAL STANDARDS	3.14
4.0 OPERATING CCAM	4.1
5.0 VALIDATION AND SENSITIVITY TESTING	5.1
REFERENCES	R.1

TABLES

3.1	Definitions of CCAM's Input Variables	3.3
3.2	Data Format	3.10
3.3	Variable Format for CCAM Driver Variables	3.12
3.4	Definitions of CCAM's Forecasted Variables	3.15
3.5	Community Service Requirements by City Size	3.20
5.1	Validation Test of CCAM Gravity Model, Hartsville Nuclear Plant	5.2
5.2	Validation Test of CCAM Gravity Model, Hartsville Nuclear Plant, with Alternative Population and Distance Effects	5.4

1.0 INTRODUCTION

The City-County Allocation Model (CCAM) was developed at Pacific Northwest Laboratory in 1984 as part of the Monitored Retrievable Storage (MRS) Program sponsored by Department of Energy (DOE) Office of Civilian Radioactive Waste Management for development of MRS Reference Site Environmental Document (PNL-5476). The Monitored Retrievable Storage facility concepts analyzed in the MRS program were judged by Pacific Northwest Laboratory (PNL) engineers to be relatively free of geologic and climate restrictions; thus, in principal it was possible to locate an MRS facility in any of the contiguous 48 states. It was therefore necessary for purposes of MRS environmental assessments and system studies to have a capability to analyze quickly any of a wide variety of potential sites for socioeconomic impact. The CCAM model helps fill this need.

The CCAM model was developed as a companion model to PNL's Metropolitan and State Economic Regions (MASTER) econometric model,⁽¹⁾ already being used in the MRS Program to estimate employment and population impacts for multi-county economic regions surrounding potential MRS sites. The CCAM model was designed to allocate population changes forecasted by the MASTER model to specific local communities within commuting distance of the MRS facility. The CCAM model was designed to then forecast the potential changes in demand for key community services such as housing, police protection, and utilities for these communities. The CCAM model uses a flexible on-line data base on demand for community services that is based on a combination of local service levels and state and national service standards. As a companion to the MASTER model, which can be utilized to provide employment and population forecasts for any county or group of counties in the United States, the CCAM model can be used to quickly forecast the potential community service consequences of economic development for local communities anywhere in the country.

(1) A summary of the MASTER model and its uses and capabilities see The Metropolitan and State Economy Regions (MASTER) Model-Overview. R. C. Adams et al., May 1983, Pacific Northwest Laboratory, Richland, Washington.

The remainder of this document is organized as follows. The next chapter discusses the general theory and specification underlying CCAM's structure. Chapter 3.0 describes CCAM in more detail, while Chapter 4.0 discusses the operation of the model. Chapter 5.0 discusses model validation.

2.0 MODEL THEORY AND SPECIFICATION

This section describes the economic literature and theory underlying CCAM, as well as model specification. The discussion is divided into two subsections, one dealing with population allocation and one dealing with community service demand.

POPULATION

Before any local socioeconomic impacts of an economic development project can be accurately detected and examined, it is necessary to determine the geographic distribution of the increases in population associated with the project. Forecasts of these settlement patterns are essential to facilitate proper planning for community services and planning for additional infrastructure in the communities that will be affected by the project. It is also important to avoid overbuilding in those communities in the area that will not experience large amounts of growth.

While forecasting the geographic distribution of population changes is necessary to determine both the type and magnitude of local socioeconomic effects, the task is complex because many different factors influence a worker's choice of residence. Some of these factors include the previous level and quality of community services available at each location, quality of available commuting routes, distance from the closest regional trading center, and the availability of housing (Murdock, Wieland, and Leistritz, 1978). Most of these influences involve a subjective interpretation by the worker that is difficult to quantify and predict.

Three types of methodologies have been widely used over the years to forecast settlement patterns (Gilmore, et al. 1982; Leistritz and Murdock, 1981). Because of the complex nature of the subject matter and frequent unavailability of specific data, most of these prevailing models can only provide broad indications of potential patterns. It is difficult to make accurate, sweeping, generalized statements.

The first method used to determine residential choice is the judgmental weighting model. This model relies on the researchers' or local knowledgeable

individuals' qualitative assessments. They are in fact educated guesses as to where the incoming workers will choose to live. These models have the advantage of reflecting the unique local characteristics of the area. Their main disadvantage, however, is that because they are subjective by nature, their accuracy is determined solely by the accuracy of the local perceptions.

The second method is the Delphi technique. This is really just a more concerted and definitive type of judgmental model. This method forms advisory committees of local leaders, businessmen, real-estate agents and general residents to establish weights and predict settlement patterns. Although this technique is more systematic and rigorous than the judgmental model, it is still subjective and is dependent upon the accuracy of local perceptions.

CCAM uses a third technique, the so-called gravity model. The premise underlying its use is that larger communities and those located closer to the project site will gain more population from the project than smaller, more distant places. In other words it assumes that the attractiveness of a residential location is inversely proportional to its distance from the project site. This relationship is roughly analogous to the concept in physics of the strength of the gravitational pull between two objects, the strength of which is proportional to both their sizes, and inversely proportional to the distance separating them. The simplest form of gravity model is shown as equation 1.

$$M_{ij} = k_1 \frac{P_i P_j}{D_{ij}^{k_2}} \quad (1)$$

where:

M_{ij} = migration (or trade of goods, or travel) between communities
i and j

P_i, P_j = populations of communities i, j

D_{ij} = distance between communities i, j

k_1, k_2 = estimated constants (k_2 generally takes on a value between 0.5 and 2.0).

These assumptions are consistent with empirical research. Researchers have found that workers tend to live in unrelatively large places close to their place of work. Most project-related migrants end up within thirty miles of the project site (Murdock and Leistritz 1979). Except in very rural areas, few employees will ever commute a distance greater than sixty miles (Leholm, Leistritz, and Wieland, 1976).

CCAM is a modified gravity model. In addition to the influence of population, the model can also account for the influence of trade centers (retail sales) and/or job availability (employment). The population weight is a particularly important factor in estimating the relative attractiveness of a given community. Most of the literature supports the conclusion that population appears to be the basic quantitative measure of a community's services. More services and facilities can generally be found in a larger community than in a smaller community. Other factors may modify the influence of population but they will not negate it (Murdock, Wieland, and Leistritz 1978). Population can also serve as an indication of a community's ability to absorb new residents. Researchers have found that as a rule most of the incoming population will settle mainly in towns with more than 1,000 residents (Murdock and Hamm 1983; Murdock, Leistritz, Schriener, 1982).

The primary drawback of the basic gravity model is its implicit assumption of uniformity amongst different communities. The model assumes a uniform ability of communities to absorb new residents. It also assumes that communities are at the same stage of development. These factors can combine to create a tendency towards mechanical application of the model (Leistritz and Murdock, 1981; Murdock and Leistritz 1979).

Most of the past experience with the gravity model has been associated with urban settings. In this environment its predictions have met with a great deal of success. Many gravity based models have been able to explain 90-plus percent of the variation in settlement patterns (Galle and Taeuber 1966).

It is much more difficult to apply the gravity model in rural settings. Rural conditions and patterns will frequently vary considerably from area to area. Different communities have different abilities to provide housing and other services. There may also be differing attitudes in rural communities

concerning change and growth. These forces combine to make forecasting in this environment very difficult (Murdock and Leistritz, 1979).

These drawbacks and criticisms are not unique to the CCAM or to the gravity model. They are a reflection of the inherent difficulty of the subject matter. Every effort should be made, however, to account for the unique local characteristics of many rural communities. Some writers suggest that this can be accomplished by applying the judgmental technique to appropriately weight and modify the population distance factors in the gravity model. If used judiciously such weighting factors can improve gravity model results (Murdock and Leistritz 1979; Murdock, Wieland, and Leistritz 1978).

Following Leistritz et al. (1979), CCAM allocates population changes via a gravity procedure modified by qualitative weighting factors. The Leistritz, et al. procedure is shown in Equation 2.

$$M_i = \frac{\left(\frac{P_i}{D_i^A} \right) \cdot W_i}{\sum_{i=1}^n \left(\frac{P_i}{D_i^A} \right) \cdot W_i} \quad (2)$$

where:

M_i = fraction of total migrants locating in city (i)

P_i = population of city (i)

D_i^A = distance between city (i) and the work site, raised to the power (A)

W_i = relative qualitative attraction of city (i).

In Murdock, Wieland, and Leistritz (1978), it is suggested that the important weighting factor in rural residential choice may be the availability of services in certain local trade centers. This is represented in CCAM by adding factors for relative local retail sales and employment to substitute for the W_i index. As finally constructed, the complete CCAM gravity allocation index is shown in Equation 3.

$$M_i = \frac{\left(\frac{P_i}{D_i^A}\right) \cdot E_i \cdot S_i}{\sum_{i=1}^n \frac{P_i \cdot E_i \cdot S_i}{D_i^2}} \quad (3)$$

where M_i , D_i^A , and P_i are defined as before, A takes on a default value of 2.0 and E_i and S_i are city i 's respective shares of total employment and retail sales for the region.

Since employment and sales tend to be highly correlated with population in many regions, in most cases this structure amounts to putting an exponent of 3 on the population term and thus simply allocating population changes in accordance with baseline population rather than distance. In cases where baseline employment or retail sales are much differently distributed than population (due to the recent location of a major employer or regional shopping center), CCAM tends to show a relocation of population within a region. In practice, unless there is "dominant" city having more than half the region's population, CCAM results do not show a great tendency for project-related population changes to occur in the largest communities in the region. The employment and retail sales weights are optional, since they may not be appropriate in all cases.

COMMUNITY SERVICES

The community service impacts of economic development projects are among the major concerns when such projects are discussed. In the phenomenon's extreme form, the so-called "boom town," population growth and demand for services outstrips the community's infrastructure, leading to social impacts through declining service quality and availability (Gilmore and Duff 1975). There are two basic approaches in the literature (Leistritz and Murdock 1981) for projecting community services impacts: 1) those focusing on new population, which is multiplied times national, regional, or local standards of average units of services per capita; and 2) those focusing on existing services. In the latter case new service requirements are based on marginal demands (demands for service above current local capacity). The average units approach

assumes that existing service bases reflect no excess supply or demand for services. The approach may therefore be in error in a given instance because of excess capacity in the system or institutional constraints. The marginal approach is dependent on obtaining reasonable estimates of current capacity of community services such as education facilities, water treatment plants, etc., which may be very difficult to do (Jones and Murdock 1978; Leistritz and Murdock 1981).

There are also two fundamental ways in which service standards are selected for analysis of community services impacts. These are the use of current local service standards and the use of more generalized standards. The first approach assumes that new population in a region will be similar in its demand for community services to the existing population. If the local communities are currently providing a given level of medical services, for example, it is assumed that the new population will be content with the same level of services. This may or may not be the case. The second approach is based on the presumption that new residents are likely to bring with them demands for community services typical of the nation as a whole or typical for a given size-class of community. Impact models containing these generalized standards include the Argonne National Laboratory's SEAM model (Stenehjem and Metzger 1976) and North Dakota State University's NEDAM model (Leistritz, et al. 1982).

Because of the great difficulty in knowing the capacity of existing community services in a given community, CCAM focuses on the new population in the region and forecasts overall community service demand on an average-units, per capita basis rather than directly attempting to determine marginal demands for new services and infrastructure. If the user then has capacity information about a specific community, he may be able to compare this estimated demand to existing capacity and learn whether additional investments may be necessary. The single exception to this approach in CCAM is in housing, where demand for occupied housing is compared to the existing housing stock in each year.

The CCAM model permits a mix of methods in determining service standards. If the user wishes to use historical average per capita service standards for a given location, CCAM contains a method for constructing estimates from information contained in the U.S. Census Bureau's County and City Data

Book on counties, cities, and places (the latter have less than 25,000 population but more than 2,500 population). In those cases of cities where data are not available, or in cases where the user wishes to override the local per capita service standard with standards of community services typical of the nation as a whole, CCAM contains a data set on services standards sorted by size of community. Finally, the user may override both options by editing the model's parameter file and replacing default entries with ones he believes are more representative for the situation he is investigating. Lists of variables and default national service standards are shown in Section 3.0.

3.0 CCAM DATA AND MODEL DESCRIPTION

This section explains the CCAM Model in more detail, beginning with the data sets that need to be prepared to run CCAM. Following this, a brief explanation is given of how CCAM processes the input data sets. Finally, a list of output variables and options that CCAM produces is presented.

