MICHIGAN SEA GRANT PROGRAM

Technical Report No. 50

A Summary of a Computer Simulation Model of the Traverse City Area (WALRUS III)

by

David O. Moses

December 1976
MICHU-SG-76-203

A Summary of a Computer Simulation Model of the Traverse City Area (WALRUS III)

by

David O. Moses

Michigan Sea Grant Program
2200 Bonisteel Blvd.
Ann Arbor, Michigan 48109
December, 1976

MICHU-SG-76-203

This work is a result of research sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant #04-6-158-44008. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

Acknowledgements

The April 1976 WALRUS (Water And Land Resource Utilization Simulation) computer simulation model evolved from the initial conceptual groundwork laid by Thomas E. Borton and Katherine Warner and the original WALRUS I game. The WALRUS I game (and the 1975 revision) was sophisticated slightly and became the WALRUS II game with computerized accounting. The WALRUS III pure simulation model - with no role playing or game component - took two years to develop with the assistance of many. Primary individuals responsible for the development of the model and the preparation of the seven Internal Reports upon which this publication is based included this author, Allan Feldt, Roy Miller, Edward Morris, and Eric Richelson. Additionally, we would like to thank the Traverse City Citizens Advisory Committee for their time and suggestions; Mr. Gordon Hayward of the Traverse Bay Regional Planning Commission for his support, data, and evaluations; the University of Michigan Sea Grant staff and researchers for their cooperation and understanding; and the many University of Michigan graduate students who participated in the development of the model.

PREFACE

The purpose of this publication is to provide the reader with an overview of a computer simulation model of a small urban area in northern Michigan. This publication provides an abstract, along with specific excerpts, for each of the seven Internal Reports which represent the complete documentation of the model. The complete series of seven Internal Reports on the model comprise some 1120 pages. These reports are on file at the Michigan Sea Grant Program, 2200 Bonisteel Blvd., Ann Arbor, Michigan, 48109, for inspection and/or reproduction.

INDEX

CHAPTER I

SUMMARY and OVERVIEW: ABSTRACT

Internal Report #I - SUMMARY and OVERVIEW - is divided into four sections. Section A provides a brief overview of the model and is reproduced here. Section B comments on the general and specific use of a tool such as WALRUS III and is reproduced here. Section C, also reproduced here, provides a brief evaluation of the tool by a local planner - Mr. Gordon Hayward of the Traverse Bay Regional Planning Commission. Section D of the Internal Report is a bibliography of the references used in the development of the model.

A. SUMMARY
A Computer Simulation Model of the Traverse City Area - WALRUS III

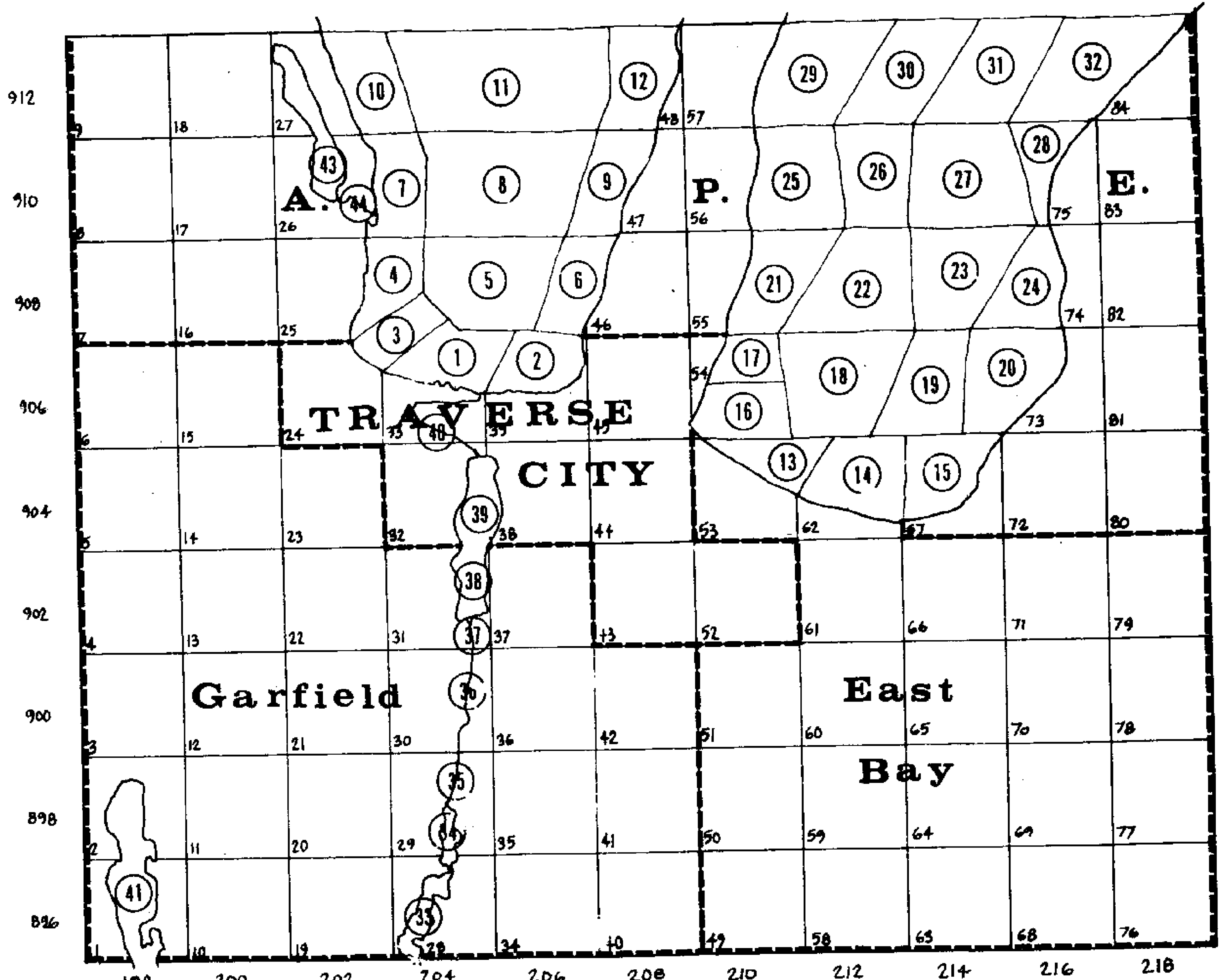
1. INTRODUCTION

The WALRUS III simulation is a computer program consisting of information, equations, and accounts which describe the Traverse City Area (see attached map) and many of the activities occurring there. The description of the area and its activities is called a data base (see Chapter II). A series of equations describing how the area will change over time or how a particular activity operates or changes is called a model or algorithm (see Chapter III). The period of time during which changes occur is called a cycle. The operation (see Chapter IV) of the simulation is as follows: at the start of each cycle, the users of the simulation are presented with the current data base; decisions (for example, a change in the number or type of an activity) are made by the users concerning the data base or the operation of one of the change models and are entered into the computer (see Chapter V); as a result of these decisions and the operations of the models the users are presented with a new description of the area or data base (see Chapter VI) and the process continues.

The following brief description of the simulation is intended for introductory purposes and is therefore very general.

2. DATA (see Chapter II)

The geographic area contained in the simulation is an 84 square mile area surrounding the lower portions of the East and West arms of Grand Traverse Bay. Included in this area is Traverse City and portions of four townships from Grand Traverse County and part of Elmwood Township from



SCALE: 3/4" = 1 MILE

Leelanau County. A data base for the remainder of Grand Traverse County has been developed but is not currently in operation within the simulation.

In order to describe this area at an initial point in time (1967), a minimal set of 55 discrete activities were developed. Associated with each of these activities or land use types is a site size, capital cost, operating period (days), season of operation, water usage, and effluent characteristics. The number of activities represented as well as additional characteristics describing them are shown below:

Activity	Number Represented	Additional Characteristics
Residential	8	- Density in dwelling units/acre
Commercial	9	- Per "unit" cost, sales price, and labor force - Labor force and salaries and wages - Units produced, sold this cycle and last, in stock
Wholesale	1	- Same as Commercial
Manufacturing	15	- Same as Commercial plus: - Profit margin - Water costs
Recreation	5	- Per tourist cost and expenditure in commercial sector - Tourist capacity and occupancy rates - Labor force and salaries - Profit margin
Agriculture	3	- Fertilizer/part-time labor force/per "unit" cost policies - Per unit price
Institutional	2	- Service areas and capacity - Percent effluent reduction - Labor force and salaries
Transportation	2	- Same as Institutions
Recreation, Public	3	- Same as Institutions
Vacant	4	- No additional characteristics

These activities (Basic Land Use Units) have been assigned to square mile units called "cells." It should be noted that the values of many of the characteristics of the individual activities will be changed as the simulation cycles due to the operation of the models (as a function of specific location and usage, for example).

The water bodies in the simulation include the entire bay, Boardman River, and Boardman, Cedar and Silver Lakes. The water bodies have been divided into 64 sub-areas called segments. At present the simulation has one secondary municipal treatment facility and one municipal water supply facility.

