

OPERATING MANUAL FOR THE
RESIDENTIAL SETTLEMENT MODEL

Minnesota Environmental Quality Board
Regional Copper-Nickel Study

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1.0 DESCRIPTION OF RESIDENTIAL SETTLEMENT MODEL

1.1 PROBLEM

In order to evaluate the secondary impacts of copper-nickel development, a new residential settlement model was developed to distribute new mine operating, construction and related secondary workers, and families within the Regional Copper-Nickel Study Area (Study Area). The distribution of in-migrating populations is assumed to be controlled by: 1) percentages of workers who would reside outside of the Study Area and commute into the Study Area; 2) that portion of the labor force already living within the Study Area which would accept operating, service, and construction positions, and therefore reduce the number of immigrating new workers settling within the Study Area; 3) proximity to roads; 4) proximity to cities; 5) proximity to areas already settled; and, 6) magnitude of population.

This distribution of workers is influenced by existing land use and environmental features of the Study Area. Principal features include: 1) concentrations of publically-owned land (federal, state, county) totaling 53 percent of the total Study Area; 2) existing iron ore and taconite mining lands along the Biwabik Iron Formation; 3) lakes and streams; and 4) potential future expansion in taconite mining land consumption and potential copper-nickel mine land uses along the Duluth Contact.

The model is also used to distribute operating workers, construction workers, and service workers from taconite plant expansions or new mines since taconite development may continue to play a major role in the shaping of settlement patterns within the Study Area.

1.2 APPLICATIONS

1.2.1 Capabilities

The present model allows the user to make separate projections of settlement patterns for mine operating, construction workers, and secondary workers and allows the user to vary any of the following development/employment circumstances:

- 1) Taconite Plant Expansions and New Development, 1976-1984.
- 2) Taconite Plant Expansions and New Development, 1985-2000.
- 3) Copper-Nickel Development, 1985-2000.
- 4) Taconite Expansions and New Development with Copper-Nickel Development.

The user can control whether or not the AMAX-Hoyt Lakes connecting road is included in the road network. Also, the user can vary individual plant employment projections and service employment projections at each of the nine Study Area cities.

The Study Area is divided into 224 square zones (Figure 1). These zones are approximately three miles on a side. Four zones are contained within a Public Land Survey (PLS) township. Each settlement zone therefore, is a quarter of one PLS township. The size of the zones represent the accuracy of settlement projections produced by the model and the assumptions and input variables used by the model. Smaller zones would present an illusion of accuracy greater than this or any model can presently produce given the available and easily obtainable data. Larger zones would so diffuse the impacts of projected residential settlement as to become meaningless.

1.2.2 Example

If one hypothesizes a mine development at Zone 2 requiring a workforce of 1,857 workers at peak production, then 1,298 workers will be new Study Area residents distributed in a pattern illustrated in Figures 2, 3, and 4. Because of the assumptions on commuting and labor force participation rates, 25 percent of the 1,857 workers will come from the existing Study Area labor force, and five percent will live outside of the Study Area.

Figures 2,3,4

1.3 ASSUMPTIONS WITHIN THE MODEL

1.3.1 Introduction

The Regional Copper-Nickel Study uses an attraction-constrained gravity model for assessing future residential settlement patterns precipitated by copper-nickel development. The attraction-constrained gravity model is a mathematical representation of the hypothesis that the distribution of workers residences is largely the result of distances from work locations and attractiveness of potential settlement locations.

1.3.2 Model Formula

The formula for the attraction-constrained exponential form of the gravity model is as follows:

$$E_{ij} = W_i$$

where: E_{ij} = the number of workers from mine i who reside in residence j ;
 and,
 $e^{-\beta d_{ij}}$ = the exponential form of distance decay function with β being
 a coefficient near 1 (usually greater than zero and less than
 one) and d_{ij} representing the distance from mine i to
 residence zone j ; and,
 A_j = attractiveness value of residence zone j raised to an alpha
 W_i = the total number of workers at mine i .

The exponential form used here assumes that more people are willing to travel longer distances than in the power form of the model. In essence, the present model assumes that, on the whole, the average journey to work distance will be greater than if the model used the power form. The exponential model assumes that the worker has a greater willingness to commute, or travel to shop, over longer distances than in the power form of the model.

1.3.3 Distance Decay

An empirically derived average commuting distance for mine operating workers was obtained through taconite employee commuting patterns (aggregated into zipcode areas). Average weighted distances were also calculated for all workers within the Study Area and for taconite construction workers using other sources (Table 1).

Table 1

The gravity model's mathematical expression for the distance that most workers are willing to travel to work (i.e. worker's travel behavior) is embodied in a distance decay function. For this settlement model, the distance decay function was calibrated so that the model's projected mean travel distances were as close as possible to the actual average distances for each employment group (i.e.

operating workers, construction workers, and secondary workers). In some cases, the beta coefficient (part of the distance decay function) was adjusted somewhat to make the overall trip pattern outputs more consistent with the subjectively derived attractiveness scores.

On the graph below, line A represents the distance decay, or interaction fall off rate for the exponential form of the gravity model, while line B represents the decay rate for the power form.

of
workers

d_{ij} (distance to work)

1.3.4 Road Network

A road network had to be assumed for home-work travel distance calculations. The model uses the Shortest Path Algorithm to calculate distances among settlement zones and mine development zones (Ostresh, 1973).

The model assumes that all roads which have been included in the road network would be passable year-round. Federal highways (U.S. routes), state trunk lines, and county state-aid highways were included in the network. In order to connect all settlement zones by the shortest possible distance, some lengths of county, Superior National Forest roads, township roads, and municipal roads were included in the road network. The model is also capable of projecting settlement patterns with the additions of new roads which may occur with new mineral development.

1.3.5 Attractiveness of Land for Settlement

The gravity model also considers attractiveness of potential residential locations. The model assumes that people will want to live near existing settlements and commercial activity ; therefore, the attractiveness function of the model is urban-oriented. In addition, the model assumes that people will continue to prefer single-family housing units. The three major factors considered in the attractiveness function are: 1) numbers of existing residential structures (an indicator for population and existing developed areas); 2) number of retail enterprises reporting sales and use taxes (an indicator of economic activity); and 3) available land for development within one mile of roads. The overall urban orientation of this attractiveness function is based upon residential settlement trends suggested in the results of the Minnesota Labor Force Survey, Taconite Construction Workers Survey, and current growth patterns.

The data for the three attractiveness indicators came from a variety of sources. A field inventory of rural residential structures conducted by the study in July-August, 1977; urban residences were estimated from 1974 housing unit estimates by municipalities (ARDC 1974) and the Cu-Ni residential structures field inventory. A list of commercial establishments reporting sales and use taxes in 1976, indicating retail and commercial activities by community (MDR 1976); and, available land was estimated using MLMIS files and Regional Copper-Nickel Study survey data (Figure 5).

Available land was defined as parcels (40 acres) of potentially developable lands which could be used for residential settlement. Parcels with certain characteristics are deemed "unavailable". These characteristics are:

- 1) Water-covered; or
- 2) Publically-owned lands (except for county tax-forfeited lands which were not in county memorial forests); or,

- 3) Land beyond one mile of a public access road or highway; or
- 4) Past, present, and future mining lands. (These lands included all lands on the Biwabik Iron Formation [as defined by Marsden (1977) to the Ultimate Pit Limit] within 1 1/2 miles of the Formation, existing minelands, and a three mile wide band along the Duluth Contact from the BWCA boundary (in the north) to the southern boundary of Township 57 north. Urban areas and parcels with existing settlements in these boundaries were not included in mining lands.

The analysis and the mapping of the remaining available parcels were completed through use of the Minnesota Land Management Information System using existing MLMIS data files and newly created Regional Copper-Nickel Study data files (Figure 5).

Figure 5

Each attractiveness factor is weighted according to its importance in determining the overall attractiveness of residential locations to immigrants when choosing their initial residence. Existing residential structures received 80 percent of all weights, sales and use tax reporting units (the economic activity indicator) was allocated a weight of 15 percent of total weights, and available land received a weight of 5 percent total weight.

In developing this model, an initial assumption was made that attractiveness was more important to secondary workers and construction workers and had more impact on their residential settlement locations than it did for mine operating workers. In order to reflect this increased significance, the attractiveness variable was raised to a power (i.e. an alpha, the attractiveness coefficient) greater than 1. The alpha coefficients to the attractiveness functions were: 1.00 for mine operating workers, 1.05 for secondary workers, and 1.100 for construction workers.

The baseline alpha coefficient of 1.00 was given to the operating workers attractiveness function. Since construction workers are usually in an area on a short-term basis, they appear to be more dependent upon finding existing housing or other short-term housing alternatives (for example, mobile homes) than do operating or construction workers (Table 2).

Table 2

The secondary worker the coefficient was raised from 1.00 to 1.05 primarily to cluster the settlement distribution closer to urban settlement zones.

1.3.6 Household Size

To derive total in-migrating population associated with mining development, the model presently assumes household sizes of 3.0 people for mine operating, construction, and secondary workers' families. Based upon the Minnesota Labor Force Survey-Form 1, the average household size for workers aged 20-45 was 3.85 persons per household. The model assumes that the new in-migrants and families coming into the Study Area will have heads-of-households aged 20-45 which will most likely comprise a majority of in-migrating households. The household size, with heads-of-households age 20-45 years moving in or after 1973, was 3.21. For those moving in or after 1975, the household size was 3.07. This was rounded to 3.0 for ease of calculation and to reflect the trend of the last eight years.

Through the Taconite Construction Workers Survey, it was determined that the average household size for taconite construction workers was 3.1 persons. The household the size was reduced to 3.0 to account for the fact that not all construction workers brought their families with them.

1.4 ASSUMPTIONS MADE BY THE USER

Four basic sets of variables must be put into to the model. These variables determine the number of workers (and families) which are actually distributed by the settlement model.

1.4.1 Incommuting Rates

Some proportion of new workers were assumed to live outside of the Study Area. This percentage varies according to the location of new employment sites. For example, it was assumed that only 5 percent of all new workers at a mine near Ely (on Spruce Road) would live outside of the Study Area based upon travel distances to the west edge of the Study Area and the relative unavailability of developable land to the east of the potential mine, and the relative abundance of available land within the Study Area. For a taconite mine near Virginia or Eveleth, which are close to the border of the Study Area, the percentages of workers assumed to reside outside of the Study Area were set between 50 and 60 percent (based upon the taconite employee commuting data) depending on the specific mine. A higher proportion of existing taconite workers near the western edge of the Study Area were shown to live outside of the Study Area (Table 3).

Table 3

The hypothesized percentages for new copper-nickel workers residing outside of the Study Area were derived from taconite workers residence-by-zipcode information, expressed residential preferences in the surveys, and through an examination of available land and the road network within and immediately adjacent to the Study Area. Thus, 5 percent of workers from Zone 2 copper-nickel development are hypothesized to live outside the Study Area, 10 percent from Zone 4 development, and 15 percent from Zone 7 development.

1.4.2 Existing Labor Pool

A second variable is the percentage of new copper-nickel or taconite jobs which would be filled by existing residents of the Study Area. These percentages and sources are outlined in Table 4 (production/operating workers), Table 5 (construction workers), and Table 6 (service workers).