The data sets created in this section are required by the main CCAM program, called CCAM.PROGRAM. A copy may be found in account LCM6883 and copied to the user's account. Hard copy of the code is shown in Appendix A. The job control language in CCAM.PROGRAM designates five input data sets. The last of these is the MASTER model output data set containing employment and population data to be allocated by CCAM. The data set's name will be the name the user assigned it when he ran MASTER. The other four data sets are described in this section. The user will use them to replace the ones contained in CCAM.PROGRAM when he copied it to his account.

DATA SET CREATION

To use CCAM, four ASCII data sets need to be created. They need to be created on the user's account on the Energy Information Administration (EIA) computer, and are called:

1. COUNTY.CCAM.DATA
2. CITY.CCAM.DATA
3. PLACES.CCAM.DATA
4. CCAM.DRIVER.

The data set COUNTY.CCAM.DATA contains all the county level data for the region. All the counties that are contained in the MASTER region need to be entered in this data set.

The format for entering this data set is as follows:

```
YEAR CROSS COUNTY XC1 XC2 XC3 XC4 XC5 XC6 XC7 XC8 XC9 XC10
```

These variables are entered on the first line; on the second line, the variables entered are:

XC11 XC12 XC13 XC14 XC15 XC16 XC17 XC18 XC19 XC20 XC21 XC22

On the third line, the variables entered are:

XC23 XC24 XC25 XC26 XC27 XC28 XC29 XC30 XC31 XC32 XC33 XC34

The fourth line contains the variables:

XC35 XC36 XC37 XC38 XC39 XC40 XC41 XC42 XC43 XC44 XC45 XC46 XC47

Table 3.1 contains the information on what each coded variable represents at the county, city and place level. Most of the variables used are from the County and City Data Book, 1983⁽²⁾ and are self-explanatory. The only variables that need additional explanation are the variables CROSS and COUNTY. The variable CROSS is the unique Federal Information Processing Standard (FIPS) number the user assigned to the county or county groups when he created the input data sets for MASTER.⁽³⁾ The COUNTY variable is the state and county code number from the County and City Data Book, 1983.

The data are entered as an ASCII data set. It takes four lines to enter the information for one county. If the County and City Data Book has a letter or a dot for a particular variable, enter the variable as a dot, i.e., (.). An example of the data format for a county is contained in Table 3.2.

(2) U.S. Department of Commerce, Bureau of the Census, County and City Data Book, 1983. U.S. Government Printing Office, 1983.

(3) The number in the case of a Metropolitan Statistical Area (MSA) is its FIPMSA number.

TABLE 3.1. Definitions of CCAM's Input Variables

<u>Counties</u>	
XC1	= Population, 1980 (April 1), total persons
XC2	= Hospitals, 1980 (number)
XC3	= Hospital beds, 1980 (number)
XC4	= Nursing homes, 1980 (number)
XC5	= Nursing homes, 1980, beds
XC6	= Nursing homes, 1980, estimated residents
XC7	= Serious crimes known to police, 1981 (number)
XC8	= New private housing units authorized by building permits, 1981 (number)
XC9	= New private housing units authorized by building permits, 1981, units in structure, percent with one unit.
XC10	= New private housing units authorized by building permits, 1981, units in structure, percent with five or more units
XC11	= New private housing units authorized by building permits, 1981, valuation (\$1000)
XC12	= Housing, 1980 (April 1), total units
XC13	= Year-round housing units, 1980 (April 1), Units in structure, percent with one unit
XC14	= Year-round housing units, 1980 (April 1), units in structure, percent with five or more units
XC15	= Year-round housing units, 1980 (April 1), occupied units - owner occupied - median monthly costs (dollars)
XC16	= year-round housing units, 1980 (April 1), occupied units - owner occupied - median value (dollars)
XC17	= Year-round housing units, 1980 (April 1), occupied units - renter occupied - total
XC18	= Year-round housing units, 1980 (April 1), occupied units - renter occupied - median gross rents

TABLE 3.1. (contd)

XC19	= Money income, 1979, per capita (dollars)
XC20	= Local government employment, 1977 (October), total full-time equivalent employees.
XC21	= Federal civilian government employees, 1981 (number)
XC22	= Manufactures, 1977, establishments - total
XC23	= Manufactures, 1977, all employees - number (1000)
XC24	= Wholesale trade, 1977, number of establishments
XC25	= Wholesale trade, 1977, sales (millions of dollars)
XC26	= Wholesale trade, 1977, paid employees
XC27	= Retail trade, 1977, establishments (number)
XC28	= Retail trade, 1977, sales, all establishments - total (\$1000)
XC29	= Retail trade, 1977, sales - selected kind of business, percent from general merchandise group stores
XC30	= Retail trade, 1977, sales - selected kind of business, percent from eating and drinking places
XC31	= Retail trade, 1977, establishments with payroll, paid employees
XC32	= Selected service industries, 1977, establishments (number)
XC33	= Selected service industries, 1977, receipts, all establishments (\$1000)
XC34	= Selected service industries, 1977, receipts by selected kinds of business, percent from hotels, motels, trailer parks and camps
XC35	= Selected service industries, 1977, receipts by selected kinds of business, percent from automotive repair services and garages
XC36	= Selected service industries, 1977, receipts by selected kinds of business, percent from amusement and recreation services
XC37	= Selected service industries, 1977, establishments with payroll-paid employees

TABLE 3.1. (contd)

XC38	= Land area, 1980, square miles
XC39	= Education, 1980, school enrollment (persons 3 years old and over), total
XC40	= Education, 1980, school enrollment (persons 3 years and over), elementary and high school
XC41	= Labor force, 1980, (census) total
XC42	= Labor force, 1980, (census) civilian labor force percent - unemployed
XC43	= Money income, 1979, income below poverty level, persons, number (1000)
XC44	= Physicians, active nonfederal 1980 (year end)
XC45	= Dentists, active 1979 (year end)
XC46	= Nurses, active and registered 1977
XC47	= Households, 1980 (April 1), persons per household, total.

Cities

X1	= Population, 1980 (April 1), total persons
X2	= Hospitals (number), 1980
X3	= Hospital beds (number), 1980
X4	= Serious crimes known to police, 1981
X5	= New private housing units authorized by building permits, 1981 (number)
X6	= New private housing authorized by building permits, 1981 (number), one unit
X7	= New private housing units authorized by building permits, 1981 (number), five or more units

TABLE 3.1. (contd)

X8	= New private housing units authorized by building permits, 1981, valuation (\$1000)
X9	= Housing, 1980 (April 1), total units
X10	= Year-round housing units, 1980 (April 1), units in structure, percent with one unit
X11	= Year-round housing units, 1980 (April 1), units in structure, percent with five or more units
X12	= Year-round housing units, 1980, occupied units - owner occupied - median monthly costs (dollars)
X13	= Year-round housing units, 1980, occupied units - owner occupied - median value (dollars)
X14	= Year-round housing units, 1980, occupied units - renter occupied - total
X15	= Year-round housing units, 1980, occupied units - renter occupied - median gross rent (dollars)
X16	= Money income, 1979, per capita income (dollars)
X17	= City government employment, 1981 (October), total full-time equivalent employees
X18	= Federal civilian government employees, 1980
X19	= Manufactures 1977, establishments
X20	= Manufactures 1977, all employees, number (1000)
X21	= Wholesale trade, 1977, number of establishments
X22	= Wholesale trade, 1977, sales, million dollars, total
X23	= Wholesale trade, 1977, paid employees
X24	= Retail trade, 1977, establishments, number
X25	= Retail trade, 1977, sales all establishments, total (\$1000)
X26	= Retail trade, 1977, sales by selected kinds of business, percent from food stores

TABLE 3.1. (contd)

X27	= Retail trade, 1977, sales by selected kinds of business, percent from general merchandise group stores
X28	= Retail trade, 1977, sales by selected kinds of business, percent from eating and drinking places
X29	= Retail trade, 1977, sales by selected kinds of business, percent from gasoline service stations
X30	= Retail trade establishments with payroll-paid employees
X31	= Selected service industries, 1977, establishments, total
X32	= Selected service industries, 1977, receipts, all establishments, total (\$1000)
X33	= Selected service industries, 1977, receipts by selected kinds of business - percent from hotels, motels, trailer parks and camps
X34	= Selected service industries, 1977, receipts by selected kinds of business - percent from automotive repair services and garages
X35	= Selected service industries, 1977, receipts by selected kinds of business - percent from amusement and recreation services
X36	= Selected service industries, 1977, establishments with payroll, paid employees
X37	= Land area, 1980, square miles
X38	= School enrollment, 1980 (persons three years old and over), total
X39	= School enrollment, 1980 (persons three years old and over), elementary and high school
X40	= Labor force, 1980 (census), total
X41	= Labor force, percent unemployed
X42	= Money income, persons below poverty level in 1979, number (1000)
X43	= Households, 1980 (April 1), persons per household
Distance	= Distance from city to work site in miles
Degrees	= Direction in degrees to city from work site (0° to 360°. True north is 0°.)

TABLE 3.1. (contd)

Places

X1	= Population, 1980 (April 1) total persons
X9	= Total housing units, 1980
X13	= Occupied housing units, 1980 (April 1), owner occupied, median value (dollars)
X15	= Occupied housing units, 1980 (April 1), median gross rent (dollars)
X16	= Money income, 1979, per capita
X37	= Land area, 1980, square miles

Distance = Distance from city to work site in miles

Degrees = Direction in degrees of place from work site (0° to 360°. True north is 0°.)

All data except Distance and Degrees are from:
U.S. Department of Commerce, Bureau of the Census, County and City Data Book, 1983. U.S. Government Printing Office, 1983.
Distance and degrees must be supplied by the user.

TABLE 3.2. Data Format

	<u>County</u>
1983	201 35015 47855 2173 1 116 106 2432 18154 75.6 8 261 32000 4616 190 6057 1518 286 43 1 100 82 642 473 138378 9.1 7.6 2465 356 25926 33.6 11.3 5.7 1177 4148 11551 10488 18917 5.0 6.4 38 15 129 2.85

	<u>City</u>
1983	201 350055 2 25476 1 139 1710 229 27.1 52.0 5925 9811 77.3 10.7 263 33400 2683 201 6107 273 251 25 . 55 46 353 302 97225 24.0 11.4 7.2 5.1 1800 230 16017 . 11.2 5.6 801 21.7 5928 5367 9864 5.4 3.3 2.74 20 270

	<u>Place</u>
1983	201 1 10385 4030 29100 167 6170 4.1 40 315

CITY DATA

The procedures necessary to enter the city data are similar to the county data set procedures. Cities are defined according to the County and City Data Book, 1983 as centers with populations greater than 25,000. Data on these population centers are entered into a data set called CITY.CCAM.DATA.

The input format is as follows:

YEAR CROSS COUNTY CITY X1 X2 X3 X4 X5 XC6

on the first line; the second line contains

X7 X8 X9 X10 X11 X12 X13 X14 X15 X16

while the third line contains the variables,

X17 X18 X19 X20 X21 X22 X23 X24 X25 X26

and the fourth line has the variables,

X27 X28 X29 X30 X31 X32 X33 X34 X35 X36

The fifth line contains the variables.

X37 X38 X39 X40 X41 X42 X43 Distance Degrees

Table 3.1 contains the definitions of all the coded variables used in creating the city data set. The variables used are found in the County and City Data Book, 1983. Again, if a variable has a missing value or a letter associated with it, enter it as a missing value, i.e., a dot (.).

The variables YEAR and COUNTY are, as explained, for the county data set. Two variables that the user will have to estimate and compute are DISTANCE and DEGREES. DISTANCE refers to the number of miles a city is located from a given point in space, such as the distance a city is located from a large energy construction project. DISTANCE must be computed from area maps. DEGREES is the variable that indicates the radial direction of city from an economic development project such as a large energy construction project. DEGREES is measured in degrees from 0 to 360 degrees (true north equals 0 degrees). DISTANCE and DEGREES should be computed as accurately as possible. A large-scale local area map should be consulted, if possible.

PLACES DATA

Since the County and City Data Book lists all population centers with populations greater than 25,000 persons as a city and those centers of population less than 25,000 persons as places, the user must create a third data set called: PLACES.CCAM.

The input format for this is:

YEAR CROSS CITY X1 X9 X13 X15 X16 X37 DISTANCE DEGREES

Again, Table 3.1 contains the definitions for each of the coded variables and Table 3.2 gives an example of the input format for a county, city and place. The variables for a place are similar to those required for the creation of CITY.CCAM.DATA.