Water may be obtained from rainfall, the ground, a water body, or municipal facility and is discharged to the ground, a water body, or a municipal facility. Each type of activity within a cell must specify a source and discharge point for the water it uses. The discharge for each activity contains amounts of the following types of effluents: Total Coliform, Biological Oxygen Demand, Total Phosphates, Total Suspended Solids, and Total Dissolved Solids.

3. MODELS (see Chapter III)

Currently, the simulation operates with three major models - Economic, Population/Migration, and Water - as well as several minor supportive algorithms and accounting routines. A brief description of the three major models follows:

Economic: The economic models determine economic operation (production, inventory, sales, employment, profits, etc.) For each of the economic activities represented in the Basic Land Use File with the exception of those considered public. Thus there are five economic models (one for each major type of economic activity - Manufacturing, Agriculture, Tourism, Retail and Service, and Wholesale) each with different assumptions and operating characteristics.

Population-Migration: The population-migration models account for some natural increase in the population and any movement into, out of, or internal to the study area. The new population then "searches" for and is distributed to housing and employment opportunities subject to an "amenity" restraint. At present, population is not differentiated as to age, sex, income, or life cycle characteristics as the initial purpose of the model was to distribute population and the resulting effluents geographically.

Water: The water models take the effluents generated by the activities on the land and distribute them to either a sewer system or, via the drainage pattern, to the receiving water segment. For the water bodies, a circulation and water quality model (an adaptation of Dr. Canale's model[1]) is exercised for two seasons each cycle and resultant effluent concentrations along with the concentrations of Dissolved Oxygen, Total Phosphorous, Total Dissolved Phosphorous, and Chlorophyl a are all reported for each segment. For municipal treatment facilities operating within their capacities, the effluents are treated and discharged to the appropriate receiving water segment. At present there is no model of the operation of the ground water system and thus the effluents are merely stored.

Each cycle, the user may set a series of parameters or variables specific to the operation of each of the models. Examples are given below:

Model	Parameter Examples
Economic	The relative contributions from total salaries, profits reinvested, tourists, and the external market area which determine the demand (dollars available) for different retail goods and services.
Population	The average number of persons living in a dwelling unit or the average number of workers in each household.
Water	The percentage of runoff "absorbed" by the land before reaching a receiving water segment by type of effluent and distance to the receiving segment.

4. USE

There appear to be two classes of use for a device like WALRUS III. The first is to demonstrate the systematic nature and general utility of modeling and simulation efforts. WALRUS III has served this purpose well with a variety of groups.

In theory however, the methodology of simulation/modeling has a much more important potential as a tool for planning and management. Its usefulness extends beyond the most common thought of applications of projection and plan evaluation. It is also a device for organizing and retrieving data, focusing

1. Steady State Modeling Program Application Manual, R. P. Canale and S. Nachiappan, Technical Report No. 27, MICHU-SG 72-207, University of Michigan Sea Grant Program, Ann Arbor, Michigan, March 1972.

with clarity on complex systems, and identifying the underlying assumptions behind many public policy arguments.

In practice, simulation/modeling has rarely realized this potential. It has been our contention that the primary reason for this apparent failure is the inability or unwillingness of the academic "model builder" to work closely with the people he hopes to serve. The user must be able to understand and evaluate the conditional predictions which WALRUS III produces before he can make judgments based on those predictions. To avoid a situation in which the simulation specialist and pragmatic decision maker move in opposite directions, the staff presented a paper describing in lay terms the potential applications and limitations of the simulation to a group of planners and decision makers in the Traverse City area. Subsequently, the group jointly developed a program defining a consistent work relationship with a select group of community leaders (the Technical Advisory Committee). The five main topics of this program on the simulation included the methodology in general, particular assumptions and operations of WALRUS III, establishment of priorities for on-going development, review and evaluation of data and results produced by the model, and the design of a program for the actual use of the model with several issues during the next year.

The program described above was completed. The Technical Advisory Committee identified three areas of future development for the simulation consistent with their needs:

1. a major revision and improvement of the population/migration model to differentiate household types, housing types, and employment opportunities.
2. the addition of a governmental services model to relate the demand for approximately ten services to the satisfaction of that demand.
3. the addition of a sewer system model allowing improved design and operation of this service.

With the anticipated "mounting" of the simulation computer program in the local area, the Traverse Bay Regional Planning Commission intended to use the simulation as a basis for the production of at least two planning reports.

B. USE

Factors Determining Implementation of Modeling Approach

The intended primary user of the WALRUS III model was the staff of the Traverse Bay Regional Planning Commission (TBRPC). The Commission is comprised of citizens at large and representatives from each unit of government (township, village, city, county) in Grand Traverse County, excepting three townships, and from Elmwood Township in Leelanau County. Their policy responsibility is advisory (by request) in nature to existing governmental organizations such as the County Department of Public Works (DPW), city and county commissions, township boards, school district, road commission, soil conservation board, etc. Both the excellent contact between the TBRPC staff and the recipient governmental organizations, and the high salience of a variety of issues to the commission provide an excellent incentive to expand the model as a tool for analysis.

As noted in the summary section of the report, the model development staff of Michigan Sea Grant worked closely with the TBRPC staff to explain the various aspects of the model. Five seminars held with the Technical Advisory Committee served to further increase the local understanding of the nature of the model. The propensity to use the model increased with an emphasis in the presentations on the range, source and direction of the model's potential errors. Compromises in the model's development - the size of the spatial unit (a smaller unit in Traverse City and a larger unit in the "out-county" areas would have been desirable) and the "fudges" in the governmental service capacity indicators for example - were explained in detail.

Given limitations on data, a high degree of interaction between the model builders and users, and the lack of a completely operational governmental sector in the model, the model is still sensitive to a variety of economic, environmental, and demographic policy variables. The operating properties (turnaround time, input/output formats) of the model were developed to enhance its utility. The access to the parameter files, modularity of subroutine design, and the documentation were all developed to allow the user greater freedom to "hand adjust" the operation of the model.

Finally, a model such as WALRUS III includes a variety (not all, by all means) of urban systems at various levels of detail and specificity. A sub-model such as Dr. Canale's water quality model, which we would term an "engineering" model, includes most of the variables, with relatively low uncertainty, affecting the output of that system. The current population-migration sub-model, on the other hand, does not include all of the variables affecting the output of that system, and we are less certain of the reliability of those variables. The revised population-migration sub-model would include more variables at greater certainty.

WALRUS III General Use

WALRUS III has been used in an educational sense to present general urban systems concepts and to describe the strengths and weaknesses of the modeling approach. The model has been used effectively in this manner during the early contact phase with the Technical Advisory Committee in Traverse City and in classroom settings at the university as well. Should the model be mounted in Traverse City, it is our hope that TBRPC staff would use the model as a vehicle for the discussion and education of their client decision makers so that the complexity of their local system could be "internalized."

During the development phase of the model, and with its continued use, the process of developing the algorithms, analyzing the output, and subsequently modifying the algorithms or parameters, provided a means to clarify assumptions about the components (and the linkages between them) of the local Traverse City system. In this sense, the model also provides an organized record of the user's thoughts on the "working" of their area for a particular period of time with a particular set of assumptions.

A related use involves the organized and readily accessible "file cabinet" of information on the activities of the study area which the model contains. Such information usually provides the base or background data for planning studies exploring transportation, land use, community facilities, manpower programs, environmental impacts, market feasibility, tourism, and the like.

The most important use of the model however is in the area of projection or prediction. It is important to note that we feel the most important concept in the application of a model such as WALRUS III in an applied policy context is that the model cannot make an absolute prediction of the future. At best, the model can make a good conditional prediction. This prediction is as good as the weakest of the assumptions in the algorithms, the data they act upon, and the *ceterus paribus* conditions. If the previously mentioned qualities are understood by the user, then the conditional predictions of future states can be evaluated on the basis of those qualities and the desirability of the resultant future state(s). The model could thus be used to compare the impacts of alternative plans and policies currently under consideration and, with analysis of those impacts, to develop "better" plans and policies. It is with this use of the model - in a plan evaluation sense - that the model becomes a management tool for the TBRPC staff enabling them to make better recommendations to their client organizations.

WALRUS III Specific Use

Scenario Development

In order to use the model in a plan evaluation sense, existing plans or scenarios must be translated into, or described in terms of, variables or commodities which the model can accept. Without being totally exhaustive, "real world" scenarios must currently be described in terms of seven major model areas. The first six of these are described in detail in Chapter IV - File Descriptions.

The user must establish prior to the execution of each cycle (or have the model generate) a set of parameters (PAR file or input routine) which fall into five general areas. The first model area involves the specification of the expected national growth rates ("total" and "real") for the next model year during which the scenario will occur. State growth rates are calculated by the model. The second area of scenario development involves the specification of a variety of economic parameters including the amount of the average welfare payment; the portion of the total growth rate incrementing the average salaries and wage payment; the portion of the total growth rate affecting the price levels for retail, service, and wholesale establishments; the percentage of total retail dollars available for wholesale; the amount of exogenous dollar contribution available for retail and service sales; and four types (resident, tourist, resident establishment profits, exogenous shopper) of consumer patterns. A set of demographic information comprises the third area of scenario development. Included in this area are the following parameters: the population growth rate (and a set of associated parameters of a normal distribution for the growth rate); the expected number of persons per dwelling unit and workers per dwelling unit (converted to persons per job); a minimum capital infrastructure investment figure and the allowable dwelling unit overcrowd percentage used in the distribution portion of the population-migration model. The fourth area of scenario development allows the user to modify the existing drainage pattern (due to highway or storm sewer construction for example) and the relative amounts of the raw effluents lost to the ground water as well. Specification of the expected weather conditions for agriculture and tourism for the next model year is the fifth area of scenario development.