Table 4,5,6

1.4.3 Operating and Construction Workforce

The projected number of copper-nickel mine operating and construction workers used in this analysis are based on the employment needed for the mine models produced by the Study's Technical Assessment Team. To derive employment estimates for new taconite plants and taconite plant expansions, three sources were used: taconite companies figures, estimates from the Arrowhead Regional Development Commission (ARDC 1976), and from the formula:

P_i

where: E_i = new workers at plant i ; and

T_i = 1977 long tonnage production capacity of plant i ; and

W_i = 1976 worker estimates at plant i ; and

P_i = estimates of new taconite plant or expanded plant production capacity at plant i .

If a company with existing facilities was identified as potentially constructing new facilities, ratios of production tonnes per worker were calculated from the company's existing facilities, unless better data were available.

1.4.4 Secondary Employment

The number of secondary jobs derived from new mining development was assumed to be 2.0 multiplied by new operating mining jobs. For example, if 1,000 new operating mining jobs were created, 2,000 new secondary jobs would be generated. These jobs would provide support services to the mine development, commercial needs, and service demands of new workers.

The employment multiplier of 2.0 was derived from SIMLAB by comparing baseline employment projections (i.e. in the future without copper-nickel development) to future employment projections considering different copper-nickel development projections and time periods (Table 7). Future employment projections in a copper-nickel future over some time period were subtracted from employment projections in the baseline run. The resulting difference then represented new jobs which could be attributable to copper-nickel development. This number of new jobs was then divided by the number of new copper-nickel mining jobs which generated the new secondary jobs. The result of this division was a secondary job multiplier. After reviewing the five multipliers which were generated by these calculations, an average secondary job multiplier of 2.0 was derived.

Table 7

To derive the total number of new jobs produced by new mining development, one needs only to add new mining jobs with the number of new secondary jobs (new mining jobs x 2 = new secondary jobs).

In order to predict residential settlement patterns, new secondary jobs were allocated to nine individual communities, and to rural areas (as one whole unit). Based upon the numbers of sales and use tax reporting units in the nine cities

and in rural areas, (MDR 1976), cities received 98% of all new secondary jobs while the rural areas received 2 percent of all new secondary jobs. The nine cities are: Ely, Babbitt, Tower, Hoyt Lakes, Aurora, Biwabik, Gilbert, Virginia, and Eveleth.

The entire formula for determining the number of new in-migrating secondary workers and for allocating these jobs is outlined. The overall formula for determining the number of secondary jobs to be filled by in-migrants is:

$$S_i = [(M_i \times 2) - [(N_i \times 0.4) + [(M_i \times 2) \times .2]]] \times 0.714$$

where: M_i = number of new mine operating jobs from mine $_i$; and

N_i = number of new miners living in Study Area working in mine; (This factor comes from the output of the operating workers settlement model); and

0.4 = multiplier for second workers from an operating worker's household; and

0.2 = multiplier for new secondary workers who will come from the existing labor pool; and

0.714 = multiplier for second workers from immigrating secondary worker households

S_i = net new secondary jobs to be filled by immigrating households

Then, to allocate a number of secondary jobs to each community (of which there are nine), the following formula is used:

$$J_i =$$

where: J_i = number of secondary jobs to be filled by in-migrating households allocated to city i ; and

P_i = population of city $_i$; and

= sum of each city's population (nine cities are used); and

S_i = net new secondary jobs to be filled by in-migrating households;
and

0.98 = percent of new secondary jobs in cities.

Once these jobs are allocated to each city, the secondary worker settlement model can then project the residential locations of the new secondary workers and families.

1.5 CONCLUSION

The values for each variable in the model can be modified if the user desires to project settlement patterns under varying assumptions. For example, major housing investment decisions involving multiple dwelling units which may be made in the future by private developers, corporations, governmental units, or non-profit organizations are not considered in the models projections. Therefore, construction of new large-scale developments could substantially alter projected settlement patterns. The impact of such decisions can be analyzed in this model by changing the attractiveness factor for a specific settlement zone and then examining the change in settlement distributions.

Both internal and external variables in the model can be modified; the external variables more easily than the internal variables. The model's ability to be modified and thus distribute population based on different assumptions is a major asset as a tool for impact analysis in land use, taxation, and community studies.

REFERENCES CITES

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- Minnesota Department of Revenue. 1976,1977. Sales and use tax reporting units. St. Paul.
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2.0 OPERATING MANUAL

2.1 INTRODUCTION

This operating manual outlines the procedures required to setup and run the residential settlement model developed by the Regional Copper-Nickel Study. The model, is composed of five major components, four of which are computerized. The major components include:

Calibration Routines

Distance (Road) Network

Main Gravity Models (Allocation Programs)

Data Files

Service Job Calculations (not computerized)

Four of these components have numerous computer programs and files. To effectively use the model, the user must understand each component, program, and procedure.

The user should review the report: Use of Gravity Models for Residential Settlement Projections, by Eric H. Bauman and Anthony C. Lea, Regional Copper-Nickel Study, 1979. This report outlines the theoretical foundation for gravity models in general, explains the concept and information contained within the Regional Copper-Nickel Study's model, and supplies an example of its use. This report is particularly important for the user to read if he wishes to change any of the parameters within the present model. In fact, this manual assumes that the reader is familiar with that report.

The manual is divided into the following sections:

1. Simplified Procedure for Running the Residential Settlement Model in its present form;
2. Formulae for Determining the Number and Distribution of Service Jobs;

3. Procedures for Using and Modifying the Complete Gravity Model
4. List and Brief Description of the Residential Settlement Model Files;
5. Flow Diagrams;
6. Copies of Key Programs

This model was developed on the University of Minnesota, University Computing Center CDC Cyber 74 computer, using FORTRAN programming language.

This manual assumes that the Cyber 74 operating system called (NOS) has not changed since December, 1978 and January, 1979.

2.2 USING THE RESIDENTIAL SETTLEMENT MODEL IN ITS PRESENT FORM

If the user is satisfied with the assumptions and parameters set for the Regional Copper-Nickel Study's residential settlement model, using the models will be greatly simplified (Figure 6). If the user is only interested in changing the numbers of employees to be distributed from mines or cities for operating, construction, or service worker forces, then the procedure which is outlined below will satisfy the user's needs. Copies of the programs used here are in Section 2.6.

STEPS	OPERATION	DIRECTIONS
1	Get program POPUL for xedit	Type in: <u>xedit,popul,p</u> then hit RETURN key
2	Go to line 150 in program POPUL	Enter: <u>150</u> then hit RETURN key
3	Modify comman	Enter: <u>m</u> then hit RETURN key
4	Change the number of in- migrants to be allocated in the model	Move the pointer to "5" in 590 type in the total number of in-migrants to be allocated Type in slash / hit the RETURN key
5	Go to line 158 in program POPUL	Enter: <u>158</u> hit the RETURN key
6	Modify command	Enter: <u>m</u> hit the RETURN key
7	Indicate the type of work force the user wishes to distribute: operating, service, or construction workers	Move the pointer to /2/ Enter: <u>1</u> or <u>2</u> or <u>3</u> 1 to run operating worker model 2 to run service worker model 3 to run construction worker model
8	Stop modifying the program and create the local file of the modified POPUL program	Enter: <u>q,</u>
9	Then attach a name to the local file and create a local file with a new name. Names should be different for each modified POPUL file (i.e. the file should be changed with every new run)	After the q, which was entered above, enter <u>aa</u> (or another two letter name) hit RETURN key
10	Save the local file	Enter: <u>save,aa</u> hit the RETURN key
11	Get permanent file PERSUB for xedit	Type in: <u>xedit,persub,p</u> hit the RETURN key
12	Move down to the 4th line of the submit file PERSUB	Type in: <u>xn3</u> hit the RETURN key
13	Modify command	Type in: <u>m</u> hit the RETURN key

STEPS	OPERATION	DIRECTIONS
14	Change the name of the percentage distribution file for that mine from which the user is interested in distributing workers	The user sees GET, CP248 -move the pointer to CP248 -enter the percentage distribution file name -hit RETURN
	The user's options are:	
	<u>FILE NAME</u>	
	OP246 Operating Workers from mine in Zone 2	
	OP248 Operating Workers from mine in Zone 4	
	OP251 Operating Workers from Mine in Zone 7	
	CP246 Construction Workers from mine in Zone 2	
	CP248 Construction Workers from mine in Zone 4	
	CP251 Construction Workers from mine in Zone 7	
	SP246 Service Workers generated because of mine in Zone 2	
	SP248 Service Workers generated because of mine in Zone 4	
	SP251 Service Workers generated because of mine in Zone 7	
15	Move to the next line	Type in: <u>xn</u> hit the RETURN key
16	Modify command	Type in: <u>m</u> hit the RETURN key
17	Attach the name given to the modified POPUL local file in Steps 9 & 10	Move the pointer to GET,POPUL=AA -type in the modified local POPUL file name from Step 9 -hit the RETURN key
18	Move two lines down	Type in: <u>xn2</u> hit the RETURN key
19	Modify command	Type in: <u>m</u> hit the RETURN key
20	Insert the name of the percent distribution file used in Step 14	Move the pointer to DISPRO(,CP248) -enter the file name from Step 14 -hit the RETURN key
21	Move two lines down	Type in: <u>xn2</u> hit the RETURN key
22	Modify command	Type in: <u>m</u> hit the RETURN key
23	The actual distribution of workers will appear on the OUTPUT file from the program POPUL. This instruction will place that output file on a permanent file. For simplicity, all of these files are called EMAPnn with a two-digit number filling the fifth and sixth place in the file name. Each time that this submit file is run, the user should attach a new EMAP file number to the EMAP in the statement.	Move the pointer to COPY,OUTPUT,EMAP36 Enter a two-digit number (DO NOT DUPLICATE NUMBERS FROM ONE RUN TO ANOTHER) hit the RETURN key

STEP	OPERATION	DIRECTIONS
24	Move to next line	Type in: <u>xn</u> hit the RETURN key
25	Modify command	Type in: <u>m</u> hit the RETURN key
26	Insert the EMAP file number that was used in Step 23	Move the pointer to RETAIN, EMAP36 Enter the EMAP file number from Step 23 hit the RETURN key
27	Stop modifying the program and create a local file of the modified PERSUB submit file	Type in: <u>q</u> hit the RETURN key
28	Run the program	Type in: <u>submit,persub</u> hit the RETURN key
29	Determine if the program has run	Type in: <u>e,jn</u> hit the RETURN key
30	You now have three options to see your output. Option 30(a) allows the user to dispose a three-dimensional plot to Bin 95 at the University Computer Center at Lauderdale. Option 30(b) allows the user to review the output on the terminal and then dispose printed output to Bin 95 at Lauderdale. Option 30(c) allows the user to simply dispose the output to Lauderdale.	
OPTION 30(a) THREE-DIMENSIONAL PLOTS		
30(a)		
(1)	Get submit file TESTSUB for xedit	Type in: <u>exedit,testsub,p</u> hit the RETURN key
(2)	Move to a line in the submit file where EMAP appears	Type in: <u>l/emap/</u> hit the RETURN key
(3)	Modify command	Type in: <u>m</u> hit the RETURN key
(4)	Insert the EMAP file numbers used in Steps 23 & 26	Move the pointer to EMAP36 -enter proper EMAP number -hit the RETURN key
(5)	Stop modifying the submit file and create a local file edition of the submit file	Type in: <u>q</u> hit the RETURN key
(6)	Run the program	Type in: <u>submit,testsub</u> hit the RETURN key
(7)	Pickup the output at Bin 95, UCC, Lauderdale	