The variable CITY contained in both the CITY.CCAM.DATA set and the PLACES.CCAM.DATA set is a number or code that is assigned to each city. The user needs to make an alphabetical listing of all cities and places within a region or subregion and number or code them sequentially. For example, if a region or subregion contains five cities whose alphabetical ranking is 1, 4, 6, 8, 9; and 5 places whose alphabetical ranking is 2, 3, 5, 7, 10, then when the city and place data sets are later merged, they will form a data set that is sequential with respect to numbers of cities and places within the region, e.g., cities and places 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

The final data set that needs to be completed is CCAM.DRIVER. This data set is similar to the data set CROSYEAR.Y7735 that the user may have created for MASTER.CCAM.DRIVER. CCAM. DRIVER contains three variables: CROSS CITY YEAR. The data set is an ASCII data set, and the variables are entered in the above format shown in Table 3.3 a space left between each variable. The CROSS variable must correspond to the region or subregion contained in the MASTER output data set the user has created.

The user also needs to create a city with the number 99. This is a "fake" city, entered for completeness, that represents a location for all county economic activity that is not allocated to cities. An example of this would be activity that is located outside of any city's city limits but still within the county. Another example would be activity in a city where no data are available at the city level. One city with the 99 designation needs to be created for each subregion; i.e., one for each CROSS.

This completes the creation of region-specific data sets. However, not all the information required by users is contained in the regional data sets. This necessitates acquiring state level data and the use of national standards, in some cases, as described below.

TABLE 3.3. Variable Format for CCAM Driver Variables

<u>CROSS</u>	<u>CITY</u>	<u>YEAR</u>
201	1	1979
201	1	1980
201	1	1981
201	1	1982
.	.	.
.	.	.
.	.	.
201	1	2030
201	2	1979
.	.	.
.	.	.
.	.	.
201	2	2030
.	.	.
.	.	.
.	.	.
201	99	1979
.		
.		
.		
201	99	2030
1601		1979
.	.	.
.	.	.
.	.	.
1601	1	2030
.	.	.
.	.	.
.	.	.
1601	99	2030

STATE LEVEL DATA

Because some of the data required by CCAM are not readily available at the county or city level, the model provides for the use of statewide or national data in their place. If the user has better information, he may, of course, substitute these county or city-specific data for statewide or national data.

The state level variables are: natural gas consumption in therms per capita per day; electricity consumption in kWh per capita per day; electricity capacity in kWh per capita per day; car registrations per capita; water consumption in gallons per capita per day; sewage in gallons per capita per day; total persons under correctional supervision per number of reported crimes; persons under correctional supervision in jail per number of reported crimes; persons under correctional supervision in prison per reported crime; persons under correctional supervision on parole; and number of registered trucks per capita. All information concerning the above variables are from the Statistical Abstract.⁽³⁾ The following tables refer the user to the appropriate tables in the Statistical Abstract to acquire the necessary information.

Table 320 on page 192 contains the information on the number of persons under correctional supervision including the total in jail, in prison, on parole, or on probation are expressed as a ratio of the total persons under correctional supervision. The total number of persons under correctional supervision is expressed as a ratio to total crime.

The total number of crimes within a state is extracted from the County and City Data Book 1983.

The information on electricity consumption and capacity is in Table 1000 on page 584 of the Statistical Abstract. The user must convert the stated figures into per-capita consumption and capacity per day, both in kWh. The natural gas consumption figures are from Table 1007, page 588 for total usage. The numbers are converted into therms per capita per day. The data on

(3) Statistical Abstract of the United States: 1984, U.S. Bureau of the Census (104th edition). Washington, D.C. 1983.

water consumption are from Table 350 under the column of fresh water consumed. The number is converted to per-capita consumption per day. Sewage ratio is calculated as seventy (70%) of fresh water consumed. The justification of the seventy percent figure is found in a report by D. J. Stenehjem and Metzger, which stated that roughly seventy (70%) of water used ends up as sewage.⁽⁴⁾

The information on vehicle registration is from Highway Statistics 1979.⁽⁵⁾ The user should use the data from the table on page 15 for total motor vehicles 1979 totals. This information should be expressed as a ratio of total vehicles registered per capita. Another variable of total trucks registered must be acquired from the table on Truck and Tractor-Truck Registration on page 18, for total trucks registered in 1979. Again, this number is expressed as a ratio of total trucks registered to population.

Once all the ratios are computed, the user sets up a SAS DO LOOP or changes the existing DO LOOPS within CCAM.PROGRAM, under DATA CCOUNT2 (line 537).

The user makes these changes by first changing the CROSS = statements at lines 622, 643 or 664 to reflect the CROSS he is interested in. The CROSS must match the ones contained in the MASTER output data set. The state data are then used for the CROSS that is contained within the state. The user replaces the numbers (e.g. at line 623) under the appropriate variables within the CROSS DO LOOP with his newly created ones. The variables that need to be changed are: GASCON, ELECON, ELECCAP, TRAFFIC, WATERCON, SEWAGE, PCS, PCSJ, PCSPR, PCSA, PCSPRO and TT. For a complete definition of these variables and of all the variables CCAM forecasts, see Table 3.4.

(4) A Framework for Projecting Employment and Population Changes Accompanying Energy Development (Vol. 2). E. J. Stenehjem and J. E. Metzger. Argonne National Laboratory, Argonne, Illinois. May 1980. Page 39.

(5) Highway Statistics, 1979. 1979. Federal Highway Administration. U.S. Department of Transportation.

TABLE 3.4. Definitions of CCAM's Forecasted Variables

AGE	= Agricultural employment
ALLO	= Allocation ratio
AMUSE	= Number of amusement facilities
ARA	= Automobile repair commercial construction activity, additions and alterations (in square feet)
ARN	= Auto repair facility, new construction activity (in square feet)
ASE	= Agricultural services, forestry, and fisheries employment
AUTO	= Number of automobile repair facilities
BIRTH	= Births
CITYGOVE	= Number of city government employees
CONE	= Construction employment
CRIME	= Number of serious crimes
DEATH	= Deaths
DEGREES	= Direction of city in degrees from work site (0° equals true north)
DISTANCE	= Distance in miles from city to work site
DME	= Durable manufacturing employment
EDA	= Education construction activity - additions and alterations (in square feet)
EDN	= Education, new construction activity (in square feet)
EDP	= Number of eating and drinking places
EIECCAP	= Electricity capacity in kWh per capita per day
EIECCON	= Electricity consumption in kWh per capita per day
EMPLOY	= Total employment
FEDE	= Number of federal government employees
FIRE	= Finance, insurance, and real estate employment
FS	= Number of food stores
GASCON	= Natural gas consumption in therms per capita per day
GMS	= Number of general merchandise stores
GOVE	= Government employment
GSS	= Number of gas stations
HA	= Number of housing units available

TABLE 3.4. (contd)

HC	= Total housing cost in 1985 dollars, monthly (sum of monthly mortgage payments plus monthly housing upkeep)
HCM	= Housing cost, monthly mortgage payments (1985 dollars)
HCUK	= Housing cost, monthly upkeep (1985 dollars)
HD	= Housing demand (units demanded)
HEALTH	= Health construction activity - additions and alterations (square feet)
HEALTHN	= Health, new construction activity (square feet)
HMF	= Housing stock, multi-family
HOTMOT	= Number of hotel and motels
HOTMOTA	= Hotel and motel, commercial construction activity - additions and alterations (square feet)
HOTMOTN	= Hotel and motel, new construction activity (square feet)
HOSP	= Number of hospitals
HOSPBEDS	= Number of hospital beds
HS	= Total housing stock
HSF	= Housing stock, single family
INCOME	= Total personal income (1985 dollars)
INSUR	= Social insurance adjustment (1985 dollars)
IS30	= Interceptor sewer, feet of 30 inch pipe
IS36	= Interceptor sewers, feet of 36 inch pipe
IS42	= Interceptor sewers, feet of 42 inch pipe
LBC	= Number of library books
LCPR	= Number of library periodicals, records, and tapes
LF	= Total labor force
LSNP	= Number of nonprofessional library staff
LSP	= Number of professional library staff
LST	= Number of total library staff
MANEST	= Number of manufacturing establishments
MH	= Number of mobile homes
MIG	= Average net migration
MINE	= Mining employment

TABLE 3.4. (contd)

MISA	= Miscellaneous commercial construction activity - additions and alterations (square feet)
MISN	= Miscellaneous new construction activity (square feet)
NA	= Number of ambulances
NDENTIST	= Number of dentists
NDME	= Nondurable manufacturing employment
NDOCTOR	= Number of physicians
NEMTS	= Number of emergency medical technicians
NES	= Number of elementary schools
NFT	= Number of fire trucks
NHS	= Number of high schools
NPO	= Number of police officers
NPV	= Number of police vehicles
NURSES	= Number of nurses
NW	= Number of individuals on welfare
OBA	= Office building construction activity - additions and alteration (square feet)
OBN	= Office buildings, new construction activities (square feet)
PCS	= Number of persons under correctional supervision
PCSJ	= Number of persons under correctional supervision in jail
PCSPA	= Number of persons under correctional supervision on parole
PCSPR	= Number of persons under correctional supervision in prison
PCSPRO	= Number of persons under correctional supervision on probation
PERCAP	= Per capita personal income (1985 dollars)
POPC	= Population
POPDEN	= Population density in persons per square mile
PROPY	= Property income (1985 dollars)
PUBA	= Public construction activity - additions and alterations (square feet)
PUBN	= Public new construction activity (square feet)
PUPE	= Public utilities, transportation and communications
RELA	= Religious construction activity - additions and alterations (square feet)
RELN	= Religious new construction activity (square feet)

TABLE 3.4. (contd)

RENTS	= Monthly rents (1985 dollars)
RESAD	= Residence adjustments to regional personal income (1985 dollars)
RFCP	= Recreational facilities: community parks (number of acres)
RFPG	= Recreational facilities: playgrounds (number of acres)
RFWP	= Recreational facilities: neighborhood parks (number of acres)
RHU	= Rental housing units
RS	= Retail sales (1985 dollars)
RSE	= Number of retail establishments
RSFT	= Recreational staff (full time)
RSPT	= Recreational staff (part time)
RTE	= Retail trade employment
RTWHA	= Retail-wholesale construction activity - additions and alterations (square feet)
RTWHN	= Retail and wholesale new construction activity (square feet)
SEWAGE	= Gallons of sewage per capita per day
SSE	= Services employment
SSEST	= Number of selected service establishments
SSS	= Selected service sales (1985 dollars)
SWSSM	= Solid waste service standards (number of persons employed in service)
SWSST	= Solid waste service standards (number of trucks)
TRAFFIC	= Number of registered cars and trucks
TRANSPAY	= Transfer payments (1985 dollars)
UER	= Unemployment rate
VR	= Vacancy rate
WAREA	= Warehouse construction activity - additions and alterations (square feet)
WAREN	= Warehouse new construction activity (square feet)
WATERCON	= Water consumption (in gallons) per capita per day
WB	= Wage bill (1985 dollars)
WHS	= Wholesale sales (1985 dollars)
WHSEST	= Number of wholesale establishments
WSTL33	= Water supply transmission lines: feet of 33 inch pipe

TABLE 3.4. (contd)

WSTL36	= Water supply transmission lines: feet of 36 inch pipe
WSTL38	= Water supply transmission lines: feet of 38 inch pipe
WSTL48	= Water supply transmission lines: feet of 48 inch pipe
WTE	= Wholesale trade employment
X37	= Size of city in square miles

NATIONAL STANDARDS

National standards are used in CCAM to forecast community service requirements when region-specific data are not available. The national standards are city size-specific. The city sizes utilized for this purpose in CCAM are: population greater or equal to 100,000; population greater or equal to 30,000 and less than 100,000; population greater or equal to 10,000 and less than 30,000; and population less than 10,000. The variables by city size are listed in Table 3.5.

The variables are forecasted by city size, within a series of SAS DO LOOPS. The DO LOOPS are set up for cities with population over 100,000; for cities between 30,000 and 99,999 population; for cities between 10,000 and 29,999 population; and for cities less than 9,999. The user, if he has better data, may replace the national data with site-specific data by changing the estimated coefficients for the variables in each DO LOOP between lines 540 and 619 for each city size or he may select one set for all cities within the region.

TABLE 3.5. Community Service Requirements by City Size (All ratios per capita amounts, unless otherwise stated. See Table 3.4 for names of variables.)