The sixth major area of scenario development allows the user to specify the timing, type, and distribution of activity additions (or subtractions) to the study area for each model year. In addition to the above activity characteristics, the user must specify for each type of activity added in a particular (cell) location the following: the number of those activities operating, water source and sewage discharge information, the operating period and season of operation, and any activity-specific economic "hand" adjustments. These charges are entered into the Current Land Use File (CLUF). See Chapter IV for further information on this. In addition, sewer and water plant information (cells serviced, treatment efficiencies, etc.) as well as per tourist expenditures on lodging and commercial establishments may be specified by entering the CLUF file. The user's decisions regarding the supply side of the land use market may be made on the basis of known private market plans (for a shopping center for example), assumptions about land use behavior (growth follows sewers for example), the individual economic activity diagnostics provided by the model (exceedingly high profits for a particular activity indicates either expansion on the entry of additional activities of that type in the area for example), or the user's own bias. The reader is referred to Chapter V where the rationale for the specification of input options, parameter values, and land use changes is presented.

The seventh area for scenario development involves modifying the actual operation of a particular algorithm in the program. If, for example, a new national market were to develop for a particular industry the user may want to make that industry more sensitive to national growth rate fluctuations as opposed to state economic conditions. Of if, for example, a new technology was forecast for a particular industry which would increase per worker productivity, the user may want to modify the sensitivity of the algorithm relating labor force to production changes for that industry.

The seven areas of scenario development described above are capable of describing a wide range (though certainly not all) of alternatives facing the study area. Although the model currently has no transportation model for example, the construction of a new highway would presumably indicate increased accessibility to the Central Business District thus implying an increase in the exogenous dollars for retail, more tourists, and a modification of the α coefficent (applied to the distance variable) in the retail and service gravity model. By the same type of logic, many indirect policy alternatives (on growth or zoning for example) may be incorporated into the model.

Impact Areas

Having examined the ways in which scenarios are developed (or the type of informational <u>input</u> the model will accept) we will now review the types of impacts (or the form of the <u>output</u>) to those scenarios that the model is capable of producing. For the first four of the five major impact areas the user must specify (in the input routine) the level of detail or aggregation of the information the model will provide. For example, in the area of economic impacts, the user may obtain information on the gross sales of all establishments (by jurisdiction if desired), or the gross sales of a particular establishment type, or the average economic operating characteristics of a particular establishment type, or the individual economic operating characteristics of a particular establishment in a particular location.

The first impact area is economics. Basically, the model provides a variety of information on the economic condition or vitality of the activities in the study area by economic sector and location if desired. Examples of the type of information provided in the economic diagnostics include (for the last and current cycle): sales and stock levels, employment and wages paid, the cost of doing business and net profits, and others.

A set of demographic characteristics comprise the second area of impacts. Information available to the user includes the number and distribution of people, housing, and jobs in the study area and those numbers and distributions as different constraints in the population migration model are relaxed. The number and distribution of tourists and the type and average age of housing is available as well.

The third area of impacts is water related. The model identifies the source and magnitude of effluent loads and the resultant concentrations in the bay, Boardman River, and the two inland lakes for the eight effluent parameters for two seasons per model year. Also available are the volume loads in the sewer and water plants.

The magnitude and distribution of the 55 activities in the study area are presented to the user either individually or by major land use category. And finally the fifth impact area provides rough information on the utilization of (water and sewer, transportation, education, and general - police and fire) governmental services. This area is currently the weakest theoretically.

The diagnostics available as well as the additional variables listed in the Active Cell File (ACF) (Chapter IV) provide additional characteristics about the study area usable in a data retrieval sense.

C. WALRUS III SIMULATION, LOCATION EVALUATION, MAY, 1976

by Gordon L. Hayward, Planner, Traverse Bay Regional Planning Commission

Introduction

In my opinion, the model is a very good planning tool, both as a storage and retrieval system and as an aid-in evaluating alternative futures; for better informed citizens, capable of making well-informed choices among the alternatives confronting them; and a more rational approach to solving conflicts over local issues.

It can provide adequate understanding of the most likely impact of a particular public decision on the total growth and development of a local system when it is made up of so many interrelationships and unanticipated interactions among its component parts.

The model in its initial form is capable of representing some of the major dimensions and linkages of the Traverse City region and providing reasonable projections of its expected growth over short periods of time. In effect, the model will show the most likely course of growth and development as well as demand for services which will occur if certain kinds of decisions are made regarding potential new land use developments in the Traverse City region.

Other internal reports have discussed the shortcomings of the model of a technical nature, and it is obvious that improvements can be made.

BASIC LAND USE FILE

The following are comments on the Basic Land Use File as a planning tool for storage and retrieval of data:

(a) Residential-Capital Cost/Rent Derivation is good;

(b) Age of Housing-Has potential for use in housing stock studies and housing recycling program cost estimates, etc.

(c) Commercial-The Commercial basic land use, while a problem to locate initially within a proper cell is very difficult to update with any degree of accuracy. This is not a major problem however, unless the data file is to be used for such purposes as trip generations in a traffic model. For that purpose, windshield verification needs to be undertaken on a regular basis for updating the file to take into account the rapid change in commercial uses within a particular structure or area.

(d) Industrial is good.

(e) Education-The desirability to differentiate school-age children in the population-migration model as an independent forecasting tool for school planning has been discussed in proposed changes for continued use of the model.

(f) Health, Sewage Plant, Water Plant, Surface Transportation, Air Terminal, Marinas, and Public open space are good.

(g) Services-There is a need to separate the <u>protective</u> services (police, fire, emergency) from the social services of churches, public and semi-public offices and meeting places because of citizen attitude regarding adequacy and deficiency analysis.

It is my opinion that continued local use of the Basic Land Use File for a storage-retrieval, and updating file would enhance its acceptability as a forecasting model by local policy makers.

MODEL STRUCTURE

The techniques used for developing the major parameter inputs into the model alone provide a great deal of insight into the interrelationships within the 'real world', knowledge of which is of great importance and concern for policy makers.

The structure of the model lends itself well to storage, update, and retrieval of basic data relating to the needs of local planning officials. Of particular benefit are the Industrial employment location, recreational characteristics, and retail characteristics etc, which are not readily available to local planning departments through regular publications.

The model displayed a little difficulty with employment-unemployment-jobs, but the improvements suggested in the Population-Migration Model will possibly correct this. It would be nice to be able to use the Population-Migration Model to explore the relationships of unemployment rates to total population growth as there seems to be some correlation between available jobs and migration patterns which would indicate that it may be very difficult to both control rate of growth and at the same time reduce unemployment rates to an acceptable level.

The Water Model has received probably the most amount of attention in the Traverse City Area because of the extreme importance of the Bays to our tourism industry and the esthetic values of the region. It is of real concern that planning take into account the effects of land use decisions on the characteristics of the bays and the rivers feeding into them. It is hoped that the effect of storm water runoff as well as effluent from sewage disposal systems could be understood so that the need for remedial measures such as spray irrigation, trickle irrigation, storm water treatment etc. could be justified prior to actual major water quality problems. The total costs of these remedial measures could then be weighed against the immediate gains to be realized by particular land use decisions.

The Economic Model shows a great deal of promise as a method of understanding the economic effects of land use decisions as well as helping to understand the parameters of economic effects to be reasonably expected because of external influences such as natural phenomena of weather etc. and man made influences such as national and state policy decisions, and national growth rates, etc.

I will not go into great amounts of detail here because the value of the model is well expressed in the two scenerios resulting in runs 9A, 10A, 11A, and 9B, 10B, 11B (1976 to 1978; see Chapter V).

REVIEW AND EVALUATION OF TWO SCENERIOS

A review of the 11A and 11B scenerios which represent two futures (low growth-poor weather, and high growth-good weather over a three year period) shows the simulated effects of those conditions.

The following points seem appropriate:

(a) The model indicates that tourism expenditures for space, retail, and wholesale would range from $31.7 Million for 11A to $38.4 Million for 11B, a difference of $6.7 Million.

This seems to be a reasonable figure since the occupancy rates of tourist establishments would allow for this increase without major expansion of facilities.

(b) The agricultural sector which is responsive to weather conditions showed a sensitivity to increased profits which indicate that other factors such as price decreases due to increased production may want to be included as a way to make them more realistic.

(c) The unemployment rate has been discussed earlier-the model shows a difference of 4.51% between 11A and 11B. This is significant only as a local condition and migration patterns would probably not allow such a condition to occur or at least not to remain for an extended period.