STEPS	OPERATION	DIRECTIONS
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OPTION 30(b) PRINTED TABLES AT THE TERMINAL AND AT LAUDERDALE

30(b)

- | | | |
|-----|---|--|
| (1) | Get EMAP file | Type in: <u>xedit,emap36,p</u>
hit the RETURN key |
| (2) | Instruct the computer to print out the output file at the terminal | Type in: <u>p*</u>
hit the RETURN key |
| (3) | Output will be printed at the terminal immediately. If the user wishes to stop this printing, instruct the computer to stop printing. | Hit the BREAK key |
| (4) | Create a local file called TEMP | Enter: <u>q,temp</u>
hit the RETURN key |
| (5) | Dispose the contents of the file to a line printer. Output will appear in Bin 95, UCC, Lauderdale | Type in: <u>-rowte</u>
hit the RETURN key |

OPTION 30(c) ONLY PRINTED OUTPUT DISPOSED TO BIN 95, UCC-LAUDERDALE

30(c)

- | | | |
|-----|--|---|
| (1) | Copy the EMAP file to a local file called TEMP | Type in: <u>get,emap36</u>
(or other EMAP number)
Type in: <u>copysbf,emap36,temp</u>
hit the RETURN key |
| (2) | Dispose the contents of the file to the line printer. Output will appear at Bin 95, UCC-Lauderdale | Type in: <u>-rowte</u>
hit the RETURN key |

*****OPTIONAL STEP*****

31 If the user is creating more than one EMAP file, the user may wish to sum two or more files. In order to do this, the user has the option of completing the following steps:

31

- | | | |
|-----|---|--|
| (1) | Get program THRESUM for xedit | Type in: <u>xedit,thresum,p</u>
hit the RETURN key |
| (2) | Move to the 6th line | Type in: <u>xn5</u>
hit the RETURN key |
| (3) | Modify command | Type in: <u>m</u>
hit the RETURN key |
| (4) | Instruct the program whether you will be summing two or three files | Move pointer to DATA/TYPE/1/
if the user is summing three EMAP files, type in <u>1</u> , OR, if the user is summing two files, type in <u>2</u>
hit the RETURN key |

STEPS	OPERATION	DIRECTIONS
(5)	Stop modifying the program and create a local file version of THRESUM	Type in: <u>q</u> hit the RETURN key
(6)	Create a permanent file version of modified THRESUM	Type in: <u>replace, thresum</u> (this must be done in order for the program to run in Step 18) hit the RETURN key
(7)	Get the submit file SUBSUM for xedit	Type in: <u>xedit, thresum, p</u> hit the RETURN key
(8)	Move to the 4th line	Type in: <u>xn3</u> hit the RETURN key
(9)	Modify command	Type in: <u>m</u> hit the RETURN key
	If you are summing three files, go to Step 31(10)(a) If you are summing two files, go to Step 31(10)(b)	
10(a)	Insert EMAP numbers for each each of the two EMAP files to be summed	Move pointer to three positions: GET,EMAP10,EMAP20,EMAP30 Type in the EMAP file numbers you wish to have summed hit the RETURN key
10(b)	Insert EMAP numbers for each of the two EMAP files to be summed	Move the pointer to two positions: GET,EMAP10,EMAP20 Type in the EMAP file numbers you wish to have summed After EMAP20, type in: .##### hit the RETURN key
(11)	Move down the file 2 lines	Type in: <u>xn2</u> hit the RETURN key
(12)	Modify command	Type in: <u>m</u> hit the RETURN key
(13)	Insert a new three digits EMAP number which names a new file which will contain the summation	Move pointer to: COPY,OUTPUT,EMAP100 Type in a new EMAP number (This number should be changed every time that SUBSUM is run) hit the RETURN key
(14)	Move to the next line	Type in: <u>xn</u> hit the RETURN key
(15)	Modify command	Type in: <u>m</u> hit the RETURN key

STEPS	OPERATION	DIRECTIONS
(16)	Insert the new summed EMAP file number. This instruction will save the summed EMAP file	Move the pointer to: RETAIN,EMAP100 Type in the same EMAP number that was used in the previous Step (15) hit the RETURN key
(17)	Stop modifying the program and create a local file edition of SUBSUM	Type in: <u>q</u> hit the RETURN key
(18)	Run the program	Type in: <u>submit,subsum</u> hit the RETURN key
(19)	For printed tables, three-dimensional plots, etc. options, see Step 30.	

2.3 FORMULAE FOR DETERMINING THE NUMBER OF SERVICE (SECONDARY) JOBS

2.3.1 Mathematical Formulae

The overall formula for determining the number of service jobs to be filled by in-migrants is:

$$S_i = [(M_i \times 2) - [(N_i \times 0.4) + [(M_i \times 2) \times .2]]] \times 0.714 \quad (1)$$

where: M_i = number of new mine operating jobs from mine_i; and

N_i = number of new miners living in Study Area working in mine:

(This factor comes from the output of the operating workers settlement model); and

2 = service job multiplier

0.4 = multiplier for second workers from an operating workers household;
and

0.2 = multiplier for new service workers who will come from the existing labor pool; and

0.714 = multiplier for second workers from immigrating secondary workers households; and

S_i = net new service jobs to be filled by immigrating households

Then, to allocate a number of service jobs to each community (of which there are nine), the following formula is used:

$$J_i = \frac{P_i}{\sum_{i=1}^9 P_i} \times (S_i \times 0.98) \quad (2)$$

$i = 1$

where: J_i = number of service jobs to be filled by immigrating households allocated to city_i; and

P_i = population of city_i; and

$\sum_{i=1}^9 P_i$ = sum of each city's population (nine cities are used); and

S_i = net new service jobs to be filled by immigrating households;

and

0.98 = percent of new service jobs in cities

Once secondary jobs are allocated to each city, the service worker settlement model can then project the residential locations of the new service workers and families.

In formula 2, population of city i (P_i) can be existing or projected population.

2.3.2 Programmed Formulae

Both of these formulae have been summarized onto programmed magnetic tapes for use on a Hewlett-Packard HP-97 programmable calculator. The program for calculating the number of net new service jobs to be filled by immigrating households (Formula 1) is:

ØØ1	*LBLH	21	11	Ø13	STO9	35	Ø9
ØØ2	RCL1	36	Ø1	Ø14	RCL7	36	Ø7
ØØ3	RCL2	36	Ø2	Ø15	RCL8	36	Ø8
ØØ4	x		-35	Ø16	-		-45
ØØ5	STO7	35	Ø7	Ø17	RCL9	36	Ø9
ØØ6	RCL3	36	Ø3	Ø18	-		-45
ØØ7	RCL4	36	Ø4	Ø19	STOI	35	46
ØØ8	x		-35	Ø2Ø	RCLI	36	46
ØØ9	STO8	35	Ø8	Ø21	RCL6	36	Ø6
Ø1Ø	RCL7	36	Ø7	Ø22	x		-35
Ø11	RCL5	36	Ø5	Ø23	PRTX		-14
Ø12	x		-35	Ø24	RTN		24

For the first run of the program, do the following steps:

PUNCH IN:

KEY STROKE:

1. Taconite or CuNi employment (e.g. 1857
employees to operate a 12.35×10^6
mtpy underground mine and mill)

STO 1

2. Service employment multiplier of 2.0

STO 2

3. New taconite or CuNi workers in the Study Area
(This number must come from an operating workers run of the gravity model)(Example 1278). STO 3
4. Second household worker multiplier of 0.4 STO 4
5. Female/male workers who will come from the Study Area of 0.2 STO 5
6. 0.714 (Reduction factor which reduces the total number of inmigrants because of second member of a household may also take a service job as did the primary household member who moved into the area and took the service job) STO 6

Now you would be ready to run the program. Either manually enter the program or pass the magnetic card through your calculator. On the HP-97, once the user presses A, the calculator executes the program. The number then appearing in the calculator would be the number of service jobs which are allocated to all nine cities in the Study Area. For example, 1756 service jobs.

For subsequent runs, the user only needs to enter new mining employment and/or the number of workers who would live in the Study Area. The multipliers in Registers 2,4,5 and 6 remain constant.

The allocation procedure (Formula 2) has been programmed (Figure 7).

In order to run this program, the user must first estimate the population of each of the nine Study Area cities for the year in which the user is interested. Population for the cities should be entered in the following order and placed in the following Registers:

<u>CITY</u>	<u>STORE POPULATION IN:</u>
Ely-Winton	STO 1
Babbitt	STO 2
Tower	STO 3
Aurora	STO 4
Hoyt Lakes	STO 5
Biwabik	STO 6
Eveleth	STO 7
Virginia	STO 8
Gilbert	STO 9

Next, enter .02 in STO A

.98 in STO C

Next, from the previous program, enter the number of net service jobs to be filled by immigrants. Store this number in STO D.

Now, if you press A, the calculator will print out the allocation of service jobs to be filled by immigrating household in the order of cities.

Ely-Winton	251.36***
Babbitt	138.77***
Tower	35.41***
Aurora	133.97***
Hoyt Lakes	178.60***
Biwabik	71.16***
Eveleth	223.95***
Virginia	562.77***
Gilbert	124.95***
RURAL	35.12***

These sample allocations were based upon 1976 population estimates.

These service job allocations are then placed in the main gravity model data files (see section 2.4.2). For taconite projections, the service job projections are located in TACSER. For CuNi projections, they are located in SGRAVD2, or SZONE2, SZONE4, or SZONE7. The variable PCN-IN (percent of the new workforce who will come from Study Area residents) should always be set to 0.0 in these files since the allocation formula has already accounted for this consideration of the number of workers from the Study Area who will work in these new service jobs. The variable PCN-OUT (the percent of total workers who will commute into the Study Area) should be set according to the wishes of the user.(see section 2.4.2, "Adjusting the Model").

2.4 PROCEDURES FOR USING AND MODIFYING THE COMPLETE GRAVITY MODEL

2.4.1 Revising the Road Network: The Shortest Path Algorithmn (SPAR02)

The user of the residential settlement model may wish to modify the existing road network and nodes which were laid out by the Regional Copper-Nickel Study Staff (See map storage file MF-7, compartment 8). This section will tell you how to make these changes. Note (d) will tell you how to change the main gravity model programs (GRAVYP1, SGRAVP1, CGRAVP1) to accomodate the modified network. Section 2.6 contains a copy of SPAR02.