Variable Name	City Size by Population			
	>100,000	100,000-30,000	30,000-10,000	<10,000
IS30	--	--	1.7735	1.9314
IS36	--	1.0453		--
IS42	0.69314	--		--
LBC	3	3.5	3.5	4
LCPR	0.0650	0.0731	0.0731	0.1100
NA	1 x NFS	1 x NFS	1 x NFS	1 x NFS
NEMTS	2.2 x NA	2 x NA	2 x NA	2 x NA
NES	1 school per 800 population 5-13 years old	1 school per 800 population 5-13 years old	1 school per 800 population 5-13 years old	1 school per 800 population 5-13 years old
NHS	1 school per 1800 population 14-17 years old	1 school per 1800 population 14-17 years old	1 school per 1800 population 14-17 years old	1 school per 1800 population 14-17 years old
NFM	0.00181	0.00144	0.00099	0.00108
NFS	0.000156	0.000131	0.000117	1
NFT	2 x NFS	2.5 x NFS	2.5 x NFS	3
NPG	0.00325	0.00217	0.002	0.00184
NPV	0.00051	0.00040	0.00033	0.00015
RFCP	0.00097	0.00096	0.0011	0.00136
RFNP	0.00065	0.00067	0.00081	0.00136
RFPG	0.00403	0.00296	0.00096	0.00121
RSFT	0.0008	0.00055	0.0004	0.00055
RSPT	0.0015	0.0024	0.0025	0.003
SWSSM	0.00026	0.00032	0.00036	0.00053
SWSST	0.000085	0.0000102	0.000116	0.000131
WSTL33	--	--	0.2662	--
WSTL36	--	--	--	0.2899
WSTL38	--	0.2093	--	--
WSTL48	0.2079	--	--	--

Source: Adopted from E. J. Stenehjem and J. E. Metzger, A Framework for Projecting Employment and Population Changes Accompanying Energy Development. Vol. II Argonne National Laboratory, Argonne, Illinois 60439. Where necessary, all ratios were converted to per capita figures from per thousand dwelling units by use of the formula: $(x/2.77)/1000$ where x is the existing number and 2.77 is the national average of persons per household.

4.0 OPERATING CCAM

Once all the data sets are created the user is ready to run CCAM. There are several options the user has for running CCAM.

The first option involves the value the user wants to use for the exponent associated with the gravity model, which allocates population to the individual cities. The default value is an exponent of 2.0. Other appropriate values are between 0.5 and 3.0. The user may select any value for which he has information, although present literature seems to suggest that an exponent of 2.0 is most appropriate for many regions. To change the exponent, the user must locate the statement "A2 = 2;" and modify the = 2 to the number the user wants. The user must also locate the statement A2 2 and change the second 2 to the number the user replaced in the A2 = 2 statement. These statements are found at lines 361, 442, 500, and 861 in CCAM.PROGRAM.

A change occurs in this procedure when the user wants to run CCAM to assess the distribution of the economic activity in a baseline case. The user needs to delete the statements DC = 1; (line 314) and DISTANCE = 1; (line 316). These statements are removed in the baseline case because the distance variable refers to the distance between the city and the plant location of a proposed economic development project. Since the baseline case assumes no proposed plant activity, therefore, any reference is irrelevant.

As explained in Section 2.0 the procedure used in CCAM to allocate population and economic activity is a modified gravity procedure of the form:

$$\text{Attractiveness} = (\text{POP}_{it} / \text{distance} * A2) / \sum_{i=1}^n (\text{POP}_{it} / \text{DISTANCE} * A2)$$

The procedure is a modified gravity model. An index of attractiveness is computed each period with that period's current population. The user may exercise the option of weighting population by retail sales (RS), employment (EMPC), housing availability (HA), or some other variable by multiplying population by the respective variables. If the user chooses to weight population,

the user must make sure he has located and changed all attractiveness indexes within CCAM. These attractiveness indexes are known as ALL0D, = ALLO = and ALL0DC, which are located on lines 443, 501 and 862, respectively.

The final option is the level of aggregation the user wants reported. CCAM will print all the variables listed in Table 3.4 by city and county, yearly. The default printout is at the county level. However, the user may want city level output, for example. To acquire city level data the user needs to insert a PROC PRINT; statement after the PROC SORT. statement associated with DATA CCOUNT4 (line 764).

The final step before the user can run CCAM is to locate the statements IF CROSS = or IF CROSS = and insert the CROSS(ES) the user is interested in. CCAM has been run for up to seventy-eight (78) cities per subregion. The CROSS = and IF CROSS = statements are found at lines 11, 22, 33, 305, 622, 643, 664, and 794.

5.0 VALIDATION AND SENSITIVITY TESTING

The CCAM model is designed to forecast economic and population impacts of development projects. Population and employment data were not available at the time the model was developed to permit direct testing of model forecasts against actual historical data. Since then, time series data have become available on the migrant labor force associated with the Tennessee Valley Authority's Hartsville Nuclear Plant (HNP) project near Hartsville, Tennessee. Tennessee Valley Authority kept track of the location of the plant construction labor force. It is therefore possible to check whether the actual pattern of immigration to the area could have been predicted by CCAM's gravity model and to test the sensitivity of the distribution of employment changes to differing values of the distance coefficient. The evaluation is summarized in Table 5.1. It was not possible to validate CCAM's prediction of local service demands since baseline demands were available for one year only and virtually no information was available on changes in demand associated with the Hartsville Nuclear Plant project.

Table 5.1 shows the predicted and actual location of HNP project personnel in 25 communities surrounding the Hartsville nuclear site. These communities contained about 70 percent of all HNP personnel, about 87 percent of all in-migrating workers who responded to TVA's survey, every city supplying more than one percent of the project workforce, and every city containing five or more HNP workers who had moved to town. In general, the table shows that large numbers of employees and large numbers of movers (in-migrants) were located in the communities where they were predicted by the model to locate; however, the simple gravity procedure was not particularly accurate in predicting exactly how many would locate in a given community. There were, however, several data problems and special factors known to influence workers' locational decisions (but not accounted for in the model) in this case that may have contributed to model inaccuracy.

- The model does not take into account either housing availability or skills in the local labor force.

TABLE 5.1. Validation Test of CCAM Gravity Model, Hartsville Nuclear Plant

City	TVA Estimated Population(a)	Miles of Road Distance from HNP to City (Estimated)(b)	(Population/ Distance) ²	3-31-78 Estimated Workers(c)	3-31-78 Actual HNP Workers(d)	3-31-78 Estimated Movers(e)	3-31-78 Actual Movers(f)
Carthage	2,491	12	17.3	109	138	34	42
Gallatin	13,362	23	25.3	160	479	49	192
Hartsville	2,243	4.5	110.8	699	315	215	166
Hendersonville	28,000	37	20.5	129	168	40	59
Lafayette	2,583	18	8.0	50	208	16	78
Lebanon	12,492	16	48.8	308	377	95	151
Nashville	469,000	50	187.6	1,183	484	364	47
Castalian Springs	150	8.7	2.0	13	76	4	58
Dixon Springs	100	2.5	16.0	101	42	31	22
Baxter	1,314	37	1.0	6	62	2	7
Cookeville	17,800	48	7.7	49	61	15	11
Gordonsville	601	17	2.1	13	32	4	7
Murfreesboro	28,700	43	15.5	98	32	30	10
Portland	3,081	37	2.3	15	40	4	5
Red Boiling Springs	956	31	1.0	6	53	2	8
Smithville	3,762	51	1.4	9	92	3	5
Westmoreland	1,423	40	0.9	6	47	2	12
Bethpage	400	33	0.4	3	35	1	12
Goodlettsville	7,541	45	3.7	23	46	7	10
Mount Juliet	1,568	31	1.6	10	70	3	13
Old Hickory	6,000	43	3.2	20	44	6	6
Pleasant Shade	150	16	0.6	4	25	1	11
Watertown	1,061	29	1.3	8	29	3	7
White House	1,305	38	0.9	6	17	2	6
Scottsville	3,584	35	2.9	18	64	6	5
Madison	21,500	46	10.2	64	73	20	6
Total	631,167		493.0	3,110	3,109	959	956

(a) From Tennessee Valley authority, Hartsville Nuclear Plants Socioeconomic Monitoring and Mitigation Report, March 31, 1978, Knoxville, Tennessee, September 1978, Appendix A.

(b) Estimated by authors from county maps.

(c) Estimated as $3,109 * (P_i/D_i^2) / \sum (P_i/D_i^2)$, for each city i.

(d) Same source as footnote (a).

(e) Estimated as $958 * (P_i/D_i^2) / \sum (P_i/D_i^2)$, for each city i.

(f) Same source as footnote (a).

- TVA ran a system of shuttle buses from several of the larger communities in the area. This probably distorted commuter patterns and also made it practical for the project to draw workers from more distant locations. It also reduced Hartsville's relative attractiveness as a residential location.

- Nashville was right on the edge of the practical commuting zone, as demonstrated by the fact that almost no workers commuted to the site from towns to the west of Nashville. However, Nashville itself is quite large in area and its population comprises almost three-quarters of the population of the 25 communities in the table. Because Nashville is large in area, potential HNP employees might have had to travel as little as 40 miles or much as 60 miles to reach the Hartsville site. This tends to make the miles of road distance to Nashville extremely uncertain.
- Road distance does not completely capture commuting time and cost because different segments of road may have different average driving speeds associated with them.
- TVA's population estimates do not necessarily apply to the same date as the estimated workforce. This could substantially affect the allocation factor in the gravity model, and hence, the forecast.
- The TVA requested a "mailing address" location rather than a jurisdictional location. In some cases, this influenced the estimate of total workers and number of workers.

Table 5.1 shows a significant overestimate of total employees for Hartsville and Nashville and an underestimate for Gallatin and Lafayette. It appears that many of the workers who the model predicted would live in Hartsville actually decided on Gallatin, a significantly larger community, but only 18 miles further from the plant site. The reasons for the significant preference for Lafayette are less clear. The model's estimate for Nashville is clearly influenced by Nashville's very large size. Probably there is very little impact on locational decision or quality of relevant city services for size of community much larger than 100 thousand persons, but the simple gravity model gives population "credit" for 469 thousand.

The CCAM model is highly sensitive to changes in the coefficient on distance. It is recommended for areas where historical impact data are available that the model be calibrated by performing estimates as shown in Table 5.2 with

TABLE 5.2. Validation Test of CCAM Gravity Model, Hartsville Nuclear Plant, with Alternative Population and Distance Effects^(a)

City	Adjusted Estimated Population	(Population/ Distance) ^{1.5}	3-31-78 Estimated Workers	3-31-78 Actual Workers	3-31-78 Estimated Movers	3-31-78 Actual Movers
Carthage	2,491	59.9	129	138	40	42
Gallatin	13,362	121.1	260	479	80	192
Hartsville	2,243	235.0	505	315	156	166
Hendersonville	28,000	124.4	267	168	82	59
Lafayette	2,583	33.8	73	208	22	78
Lebanon	12,492	195.2	420	377	129	151
Nashville	100,000 ^(b)	282.8 ^(c)	608	484	187	47
Castalian Springs	150	5.8	12	76	4	58
Dixon Springs	100	25.3	54	42	17	22
Baxter	1,314	5.8	12	62	4	7
Cookeville	17,800	53.5	115	61	35	11
Gordonsville	601	8.6	18	32	6	7
Murfreesboro	28,700	101.8	219	32	67	10
Portland	3,081	13.7	29	40	9	5
Red Boiling Springs	956	5.5	12	53	4	8
Smithville	3,762	10.3	22	92	7	5
Westmoreland	1,423	5.6	12	47	4	12
Bethpage	400	2.1	5	35	1	12
Goodlettsville	7,541	25.0	54	46	17	10
Mount Juliet	1,568	9.1	20	70	6	13
Old Hickory	6,000	21.3	46	44	14	6
Pleasant Shade	150	2.3	5	25	2	11
Watertown	1,061	6.8	15	29	5	7
White House	1,305	5.6	12	17	4	6
Scottsville	3,584	17.3	37	64	11	5
Madison	21,500	68.9	148	73	46	6
Total	262,167	1163.7	3,109	3,109	959	956

(a) Sources of columns same as Table 5.1.

(b) Restricted to 100,000 population. See text.

(c) Based on 50 miles, the center of Nashville, rather than the nearest point to the work site.

alternate values of distance, population, or the distance coefficient until the best fit to historical data is obtained. A value of 2.0 may be used for the distance coefficient if no other data are available.