(d) The following items seem reasonable and illustrate the sophistication of the model.

ITEM	11A	11B
Population	34,084	36,053
Occupied Dwelling Units	10,382	10,847
Vacant Dwelling Units	0	675
Jobs Taken	10,843	12,102
Gross Retail Sales	$206.6 Million	$265.3 Million
Total Salaries and Wages	$161.3 Million	$197.3 Million
Total Business Profits	$ 42.6 Million	$ 70.5 Million
Tourism Contribution to Retail and Wholesale	$ 21.6 Million	$ 26.6 Million
Tourism Expenditures for Space	$ 10.1 Million	$ 11.8 Million

(e) The average net income of establishments shows the types of establishments which are quick responders to changes in economic and weather conditions. The prime examples are building supplies, food stores, business service, wholesale, and large resorts.

The results of the simulation runs seem reasonable except for general merchandise, which showed a decrease of average net income between 11A and 11B and some types of establishments which have very low numbers of establishments for that type. Boat building (BLU 30) is a good example of the latter.

(f) It is interesting that the model predicts an over building of housing units during good growth periods. This did occur in the 1972 to 1974 year period when '72 and '73 were growth years and '74 was a poor year resulting in vacant new houses and high unemployment in the construction industry.

CHAPTER II

DATA DEVELOPMENT: ABSTRACT

Internal Report # 2 - DATA DEVELOPMENT - describes the process and assumptions used in the development of the initial data base describing the Traverse City area. The report is divided into three sections. Section A - Data Construction - presents the basis for the development of the characteristics of the 55 Basic Land Use (BLU) activities. After an introduction, the data development process used in describing all the major activity types is presented. The retail and service activity description is presented here as an example.

Section B - Data Assignment - presents the process of first determining what activities existed in the "real world" in the study area and second, the process by which the BLUs were assigned to represent those activities. After locating the study area geographically and an introduction, the assignment process for each of the major activity types is presented. As an example, the tourism activity assignment process is presented here.

The third section of this Internal Report describes the derivation of the water related data used in the simulation. Included in this section are the derivation of the effluent loads, agricultural fertilizer policy effects, water use figures, the drainage pattern and run-off parameters, and the determination of which activities are sewered and watered. The derivation of the effluent loads is presented here as an example.

A. DATA CONSTRUCTION

Introduction

The approach used in constructing the WALRUS III data base was to develop on a disaggregate level, a minimal set of activities capable of describing both aggregate and disaggregate characteristics of the study area with fair accuracy. This process differs from a land use classification or coding scheme in that each activity described must be capable of operating (or being operated upon) in one sense or another and therefore requires both a set of static and a set of variable descriptors.

In order to describe the study area at an initial point in time (1967), a minimal set of 55 activities representing various public and private uses of the land and activity were developed. Each activity or land use type is referenced by a number (1-55) and a proper name and is termed a Basic Land Use Unit (BLU). The correspondence of the BLUs with the two-digit Standard Industrial Classification (SIC) codes are presented in the following table. Associated with each of the BLUs are a site size, capital cost, operating period (days), season of operation (summer, winter, year round), water usage, and effluent characteristics. Additional individual BLU characteristics are provided depending on in which major land use category the particular BLU has been classified. The sum of the characteristics describing a particular BLU are intended to represent the "average" or typical operating characteristics of an activity of that particular type at an initial point in time.

The classification presented in the following table was developed for operational as well as display purposes (diagnostics may be requested by minor or major type).

BASIC LAND USE UNIT CORRESPONDENCE

with

STANDARD LAND USE CODE

B.L.U.		S.I.C. CODE	B.L.U.		S.I.C. Code
1-8	Residential	11	31	Canning Industry	21(33)
9	Apparel, Accessories	56	32	Concrete Products	32(62)
10	Eating, Drinking Estab.	58	33	Transportation Equipment	34(42)
11	Building Supplies Home Furnishings	52,57 66	34	Camps	75
12	Food Stores	54	35	Cottages	15(10)
13	Misc. Business Services	61,63,65	36-38	Resorts I, II, III	15(10)
14	Misc. Repair	64(9)	39	Land Crops	81(43)
15	Personal Services Drug Stores	62	40	Tree Crops	81(41)
16	Auto Repair, Service Station, Sales	55,64(1)	41	Grazing	81(61)
17	General Merchandise Group Stores	53	42	Education	68
18	Wholesale	51	43	Health	65(13)
19	Leather Industry	23(67)	44	Services	67,69
20	Printing Industry	27(10)	45	Sewage Plant	48(4)
21	Research Industry	35	46	Water Plant	48(3)
22	Meat Products Industry	21(11)	47	Surface Transportation	45,46,41(1)
23	Food Products Industry	21(50)	48	Air Terminals	43(1)
24	Wood Products Industry	24(40)	49	Marinas	74(4)
25	Furniture Industry	25(10)	50	Misc. Recreation - Golf Ski, Fair Ground	73,74(1)
26	Fiber Glass Industry	31(40)	51	Parks	76(10)
27	Tool and Die Industry	34	52	Public Open Space	76(9)
28	Die Castings Industry	34	53	Vacant Grasslands	91
29	Chemical Industry	28(92)	54	Vacant Forest	92
30	Boat Building Industry	34(43)	55	Vacant Water	93

BLU CLASSIFICATION

BLU Reference	Minor Land Use Type	Major Land Use Type	Sector Type
1-8	Residential	Residential	Private
9-17	Retail/Service	Retail/Service & Wholesale	Private
18	Wholesale	Retail/Service & Wholesale	Private
19-33	Industrial	Industrial	Private
34-38	Recreation	Recreation	Private
39-41	Agriculture	Agriculture	Private
42-44	Institutional	Public	Public
45-46	Public Utility	Public	Public
47-48	Transportation	Public	Public
49-51	Public Recreation	Public	Public
52	Public Open Space	Public	Public
53-54	Vacant Land	Vacant	Vacant
55	Vacant Water	Vacant	Vacant

All of the initial (1967) characteristics mentioned above (and to be described in detail in following sections) describing an "average" activity or BLU are non-location specific. They are "static" in the sense that each time an activity is added to the study area, it will have those characteristics. The Basic Land Use File (BLUF) contains the descriptions of the 55 activities.

Each activity (or groups of the same activity in the same location) has an additional set of characteristics specific to its location. These include the following for each BLU:

- -the number of activities in a location
- -the number of those activities which are operating
- -the number of those activities connected to a sewer system
- -the identification number of the sewage plant
- -the identification number of the water source
- -the operation period if other than the "default"* operating period listed in the BLUF
- -the primary season of operation if other than the "default"* season listed in the BLUF
- -fertilization policy for agricultural activities if other than the "default medium"*

*for ease of entry when adding land use types.

In addition, as the simulation cycles, the various economic models will change many of the initial "static" BLUF economic characteristics of an activity. These "dynamic" variables include the units stocked, produced, and sold; the cost and price/unit; labor force and salaries/wages; and gross and net revenues. Both the last and current cycle's status of these dynamic variables are stored (and are available on output) as the future behavior of many of the private sector economic activities is dependent upon their past performance. The location-specific and dynamic variables described above (along with additional variables pertaining to the economic models and the sewer/water plant operations) are contained in the Current Land Use File (CLUF). The organization and structure of both files - BLUF and CLUF - are described in detail in Internal Report #4 entitled <u>File Descriptions.</u>

After exercising the simulation over several cycles, the operating characteristics of the private economic sector activities will have been generated by the models. Note that with the addition of a new activity (say in cycle 5), some of the variable characteristics will be the average value from all of the BLUs of the same type operating last cycle (see DYNABLU subroutine description in Internal Report #3).

This section of the Internal Report describes the process of obtaining the initial characteristics for the BLUs. Since the method of describing the BLUs was usually the same for those within a Minor Land Use Classification, this section has been subdivided into the 13 minor Land Use Classifications. The final initial descriptions of all 55 BLUs are presented in the BLUF printout for the initial cycle in Internal Report #6.

DATA CONSTRUCTION EXCERPT-

BLUs 9-17: COMMERCIAL

Introduction

The objectives used in developing the descriptors for the nine retail and service activity (BLU) types were to present initial typical or "average" characteristics of individual activities, that were capable of being operated on by the models, that when aggregated to normally "measurable" units (by the census - city, township, county, etc.) would accurately reflect such things as labor force, salaries paid, effluent loads, land use, profits, and gross sales. To achieve this was difficult and presented many problems. As mentioned elsewhere in this series of chapters, one of the deficiencies as it currently exists is that nowhere is the construction industry explicitly represented. Several of the construction related (not construction site specifically) activities (materials, supplies, office, storage, for example) were assigned to BLU 11 "Home Furnishings" however. A second problem was that the location of a particular activity (downtown vs. out-county) produces different operating characteristics for the same activity. The RASIG (Retail and Service Income Generator) submodels develop these differences as the simulation cycles; however, the behavior of the out-county establishments fluctuates quite a bit in the early cycles as the initial characteristics of the establishments are more reflective of establishments in a more central location.