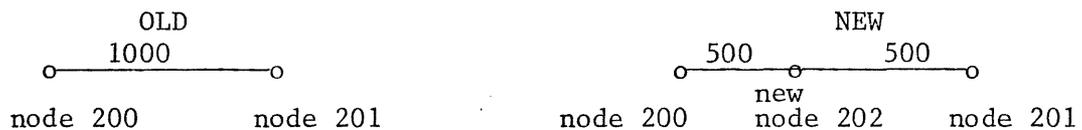
Step (1) Place new nodes on the network map.

(2) Measure the distances between the new nodes and all adjacent nodes. These distances and nodes should be recorded as in Figure 8. The distances should be recorded in mile x 100. For example, if the distance between new node AA and node BB were two miles, the distance on the coding sheet would be 200. After you have completed your recording of nodes and distances.....

(3) xedit, spad2 (if you want to amend the road network which includes the proposed AMAX road) or

xedit, spad3 (if you want to amend the road network which does not include the proposed AMAX road).

- (4) _ (this takes you to the bottom of the file)
- (5) Hit the RETURN key. You will now be in the INPUT mode. Type in the node A identifying number, the node B identifying number, and the distance in the columns listed on the example sheet (figure 8). Then hit the RETURN key and you will be at the next line to input. Continue until you have inserted all of your additions. After the last line of addition, hit RETURN once, then again. You will now be out of the INPUT mode.
- (6) t (This will put you at the beginning of the file)
- (7) Now you must get rid of the old links. For example:



you would have entered in step (5) the following:

Node A (from i)	Node B (from i)	Distance
200	202	500
202	201	500

Now type in l/200/

- (8) The xedit routine will search until it finds a 200. if that point shows:
200 201 1000
then you have found the node link to be deleted. If that line with a 200 is not the proper link, then type l/200/ again until you find it. Once you have found the link which must be deleted (since you have created new links which substitute for the old links), type in d. This will delete the old link.

- (9) This process should be continued until you have deleted all of the old links in your network. If you fail to delete all of the old links, the network will be incorrectly calculated by the SPAP02 program.
- (10) Once you have completely modified the network, you must specify in this data deck the actual node numbers from which you want distances calculated to other nodes. The actual node numbers are called index nodes. Presently, the two data files (SPAD2 and SPAD3) have twenty-eight index nodes. (See Appendix for more information on the actual nature of the Shortest Path Algorithm program.) Once you have counted up the total number of new index nodes, type t (top of file).
- (11) type p (print)
- (12) In columns 14 and 15, check to see if this number corresponds to the total number of index nodes you want. For example, Figure 9 shows that 28 index nodes are used in this data file. If you would add three new index nodes, this number would have to be raised to 31.
- (13) Next, type in xn, then p4. The computer will then print out the index node numbers. Check to see if these numbers are appropriate. If you need to add index node numbers, add them according to the following format:
- (8(4x,I6))
- (14) If you have now completed making all additions and deletions to the network data file (either SPAD2 or SPAD3), type in q, then replace, spad2 or spad3. This will permanently enter your corrections.

- (15) Next, count the number of nodes to which you want distances calculated from the index nodes. For example, in the Regional Copper-Nickel Study Area network without the AMAX road, there are 170 nodes. (Each node represents one gravity model zone which is accessible by road). There are 173 nodes in the network which considers the proposed AMAX road.

Therefore, if you make new gravity model cells or zones accessible, then you must increase the number of nodes. At least one node must be assigned to each accessible zone. If you want to run the Shortest Path Algorithm (SPAPRO2) again, you must follow these procedures.

- (16) xedit, spapro2

- (17) then type in l/njpunch/. This instruction will locate you at a statement which reads:

```
NJPUNCH=173
```

- (18) If that number of nodes is appropriate, then type in q. If that number is not appropriate type in m, and move the pointer to:

```
NJPUNCH=173
```

- (19) Insert the new number: then type in q; then type in replace,spapro2.

- (20) After all corrections, modifications have been made to the main program SPAPRO2 and to any of the data files SPAD2 or SPAD3, you can run the program to calculate the new network.

Type in the following statements to run the program:

```
get, spapro2,spad2
x,mnf, e=4, i-spapro2,l=listit,b=bispa,p=5000
bispa(spad2, temp1, temp2)
replace, temp2-epunch
route(temp1,dc=lp,tid=bc,bin=95
route(temp2,dc=pu,tid=bc,bin=95)
```

TEMP1 will give you a print-out of your results. TEMP2 will give you a punched version of the results, if you desire. Otherwise, the results of the program will be saved on EPUNCH.

If you want to run SPAD3, the cards are the same except:

```
bispa(spad3, temp1, temp3)
replace, temp2=epunch2
```

(21) NOTES:

- a. Each time you change anything in the network, go back through all of these steps to assure yourself that the network is accurate.
- b. Presently, data in EPUNCH2 (the result of running SPAPRO2 with SPAD3) represents the road network without the AMAX road. EPUNCH2 is used directly by the main gravity model programs (e.g. GRAVYP1). Data in EPUNCH (the results of running SPAPRO2 with SPAD2) represents the road network with the proposed AMAX road. EPUNCH is also used directly by the main gravity model program (e.g. GRAVYP1)
- c. You can create other EPUNCH files. For example, you could create a new road, along the Embarrass Valley or along the Duluth Contact. If you hypothesize new nodes and links, you can simply make these changes in a local file edition of SPAD2 or SPAD3 and then save that local file with a new name. For example:

```
q,spad5
```

```
save,spad5
```

You would then use this new file name wherever SPAD2 had been used. You would then also want to call your new EPUNCH file EPUNCH5.

d. If you wish to add additional index nodes into the road network which will subsequently be used by the main gravity model programs, and if you want to recalibrate the beta coefficient (described in later section 2.4.3), you will need to modify the following files:

GRAVYP1	SERCALI
SGRAVP1	CONBRU1
CGRAVP1	SERBRU1

The modifications in files GRAVYP1, SGRAVP1, CGRAVP1, and SERCALI are:

<u>AT LINE:</u>	<u>CHANGE</u>	<u>TO:</u>
00120	XMILES(28,224)	XMILES(*,224)
00120	IXNODE(28)	IXNODE(__*)
00994 (does not apply to SERCALI)	,J=24,28)	,J=24 __*)

Insert the new total numbers of index nodes where this symbol appears*.

For CONBRU1 and SERBRU1, at line 1, change 170 to the number of index nodes. This number should be the same number as was set as NJPUNCH=___ in SPAPRO2.

2.4.2 Running the Complete Model

Files--The user must be aware that there are four sets of files to use when running the full version of the gravity model. These file sets are:

1. Main data files
2. Main gravity model allocation programs
3. Distance network files
4. Submit files

Data Files--Data files (for example see Figure 11) are divided into three types: operating, service, and construction workers. These may be divided into further types: taconite and copper-nickel. The following data files are presently in the socio-economic Regional Copper-Nickel Study files:

<u>Taconite</u>	<u>Years</u>	<u>File Names</u>
Operating Workers	1976-1984	TACGRAV
Service Workers	1976-1984	TACSER
Construction Workers	1976-1984	CONTACG
<u>Copper-Nickel</u>		
Operating Workers	1985-2000	GRAVYD2
Construction Workers	1985-2000	CGRAVD2
Service Workers from Zone 2 Development		SZONE2
Service Workers from Zone 4 Development		SZONE4
Service Workers from Zone 7 Development		SZONE7
Service Workers from Development in Zones 2&4		SZONE2

The taconite and copper-nickel data files contain:

- 1) Attractiveness Function Alpha Coefficient
- 2) Distance Decay Beta Coefficient
- 3) Employment Projections
- 4) Assumed percentages of workers who will come from residents of Study Area (PCN-IN)
- 5) Assumed percentages of workers who will live outside the Study Area but who will work within the Study Area (PCN-OUT)
- 6) Attractiveness Data (by gravity model zone)
 - Road intersection (RD)
 - Residential structure (RS)
 - Reporting units (RU)
 - Commercial structures (CS)
 - Available land w/o CuNi (ACW) or Available land w/CuNi (AL)
 - Available land within 1 mile of a road w/o CuNi (RO), or Available land within 1 mile of a road w/CuNi (RA)
 - Available land w/in ½ mile of a lake or ¼ mile of a stream w/o CuNi (WO) or w/CuNi (WA)
 - Total cells within each gravity model zone (TC)

Reference to "Available land w/o CuNi" means that the data represents available land in a future scenario that does not include copper-nickel mine development. In a "future w/o CuNi scenario", taconite mining is assumed to need increased land area. A scenario of "Available land w/CuNi" assumes new copper-nickel mining land requirements and taconite mining land requirements.

Other attractiveness factors are derived within the gravity model once the distance network is read into the program. These factors are:

- Distance to Virginia
- Distance to Virginia, Ely, or Two Harbors

With regards to these attractiveness factors, all factors are read into the gravity model program (GRAVYP1 for operating, SGRAVP1 for service workers, CGRAVP1 for construction workers). Only three factors are actually used in the calibrations, however. These factors are: Residential Structures (RS), Reporting Units (RU), and Available Land within 1 mile of roads (RO or RA). The user can change the attractiveness factors which are used or the weights attached to these factors. Such changes require, however, recalibration of the alpha and beta coefficients. Recalibration will be covered later.

Distance Files--EPUNCH2 provides the distance from 28 index nodes (employment centers) to 170 road-accessible gravity model zones, assuming that there is no AMAX road. EPUNCH provides the distance network to 173 gravity model zones assuming the presence of a proposed AMAX road connecting Hoyt Lakes and potential AMAX site in Copper-Nickel Study Development Zone 4 near Babbitt. The distance network can be modified. This procedure is contained in Section 2.4.1 of these instructions.

Main Gravity Model-- The main gravity model has three versions:

- GRAVYP1 for operating mine workers distribution
- SCRAVP1 for service workers distribution
- CGRAVP1 for construction workers distribution

The differences in these programs are minor. The two major differences are:

- 1) Each program identifies the output as being operating, service, or construction.
 - 2) The program provides percentage distribution of workers to each zone.
- GRAVYP1 produces these distributions onto file OPRCENT. SGRAVP1 produces

these distributions onto file SPRCENT. CGRAVP1 produces these distributions onto CPRCENT.

Submit Files--A submit file is used to call the distance network file, data file, and a main gravity model program. This file then directs the computer to run the model and to produce output. These files will be discussed later in this section.

Running the Model

Assuming that you, the user, are completely satisfied with all assumptions, employment projections, and road networks, the model is relatively easy to run (Figure 10).

(1) You will need to decide which road network files you want to use and which data files you want. You may use any one file from each category of data, gravity model, and road network, file groupings.

	<u>DATA FILE</u>	<u>GRAVITY MODEL</u>	<u>ROAD NETWORK</u>
OPERATING	TACGRAV	GRAVYP1	EPUNCH
	GRAVD2		EPUNCH2 (or other versions)
SERVICE	TACSER	SGRAVP1	EPUNCH
	SGRAVD2		EPUNCH2 (or other versions)
	SZONE2		
	SZONE4		
	SZONE7		
CONSTRUCTION	CONTACTG	CGRAVP1	EPUNCH
	CGRAVD2		EPUNCH2 (or other versions)

(2) Once you have decided upon which files you want to use, next decide the type of output you want, this will determine the SUBMIT file you will use.