REFERENCES

- Galle, O. R., and K. E. Taeuber. 1966. "Metropolitan Migration and Intervening Opportunities." American Sociological Review 31(1):5-13.
- Gilmore, J. S., and M. K. Duff. 1975. Boom Town Growth Management: A Case Study of Rock Springs--Green River, Wyoming. Westview Press, Boulder, Colorado.
- Gilmore, J. S., et al. 1982. Socioeconomic Impact of Power Plants. EPRI EA-2228. Electric Power Research Institute, Palo Alto, California.
- Jones, L. L., and S. H. Murdock. 1978. "The Incremental Nature of Public Service Delivery: Implications for Rural Areas." American Journal of Agricultural Economics 60(5):955-960.
- Leholm, A. G., F. L. Leistritz and J. S. Wieland. 1976. "Profile of Electric Power Plant Construction Work Force." Ag. Economics Statistics. No. 22. Department of Agricultural Economics, North Dakota Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota.
- Leistritz, F. L., and S. H. Murdock. 1981. The Socioeconomic Impact of Resource Development: Methods for Assessment. Social Impact Assessment Series No. 6. Westview Press, Boulder, Colorado.
- Leistritz, F. L., S. H. Murdock, N. E. Toman, and T. A. Hertsgaard. 1979. "A Model for Projecting Localized Economic, Demographic, and Fiscal Impacts of Large-Scale Projects." Western Journal of Agricultural Economics. 4(2):1-16.
- Leistritz, F. L., et al. 1982. North Dakota Economic-Demographic Assessment Model (NEDAM): Technical Description. Agricultural Economics Report No. 158. Department of Agricultural Economics, North Dakota Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota.
- Murdock, S. H., and R. R. Hamm. 1983. "Assessing the Demographic and Public Service Impacts of Repository Siting." Chapter 8 from Nuclear Waste: Socioeconomic Dimensions on Long Term Storage. S. H. Murdock, F. L. Leistritz, and R. R. Hamm., eds. Westview Press Inc., pp. 135-156.
- Murdock, S. H., and F. L. Leistritz. September 1979. Energy Development in the Western United States: Impact on Rural Areas. Praeger Publishers, New York.
- Murdock, S. H., F. L. Leistritz. 1983. Methods for Assessing the Socioeconomic Impacts of Large Scale Resource Developments: Implications for Nuclear Repository Siting. ONWI-266, Battelle Project Management Division, Columbus, Ohio.

- Murdock, S. H., F. L. Leistritz, and E. Schriener. 1982. "Local Demographic Changes Associated with Rapid Growth." Chapter 3 from Coping with Rapid Growth in Rural Communities. B. A. Weber and R. E. Howell, eds. Westview Press Inc., pp. 63-96.
- Murdock, S. H., J. S. Wieland, and F. L. Leistritz. 1978. "An Assessment of the Validity of the Gravity Model for Predicting Community Settlement Patterns in Rural Energy-Impacted Areas in the West." In Land Economics, Vol. 54, pp. 461-471.
- Stenehjem, E. J., and J. E. Metzger. 1976. A Framework for Projecting Employment and Population Changes Accompanying Energy Development. ANL/AA-14, 2 Vols., Argonne National Laboratory, Argonne, Illinois.
- Tennessee Valley Authority. 1978. Hartsville Nuclear Plants Socioeconomic Monitoring and Mitigation Report, March 31, 1978. Tennessee Valley Authority, Knoxville, Tennessee.
- Wieland, J. S., F. L. Leistritz, and S. H. Murdock. 1977. Characteristics and Settlement Patterns of Energy Related Operating Workers in the Northern Great Plains. Agricultural Economics Report No. 123. Department of Agricultural Economics, North Dakota Agricultural Experiment Station, North Dakota State University, Fargo North Dakota.

APPENDIX A

CCAM.PROGRAM LISTING

```

1. //LCMUAAAA JOB (6883,FOR,,50),CLARK,TIME=(2,00)
2. // EXEC SAS, SORT=16, REGION=500K, OPTIONS='S=72 LS=120', TIME=(2,00)
3. //I1 DD DSN=CN6883.LCM.COUNTY.CCAM.DATA, DISP=OLD
4. //I2 DD DSN=CN6883.LCM.CITY.CCAM.DATA, DISP=OLD
5. //I3 DD DSN=CN6883.LCM.PLACES.CCAM.DATA, DISP=OLD
6. //I5 DD DSN=CN6883.LCM.ARID.CONCASKS.OUTPUT, DISP=OLD
7. //I6 DD DSN=CN6883.LCM.CCAM.DRIVER, DISP=OLD
8. DATA COUNTY1; INFILE I1;
9. INPUT YEAR CROSS COUNTY XC1-XC10 #2 XC11-XC22 #3 XC23-XC34
10. #4 XC35-XC47;
11. IF CROSS=201 OR CROSS=202;
12. ARRAY COR(I) XC1-XC47;
13. DO I=1 TO 37 ;
14. IF COR=. THEN COR=0;
15. END;
16. XC19=XC1*XC19;
17. DROP YEAR I;
18. PROC SORT; BY CROSS COUNTY;
19. DATA CITY1; INFILE I2 ;
20. INPUT YEAR CROSS COUNTY CITY X1-X6 #2 X7-X16 #3 X17-X26 #4 X27-X36
21. #5 X37-X43 DISTANCE DEGREES;
22. IF CROSS=201 OR CROSS=202;
23. ARRAY COR(I) X1-X43;
24. DO I=1 TO 43;
25. IF COR=. THEN COR=0;
26. END;
27. X16=X1*X16;
28. DROP I COUNTY YEAR;
29. PROC SORT; BY CROSS;
30. DATA PLAC1; INFILE I3;
31. INPUT YEAR CROSS CITY X1 X9 X13 X15 X16 X37 DISTANCE DEGREES;
32. X16=X16*X1;
33. IF CROSS=201 OR CROSS=202;
34. ARRAY COR(I) X1 X9 X13 X15 X16 X37;
35. DO I=1 TO 5;
36. IF COR=. THEN COR=0;
37. END;
38. DROP I YEAR;
39. PROC SORT; BY CROSS;
40. PROC MEANS DATA=COUNTY1 NOPRINT SUM;
41. VAR XC1-XC47; BY CROSS; OUTPUT OUT=COUNTY2
42. SUM=XC1-XC47;
43. PROC MEANS DATA=COUNTY1 NOPRINT MEAN;
44. VAR XC1-XC47; BY CROSS; OUTPUT OUT=COUNTY3
45. MEAN=XC1-XC47;
46. DATA COUNTY4; SET COUNTY2;
47. KEEP CROSS XC1-XC8 XC11 XC12 XC17 XC19-XC28
48. XC31-XC33 XC37-XC41 XC43-XC46;
49. PROC SORT; BY CROSS;
50. DATA COUNTY5; SET COUNTY3;
51. KEEP CROSS XC9 XC10 XC13 XC14 XC15 XC16 XC18 XC29 XC30 XC34 XC35
52. XC36 XC42 XC47;
53. PROC SORT; BY CROSS;
54. DATA COUNTY6; MERGE COUNTY4 COUNTY5; BY CROSS;
55. PROC MEANS DATA=CITY1 NOPRINT SUM;
56. VAR X1-X43; BY CROSS; OUTPUT OUT=CITY2
57. SUM=X1-X43;
58. PROC MEANS DATA=CITY1 NOPRINT MEAN; VAR X1-X43 DISTANCE DEGREES;
59. BY CROSS; OUTPUT OUT=CITY3 MEAN=X1-X43 DISTANCE DEGREES;
60. DATA CITY4; SET CITY2;

```

```

61.    KEEP CROSS X1-X5 X8 X9 X14 X16-X25 X30-X32 X36 X38-X40 X42;
62.    PROC SORT; BY CROSS;
63.    DATA CITY5; SET CITY3;
64.    KEEP CROSS X6 X7 X10 X11 X12 X13 X15 X26-X29 X33-X35 X37 X41 X43
65.    DISTANCE DEGREES;
66.    PROC SORT; BY CROSS;
67.    DATA CITY6; MERGE CITY4 CITY5; BY CROSS;
68.    PROC SORT; BY CROSS;
69.    DATA ROC1; MERGE COUNTY6 CITY6; BY CROSS;
70.    AX1=XC1-X1;
71.    AX2=XC2-X2;
72.    AX3=XC3-X3;
73.    AX4=XC7-X4;
74.    AX5=XC8-X5;
75.    AX6=XC9;
76.    AX7=XC10;
77.    AX8=XC11-X8;
78.    AX9=XC12-X9;
79.    AX10=XC13;
80.    AX11=XC14;
81.    AX12=XC15;
82.    AX13=XC16;
83.    AX14=XC17-X14;
84.    AX15=XC18;
85.    AX16=XC19-X16;
86.    AX17=XC20-X17;
87.    AX18=XC21-X18;
88.    AX19=XC22-X19;
89.    AX20=XC23-X20;
90.    AX21=XC24-X21;
91.    AX22=XC25-X22;
92.    AX23=XC26-X23;
93.    AX24=XC27-X24;
94.    AX25=XC28-X25;
95.    AX26=X26;
96.    AX27=X27;
97.    AX28=X28;
98.    AX29=X29;
99.    AX30=XC31-X30;
100.   AX31=XC32-X31;
101.   AX32=XC33-X32;
102.   AX33=X33;
103.   AX34=X34;
104.   AX35=X35;
105.   AX36=XC37-X36;
106.   AX37=X37;
107.   AX38=XC39-X38;
108.   AX39=XC40-X39;
109.   AX40=XC41-X40;
110.   AX41=XC42;
111.   AX42=XC43-X42;
112.   AX43=XC47;
113.   ARRAY COR(I) AX1-AX43;
114.   DO I=1 TO 43;
115.   IF COR<0 THEN COR=0;
116.   END;
117.   KEEP CROSS AX1-AX43 XC1;
118.   PROC SORT; BY CROSS;
119.   DATA EP1; MERGE ROC1 PLACE1; BY CROSS;
120.   PROC SORT; BY CROSS CITY;

```

```

121. DATA EP2; SET EP1;
122. IF AX1=0 THEN AX1=1;
123. IF AX9=0 THEN AX9=1;
124. Z1=X1/AX1;
125. Z2=X9/AX9;
126. IF Z1=. THEN DO;
127. Z1=X1/XC1;
128. END;
129. IF Z2=. THEN DO;
130. Z2=X1/XC1;
131. END;
132. X2=Z1*AX2;
133. X3=Z1*AX3;
134. X4=Z1*AX4;
135. X5=Z2*AX5;
136. X6=AX6;
137. X7=AX7;
138. X8=AX8;
139. X10=AX10;
140. X11=AX11;
141. X12=AX12;
142. X14=AX14;
143. X17=Z1*AX17;
144. X18=Z1*AX18;
145. X19=Z1*AX19;
146. X20=Z1*AX20;
147. X21=Z1*AX21;
148. X22=Z1*AX22;
149. X23=Z1*AX23;
150. X24=Z1*AX24;
151. X25=Z1*AX25;
152. X26=AX27;
153. X27=AX27;
154. X28=AX28;
155. X29=AX29;
156. X30=Z1*AX30;
157. X31=Z1*AX31;
158. X32=Z1*AX32;
159. X33=AX33;
160. X34=AX34;
161. X35=AX35;
162. X36=Z1*AX36;
163. X38=Z1*AX38;
164. X39=Z1*AX39;
165. X40=Z1*AX40;
166. X41=Z1*AX41;
167. X42=Z1*AX42;
168. X43=AX43;
169. ARRAY COR(I) X1-X43;
170. DO I=1 TO 43;
171. IF COR<0 THEN COR=0;
172. END;
173. KEEP CROSS CITY X1-X43 DISTANCE DEGREES;
174. PROC SORT; BY CROSS;
175. PROC MEANS DATA=EP2 NOPRINT SUM;
176. VAR X1-X43; BY CROSS; OUTPUT OUT=EP3 SUM=X1-X43;
177. DATA EP4; SET EP3;
178. KEEP CROSS X1-X5 X8 X9 X14 X16-X25 X30-X32 X36-X40 X42;
179. PROC SORT; BY CROSS;
180. PROC MEANS DATA=EP2 NOPRINT MEAN;

```

```

181.    VAR X1-X43 DISTANCE DEGREES; BY CROSS; OUTPUT OUT=EP5 MEAN=X1-X43
182.    DISTANCE DEGREES;
183.    DATA EP6; SET EP5;
184.    KEEP CROSS X6 X7 X10 X11 X12 X13 X15 X26-X29 X33-X35 X37 X41
185.    DISTANCE DEGREES;
186.    PROC SORT; BY CROSS;
187.    DATA ROC2; MERGE ROC1 EP4 EP6; BY CROSS;
188.    X1=AX1-X1;
189.    X2=AX2-X2;
190.    X3=AX3-X3;
191.    X4=AX4-X4;
192.    X5=AX5-X5;
193.    X6=AX6;
194.    X7=AX7;
195.    X8=AX8-X8;
196.    X9=AX9-X9;
197.    X10=AX10;
198.    X11=AX11;
199.    X12=AX12;
200.    X13=AX13;
201.    X14=AX14-X14;
202.    X15=AX15;
203.    X16=AX16;
204.    X17=AX17-X17;
205.    X18=AX18-X18;
206.    X19=AX19-X19;
207.    X20=AX20-X20;
208.    X21=AX21-X21;
209.    X22=AX22-X22;
210.    X23=AX23-X23;
211.    X24=AX24-X24;
212.    X25=AX25-X25;
213.    X26=AX26;
214.    X27=AX27;
215.    X28=AX28;
216.    X29=AX29;
217.    X30=AX30-X30;
218.    X31=AX31-X31;
219.    X32=AX32-X32;
220.    X33=AX33;
221.    X34=AX34;
222.    X35=AX35;
223.    X36=AX36-X36;
224.    X37=X37;
225.    X38=AX37-X38;
226.    X39=AX39-X39;
227.    X40=AX40-X40;
228.    X41=AX41;
229.    X42=AX42;
230.    X43=AX43;
231.    ARRAY COR(I) X1-X43;
232.    DO I=1 TO 43;
233.    IF COR<0 THEN COR=0;
234.    END;
235.    CITY=99;
236.    KEEP CROSS CITY X1-X43 DISTANCE DEGREES ;
237.    PROC SORT; BY CROSS CITY;
238.    DATA PLACE2; SET EP2;
239.    DATA CITY7; SET CITY1;
240.    PROC SORT; BY CROSS CITY;