Other difficulties were encountered with the classification of particular real world activities into the BLU types (miscellaneous retail types, snowmobile race tracks for example). See the "Data Assignment" section of this report for the methods used to resolve this.

Retail Demand Composition

As described in Chapter III, retail demand (or the dollars available to be spent in each of the nine commercial categories) is developed from four components:

1) TSAW - portions of resident salaries and wages earned not going to rent or savings.
2) TINC - portions of resident establishments' profits not allocated to debt retirement or investment.
3) TOUR - portions of tourist monies not spent on rooms.
4) EXO - portions of monies spent in resident commercial establishments from sources external to the study area (primarily exogenous markets but also some retirement income).

Local planners determined that roughly one third of commercial sales was provided by sources external to the area (EXO + TOUR); the data assembledge and model runs appear to verify this.

Table II, "Parts I & II", of Chapter V presents the initial (and modifications to the) allocations (%) of the four demand components to the nine retail and service types. The derivation of the cycle i (1967) retail demand percents for each BLU establishment type was as follows:

1) the total dollar amounts for the four demand components were known approximately after all economic BLUs were developed.
2) the gross sales per BLU establishment type for the city was available from the Census of Business, Vol. 2.
3) the distribution of TSAW (excluding rent and savings) among the nine retail types were developed from: a) Office of Economic Expansion, Michigan Department of Commerce, b) U.S. Department of Commerce, Detailed Housing Characteristics, Michigan, c) U.S. Department of Labor, State Economic and Social Indicators, d) and staff estimates.
4) by applying 3) to 1) for TSAW and subtracting that sum from 2) the result was the dollar amount to be allocated between TINC, EXO and TOUR. A series of staff estimates of the different consumption patterns for tourists, profits, and exogenous shoppers were made until the balance was achieved.

The basis for changes to the initial demand composition is presented in Chapter V.

Descriptor Derivations

The SITE SIZE for each of the commercial BLUs was estimated from the windshield surveys and the aggregate land use budgets for the city. The estimates, ranging from .25 to .75 acres, include the structure plus some area allocated to related uses (landscaping, parking, etc.). As the model currently operates, multiple (second story) uses on the same site are not reflected - this could be resolved by allowing selected BLUs to have a site size of Ø. By adhering to the 640 acre cell size, the vacant land totals for several of the downtown cells are probably low as a result of this problem.

As mentioned before, the development of the initial 1967 commercial characteristics was based on Traverse City Data. As described in Section B of this chapter, the 1972 update of these characteristics considered all out-county establishments as well.

The first step in the descriptor development was to allocate the 62 Miscellaneous Retail Stores listed in the census to the nine BLUs. The following table provides the distribution of establishments included in the Miscellaneous category to the BLU types that we used.

Miscellaneous Retail Allocation

BLU	Census Category	# Establishments Assigned
9. Apparel, Accessories	Antique & Secondhand	4
	Sporting Goods	4
	Jewelry	4
	Cigar Stores	4
11. Building Supplies, Home Furnishings	Florists	4
	Hay, Grain, Feed	4
	Other Farm	2
	Garden Supply	4
13. Misc. Business Services	Books, Stationery	4
	News Dealers	4
15. Personal Services Drug Stores	Fuel, Ice Dealers	4
	Hobby	4
	Gift & Novelty	4
	Camera	4
	Optical goods	4
	Liquor	4
	TOTAL	62

The next step was to allocate the remaining census categories to the BLU types. The following table presents that distribution.

Remaining Census-to-BLU Allocation 1967

Census Category Title	# Establishments	BLU Title		# Establishments
-Building materials, hardware, farm equipment dealers	22	11.	Building Supplies, Home Furnishings	22
-General merchandise group stores	14	17.	General Merchandise Group Stores	14
-Food stores	40	12.	Food Stores	40
-Automotive dealers	26	16.	Auto Repair, Service Station, Sales	26
-Gasoline service stations	43	16.	Auto repair, Station, Sales	43
-Apparel and accessory stores	22	9.	Apparel, Accessories	22
-Furniture, home furnishings and equipment	27	11.	Building Supplies, Home Furnishings	27
-Eating and drinking Establishments	49	10.	Eating, Drinking Establishments	49
-Drug stores and proprietary stores	15	15.	Personal Services, Drug Stores	15
-Nonstore retailers	11	13.	Misc. Business Services	11
-Personal services	71	15.	Personal Services, Drug Stores	71
-Misc. business services	35	13.	Misc. Business Services	35
-Auto repair, services garages	13	16.	Auto Repair, Service Station, Sales	13
-Misc. repair services	11	14.	Misc. Repair	11
-Motion pictures	4	15.	Personal Services, Drug Stores	4
-Other amusement, recreation services	14	15.	Personal Services, Drug Stores	14
TOTALS	417			417

Note that census category "Hotels, motels, tourist courts, camps" has been assigned in the tourist BLUs 34-38.

The third step was to obtain the sales volume figures for the three census categories where those figures were not available due to "disclosure." The sum of the three disclosures was known by subtraction ($6,567,000); the distribution of this was estimated. The following table presents the disclosure procedure.

Census Disclosure Allocation

Type	Disclosed Sales & (%)	# Stores	Sales/Store
Apparel, accessories	$ 4,596,900 (70)	22	$ 208,950
Drug, proprietary	1,182,060 (18)	15	78,804
Nonstore retail	788,040 (12)	11	71,640
TOTALS	6,567,000 (100)	48	

Now that the census establishments have been allocated to the BLU types and the sales disclosure resolved, the process of determining the remaining economic characteristics will be presented. Since this process was the same for all the commercial BLUs, we will go through it once (see table) using BLU 9 as an example (the remaining BLU characteristics as developed are listed in the Initial BLUF output, Chapter VI).

The RASIG diagnostics in Chapter VI and the Net Income Summary Table VII in Chapter V indicate how the initial descriptors of the commercial BLUs were modified as the model cycled through time.

RASIG Gravity Model Data

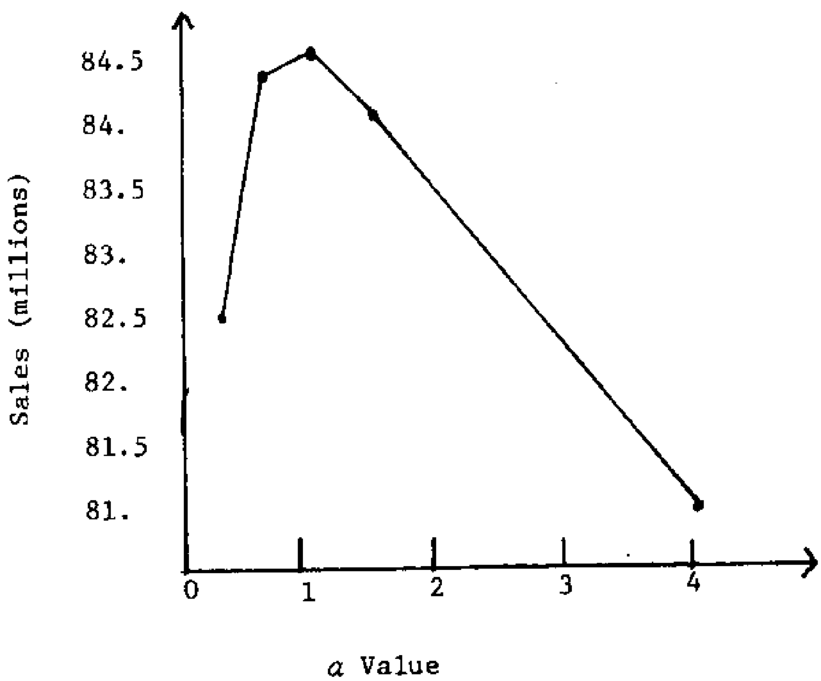
There were two basic areas of data development for the RASIG gravity model. The first was the generation of nine (one for each BLU type) coefficients (WGTS) to differentiate relative floor space (sale/sq. ft. implied) - used in the calculation of the variable "ZZ" to measure the attractive pull of a cell for shoppers. We defined WGTS for each BLU as the percent of the site occupied by the building times the percent of the building devoted to sales. The development figures for the nine BLU types are presented below.

WGTS DERIVATION

BLU	Site Size (Acres)	Bldg. Sq. ft. (% of site)	Sales Sq. Ft. (% of Bldg.)	WGTS Value
9	.25	6,534 (60)	3,463 (53)	.3180
10	.5	10,890 (50)	2,614 (24)	.1200
11	.75	21,236 (65)	4,672 (22)	.1210
12	.5	16,335 (75)	8,166 (50)	.3750
13	.25	4,356 (40)	1,568 (36)	.1440
14	.25	5,545 (50)	1,220 (22)	.1100
15	.25	5,545 (50)	1,331 (24)	.1200
16	.25	8,168 (75)	6,126 (75)	.5625
17	.5	18,513 (85)	17,217 (93)	.7905

The average sales per square foot figure for all commercial establishments based on the above data was $46.99 in 1967.

The second piece of data needed for the gravity model was a value for α (the exponent applied to the distance variable). This exponent effects the distribution of sales between concentrations of retail activity (downtown) and areas of few establishments. The empirically derived approximate (because of random effect) curve indicating the value for α and the resulting downtown (Traverse City) sales figures is presented below.