<u>DESIRED OUTPUT</u>	<u>SUBMIT FILE TO USE</u>
Printed Tables and 3D Plots*	ERICSUB
Printed Tables and Only*	ESUBOUT
3D Plots Only*	ESUBNOO
Data Only retained*	ESUBFIL

*Data is retained w/in the computer and stored under the zzz6670 account.

Each file is listed in Section 2.7.

Notice that within each file, there is a statement which reads

```
RETAIN, MAPOUT = EMAP50, TMAPOUT = ETMAP50
```

This statement saves the distribution from the gravity model run in a form which can be summed, subtracted, or plotted. If you wish to save these distributions, it is advised that you identify them accordingly by setting an EMAP number (by using XEDIT).

If you do not want to exercise this EMAP option, Xedit the file; type in l/retain/ which will locate you at the RETAIN statement. Then type in d which will delete the statement, then type in q.

To actually run the mode, select the files you desire, then

- 1) On lines 4 and 7, substitute your desired data file (e.g. GRAVYD2) and distance file (e.g. EPUNCH2) through typing in m and moving the pointer to the appropriate spot.
- 2) On lines 5 and 6, insert the main gravity model program you want to use (i.e. GRAVYP1, SGRAVP1, or CGRAVP1).

3) After you have specified your files and have labelled any output files, type in q.

4) Type in submit, ericsub or
submit, esubout or
submit, esubnoo or
submit, esubfil

This will actually run the program

5) If you should want a listing of the percentages of workers allocated to each zone use the following submit files:

<u>FOR:</u>	<u>USE:</u>
Construction	ESUBCON
Service	ESUB
Operating	ESUBNOP

Adjusting the Model

The resulting output from running the submit files are used in building the percentage distribution files used in the simplified gravity model. (see section 2.2)

Adjusting the model involves a significant amount of work. This outline will discuss the modification procedures in order of increasing difficulty.

1) EMPLOYMENT: WORKERS DRAWN FROM EXISTING LABOR POOL (PCN-IN): IN
COMMUTERS (PCN-OUT): NUMBER OF MINES

(A) Employment--Simply substitute the desired number of new workers for each employment center (i.e. an index mode in the distance network). After line 4 in each data file (e.g. GRAVYD2, TACGRAV), insert a line (or modify an existing line).

For Example: See Figure 11.

Col. 7-10 Employment Center (index node)

Col. 23-27 Employment Projection

Col. 51-70 Name of Employment Center

One new line must be completed for each new employment center
(Do not exceed a total of 25 centers)

- (B) Reducing Worker In-Migration Projections for Operating and Construction Workers (PCN-IN and PCN-OUT)--As has been outlined for service workers, not all of the new jobs will be filled by new in-migrants. A portion of the new jobs will probably be filled by residents of the Study Area. In addition, a portion of the jobs will be filled by workers commuting into the Study Area. In the case of operating jobs, some percentage of these new jobs will probably be filled by construction workers who "cross-over" into the operating jobs.

Estimates of these percentages are noted on Tables 8, 9 and 10 in the description of the Residential Settlement Model. These numbers enter into the data files on Line 4 and on the employment lines following line 4.

	<u>Variable Name</u>	<u>Variable Description</u>
Line 4		
Col. 57-62	PCN-IN	-Percent of workers coming from within the Study Area (always set to 0.0 for service workers)
After Line 4		
Col. 42-47	PCN-OUT	-Percent of new workers who will be in-commuters

These variables are located in all of the main gravity model data files.

Construction workers cross-over employment is calculated by hand. Any decreases in in-migrating operating workers caused by construction worker cross-over are calculated before the employment figures are inserted into the gravity model data files.

(C) Number of Work Centers--This variable is labeled as NMINES. On line 4, Col. 41-43 insert one number which represents the total number of work centers used in this run of the model. For example, if you were projecting mine operating-workers from Mines 246, 248 and 251, the value for MINES would be 3.

Existing Attractiveness Factors

The existing main gravity model program uses the following attractiveness variables to form the total attractiveness function:

<u>FACTOR</u>	<u>WEIGHT</u> (Total of 10)
Existing residential structures (surrogate population indicator)	8.0
Sales and use tax reporting units (surrogate commercial activity indicator)	1.5
Available, developable land within 1 mile of roads	0.5

The user has the option of changing the weight and/or attractiveness factors.

Other factors, which are available within the existing data files (e.g.

GRAVYD2) or when the gravity model runs, are:

Highway/road intersections

Rural commercial structures

Available, developable land
within one-half mile of lakes
and one-fourth mile of streams

Distance to Virginia (the regional
trade center)

Distance to Virginia, Ely or Two Harbors
(3 highest order towns)

In addition, data has been processed for another variable which is not on an existing data file (i.e. GRAVYD2, TACGRAV, etc) but which is stored within the Socio-Economic archive tapes. This attraction variable is: Available developable land within one-half mile of lakes and one-fourth mile of streams and

within 1 mile of roads. This variable is identified on archive tapes as WARA2.

Changing the attractiveness factors and weights within the main gravity model allocation programs (SGRAVP1, GRAVYP1, CGRAVP1) is quite simple. Statements 1656 to 1666 label each attractiveness factor (which are referenced within the program as RD (I,n). Statements 1670 to 1760 control which features are used in building the attractiveness function and the internal weights which are placed on each factor within the attractiveness function.

The attractiveness function is mathematically represented in Statement 1760. Here you see the RD(I,2)--residential structures, RD(I,3)--reporting units and RD(I,6)--available land within 1 mile of a road comprise the attractiveness function. Their values are summed and become RD(I,11).

If the user wants other factors excluded or included, simply insert or delete the appropriate RD(I,n) in Statement 1760 using XEDIT. You then will probably need to modify the weights in relevant factors in Statements 1670-1750.

For example, if the user wanted to decrease the weight of RD(I,2) from 8.0 to 5.0, the weights in Statement 1680 would be changed from 8.0 to 5.0. If the user wanted to delete RD(I,3) from the attractiveness function, RD(I,3) would be deleted from Statement 1760. Statement 1690 would not have to be modified since statement 1760 actually controls which factor are mathematically included in the gravity model formula. If the user wanted to add RD(I,1) and give it a weight of 3.0, the weight would need to be changed in 1670 from 0.0 to 3.0. Then the user would insert RD(I,1) in Statement 1760. At this point, the gravity model would consider a new attractiveness function.

While these modifications are relatively easy, the user must recalibrate the model. This is to say, the user must derive a new attractiveness function coefficient (alpha - α) and a new distance decay coefficient (beta - β). This process is described in Section 2.4.3 of this document.

After calibration, new alpha and beta coefficients would be inserted into line 1 or line 2 in each data file before the model would be run.

2.4.3 Calibration

At this point, you, the user, having decided to consider new attractiveness factors (whether already on file or newly created) must recalibrate the attractiveness coefficient (alpha - α) and the distance decay coefficient (beta - β). To do this, the user must consider three elements:

(A) Values for each new attractiveness factor must be gathered for either zipcode areas or for each gravity model zone. (If the user wants to use existing attractiveness factors already in a data file, the data is obviously already gathered.)

(B) If data can be collected by zipcode and if the user has collected actual number of workers who live within the zipcode area, the user can calibrate an operating worker gravity model the calibration programs CALIBER and BRUTE (Figure 12) (discussed below). If attractiveness or flow data are not available by zipcode area, data must be obtained by gravity model zone. The user then will need to use calibration programs SERCALI and SERBRUT (Figure 13). Further, the user will need to use the average journey-to-work distances for operating, service, and construction workers. These distances will be used in data files to run SERBRUT (discussed below). These distances are:

11.31 miles	-	service workers
17.28 miles	-	operating workers
25.51 miles	-	construction workers

(C) The user must also decide whether to use the exponential or power versions of the gravity model. While the user can calibrate both, this does require some extra work. Calibrating one version is easier.

These instructions assume that the exponential model will be calibrated.

Limited Calibration (beta)

Attractiveness data should be collected for each of 224 gravity model zones. After this is done, for each variable, the user must create a file containing the attractiveness factor values for each zone.

Line 1	Col. 1	type /
	Col. 2-3	two letter abbreviations of the attractiveness variable name.
	Col. 4	type /
	Col. 5	blank
	Col. 6 -70	attraction value name (Format F10.4)
Lines 2-225	Col. 1	type /
	Col. 2-3	two letter abbreviations of the attractiveness variable name
	Col. 4	type /
	Col. 5	blank
	Col. 6 or 6-7 or 6-7-8	number of zone (1-224)
next col.		blank
next 10 columns		attraction value (Format F10.4)

After all attraction values and labeling is complete, save the file. Review the file to assure that no errors have occurred.

Now, the new data must be "fit" into the parameters of the main gravity model program (i.e. DIMENSION statements and the density conversion may need to be

Limited Calibration (beta)

Attractiveness data should be collected for each of 224 gravity model zones. After this is done, for each variable, the user must create a file containing the attractiveness factor values for each zone.

Line 1
~~Card~~ Col. 1 type *f* /
Col. 2-3 two letter abbreviations of the attractiveness variable name.
Col. 4 type *f* /
Col. 5 blank
lines Col. 6 -70 Attraction value name (Format F10.4)
~~Card~~ 2-225 Col. 1 type *f* /
Col. 2-3 two letter abbreviations of the attractiveness variable name.
Col. 4 type *f* /
Col. 5 blank
Col. 6 or
6-7 or Number of the zone (1-224)
6-7-8
next col. blank
next 10 columns attraction value (Format F10.4)

After all attraction values and labelling is complete, save the file. Review the file to assure that no errors have occurred.

Now, the new data must be "fit" into the parameters of the main gravity model program (i.e. DIMENSION statements and the density conversion may need to be modified; and the attractiveness factor labelling and weighting statements may be to be modified).

When your data is inserted into one of the main gravity model data files (e.g. GRAVD2), you can run the data on SERCALI to obtain new attractiveness *Z_A*-scores to be used in the SERBRUT calibration routine. In addition, this new data can be used to *r*un the main gravity model. The users should review

modified; and the attractiveness factor labeling and weighting statements may need to be modified).

When your data is inserted into one of the main gravity model data files (e.g. GRAVD2), you can run the data on SERCALI to obtain new attractiveness Z-scores to be used in the SERBRUT calibration routine. In addition, this newdata can be used to run the main gravity model. The users should review statements 460 to 720 and statements 1350 to 1770 to assure that the data is processed through the program correctly.

If new data is used, the user must insert the new information into the service workers data files (e.g. SGRAVD3, or TACSER) and the construction workers data files (e.g. CGRAVD2), in the main program, and in SERCALI.

1) Assuming that the new attraction data has been entered onto main data files and that the main programs have been modified to accommodate this new data, the program SERCALI will be run in order to generate attraction Z-scores for use in the actual calibration program (SERBRUT).

A) First, xedit., subcali, p (This is the submit file which runs the program SERCALI).

B) On line 4, insert the main data file name you wish to use in your run. For example, GET, GRAVD2, EPUNCH2.

C) On line 8, again insert the data file name and distance file name.

D) Type in q to finish your work with the submit file.

E) Now type in submit, subcali. This actually runs the program.