```

```

241. DATA CITYALL; MERGE CITY7 PLACE2 ROC2; BY CROSS CITY;
242. PROC SORT; BY CROSS;
243. PROC MEANS DATA=CITYALL NOPRINT MEAN; VAR DEGREES DISTANCE;
244. BY CROSS; OUTPUT OUT=DC MEAN=DEGREES DISTANCE;
245. DATA DC1; SET DC;
246. DC=DISTANCE;
247. DG=DEGREES;
248. KEEP CROSS DG DC;
249. PROC SORT; BY CROSS;
250. DATA COUNTY7; MERGE COUNTY6 DC1; BY CROSS;
251. DATA CITCOUNT; MERGE CITYALL COUNTY7; BY CROSS;
252. XC9=XC9/100;
253. XC10=XC10/100;
254. XC11=((XC11)/1.4485)*1.332;
255. XC13=XC13/100;
256. XC14=XC14/100;
257. XCM=1-(XC13+XC14);
258. XC14=XCM+XC14;
259. XC15=(XC15)*1.332;
260. XC16=(XC16*1.1054)*1.332;
261. XC18=(XC18)*1.332;
262. XC19=XC19*1.332;
263. XC25=((XC25)*1.655)*1.332;
264. XC28=((XC28)*1.3248)*1.332;
265. XC29=XC29/100;
266. XC30=XC30/100;
267. XC33=((XC33)*1.3248)*1.332;
268. XC34=XC34/100;
269. XC35=XC35/100;
270. XC36=XC36/100;
271. XC42=XC42/100;
272. XC43=XC43*1000;
273. X6=X6/100;
274. X7=X7/100;
275. X8=(X8)*1.332;
276. X10=X10/100;
277. X11=X11/100;
278. XM=1-(X10+X11);
279. X11=X11+XM;
280. X12=(X12)*1.332;
281. X13=X13*1.332;
282. X14=X14/X9;
283. X15=(X15)*1.332;
284. X16=(X16*1.1054)*1.332;
285. X20=X20*1000;
286. X22=((X22*1.6550)*1.332);
287. X25=((X25)*1.3248)*1.332;
288. X26=X26/100;
289. X27=X27/100;
290. X28=X28/100;
291. X29=X29/100;
292. X32=((X32)*1.3248)*1.332;
293. X33=X33/100;
294. X34=X34/100;
295. X35=X35/100;
296. X41=X41/100;
297. X42=X42*1000;
298. PROC SORT; BY CROSS CITY ;
299. DATA MASTER; SET I5.ARIDTA;
300. IF YEAR GE 1979;

```

```

301. PROC SORT; BY CROSS YEAR;
302. DATA DRIVER; INFILE I6;
303. INPUT CROSS CITY YEAR;
304. DATA DRIVER1; SET DRIVER;
305. IF CROSS=201 OR CROSS=202;
306. PROC SORT; BY CROSS CITY;
307. DATA DCOUNT; MERGE CITCOUNT DRIVER1; BY CROSS CITY;
308. PROC SORT; BY CROSS CITY YEAR;
309. DATA DCOUNT1; SET DCOUNT;
310. PROC SORT; BY CROSS YEAR;
311. DATA CMASTER; MERGE DCOUNT1 MASTER; BY CROSS YEAR;
312. PROC SORT; BY CROSS CITY YEAR;
313. DATA CMASTER1; SET CMASTER;
314. DC=1;
315. DIS=DISTANCE;
316. DISTANCE=1;
317. POPC=(X1/XC1)*POP;
318. EMPC=((X40*(1-X41))/(XC4I*(1-XC42)))*TOTEMP;
319. HS=X9;
320. AGE=(EIJT1/TOTEMP)*EMPC;
321. ASE=(EIJT2/TOTEMP)*EMPC;
322. MINE=(EIJT3/TOTEMP)*EMPC;
323. CONE=(EIJT4/TOTEMP)*EMPC;
324. NDME=(EIJT5/TOTEMP)*EMPC;
325. DME=(EIJT6/TOTEMP)*EMPC;
326. PUBE=(EIJT7/TOTEMP)*EMPC;
327. WTE=(EIJT8/TOTEMP)*EMPC;
328. RTE=(EIJT9/TOTEMP)*EMPC;
329. FIRE=(EIJT10/TOTEMP)*EMPC;
330. SSE=(EIJT11/TOTEMP)*EMPC;
331. GOVE=(EIJT12/TOTEMP)*EMPC;
332. RIWB=PRYC/WAGEBL;
333. POPER=POP/TOTEMP;
334. INCOME=(X16/XC19)*PRYC;
335. HC=X13;
336. HP=X13;
337. HSF=X9*X10;
338. HMF=X9*X11;
339. RENTS=X15;
340. HCM=(HC*3.24)/360;
341. HCUX=X12;
342. HS=HSF+HMF;
343. MH=HS*0.05;
344. HS=HS*0.95;
345. HS=HS+MH;
346. HC=HCM+HCUX;
347. HDC=POP/XC47;
348. HSC=XC12;
349. NMH=0.20*DIF(HDC);
350. MHC=0.05*HSC;
351. HSC=0.95*HSC;
352. HSC=MHC+HSC;
353. HD=POPC/X43;
354. HAC=HSC-HDC;
355. HA=HS-HD;
356. VR=HA/HS;
357. NMF=NNFRD68+NNFRD69+NNFRD60+NNFRD62;
358. NSF=NNFRD61;
359. NMH=0.20*(NMF+NSF);
360. RHA=HD/HDC;

```

```

361. A2=2;
362. EMPLOY=AGE+ASE+MINE+CONE+NDME+DME+PUBE+WTE
363. +RTE+FIRE+SSE+GOVE;
364. INCOME=((AGE*WRAGR32)+(AGE*WRAFF21)+(WRMIN22*MINE)
365. +(WRCON23*CONE)+(WRNDM24*NDME)+(WRDUR25*DME)
366. +(WRPUT26*PUBE)+(WRWHL27*WTE)+(WRRET28*RTE)
367. +(WRFIR29*FIRE)+(WRVIC30*SSE)+(WRGOV31*GOVE)))
368. *RIWB;
369. WB=((AGE*WRAGR32)+(AGE*WRAFF21)+(WRMIN22*MINE)
370. +(WRCON23*CONE)+(WRNDM24*NDME)+(WRDUR25*DME)
371. +(WRPUT26*PUBE)+(WRWHL27*WTE)+(WRRET28*RTE)
372. +(WRFIR29*FIRE)+(WRVIC30*SSE)+(WRGOV31*GOVE)));
373. PROC SORT; BY CROSS CITY YEAR;
374. DATA AAA; SET CMASTER1;
375. IF YEAR=1979;
376. KEEP CROSS CITY YEAR HC HP RENTS HCM HCUK HS MH HSC HSF HMF RHA
377. NSF NSF NMH;
378. PROC SORT; BY CROSS CITY YEAR;
379. DATA BBB; SET CMASTER1;
380. DROP HC HP RENTS HCM HCUK HS MH HSC HSF HMF;
381. PROC SORT; BY CROSS CITY YEAR;
382. DATA CCC; MERGE AAA BBB; BY CROSS CITY YEAR;
383. PROC SORT; BY CROSS CITY YEAR;
384. PROC MODEL ;
385. ENDOGENOUS
386. HC HP RENTS HCM HCUK HS MH HSC
387. HSF HMF
388. ;
389. EXOGENOUS
390. RHA NSF NSF NMH
391.
392.
393.
394. ;
395. PARAMETERS
396. A1 1.01
397. A3 0.9909
398. A6 3.24 ;
399. HSC=(LAG(HSC)*A3)+NSF+NSF+NSF;
400. HP=LAG(HP)*A1;
401. HSF=(LAG(HSF)*A3)+(NSF*RHA);
402. HMF=(LAG(HMF)*A3)+(NSF*RHA);
403. MH=(LAG(MH)*A3)+(NSF*RHA);
404. HS=HSF+HMF+MH;
405. HCM=((LAG(HP)*A1)*A6)/360;
406. HCUK=LAG(HCUK)*A1;
407. HC=HCM+HCUK;
408. RENTS=LAG(RENTS)*A1;
409. PROC SIMNLIN SEIDEL MAXITER=600 OUT=CA1
410. NOPRINT START=1; BY CROSS CITY ;ID YEAR;
411. DATA FIXX1; SET CA1;
412. IF YEAR GE 1980;
413. PROC SORT; BY CROSS CITY YEAR;
414. DATA FIXX2; SET CMASTER1;
415. DROP HC HP RENTS HCM HCUK HS MH HSC;
416. PROC SORT; BY CROSS CITY YEAR;
417. DATA FIXX3; MERGE FIXX1 FIXX2; BY CROSS CITY YEAR;
418. IF YEAR GE 1980;
419. ND=POPC/X43;
420.

```



```

421.   HDC=POP/XC47;
422.   HAC=HSC-HDC;
423.   HA=HS-HD;
424.   IF HA<=0 THEN HA=MH;
425.   IF HAC<=0 THEN HAC=NMH;
426.   VR=HA/HS;
427.   IF VR<=0 THEN VR=0.005;
428.   DATA CMASTER2; SET FIXX3;
429.   IF YEAR=1980;
430.   RSR=X25/INCOME;
431.   RSRC=XC28/PRYC;
432.   KEEP CROSS CITY RSR RSRC;
433.   PROC SORT; BY CROSS CITY;
434.   DATA CMASTER3; SET FIXX3;
435.   PROC SORT; BY CROSS CITY ;
436.   DATA TEMP;MERGE CMASTER2 CMASTER3;BY CROSS CITY;
437.   PROC SORT; BY CROSS CITY YEAR;
438.   DATA CMASTER4; SET TEMP;
439.   IF YEAR GE 1980;
440.   RS=(RSR*INCOME);
441.   RSC=(RSRC*PRYC);
442.   A2=2;
443.   ALLOD=((POP*RS*EMPLOY*HA)/HC)/(DISTANCE**A2);
444.   PROC SORT; BY CROSS CITY YEAR;
445.   DATA CMASTERT;SET CMASTER4;
446.   KEEP CROSS CITY YEAR ALLOD;
447.   PROC SORT; BY CROSS YEAR;
448.   PROC MEANS DATA=CMASTERT NOPRINT SUM;
449.   VAR ALLOD; BY CROSS YEAR; OUTPUT OUT=CMaster5
450.   SUM=ALLOD;
451.   DATA CMASTER6; SET CMASTER5;
452.   KEEP CROSS YEAR ALLOD;
453.   PROC SORT; BY CROSS YEAR;
454.   DATA AALLO; SET CMASTER6;
455.   IF YEAR=1980;
456.   KEEP CROSS YEAR ALLOD;
457.   PROC SORT; BY CROSS YEAR;
458.   DATA BALLO; SET CMASTER4;
459.   IF YEAR=1980;
460.   ALLON=ALLOD;
461.   KEEP CROSS CITY YEAR ALLON;
462.   PROC SORT; BY CROSS YEAR;
463.   DATA CALLO; MERGE AALLO BALLO; BY CROSS YEAR;
464.   IF YEAR=1980;
465.   PROC SORT; BY CROSS CITY YEAR;
466.   DATA DALLO; SET CALLO;
467.   IF YEAR=1980;
468.   ALLO=ALLON/ALLOD;
469.   KEEP CROSS CITY YEAR ALLO;
470.   PROC SORT; BY CROSS CITY YEAR;
471.   DATA ESD; SET CMASTER4;
472.   PROC SORT; BY CROSS CITY YEAR;
473.   DATA CMASTER7;MERGE ESD DALLO;BY CROSS CITY YEAR;
474.   IF YEAR=1980;
475.   KEEP CROSS CITY YEAR POPC AGE ASE MINE CONE NDME DME
476.   RS PUBE WTE RTE FIRE SSE GOVE INCOME EMPLOY ALLD
477.   ;
478.   PROC SORT; BY CROSS YEAR;
479.   DATA CMASTER8; SET CMASTER4;
480.   DROP AGE ASE MINE CONE NDME DME RS