INITIAL DESCRIPTOR DEVELOPMENT PROCESS
EXAMPLE: BLU 9 - Apparel, Accesories (1967)

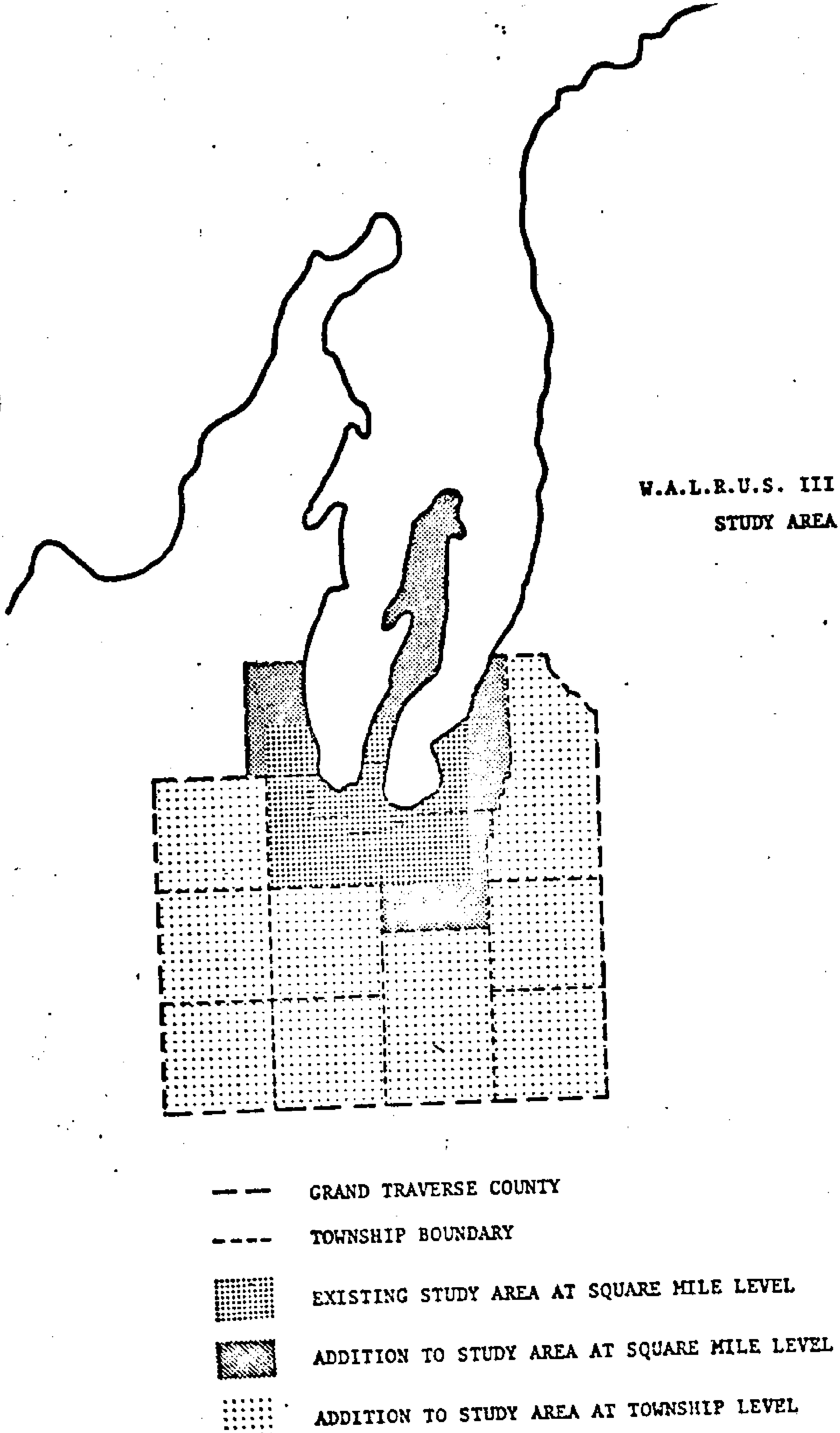
STEP	TITLE	SOURCE	COMMENTS	FIGURE
(1)	Gross Sales	The census lists 22 Apparel/Accessory stores with disclosed sales of $208,950 added to 16 Misc. Retail stores with average sales of $122,919.53 for a total of 38 stores with an average of $172,727.	The difference between the figure at the right and the "SOURCE" sales figure is due to rounding in (3). Calculated in RASIG.	$ 172,678.
(2)	SALES PRICE	Staff estimate.	To represent a "market basket", or average purchase price.	$ 18.37
(3)	SALES	(1) ÷ (2)	The unit is the "market basket". SALES T-1 was set equal to this.	9,400.
(4)	LABOR FORCE	From the aggregate payroll employees in the census, staff estimates.	Represents full time equivalent labor force.	5
(5)	SALARIES & WAGES	From the aggregate payroll in the census, estimates from Dr. Braden (Bus. Ad. Sch.).	Some of the first cut figures were inflated slightly to help generate sufficient TSAW.	$ 4,900.
(6)	Profit Estimate	From Dr. Braden (Bus. Ad. Sch.).	Average percent of sales for profits. <u>Not</u> used in RASIG.	7% (9%)[a]
(7)	Total Operating Costs	(1) - [(4) x (5)] - [(1) x (6)]	This figure is actually $136,090.54 - rounding in step (9) produces the figure at the right. Calculated in RASIG.	$ 136,012.50
(8)	STOCK	Staff estimate of units ordered.	To create some inventory. See note below.	9,750 (9,400)[a]
(9)	COST PER UNIT	(7) ÷ (8)		$ 13.95
(10)	LABOR FORCE PER UNIT	(4) ÷ (8)	Provides the basis for modifying the labor force over time.	.00051
(11)	PRODUCTION LIMIT	Staff estimate.	"Production" is more appropriate to manufacturing; here it represents the upper limit on sales before expansion.	10,240
(12)	CAPITAL INV.	Local architect provided based on size, etc.	In 1967 dollars.	$ 94,000.

[a] NOTE: (8) was set equal to (3) - thus raising (6) - during the calibrations runs from 1967 to 1972 - to reduce inventory fluctuations in later cycles.