F) Your output (distance network and attraction scores) will be on a file called ATTRACT. To see your ddat type in xedit, attract, p.

G) Type in p* if you want to see your entire file, or type in l/attraction/ if you want to see your new Z-attraction scores. Typing l/attraction/ will locate you at ****ATTRACTION DATA****. All lines following ****ATTRACTION DATA**** will contain your new attraction Z-scores which will be inserted into CONBRU1 (the data file to calibrate and construction workers distance decay coefficient). SERBRU1 (the data file to calibrate a service workers' distance decay coefficient) or OPBRU1 (the data file to calibrate an operating mine workers distance decay coefficient).

If the user wishes to run more than 1 set of new attractions Z-scores, the ATTRACT file should be renamed in the SUBCALI submit file each time it is submitted (e.g. ATT1, ATT2, ATT3).

2) The attraction Z-scores from ATTRACT can be added to the data files or files representing the workforce type for which your need to calibrate.

The data files already on the disk are:

CONBRU1	for construction workers
SERBRU1	for service workers
OPBRU1	for operating workers

These new attractions Z-scores should be inserted at line 51. See below for more information.

3) In order to run SERBRUT (the calibration program) an or all of the data files listed in 2) above must either be modified or a new file created using the appropriate format. (For example, see Figure 14.)

<u>Line</u>	<u>Columns</u>	<u>Variable</u>	<u>Remarks</u>
Line 1	Col 2	KK	Insert either 1, 2, or 3: 1- to calibrate power model 2-to calibrate exponential model 3- to calibrate both set the number of models. For example, 170 set the number of employment locations

<u>Line</u>	<u>Columns</u>	<u>Variable</u>	<u>Remarks</u>
Line 2 - This line sets the parameters of the calibration search for the beta coefficient for the power model.			
	40-49	MINB	Set the number where you want the search to begin. For example, -1.500
	50-59	MAXB	Set the numbers where you want the search to stop.
	60-69	STEP B	For example -1.000 set the incremental step number. In what increments do you want your search to proceed. (For example: 0.001)
Line 3	1-9	AVEDIST	Set the average journey to work distance--they should already be set in an existing file. If you are building your own files, use of the following per file: Service - 11.31 miles Construction - 25.51 miles Operating - 17.28 miles
Line 4--In the program, <u>the distance network</u> is called COST or C(I,J). These are the distances from points of employment to each node.			
	2-3-4		Employment Center Number
Lines 4-16	7-11 12-16 17-21 22-26 27-31 32-36 37-41 42-46 47-51 52-56 57-61 62-66 67-71		Distance from employment center to each node (Format F5.1)
Line 17	7-11		Distance from employment center to last node
Line 18	skip		
Line 19-48			Repeat the same format as in lines 4-18 for each employment center. Following the last distance matrix, total employment at each employment center is listed. For this example this will be done at line 49 (i.e. there were 3 employment centers for which matrices were included.)

<u>Line</u>	<u>Columns</u>	<u>Variable</u>	<u>Remarks</u>
Line 49	1-10	CONBRU1	Employment at an employment center. One total figure for each group of ten columns
	11-20	or	
for	21-30	OPBRU1	
SERBRU1	31-40		
	41-50		
	51-60		
	1-10		
	11-20		
	21-30		
Line 51	7-18		
52	skip		
53	7-18		(Format F18.5)
54	skip		
387	7-18		
388	skip		

NOTE: This whole block of attractions Z-scores can be merged into CONRU11, SERBRU1, or OPBRU1. (Consult a programmer who is familiar with UCC's XEDIT capabilities.)

Line 389	40-49		Set the number where you want your search to begin for the exponential model Example -0.1500
	50-59		Set the number where you want your search to stop Example -0.0905
	60-69		Set the incremental step number Example .005

4) Once you have set up your data file, you are now ready to run the calibration program. To run the program, either create a submit file or run on-line.

get, serbrut, serbrul

r, serbrut, serbrul

x, mnf, e = 4, l = serbrut, b = brut, l = listout

brut (serbrul, calout)

If the program doesn't run, xedit, listout

p*

and/or type in l/dayfile

If the program runs, type:

save, calout

route (calout, dc=lp, tid = bc, bin = 95)

This will save the output and route a copy of the output to Bin 95 at UCC.

5) Evaluating your SERBRUT output--Once you have output from SERBRUT, you should first review the cost (distance) data, average commuting distance, total employment and attraction Z-scores to determine if they correspond to the data file (e.g. CONBRU1). If they do not, recheck SERBRUT, the data file, and the original submit file SUBCALI. If the "echo" printout is correct, you are ready to evaluate the output. (Figure 15)

This output represents the exponential mode. The output will be the same for the power model.

The object is to locate a beta value which yields a distance maximum likelihood estimator (DISMAXL) of .000. Once you have found an estimator of zero, you could use the corresponding beta as your distance decay coefficient in line 2 of the main gravity model file (for the appropriate workforce) if the coefficient is reasonable.

Reasonableness may be determined in at least two ways: First, the user should speak with a knowledgeable person in settlement modeling. Second, the beta can be tried in a run of the gravity model to see if the worker distribution is reasonable. If the beta does not appear to be reasonable, new attractiveness functions (i.e. new factors and/or weighting) can be tried in order to recalibrate.

The user must remember, however, that this calibration just described can only generate data to select a distance decay coefficient (beta). The attractiveness coefficient (alpha) must be obtained separately.

Complete Calibration (alpha and beta)

Using BRUTE and associated programs, the user can calibrate the gravity model for operating workers, using new attractions factors or weights. In order to do this, however, attractiveness data must be collected by 15 or 17 zip-code areas (Figure 16).

1) As with SERCALI and SERBRUT, the user must first construct a data file. (see Section 2.6.5) (GRAVDAT) to run a program (CALIBER) to produce attraction Z-scores for each zip-code area. These scores are then inserted in a data file to run the calibration program (BRUTE).

A) The variables on data file GRAVDAT are listed on Table 11. In order to use GRAVDAT, the user will need to reenter the data into a new file from the printout.

B) The user could, next, add any new attraction variables to the data file GRAVDAT.

C) CALIBER is the program which produces attraction Z-scores (using GRAVDAT). CALIBER will have to be modified, however, to consider new attraction variables.

The user should note that statements 491 to 560 CALIBER are similar to statements 1656 to 1760 in SERCALI. The RD (I,n) identifiers are different, however. Program CALIBER manipulates more variables (Table 12).

D) To run CALIBER, the user types in:

fetch, calcomp

caliber, gravdat

x,mnf, e = 4, i = caliber, k, b - bob, l = temp

bob (temp)

In order to see the relevant output, the user should type:

xedit, newd 1

E) CALIBER will produce attractiveness Z-scores. These scores will be in the third column of the output file presently called NEWD1. Each zip-code will have the same score reported two, three or four times. An attractiveness score must be used for each Plant (mine) to Zip-code Area flow or linkage of mine workers. The user should only extract 1 score for each zip-code area, or 15 in total for each of four mines.

F) The entire data file to input into BRUTE is illustrated on Figure 17.

Figure 18 through Figure 24 identifies the required variables which the user must supply.

As with SERBRU1, CONBRU1, or OPBRU1, the user sets the search parameters for the beta coefficient. Unlike SERBRU1, CONBRU1 or OPBRU1, however, the user must also set the search parameter for the alpha coefficient. For example, the beginning search parameters for the alpha (attractiveness) coefficient should be:

MINA	0.650
MAXA	1.300
STEPA	0.030

Option: The user may wish to run regression analysis on the output to obtain some initial idea of where to search for the best beta and alpha coefficients in the BRUTE calibration program. To run this regression using the CALIBER output file NEWD1, the user can type in the following:

fetch, multreg
multreg
read newd1 0
regs 2 on 1, 5
regs 2 on 4, 5

The exponential model's regression analysis is run on "regs 2 on 1, 5".

The power model's regression analysis is run on "regs 2 on 4, 5".

G) Once the data file (e.g. BRUTDAT for this hypothetical example) is completed, the user should type in the following instructions:

get, brute, brutdat
x, mnf, e = 4, i = brute, l = brutout, b = bob
bob (brutdat, brutout)

Then the user can type in:

xedit, brutout
p*

to see the results. If the user only wished to route the output through the printers at UCC-Lauderdale, type in:

xedit, brutout
q, temp
- rowte

BRUTOUT will then be disposed to Bin 95 in Lauderdale.

Interpreting BRUTOUT

The objective is to find alpha and beta at a point where R^2 is maximized and the distance estimator (DISMAXL) is at or close to zero. See example on Figure 25. Whether the user is attempting to calibrate the power or exponential models, this objective does not change. (Figure 26 illustrates the "data echo".)

To facilitate the users search for the best R^2 and DISMAXL, the programmer has added an indicator. At the top row, you will note a column occupied by a lone

zero. When this zero becomes an asterik*, the R^2 and DISMAXL are entering a mathematical area where the values of R^2 and DISMAXL may meet the maximizing and best-fit objectives.

If you, the user, has chosen to run both the power and exponential versions, after the power version has run, a line ****NEW PROBLEM**** will appear on the output. After this line, the exponential model output will appear.

Based upon past experiences user will probably need to run BRUTE several times. With each new run, the user should try to narrow down the gross search area, but decrease the incremental steps so that you "fine tune" the search within a smaller mathematical area. Once the user has located the best alpha and beta values, these values can be inserted into lines 2 and/or 3 in the appropriate main gravity model data files (e.g. GRAVYD2, TACGRAV).

2.5 RESIDENTIAL SETTLEMENT (GRAVITY) MODEL FILES

2.5.1 Calibration Files

CALIBER	Program. Produces attraction Z-scores for use in BRUTE (for calibrating alpha and beta coefficients for mine operating workers).
SERCALI	Program. Produces attraction Z-scores for use in SERBRUT (for calibrating beta coefficients for operating, service, or construction work foreces).
GRAVXX	Program. Original version of BRUTE, as provided by Anthony C. Lea, formerly Dept. of Geography, University of Minnesota. Now with U-Toronto.
BRUTE	Program. Alpha and beta coefficient calibration program (for mine operating workers).
SERBRUT	Program. Beta calibration program which produces data to select a distance decay coefficient (beta value). Can use CONBRU1, SERBRU1, OPBRU1 data files. Output (when used with SUBCALI submit file) is ATTRACT. Programs primarily used to calibrate gravity model when actual flow data is not available, but an average journey-to-work distance is available.
CONBRU1	Data. Data file to run construction worker gravity model calibration (beta). User SERBRUT (Data by 224 gravity model zones).
SERBRU1	Data. Same as CONBRU1, except it calibrates service workers beta.
OPBRU1	Data. Same as CONBRU1, except it calibrates operating workers beta.

2.5.2 Road Network Files

SPAPROG	Program. Shortest Path Algorithm (SPA) written by L. Ostresh, U-Iowa. Calibrates shortest paths in a network.
SPAPRO2	Program. SPA (from above), modified slightly for use by RCNS. Data files: SPAD2, SPAD3.
SPAD3	Data. Network data and control cards to use with SPAPRO2 to generate a network. Produces EPUNCH2 (The road network, in the Regional Copper-Nickel Study Area, without the proposed AMAX road from Hoyt Lakes to the Reserve pit area). Network does not consider variations in road quality of travel.