```

```

431.      PUBE WTE RTE FIRE SSE GOVE INCOME EMPLOY POPC ALLOD
432.      ;
433.      PROC SORT; BY CROSS YEAR;
434.      DATA CMASTER9; MERGE CMASTER8 CMASTER6 CMASTER7; BY CROSS YEAR;
435.      PROC SORT; BY CROSS CITY YEAR;
436.      DATA CHECK; SET CMASTER9;
437.      PROC PRINT; VAR CROSS CITY YEAR ALLO ALLOD AGE HA HC POPC RS DISTANCE
438.      ;
439.      PROC MODEL;
440.      ENDOGENOUS
441.      WB AGE ASE MINE CONE NDME DME PUBE WTE RTE FIRE SSE GOVE
442.      INCOME RS POPC ALLO EMPLOY;
443.      EXOGENOUS
444.      WRMIN22
445.      HC HA WRWHL27 WRRET28 WRFIR29 WRVIC30 WRGOV31 WRAGR32 WRAFF21
446.      WRCON23 WRNDM24 WRDUR25 WRPOT26 ALLOD EIJT1 EIJT2 EIJT3 EIJT4 EIJT5
447.      EIJT6 EIJT7 EIJT8 EIJT9 EIJT10 EIJT11 EIJT12 POP RIWB POPER
448.      RSR DISTANCE;
449.      PARAMETERS
450.      A2 2;
451.      ALLO=(((POPC*EMPLOY*RS*HA)/HC)/((DISTANCE**A2))/ALLOD;
452.      POPC=LAG(POPC)+(DIF(EMPLOY)*POPER;
453.      AGE=LAG(AGE)+(DIF(EIJT1)*LAG(ALLO));
454.      ASE=LAG(ASE)+(DIF(EIJT2)*LAG(ALLO));
455.      MINE=LAG(MINE)+(DIF(EIJT3)*LAG(ALLO));
456.      CONE=LAG(CONE)+(DIF(EIJT4)*LAG(ALLO));
457.      NDME=LAG(NDME)+(DIF(EIJT5)*LAG(ALLO));
458.      DME=LAG(DME)+(DIF(EIJT6)*LAG(ALLO));
459.      PUBE=LAG(PUBE)+(DIF(EIJT7)*LAG(ALLO));
460.      WTE=LAG(WTE)+(DIF(EIJT8)*LAG(ALLO));
461.      RTE=LAG(RTE)+(DIF(EIJT9)*LAG(ALLO));
462.      FIRE=LAG(FIRE)+(DIF(EIJT10)*LAG(ALLO));
463.      SSE=LAG(SSE)+(DIF(EIJT11)*LAG(ALLO));
464.      GOVE=LAG(GOVE)+(DIF(EIJT12)*LAG(ALLO));
465.      WB=(((AGE*WRAGR32)+(AGE*WRAFF21)+(WRMIN22*MINE)
466.      +(WRCON23*CONE)+(WRNDM24*NDME)+(WRDUR25*DME)
467.      +(WRPOT26*PUBE)+(WRWHL27*WTE)+(WRRET28*RTE)
468.      +(WRFIR29*FIRE)+(WRVIC30*SSE)+(WRGOV31*GOVE)));
469.      EMPLOY=AGE+ASE+MINE+CONE+NDME+DME+PUBE+WTE
470.      +RTE+FIRE+SSE+GOVE;
471.      INCOME=WB*RIWB;
472.      RS=RSR*INCOME;
473.      PROC SIMNLIN SEIDEL MAXITER=600 OUT=CITYALL NOPRINT START=1;
474.      BY CROSS CITY; ID YEAR;
475.      DATA CITYALL1; SET CITYALL;
476.      IF YEAR GE 1980;
477.      KEEP ALLO POPC EMPLOY AGE ASE MINE CONE NDME DME PUBE
478.      WTE RTE FIRE SSE GOVE INCOME RS CROSS CITY YEAR WB ;
479.      PROC SORT; BY CROSS CITY YEAR;
480.      PROC PRINT;
481.      DATA CROSS; SET FIXX3;
482.      IF YEAR GE 1980;
483.      DROP POPC EMPLOY AGE ASE MINE CONE NDME DME PUBE
484.      WTE RTE FIRE SSE GOVE INCOME RWB ;
485.      DATA CITYALL2; MERGE CROSS CITYALL1; BY CROSS CITY YEAR;
486.      PROC SORT; BY CROSS CITY YEAR;
487.      DATA CCOUNT2; SET CITYALL2;
488.      IF X20=0 THEN X20=1;
489.      IF X22=0 THEN X22=1;
490.      IF POPC GE 100000 THEN DO;

```

```

541. NFS=(.000156*POPC);
542. NFM=(.002*POPC);
543. NA=(NFS*1);
544. NEMTS=(NA*2.2);
545. NFT=(2*NFS);
546. NPO=(.000325*POPC);
547. NPV=(.00051*POPC);
548. WSTL48=(.2079*POPC);
549. IS42=(.69314*POPC);
550. SWSST=(.0005*POPC);
551. SWSSM=(.00228*POPC);
552. RSFT=(.0008*POPC);
553. RSPT=(.0015*POPC);
554. RFPG=(.0081*POPC);
555. RFNP=(.0013*POPC);
556. RFCP=(.0019*POPC);
557. LBC=(3*POPC);
558. LCPR=(.0650*POPC);
559. END;
560. IF POPC LT 100000 AND POPC GE 30000 THEN DO;
561. NFS=(.000131*POPC);
562. NFM=(.001805*POPC);
563. NA=(NFS*1);
564. NEMTS=(NA*2);
565. NFT=(2.5*NFS);
566. NPO=(.000217*POPC);
567. NPV=(.0086*POPC);
568. WSTL38=(.2093*POPC);
569. IS36=(1.0453*POPC);
570. SWSST=(.00078*POPC);
571. SWSSM=(.00273*POPC);
572. RSFT=(.0006*POPC);
573. RSPT=(.0024*POPC);
574. RFPG=(.003*POPC);
575. RFNP=(.003*POPC);
576. RFCP=(.0007*POPC);
577. LBC=(3.5*POPC);
578. LCRR=(.0731*POPC);
579. END;
580. IF POPC GE 10000 AND POPC LT 30000 THEN DO;
581. NFS=(.000117*POPC);
582. NFM=(.0016*POPC);
583. NA=(NFS*1);
584. NEMTS=(NA*2);
585. NFT=(2.5*NFS);
586. NPO=(.000812*POPC);
587. NPV=(.00033*POPC);
588. WSTL33=(.2662*POPC);
589. IS30=(1.7734*POPC);
590. SWSST=(.0084*POPC);
591. SWSSM=(.00312*POPC);
592. RSFT=(.0004*POPC);
593. RSPT=(.0025*POPC);
594. RFPG=(.0010*POPC);
595. RFNP=(.0008*POPC);
596. RFCP=(.0011*POPC);
597. LBC=(3.5*POPC);
598. LCPR=(.0731*POPC);
599. END;
600. IF POPC LT 10000 THEN DO;

```

```

601. NFS=1;
602. NFM=(10+(.0008*POPC));
603. NA=NFS;
604. NEMTS=(NA*2);
605. NFT=3;
606. NPO=(.000184*POPC);
607. NPV=(.0030*POPC);
608. WSTL36=(.2899*POPC);
609. IS30=(1.9314*POPC);
610. SWSST=(.00101*POPC);
611. SWSSM=(.00354*POPC);
612. RSFT=(.0005*POPC);
613. RSPT=(.003*POPC);
614. RFPG=(.0012*POPC);
615. RFNP=(.0010*POPC);
616. RFCP=(.0014*POPC);
617. LBC=(4*POPC);
618. LCPR=(.1100*POPC);
619. END;
620. NES=((POPC/POP)*POP513)/800;
621. NHS=((POPC/POP)*POP1417)/1800;
622. IF CROSS=201 OR CROSS=202 THEN DO;
623. GASCON=(7.6752*POPC);
624. ELECCON=(52*POPC);
625. ELECCAP=(92*POPC);
626. TRAFFIC=(.5542*POPC);
627. WATERCON=(2989*POPC);
628. SEWAGE=(2003*POPC);
629. CRIME=((X4/X1)*POPC);
630. PCS=(.00894*CRIME);
631. PCSJ=(.1098*PCS);
632. PCSPR=(.2177*PCS);
633. PCSPA=(.1591*PCS);
634. PCSPRO=(.5134*PCS);
635. TT=(.01946*POPC);
636. TTMRS=0;
637. IF YEAR GE 1998 AND YEAR LE 2022 THEN DO;
638. TTMRS=0;
639. END;
640. TT=TT+TTMRS;
641. TTRAFFIC=TRAFFIC+TT;
642. END;
643. IF CROSS=1601 OR CROSS=1602 THEN DO;
644. GASCON=(9.1892*POPC);
645. ELECCON=(25*POPC);
646. ELECCAP=(57*POPC);
647. TRAFFIC=(.1157*POPC);
648. WATERCON=(1574*POPC);
649. SEWAGE=(1055*POPC);
650. CRIME=((X4/X1)*POPC);
651. PCS=(.1671*CRIME);
652. PCSJ=(.0618*PCS);
653. PCSPR=(.1418*PCS);
654. PCSPA=(.0885*PCS);
655. PCSPRO=(.70078*PCS);
656. TT=(.02966*POPC);
657. TTMRS=0;
658. IF YEAR GE 1998 AND YEAR LE 2022 THEN DO;
659. TTMRS=0;
660. END;

```

```

661. TT=TT+TTMRS;
662. TTRAFFIC=TRAFFIC+TT;
663. END;
664. IF CROSS=1761 OR CROSS=1762 THEN DO;
665. GASCON=(3.2033*POPC);
666. ELECCON=(37*POPC);
667. ELECCAP=(90*POPC);
668. TRAFFIC=(.2826*POPC);
669. WATERCON=(1983*POPC);
670. SEWAGE=(1329*POPC);
671. CRIME=((X4/X1)*POPC);
672. PCS=(.2007*CRIME);
673. PCSJ=(.0698*PCS);
674. PCSPR=(.2561*PCS);
675. PCSPA=(.0992*PCS);
676. PCSPRO=(.5750*PCS);
677. TT=(.00991*POPC);
678. TTMRS=0;
679. IF YEAR GE 1998 AND YEAR LE 2022 THEN DO;
680. TTMRS=0;
681. END;
682. TT=TT+TTMRS;
683. TTRAFFIC=TRAFFIC+TT;
684. END;
685. POPDEN=POPC/X37;
686. NDOCTOR=((XC44/XC1)*POPC);
687. NDENTIST=((XC45/XC1)*POPC);
688. NURSES=((XC46/XC1)*POPC);
689. HOSP=((X2/X1)*POPC);
690. LSP=(POPC/1500);
691. LSNP=(LSP/4);
692. LST=LSP+LSNP;
693. HOSPBEDS=((X3/X2)*HOSP);
694. NW=((X42/X1)*POPC);
695. LF=(X40/X1)*POPC;
696. UER=1-(EMPLOY/LF);
697. WHS=((X22/X25)*RS);
698. SSS=((X32/X25)*RS);
699. RSE=((X24/X25)*RS);
700. FS=(X26*RSE);
701. GMS=((X27*RSE));
702. EDP=((X28*RSE));
703. GSS=((X29*RSE));
704. WHSEST=((X21/X22)*WHS);
705. SSEST=((X31/X32)*SSS);
706. HOTMOT=(X33*SSEST);
707. AUTO=(X34*SSEST);
708. AMUSE=(X35*SSEST);
709. MANEST=((X19/X20)*(NDME+DME));
710. CITYGOVE=((X17/(X17+X18))*GOVE);
711. FEDE=(GOVE-CITYGOVE);
712. RTWHN=((RTE+WTE)/(EIJT8+EIJT9)*DKNXXX11);
713. OBN=((EMPLOY/TOTEMP)*DKNXXX12);
714. ARN=((POPC/POP)*DKNXXX13);
715. WAREN=((WTE/EIJT8)*DKNXXX14);
716. EDN=((POPC/POP)*POP517)*DKNXXX15);
717. HEALTHN=((POPC/POP)*DKNXXX16);
718. PUBN=((GOVE/EIJT12)*DKNXXX17);
719. RELN=((POPC/POP)*DKNXXX18);
720. HOTMOTN=((POPC/POP)*DKNXXX19);