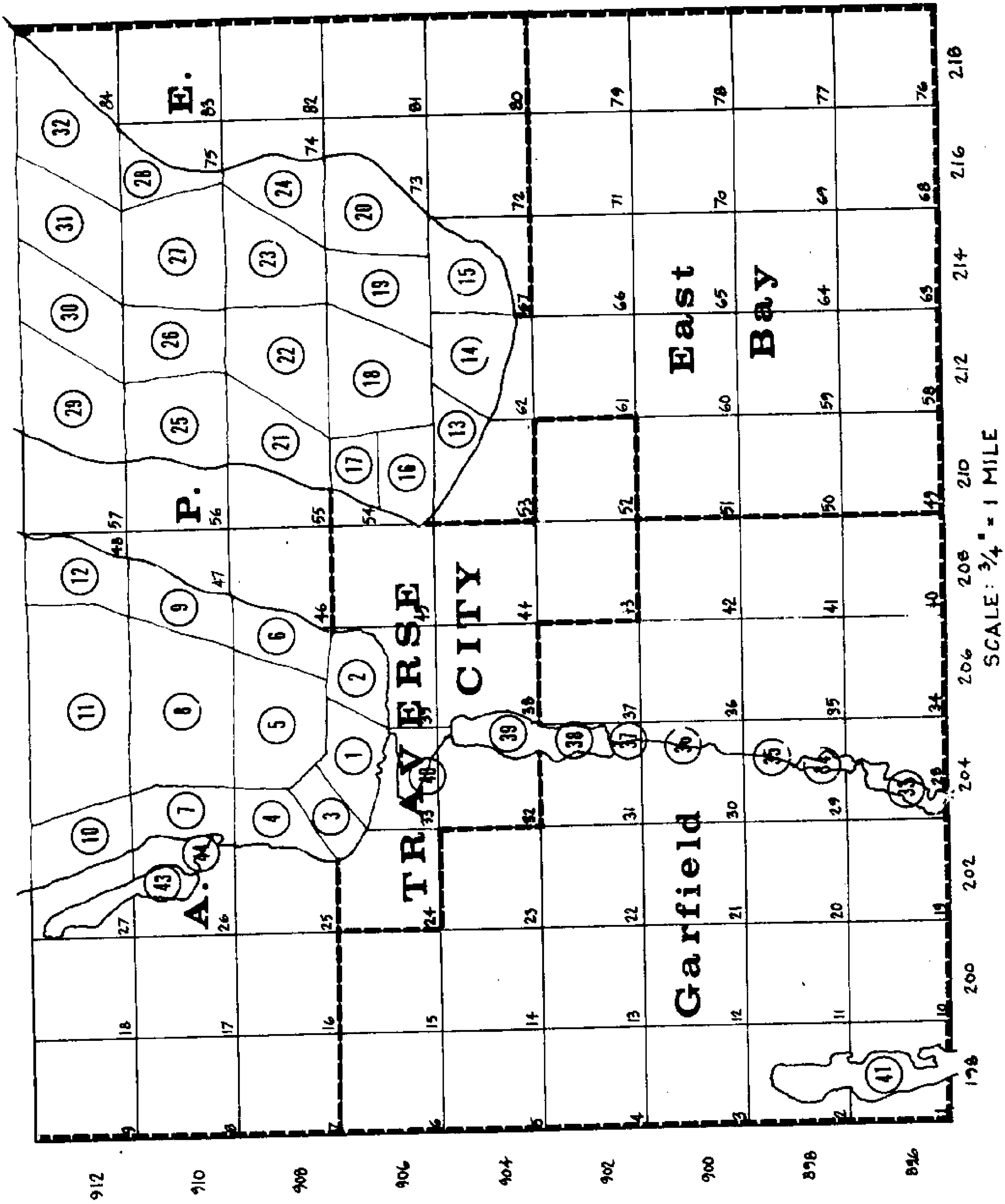
B. DATA ASSIGNMENT

Introduction

The area of the northern part of the lower Michigan peninsula constitutes the geographic study area for WALRUS III. Adjacent to Lake Michigan, the study area includes the East and West Arms of Grand Traverse Bay, Traverse City, and portions of Grand Traverse and Leelanau Counties. The following townships are included in the "operational" study area (as noted in Chapter III, a data base for all of Grand Traverse County was developed): Peninsula (southern portion), Acme (western portion), Elmwood (eastern portion), East Bay (northwestern portion), and Garfield. The boundaries of the study area are defined by hypothetically extending the following roads: Wilson Road on the north, Potter/Hoch/Rennie Roads on the south, Lantner Road on the east, and Green Road on the west. The intersection of the above road extensions define an area of approximately 99 square miles (including water surface area). The jurisdictional boundaries in the WALRUS III study area do not precisely reflect those of the real world. The following two maps help to locate the study area and define the square mile operating units called "cells."



W.A.L.R.U.S. III SIMULATION
STUDY AREA


TRAVERSE CITY
Garfield
East Bay
A. P. E.
SCALE: 3/4" = 1 MILE

To describe the study area in terms of the 55 different Basic Land Use (BLU) types involved two distinct steps: first, to ascertain exactly what existed; and second, to translate that into the Basic Land Use Units which the model "understands." Relatively complete data existed for Traverse City, so finding out what activities were there entailed coordinating the following data sources:

1. Land use maps of Grand Traverse County prepared by the Grand Traverse Bay Regional Planning Commission
2. Land Use maps of 9 of the townships prepared from photos (aerial) taken in 1972 at 8"=1 mile
3. USGS topographical maps prepared in 1956
4. Road maps of Grand Traverse County and Traverse City
5. Our own windshield surveys
6. The 1970 Census of Population and Housing
7. The 1972 Census of Selected Service
8. The 1972 Census of Retail Trade
9. The 1972 Census of Wholesale Trade
10. The 1972 Census of Manufacturing
11. Non-confidential sections of the 1974 Michigan Employment Security Commission data.
12. Published brochures on Grand Traverse County Tourism by the Traverse City Chamber of Commerce
13. Michigan Agricultural statistics, 1971 published by the Michigan Depart- ment of Agriculture
14. Lists of educational facilities prepared by the Board of Education
15. Lists of all the churches prepared by planning department
16. "Grand Traverse County Pilot Housing Study" 1972 prepared for the Regional Comprehensive Planning program of the Northwest Region financed by the U.S. Department of Housing and Urban Development (HUD)

17. The Traverse City Area Telephone Book and Yellow Pages

18. Special help from Mr. G. Hayward of the Traverse City Planning Department

For the remainder of the study area, however, the task was much more complex. Not only did the study area contain only part of the rest of the county, but also in the cases of Acme, Peninsula, East Bay, and Elmwood, only partial townships. Elmwood presented additional problems since it is not in Grand Traverse, but rather in Leelanau County.

The first problem was resolved by assembling an up-to-date data base for the entire county. The advantage of this is that we were able to check our data against existing census data to determine reliability and then simply extract the 84 cells in the study area. Unfortunately, the reliability of Elmwood Township data is still in question.

For the county data base, square mile cells were used in Traverse City, Garfield, and all of East Bay, Acme, Peninsula, and Elmwood, while in Long Lake, Green Lake, Grant, Blair, Mayfield, Paradise, Fife Lake, Union, and Whitewater each township was a unit. The method of building the larger data base helped our accuracy immeasurably. This new method helped best in the manufacturing, commercial, and wholesale sectors where census data differentiates only Traverse City and the remainder of the county. Whereas with the 1967 data base much guessing accompanied the breakdown of data for the study area and the remainder of Grand Traverse County, no such inaccuracies were involved with the 1972 updated data base.

DATA ASSIGNMENT EXCERPT-

BLUs 34-38: TOURIST SECTOR

Most of the data accumulated in this section was sent to us by the Grand Traverse County Regional Planning Commission. Major sources include: a list of all Grand Traverse County Lodging Accomodations, prepared by the Grand Traverse Area Data Center, "Accommodations and Private Campsites in the Traverse City Area of Michigan," published by the Traverse City Area Chamber of Commerce, windshield surveys, and the township maps.

Camps and Campgrounds BLU 34

Two different types of activities were translated into BLU 34. The first is the overnight campground, with 40 sites per BLU of 10 acres. The second consists of camps for children, either overnight or day camps. Here, too, approximately forty children would occupy one camp BLU. Following is a list of campgrounds in Grand Traverse County, the number of sites of each, the number of BLU 34's each was translated into, and the number of sites in the simulation.

Name	Location (cell reference #)	Sites	BLU 34	Simulation Sites
Arbetus Lake #4	214-892	52	1	40
Brown's Dam	216-890	9	-	-
Spider Lake	216-894	15	1	40
Spring Lake	216-892	32	1	40
Yogi Bear	214-898	171	4	160
		279	7	280
Silver Lake View	896-198	10	-	-
Holiday Park	198-898	70	2	80
		80	2	80
Sundown Campground	216-906	43	1	40
Borealis Campground	222-916	60	1	40
		103	2	80

Name	Location (cell reference # or township)	Sites	BLU 34	Simulation Sites
Old Mission	932-212	29	1	40
		29	1	40
Chippewa	Fife Lake	52	2	80
Interlochen	Green Lake	553		
Robert's Landing	Green Lake	45	17	680
Holiday Park	Green Lake	79		
White Water	Whitewater	40	1	40
Union's Rustic	Union	25	1	40
Miller's Meadow	Garfield	30	2	80
Jackson Creek	Garfield	44		
Traverse City State Forest	East Bay 212-904	333	6*	240
		1,692	41	1,640

* the mismatch here was deliberate because the density of sites is greater than 1/4 acre each. Too much land was being used up by the campsites, so we used the reduced number of sites.

Although the list of campsites was sent to us, the locations were not always given. In some cases, best guesses were used. Half of Holiday Park campground was placed in Green Lake Township and half in Garfield Township's cell 2 because it appears to be on the border, but we did not know how many campsites should have gone to each. Also, Jackson Creek Trail Camp did not list the number of sites. The figure of 44 sites was derived from the total (1,737) less the total identified (1,693) less the 45 which were associated with motels.

The second component of BLU 34 is camps for children. These were identified from various maps, including: the USGS topographical map, the Grand Traverse Bay Regional Planning Commission maps, and the 8 inch = 1 mile township maps; their sizes were given to us by Mr. Hayward of the Planning Department. There were six such camps:

In East Bay: Cell 892-814 Camp Grelick 30-40 children
892-814 Camp Arbetis 30-40 children
892-818 Camp Hazza Witke 30-40 children

In Long Lake: Girl Scouts: 30-40 children
4H 150 children and multi-use building

In Whitewater: Palaestrium Wrestling Camp 70-80 boys

The first 4 were assigned 1 BLU 34 each, while the fifth was translated into 3 BLU 34's and 1 service BLU 44, and the sixth was assigned 2 BLU 34's.

For the other Tourist BLU's, (35-38), we used the same lodging and accommodation list provided by Mr. Hayward. Since all the addresses were included on the list, street maps of the city and county were used for placement in the proper cell. The following worksheets show the process of assignment. On worksheet I the number of establishments and the number of rooms in each are listed. The number of rooms, however, is not the only concern. In East Bay's Cell 53, for instance, the Indian Trail Lodge has 66 units. Nevertheless, we could not classify it as a BLU 38 and a BLU 36 because a BLU 38, not only has 40 rooms, but includes an indoor-outdoor pool, a sauna, a play area, a covered entrance, paved parking, landscaping, and a bar/restaurant. Consequently, 2 BLU 37's, which are two-story structures with an outdoor pool, were assigned. Below is an example of the logic which went behind assigning the various resorts.