SPAD2 Data. Same as SPAD3, except that it includes the proposed AMAX road in the network. Produces EPUNCH.

EPUNCH2 Output. Output from mining SPAPRO2 with SPAD3. Output is in a form readable by the gravity model programs. (Network w/o AMAX road).

EPUNCH Output. Output from running SPAPRO2 with SPAD2. Output is in a form useable by the gravity model programs. (Network w/AMAX road).

2.5.3 Gravity Model - Data Files

EPUNCH2 Road network w/o AMAX road (from SPAPRO2 and SPAD3).

EPUNCH Road network w/AMAX road (from SPAPRO2 and SPAD2).

GRAVD2 CuNi Development Scenario--Operating Workers (Mines in zones 2, 4, 7)

SGRAVD2 CuNi Development Scenario--Service Workers (Mines in zones 2, 4, 7)

CGRAVD2 CuNi Development Scenario--Construction workers (Mines in zones 2, 4, 7).

TACGRAV Taconite Development Scenario 1976-1984--Operating Workers

TACSER Taconite Development Scenario 1976-1984--Service Workers

CONTACG Taconite Development Scenario 1976-1984--Construction Workers

SZONE2 CuNi Development Scenario--Service workers from Development in Zone 2.

SZONE4 CuNi Development Scenario--Service workers from Development in Zone 4.

SZONE7 CuNi Development Scenario--Service workers from Development in Zone 7.

SZONE24 CuNi Development Scenario--Service workers from Development in Zones 2 and 4.

Gravity Model Programs

GRAVYP1 Main gravity model for distributing operating workers from mines. Use with gravity model data files (e.g. GRAVD2) and distance data (e.g. EPUNCH2).

SGRAVP1 Main gravity model for distributing service workers from cities because of development. Use with gravity model data files (e.g. TACSER, SGRAVD2) and distance data (e.g. EPUNCH2).

CGRAVP1 Main gravity model for distributing construction workers from mines. Use with gravity model data files (e.g. CGRAVD2) and distance data (e.g. EPUNCH2).

Submit Files (all run gravity model programs)

ERICSUB Output--Printed table and plots

ESUBNOO Output--Plots only

ESUBOUT Output--Printed tables only

ESUBFIL Output--No routed output (data on disk).

ESUBCON Produces CPRCENT -- percent distributions of immigrating construction workers to each gravity model zone. (Multiply a CPRECENT percentage distributions for a zone times total immigrating workers to produce a number of workers allocated to the zone. See SIMPLIFIED GRAVITY MODEL RUNS).

ESUB Produces SPRCENT. Percentage distribution for service workers (See ESUBCON)

ESUBNOP Produces OPRCENT. Percentage distributions for operating workers (See ESUBCON).

2.5.4 Simplified Gravity Model Files

Submit Files

PERSUB Combines the program POPUL and a percentage distribution of immigrants program (e.g. OP246). Much less expensive than running GRAVYP1, EPUNCH2, and GRAVD2 for example. Output called EMAP nn.

SUBSUM Runs the program THRESUM to combine two or three EMAP files into one new EMAP file.

Programs

POPUL This program takes a total number of immigrants (changed each time by the user) and, using a percentage distribution file, allocates some number of new immigrating households based upon the appropriate percentage for each zone. Program uses Percent Distribution files. (e.g. OP246)

Thresum	This program takes two or three EMAP files and combines them into one EMAP file.
Percent Distributions (224 percentages to each file)*	
FINALOP	CuNi operating workers from mines in Zone 2, 4, 7
OP246	CuNi Operating workers from mine in Zone 2
OP248	CuNi Operating workers from mine in Zone 4
OP251	CuNi Operating workers from mine in Zone 7.
FINALS	Service workers caused by CuNi Development in Zones 2, 4, 7.
SP246	Service workers caused by CuNi Development in Zone 2
SP248	Service workers caused by CuNi Development in Zone 4
SP251	Service workers caused by CuNi Development in Zone 7.
FINALCP	CuNi construction workers from mine in Zones 2, 4, 7
CP246	CuNi construction workers from mine in Zone 2.
CP248	CuNi construction workers from mine in Zone 4.
CP251	CuNi construciton workers from mine in Zone 7
FINLOAM	CuNi operating workers from mines in Zones 2, 4, 7 w/AMAX road

2.5.5 Plotting Files

ZONEPLT	Binary version of ZONPLT. Plots 2 dimensional maps of settlement distributions in RCNSA (by 224 cells) and 3 dimensional plots. Plots worker (household) distribution from MAPOUT, and population distribution (workers x 3.0) from TMAPOUT. MAPOUT and TMAPOUT are standard output files (which may or may not be retained) from gravity models GRAVYP1, SGRAVP1, or CGRAVP1. Scales are held constant from plot to plot.
ZONPLT	Source code version of ZONEPLOT.
PLTZON	Source code version of ZONPLT3.

ZONPLT3 Binary version of PLTZON. Plotting routine which is used in submit file ZONSUB. Plotting routing has adjusted scale to show differences (mathematical) between two distributions, or the summations of two distributions.

TESTSUB Submit file which routes plots of EMAP files.

ERICPLT As with all other plots above, creates 2-D and 3-D plots of settlement distributions. Only difference--reads in fix format. All other plot files read in free format.

2.5.6 For Summations and Differences Plotting

SUBFORS Submit file. Runs gravity model and creates files which can be summed using ZONSUB. MAPOUT (workers) and the TMAPOUT (population) from the gravity model (GRAVYP1, SGRAVP1, or CGRAVP1) are set to an EMAP and ETMAP file.

ZONSUB Submit file to plot summations of two EMAP (workers) and ETMAP (population) files. Also plots the difference between EMAP and ETMAP files.

To activate summation:
set ONSW (1). CUNISUM will show summation.

To activate differences:
set ONSW (2). CUNISUM will not show differences. CUNISUM will not be used by the program.

2.5.7 Reference Files

EXPGRAV Program. Simplified version of exponential form of gravity model.

GRAVIT2 Program. Simplified version of power form of gravity model.

OPRMARK Operating worker--percent distributions of immigrants to each of 224 gravity model zones. File produced for Mark Donaldson's tax modeling.

CPRMARK Construction worker--percent distributions of immigrants to each of 224 gravity model zones. File produced for Mark Donaldson's tax modeling.

POPZONE Data. Estimate of 1976 population by gravity model zone. This file whould only be used to generate a 3D plot of "existing or baseline" population within the RCNSA to provide a visual impression of population distribution.

OPFINAL Sample output of CuNi Operating Workers
Distribution (GRAVYD2, EPUNCH2, GRAVYP1).

CPFINAL Sample output of CuNi Construction Workers
Distribution (CGRAVD2, EPUNCH2, CGRAVP1).

FINTACO Output from Taconite Operating Workers
Distribution (1976-1984) (CONTACG, EPUNCH2, CGRAVP1)

FINTACC Output from Taconite Construction Workers
Distribution (1976-1984) (CONTACG, EPUNCH2, CGRAVP1).

FINTACS Output from Taconite Service Workers
Distribution (1976-1984) (SGRAVD4, EPUNCH2, SGRAVP1).

SP2 Output from CuNi Development Scenario--Service
workers caused by mine in Zone 2

SP4 Output from CuNi Development Scenario--Service
workers caused by mine in Zone 4.

SP24 Output from CuNi Development Scenario--Service
workers caused by mines in Zones 2 and 4.

CGRAVD6 Sample taconite construction data file for
taconite expansion 1985-2000. DO NOT USE
since percentages of PCN-IN, PCN-OUT and the mines
included in the future are not necessarily correct.

GRAVYD6 Sample taconite operation data file for taconite
expansion 1985-2000. DO NOT USE since percentages
of PCN-IN, PCN-OUT and the mines included in the
future are not necessarily correct.

Table 1. Mean weighted commuting distances.

<u>TYPE OF WORKERS</u>	<u>AVERAGE (MEAN) WEIGHTED DISTANCES</u>
Taconite Workers (including mine administration personnel)	17 miles ^a
All Workers	11 miles ^b
Taconite Construction Workers	25 miles ^c

SOURCES: ^aDerived from tables interpreting taconite employee residence locations generalized to zipcode areas and using the town associated with the zipcode as the residence location. Data from: Hanna Mining Co., U.S. Steel Corp., Pickands-Mather, Inc., Reserve Mining Co., and Oglebay-Norton, 1976. Inland Steel Mining Co. also provided data in 1978.

^bDerived from tables compiling and interpreting commuting distance data from Minnesota Labor Force Survey-Form 1 (Mesabi).

^cDerived from taconite construction workers survey sponsored by MEQB Regional Copper-Nickel Study, 1977.

Table 2. Housing ownership among taconite construction workers in the Regional Copper-Nickel Study Area.

Construction ^a Workers Residing	(in percent)			N
	Own	Rent	Other	
less than 6 mths. in Area	38	53	9	58
6 mths. - 1 yr. in Area	31	60	9	68
1 yr. - 2 yr. in Area	38	58	4	204
2 yr. - 5 yr. in Area	63	34	3	271
<u>5+ yr. in Area</u>	<u>87</u>	<u>13</u>	<u>0</u>	<u>224</u>
Average	59	38	3	825
All Residents ^b	84	15	1	509

Source: ^aTaconite Construction Workers Survey, 1977.

^bMinnesota Labor Force Survey, 1977.

Table 3. Percentages of taconite employees living outside of the Regional Copper-Nickel Study Area.

<u>Company</u>	<u>Plant Location</u>	<u>Estimated Percent of Employees Living Outside RCNSA</u>
U.S. Steel	Mountain Iron	49%
Reserve (Babbitt Plant only)	Babbitt	7%
Erie (Hoyt Lakes Plant only)	Hoyt Lakes	6%
Eveleth Taconite	Eveleth & Forbes	56%
Inland Steel	Virginia	29%
Hibbing Taconite	Hibbing-Chisolm	99%
Hanna Mining	Nashawak & Keewatin	99%

Source: Taconite employees commuting data, supplied by zipcode area. Data from U.S Steel, Reserve, Erie, Oglebay-Norton (Eveleth Taconite), Pickands Mather (Hibbing Taconite), Hanna in 1976. Inland Steel Mining Co. data was 1978.

Table 4. Hypothesized sources of employees for operating workforce.

SOURCE	PERCENT OF TOTAL WORKERS		
	Development Zone 2	Development Zone 4	Development Zone 7
Males from Study Area Labor Pool ¹	15%	15%	15%
Females from Study Area Labor Pool ²	10%	10%	10%
Construction Crossover Workers from Study Area ³	-----	VARIABLE	-----
Construction Crossover Workers Who Were Immigrants ⁴	-----	VARIABLE	-----
Males commuting from outside Study Area ⁵	5%	8%	15%
New Operating Immigrant Heads-of-Households ⁶	-----	VARIABLE	-----
TOTAL	100%	100%	100%

Sources: 1,2A survey of the Minnesota taconite companies shows that women comprise an average of 7% of the production/maintenance/office and administration workforce (1978 data). At one plant, the average is expected to be 10% by January, 1979. The total estimate was increased to 10% assuming that female labor force participation will continue to increase in the future.