```

```

721. MISN=((POPC/POP)*DKNXXX20);
722. RTWHA=((RTE+WTE)/(EIJT8+EIJT9)*DKAXXX01);
723. OBA=((EMPLOY/TOTEMP)*DKAXXX02);
724. ARA=((POPC/POP)*DKAXXX03);
725. WAREA=((WTE/EIJT8)*DKAXXX04);
726. EDA=((POPC/POP)*POP517)*DKAXXX05);
727. HEALTHA=((POPC/POP)*DKAXXX06);
728. PUBA=((GOVE/EIJT12)*DKAXXX07);
729. RELA=((POPC/POP)*DKAXXX08);
730. HOTMOTA=((POPC/POP)*DKAXXX09);
731. MISA=((POPC/POP)*DKAXXX10);
732. PROPY=((INCOME/PRYC)*YTRIDR36);
733. TRANPAY=((INCOME/PRYC)*YTPR37);
734. RESAD=((INCOME/PRYC)*RESADR38);
735. INSUR=((INCOME/PRYC)*INSURR39);
736. PERCAP=(INCOME/POPC);
737. BIRTH=((POPC/POP)*BIRTH5);
738. DEATH=((POPC/POP)*DEATH5);
739. MIG=((POPC/POP)*AVGMIG33);
740. HD=POPC/X43;
741. HA=HS-HD;
742. VR=HA/HS;
743. IF VR<0 THEN VR=0;
744. RHU=HS*X14;
745. PROC SORT; BY CROSS CITY YEAR;
746. DATA CCOUNT3; SET CCOUNT2;
747. KEEP CROSS CITY YEAR
748. POPC EMPLOY AGE ASE MINE CONE NDME DME PUBE WTE RTE FIRE
749. SSE GOVE HC INCOME WB RS NFS NFM NA NEMTS NFT NPO NPV
750. WSTL48 WSTL38 WSTL33 WSTL36 IS42 IS36 IS30 SWSST SWSSM
751. RSFT RSPT RFPG RFNP RFCP LBC LCPR NES NHS GASCON ELECCON
752. ELECCAP TRAFFIC WATERCON SEWAGE CRIME PCS PCSJ PCSPRO PCSPA
753. TTRAFFIC MH VR HSF HMF HCM HCUK RENTS HDC HD HSC HAC
754. POPDEN RHU NDOCTOR NDENTIST NURSES HOSP HOSPBEDS NW LF UER
755. WHS SSS RSE FS GMS EDP GSS WHSEST SSEST HOTMOT AUTO
756. AMUSE MANEST CITYGOVE FEDE RTWHN OBN ARN WAREN EDN HEALTHN
757. PUBN RELN HOTMOTN MISN RTWHA OBA ARA WAREA EDA HEALTHA
758. PUBA RELA HOTMOTA MISA PROPY TRANPAY RESAD INSUR PERCAP
759. BIRTH DEATH MIG DISTANCE DEGREES X37 LSP LSNP LST HA HS
760. RSC POP TOTEMP;
761. PROC SORT; BY CROSS CITY YEAR;
762. DATA OUTPUT; SET CCOUNT3;
763. DATA CCOUNT4; SET CCOUNT3;
764. PRDC SORT; BY CROSS YEAR;
765. PROC MEANS DATA=CCOUNT4 NOPRINT SUM;
766. VAR POPC EMPLOY AGE ASE MINE CONE NDME DME PUBE WTE RTE FIRE
767. SSE GOVE HC INCOME WB RS NFS NFM NA NEMTS NFT NPO NPV
768. WSTL48 WSTL38 WSTL33 WSTL36 IS42 IS36 IS30 SWSST SWSSM
769. RSFT RSPT RFPG RFNP RFCP LBC LCPR NES NHS GASCON ELECCON
770. ELECCAP TRAFFIC WATERCON SEWAGE CRIME PCS PCSJ PCSPRO PCSPA
771. TTRAFFIC MH VR
772. POPDEN RHU NDOCTOR NDENTIST NURSES HOSP HOSPBEDS NW LF UER
773. WHS SSS RSE FS GMS EDP GSS WHSEST SSEST HOTMOT AUTO
774. AMUSE MANEST CITYGOVE FEDE RTWHN OBN ARN WAREN EDN HEALTHN
775. PUBN RELN HOTMOTN MISN RTWHA OBA ARA WAREA EDA HEALTHA
776. PUBA RELA HOTMOTA MISA PROPY TRANPAY RESAD INSUR PERCAP
777. HSF HMF HC RENTS HCM HCUK HS MH HS HDC HD HSC HAC HA VR
778. BIRTH DEATH MIG DISTANCE DEGREES X37 LSP LSNP LST HA HS;
779. BY CROSS YEAR; OUTPUT OUT=CCOUNT5 SUM =
780. POPC EMPLOY AGE ASE MINE CONE NDME DME PUBE WTE RTE FIRE

```

```

781. SSE GOVE HC INCOME WB RS NFS NFM NA NEMTS NFT NPO NPV
782. WSTL48 WSTL38 WSTL33 WSTL36 IS42 IS36 IS30 SWSST SWSSM
783. RSFT RSPT RFPG RFNP RFCP LBC LCPR NES NHS GASCON ELECCON
784. ELECCAP TRAFFIC WATERCON SEWAGE CRIME PCS PCSJ PCSPRO PCSPA
785. TTRAFFIC APT513 APT54 APT34 SFD DUP MH HRESCON VR
786. POPDEN RHU NDOCTOR NDENTIST NURSES HOSP HOSPBEDS NW LF UER
787. WHS SSS RSE FS GMS EDP GSS WHSEST SSEST HOTMOT AUTO
788. AMUSE MANEST CITYGOVE FEDE RTWHN OBN ARN WAREN EDN HEALTHN
789. PUBN RELN HOTMOTN MISH RTWHA OBA ARA WAREA EDA HEALTHA
790. PUBA RELA HOTMOTA MISA PROPY TRANPAY RESAD INSUR PERCAP
791. HSF HMF HC RENTS HCM HCUK HS MH NS HDC HD HSC HAC HA VR
792. BIRTH DEATH MIG DISTANCE DEGREES X37 LSP LSNP LST HA HS;
793. DATA CCOUNT6; SET CCOUNT5;
794. IF CROSS=201;
795. IF YEAR=1995 OR YEAR=2010 OR YEAR=2020;
796. POPDEN=POPC/X37;
797. PERCAP=INCOME/POPC;
798. VR=HA/HS;
799. UER=1-(EMPLOY/LF);
800. TOTACRES=RFPG+RFNP+PFCP;
801. KEEP PCS NDOCTOR HOSPBEDS NW NPO HS TOTACRES GASCON ELECCON
802. WATERCON NFM ND CROSS YEAR;
803. PROC SORT; BY CROSS YEAR;
804. PROC PRINT;
805. DATA TDIRDIS; SET CCOUNT2;
806. PROC SDRT; BY CROSS;
807. DATA TTDIR; SET COUNTY6;
808. KEEP CROSS XC38;
809. PROC SORT; BY CROSS;
810. DATA DIRDIS; MERGE TDIRDIS TTDIR; BY CROSS;
811. DIR='L';
812. IF DEGREES GE 0 AND DEGREES LE 11.25 THEN DIR='N';
813. IF DEGREES GT 11.25 AND DEGREES LE 33.75 THEN DIR='NNE';
814. IF DEGREES GT 33.75 AND DEGREES LE 56.25 THEN DIR='NE';
815. IF DEGREES GT 56.25 AND DEGREES LE 78.75 THEN DIR='ENE';
816. IF DEGREES GT 78.75 AND DEGREES LE 101.25 THEN DIR='E';
817. IF DEGREES GT 101.25 AND DEGREES LE 123.75 THEN DIR='ESE';
818. IF DEGREES GT 123.75 AND DEGREES LE 146.25 THEN DIR='SE';
819. IF DEGREES GT 146.25 AND DEGREES LE 168.75 THEN DIR='SSE';
820. IF DEGREES GT 168.75 AND DEGREES LE 191.25 THEN DIR='S';
821. IF DEGREES GT 191.25 AND DEGREES LE 213.75 THEN DIR='SSW';
822. IF DEGREES GT 213.75 AND DEGREES LE 236.25 THEN DIR='SW';
823. IF DEGREES GT 236.25 AND DEGREES LE 258.75 THEN DIR='WSW';
824. IF DEGREES GT 258.75 AND DEGREES LE 281.25 THEN DIR='W';
825. IF DEGREES GT 281.25 AND DEGREES LE 303.75 THEN DIR='WNW';
826. IF DEGREES GT 303.75 AND DEGREES LE 326.25 THEN DIR='NW';
827. IF DEGREES GT 326.25 AND DEGREES LE 348.75 THEN DIR='NNW';
828. IF DEGREES GT 348.75 AND DEGREES GE 360 THEN DIR='N';
829. IF DISTANCE LE 5 THEN DISTANCE=5;
830. IF DISTANCE GT 5 AND DISTANCE LE 10 THEN DISTANCE=10;
831. IF DISTANCE GT 10 AND DISTANCE LE 20 THEN DISTANCE=20;
832. IF DISTANCE GT 20 AND DISTANCE LE 30 THEN DISTANCE=30;
833. IF DISTANCE GT 30 AND DISTANCE LE 40 THEN DISTANCE=40;
834. IF DISTANCE GT 40 AND DISTANCE LE 50 THEN DISTANCE=50;
835. IF DISTANCE GT 50 THEN DISTANCE=60;
836. KEEP CROSS CITY YEAR POPC DISTANCE XC38 DIR;
837. PROC SORT; BY DIR DISTANCE YEAR;
838. PROC MEANS DATA=DIRDIS NOPRINT SUM;
839. VAR PDPC XC38; BY DIR DISTANCE YEAR;
840. OUTPUT DUT=DIRDIS1 SUM=PDPC XC38;

```

```

341. DATA DIRDIS2; SET DIRDIS1;
342. DC=DISTANCE;
343. A=0;
344. IF DC=5 THEN A=XC38*(.002740/16);
345. IF DC=10 THEN A=XC38*(.010959/16);
346. IF DC=20 THEN A=XC38*(.043836/16);
347. IF DC=30 THEN A=XC38*(.098630/16);
348. IF DC=40 THEN A=XC38*(.175342/16);
349. IF DC=50 THEN A=XC38*(.273973/16);
350. IF DC=60 THEN A=XC38*(.394521/16);
351. POPDEN=POPC/A;
352. PROC SORT; BY DIR DISTANCE YEAR;
353. PROC PRINT;
354. DATA TEMP1; SET MASTER;
355. PROC SORT; BY CROSS;
356. DATA TEMP2; SET DC1;
357. PROC SORT; BY CROSS;
358. DATA TEMP3; MERGE TEMP1 TEMP2; BY CROSS;
359. PROC SORT; BY CROSS YEAR;
360. DATA ALLO; SET CCOUNT6;
361. A2=2;
362. ALLODC=((POPC*EMPLOY*R5)/HC)/(DC**A2);
363. KEEP CROSS YEAR ALLODC POPC EMPLOY R5 HA HC OC;
364. PROC SORT; BY YEAR;
365. PROC MEANS DATA=ALLO NOPRINT SUM;
366. VAR ALLODC; BY YEAR ; OUTPUT OUT=ALLODC1 SUM=ALLODC;
367. DATA ALLODC2; SET ALLODC1;
368. PROC SORT; BY YEAR;
369. DATA ALLODC3; SET ALLO;
370. ALLOC=ALLODC;
371. KEEP CROSS YEAR ALLOC;
372. PROC SORT; BY YEAR;
373. DATA ALLODC4; MERGE ALLODC3 ALLODC2; BY YEAR;
374. PROC SORT; BY CROSS YEAR;
375. DATA ALLODC5; SET ALLODC4;
376. ALLO=ALLOC/ALLODC;
377. PROC SORT; BY CROSS YEAR;
378. PROC PRINT; VAR CROSS YEAR ALLO;

```


DISTRIBUTION

<u>No. of Copies</u>		<u>No of Copies</u>	
	<u>OFFSITE</u>		<u>ONSITE</u>
30	DOE Technical Information Center	3	<u>DOE Richland Operations Office</u>
			M. Dayani
4	James A. Carlson		R. D. Izatt
	Office of Civilian Radioactive Waste Management		J. J. Sutey
	Department of Energy	32	<u>Pacific Northwest Laboratory</u>
	1000 Independence Avenue		M. J. Scott (10)
	Washington, D.C. 20585		R. J. Moe
2	Peter Gross		R. E. Heineman, Sr.
	Oak Ridge Operations Office		D. J. Silveira
	P.O. Box E		G. H. Sewart
	Oak Ridge, Tennessee 37831		S. L. Beck
			Economics Library (10)
			Technical Information (5)
			Publishing Coordination MH (2)