Further, it was assumed that the male labor force pool would exceed the female rate, 15 percent was assumed.

$\frac{{}^3\text{EC X .12}}{\text{OP}}$ where: EC = absolute number of Cu-Ni construction workers who are in-commuters or were drawn from existing labor pool.
 .12 = Crossover rate to operating workforce (based on a private conversation with the President of the Iron Range Building & Trades Union, May, 1978).
 OP = Total number of Cu-Ni operating workers

$\frac{{}^4\text{IC X .12}}{\text{OP}}$ where: IC = absolute number of immigrant construction workers

⁵Cu-Ni staff estimate. (see text)

⁶Remaining percentages

*NOTE: The actual immigration rate used for the operating workforce is the sum of the percentages obtained for "new operating immigrants" and "construction crossover immigrants." To eliminate overestimation of immigrants, the entire immigrant construction workforce distribution was considered transient and those construction immigrants who joined the operating workforce were distributed as operating workers.

Table 5. Hypothesized sources of new employees for construction workforce

<u>Source</u>	PERCENT OF TOTAL WORKFORCE		
	<u>Zone 2</u>	<u>Zone 4</u>	<u>Zone 7</u>
Males from Study Area Labor Pool ¹	21%	21%	21%
Females from Study Area ²	1%	1%	1%
Males Commuting from Outside Study Area ³	30%	40%	50%
Male Head-of-Household ⁴ In-migrants	48%	38%	28%
TOTAL	100%	100%	100%

Sources: ¹Taconite construction workers survey, 1977.

²Estimate based on a conversation with the President, Iron Range Building and Trades Union, Virginia, MN (September, 1978). At that time, no women were members of the union.

³Cu-Ni staff estimate. Based upon average journey-to-work distance for construction workers seems further than for operating/production workers.

⁴Remaining percentages.

Table 7. Secondary job multipliers derived from SIMLAB copper-nickel development scenarios.

SIZE OF COPPER-NICKEL MINE	TIME PERIOD	MULTIPLIER IN SCENARIO	
		With Construction Sector	Without Construction Sectors
12.35 X 10 ⁶ mtpy	1987-2015	----	1.99
16.68 X 10 ⁶ mtpy	1986-2015	----	2.24
	1982-2015	1.95	----
20.00 X 10 ⁶ mtpy	1986-2015	----	2.1
	1982-2015	1.95	----

SOURCE: SIMLAB projections.

Table 8. PCN-IN and PCN-OUT for Construction Workforce Data Inputs.

Source	PERCENT OF TOTAL WORKFORCE			
	Zone 2	Zone 4	Zone 7	
Males from Study Area Labor Pool ¹	21%	21%	21%	PCN-IN
Females from Study Area ²	1%	1%	1%	
Workers Commuting from Outside Study Area ³	30%	40%	50%	PCN-OUT
Heads-of-Household ⁴ In-migrant	48%	38%	28%	
TOTAL	100%	100%	100%	

Sources: ¹Taconite construction workers survey, 1977.

²This estimate is based on a private conversation with the President of the Iron Range Building and Trades Union in September, 1978.

³Cu-Ni staff estimate. See Regional Copper-Nickel Study Level I report "Description of the Residential Settlement Model," by Eric H. Bauman and Anthony Lea.

⁴Remaining percentages.

Figure 11. Example of GRANYD2 Data File

Gravity Model Data File with CuNi Workers Only and no Taconite Workers

```
Exponential Model Parameters - ALPHA = 1.00000 - BATA = -0.10575
Power      Model Parameters - ALPHA = 1.00000 - BATA = -1.27000
Mine Work Center Employment - NMines = 3 - PCN IN = .2500
MWCN = 246 - Employ = 1857 - PCN OUT = .0500 Zone 2 (INCO-Hanna)
MWCN = 248 - Employ = 2220 - PCN OUT = .0800 Zone 4 (Amax)
MWCN = 251 - Employ = 1999 - PCN OUT = .1500 Zone 7 (Exxon)
"RD" Road Miles Indicator
"RD" 1 24
"RD" 2 16
"RD" 3 12
"RD" 4 32
```

Table 9. PCN-IN and PCN-OUT for Operating Workforce Data Inputs

SOURCE	PERCENT OF TOTAL WORKERS			
	Development Zone 2	Development Zone 4	Development Zone 7	
Males from Study Area Labor Pool ¹	15%	15%	15%	PCN-IN
Females from Study Area Labor Pool ²	10%	10%	10%	
Construction Crossover Workers from Study Area ³	- - - - -	VARIABLE	- - - - -	
Construction Crossover Workers Who Were Immigrants ⁴	- - - - -	VARIABLE	- - - - -	
Males commuting from outside Study Area ⁵	5%	8%	15%	PCN-OUT
New Operating Immigrant Heads-of-Households ⁶	- - - - -	VARIABLE	- - - - -	
TOTAL	100%	100%	100%	

Sources: 1,2 A survey of the Minnesota taconite companies shows that women comprise an average of 7% of the production/maintenance/office and administration workforce (1978 data). At one plant, the average is expected to be 10% by January, 1979. The total estimate was increased to 10% assuming that female labor force participation will continue to increase in the future.

Further, it was assumed that the male labor force pool would exceed the female rate, x 15 percent was assumed.

³ $\frac{EC \times .12}{OP}$ where: EC = absolute number of Cu-Ni construction workers who are in-commuters or were drawn from existing labor pool.
 .12 = Crossover rate to operating workforce (based on a private conversation with the President of the Iron Range Building & Trades Union, May, 1978).
 OP = Total number of Cu-Ni operating workers

⁴ $\frac{IC \times .12}{OP}$ where: IC = absolute number of immigrant construction workers

⁵Cu-Ni staff estimate. See Regional Copper-Nickel Study Level I report, "Description of the Residential Settlement Model", by Eric H. Bauman & Anthony Lea.

⁶Remaining percentages

*NOTE: The actual immigration rate used for the operating workforce is the sum of the percentages obtained for "new operating immigrants" and "construction crossover immigrants." To eliminate overestimation of immigrants, the entire immigrant construction workforce distribution was considered transient and those construction immigrants who joined the operating workforce were distributed as operating workers.

Table 10. PCN-IN and PCN-OUT for Secondary Workforce Data

SOURCE	PERCENT OF TOTAL WORKFORCE						Other Cities	
	Virginia	Eveleth	Gilbert	Biwabik	Aurora			
Males and Females from Study Area Labor Pool ¹	20%	20%	20%	20%	20%	20%		
Workers Commuting from Outside Study Area ²	25%	25%	15%	10%	5%	0%		PCN-OUT
Secondary Jobs Filled by Second Members of new Cu-Ni Operating Households (.4 x new Cu-Ni families)] ³	-----	-----	VARIABLE	-----	-----	-----		PCN-IN
Secondary Jobs Filled by Second Members of new Cu-Ni Service Households (1/1.4 x new gross service families)] ⁴	-----	-----	VARIABLE	-----	-----	-----		
Heads-of-Household In-migrant	-----	-----	VARIABLE	-----	-----	-----		
TOTALS	100%	100%	100%	100%	100%	100%	100%	

Sources: ¹Cu-Ni staff estimates: 10%-female; 10% male.

²Cu-Ni staff estimate based upon (1) shorter average journey-to-work distances for service workers, and (2) hypothesis that service workers tend to live in or immediately adjacent to communities where they are employed in retail stores, and warehouses.

³An average of 40% of all households in the State of Minnesota have two or more employed persons. Therefore Cu-Ni staff estimates that some service workers will come from 40% of new in-migrating copper-nickel operating workers households (Minnesota Labor Force Survey, 1977).

⁴Forty percent of new in-migrating households for secondary jobs will also supply a second worker for service jobs.

Figure 15. Example of Serbrut Output.

EXPFORM

Objective Function for New A Value

BETA = -.120 Distance max likelihood estimator = -1.4233

EXPFORM

Objective Function for New A Value

BETA = -.115 Distance max likelihood estimator = -.8867

EXPFORM

Objective Function for New A Value

BETA = -.110 Distance mak likelihood estimator = -.3216

EXPFORM

Objective Function for New A Value

BETA = -.105 Distance max likelihood estimator = .2724

EXPFORM

Objective Function for New A Value

BETA = -.100 Distance mak likelihood estimator = .8952

EXPFORM

Objective Function for New A Value

BETA = -.095 Distance max likelihood estimator = 1.5468

Table 11. Variables for data file GRAVDAT per zipcode area.

Variable Name	Location		Format
	Line	Column	
Zipcode Area Name	1	11-20	A10
Distance to Plant	1	23-26	F4.1
Distance to Hospital	1	29-32	F4.1
Available Land	1	34-39	F6.1
Available Land w/in 1 mile of roads	1	42-46	F5.1
Available Land w/in 1/2 mile of lakes and 1/4 mile of streams	1	49-53	F5.1
Miles of passable roads	1	56-60	F5.1
Distance to Vigrinia (Regional Trade Center)	1	63-66	F4.1
Distance to Ely, Virginia or Two Harbors	1	69-72	F4.1
Plant (mine) Name	2	11-20	A10
Number of Commercial Structures (Rural)	2	23-25	F3.0
Number of Residential Structures	2	27-30	F4.0
Number of Employees living in Zipcode Area (from mine	2	34-37	F4.0
Total Number of 40 acre cells in Zipcode Area	2	40-45	F6.1
Number of sales and Use Tax Reporting Units	2	49-53	F.51

Table 12. Variables used in program caliber

VARIABLE NAME	RAW VARIABLE	RD(I,n)		WEIGHTED
			Z-SCORED	
1. zone name	1		----	----
2. distance to plant	2		----	----
3. distance to hospital	3		22(9)	37
4. available land	4		23(5)	34
5. available land w/in 1 mi. of roads	5		24(6)	35
6. available land w/in 1/2 mi. of lakes and 1/4 mi. of streams	6		25(7)	----
7. miles of road	7		----	----
8. distance to Virginia	8		----	----
9. distance to Virginia, Ely or Two Harbors	9		26(10)	----
10. Number of commercial structures (rural)	10		----	----
11. number of residential structures	11		----	----
12. number of employees from mine living in zipcode area	12		----	----
13. total 40 acre cells in area	13		----	----
14. Number of sales and use tax reporting units	14		----	----
15. road density (7 13)	15		27(1)	36
16. residential structures density (11 4)	16		28	----
17. commercial structures density (10 4)	17		29	----
18. reporting units density (14 4)	18		30	----
19. residential structures density (11 13)	19		31(2)	----

20.	commercial structures density (10 13)	20	32(3)	----
21.	reporting units density (14 13)	21	33(4)	----
22.	attractiveness	40	----	----
23.	log distance	41	----	----
24.	log attractiveness	42	----	----

NOTES:

All numbers appearing in parenthesis indicate that the variable was used in the main gravity model programs (GRAVYP1, SGRAVP1, CGRAVP1) and SERCALI. The numbers correpsond to the number used in those programs.