Cell 53:

		Assigned BLU	Rooms
D-Orr Haus Motel	15 units	1-36	20
Gustely's Sandy Beach	12 units	1-35	10
Indian Trail Lodge	66 units	2-37	60
Mr. B's Motor Inn	10 units	1-35	10
North Wood Courts	10 units	1-35	10
Reef Motel	23 units	1-36	20
Rest Wood Motel	13 units	1-35	10
Shore Haven Cottages	23 units	1-36	20
Ranch Motel	12 units	1-35	10
9 establishments	184 units		170

Since we were 10 units short, and since we already had one extra BLU, we simply changed one of the BLU 35's to a BLU 36. This gave us 4 35's, 4 36's, 2 37's and 180 room total.

Worksheet 1

Cell	Establishments	Units	
73 AC	12	10,7,11,6,15,4,8,8,8,9,6,8	=100
67 AC	8	36,11,8,13,13,12,30,5	=128
39 TC	13	3,30,10,12,23,5,22,126,5,14,33,18,14	=315
62 EB	8	27,3,9,22,12,27,13,10	=123
45 TC	8	25,28,80,20,40,7,14,15	=229
52 TC	1	3	= 3
53 EB	9	15,12,66,10,10,12,23,13,23	=184
72 AC	1	10	= 10
33 TC	2	15,136	=151
29 GAR	1	13	= 13
76 AC	1	6	= 6
84 AC	1	8	= 8
214-892 EB	2	3,9	= 12
214-894 EB	1	2	= 2
218-894 EB	3	5,15,5	= 25
214-890 EB	2	11,9	= 20
216-890 EB	1	3	= 3
220-892 EB	1	7	= 7
198-898 GAR2	2	9,8	= 17
914-196 ELM	1	32	= 32
934-212 PEN	1	4	= 4
Green LK	5	12,4,12,8,8	= 44
White Water	3	6,10,9	= 25
Paradise	1	9	= 9
Fife LK	1	10	= 10
Union	1	16	= 16
Long Lake	1	1	= 1
Blair	1	5	= 5
Not located	4	3,3 (in city) 12,6 (not in city)	= 24
	96		1,526

Worksheet 2

Cell		Actual Total Rooms	BLU 35	BLU 36	BLU 37	BLU 38	Simulation Total Rooms
T.C.	33	151		2	1	2	150
	39	315	5	5	3	2	320
	45	229	1	5	4		230
	52	3					0
GAR	2	17	2				20
	29	13	1				10
AC	67	128	3	2	2		130
	72	10	1				10
	73	100	10				100
	84	6	1				10
EB	76	8	1				10
	53	184	4	4	2		180
	62	123	4	1	2		120

Worksheet 2 (cont'd)

Cell	Actual Total Rooms	BLU 35	BLU 36	BLU 37	BLU 38	Simulation Total Rooms
EB						20
214-890	20	2				10
214-892	12	1				
214-894	2					10
216-890	3	1				30
218-894	25	3 (1*)				10
220-890	7	1				
ELM					1	40
914-196	32					
PEN						10
934-212	4	1				40
Green Lake	44	4				20
Whitewater	25	2				10
Paradise	9	1				10
Fife Lake	10	1				20
Union	16	2				10
Long Lake	1	1 *				10
Blair	5	1				
	1,502					1,540

1,502
+24
* +18 - single cottages
1,544

Worksheet 3

Hotels, Motels, and Resorts

Traverse City:	26 establishments	704 units
East Bay:	24 establishments	358 units
Acme :	22 establishments	246 units
Green Lake:	4 establishments	40 units
Long Lake:	2 establishments	5 units
Garfield:	6 establishments	55 units
Whitewater:	3 establishments	25 units
Fife Lake:	1 establishment	10 units
Union:	1 establishment	16 units
Peninsula:	1 establishment	4 units
Elmwood:	1 establishment	32 units
Paradise	1 establishment	9 units
+ Campbell and Jackson resort (not located)		20 units
		1,524

The preceding worksheets are relatively self-explanatory with three exceptions. First, Timberlee Hills Ski Resort, with 32 rooms, was classified as a BLU 38 because it has all of the characteristics of a Resort type III. It has a heated pool, sauna, restaurant, and bar, indoor-outdoor tennis, boating, horseback riding, fishing, and skiing. The second resort needing note is the Holiday Inn in cell 39. With 126 rooms, air-conditioning, an indoor pool, paved parking, and a nice dining room and assorted shops, it was classified as 2 BLU 38, 1 BLU 37, and 1 BLU 35. The third is the Park Place Motor Inn, with 136 rooms, air-conditioning, an indoor pool, parking, two dining rooms, and various shops. It was similarly classified as 2 BLU 38's, 1 BLU 37, and 1 BLU 36.

In addition to the resorts, we also classified seasonal housing as BLU 35, with ten cottages assigned to 1 BLU. Although most of these units are not open for general rental, they have many characteristics of motels, and are therefore assigned here. (one reason is that the occupants are not usually in the workforce; secondly, their need for public services are small; thirdly, and most critically for the initial design purposes of the model, their water pollution effects are also only seasonal; finally, their additions to the retail sales market are like tourist's expenditures). The HUD study was again used to determine the total amount of seasonal housing within each township. Allocation to particular cells was based on the location and density as noted from the large township maps. Inland lake-front property and houses in forested areas were generally used for locating these seasonal units. Below is a chart comparing the census's seasonal housing with ours.

Township	Census	Simulation
Acme	261*	-
Blair	44	40
East Bay	300	300
Fife Lake	92	90
Garfield	67	70
Grant	22	30
Green Lake	372	370
Long Lake	350	350

Township	Census	Simulation
Mayfield	2	-
Paradise	22	20
Peninsula	693*	-
Traverse City	36	-
Union	16	20
Whitewater	115	120
	2,392	1,410
assumed to be *migrant housing	-954	
	1,438	

Following is a comparison between the county's resort units as reported by the 1972 census and those contained in the 1972 simulation data base.

- From the simulation data base:

	#/BLU	# units
BLU 35	200 (141 cottages)	2,000 (1410 cottages)
BLU 36	19	380
BLU 37	14	420
BLU 38	5	200
		3,000

- From the census and Chamber of Commerce reports:

# of Hotel, Motel, and Resort Rooms	1,524
# of cottage units	1,438
	2,962

It should be noted here that the simulation's figures on tourist money spent for accomodations does not match the census's. The reason for this is that our tourist dollars include expenditures for <u>seasonal</u> housing (i.e. "rent") which the census does not. And since almost one-half of the total tourist units are these seasonal cottages, the sales figures for the county are much higher than in the census.

C. WATER DATA EXCERPT-

DERIVATION OF EFFLUENT LOADINGS

The BLUs in the WALRUS III simulation are capable of generating an effluent load based on the activity type, an effluent load based on a per capita or average usage figure, or both (or none). The table which follows presents the type of effluent loading by BLU type.

LOAD TYPE	BLU #	Name
None	46	Water Plant
	47	Surface Transportation
	55	Vacant water
Just per capita	1-8	Residential
	42	Education
Just activity based	9-17	Retail and Service
	18	Wholesale
	19-33	Industrial
	39-41	Agriculture
	52	Public Open Space
	53-54	Vacant land
Both activity and per capita	43	Health
	44	Services
	48	Air Terminals
	49	Marinas
	50	Misc. Rec.
	51	Parks
	34-38	Tourism (except for BOD,TSS,TDS for activity loads)

Note: BLU 45: Sewage Plant generates a treated load from all activities sewered.

The data for both loading types is expressed in the units show in the following table.

Effluent	BLUF loading units	Transformed to	WQUAL model loading inputs
Total Coliform	cells/day		cells/day
BOD	lbs/day		mg/day
Total Phosphates*	lbs/day		mg/day
TSS	lbs/day		mg/day
TDS	lbs/day		mg/day

* Collected as phosphates (PO_4) for the point source BLUs and phosphorous pentoxide (P_2O_5) for the non-point source BLUs; both converted to total phosphorous (see "Water Models" in Chapter #3) for WQUAL Model.

The BLUs classified as point source effluent generators included 1-38 (Residential, Commercial, Wholesale, Industrial), 42-44 (Education, Health, Services), and 48-49 (Air Terminals, Marinas). The references used in developing the effluent loads for the point source BLUs included the following:

1) A Study of Residential Water Use, F.P. Linaweaver, et. al., HUD, Federal Housing Administration, HUD TS-12, Feb. 1967.

2) Water for Industry, ed. Graham, American Association for Advancement of Science, 1956.

3) Water Treatment for Industrial and Other Uses, Nordell, Reingold, N.Y., 1972.

4) Urban Planning Aspects of Water Pollution Control, Grava, Columbia University Press, 1969.

Using the above sources, the verbal descriptions provided in Section A of this Internal Report, and the following assumptions for particular BLUs, the effluent characteristics were developed for each of the point source BLUs.

BLU # - Name	Assumption
10 Eating, Drinking	65 meals per day
16 Auto Repair, Service Station	no car washing
19 Leather Industry	leather fabrication

BLU # - Name	Assumption
20 Printing Industry	small weekly newspaper
22 Meat Products Industry	meat (hogs) packing plant
23 Food Products Industry	bakery
27 Tool and Die Industry	1956 treatment adequate
29 Chemical Industry	smokeless powder
31 Canning Industry	cherries
32 Transportation Equipment	aircraft parts
30 Boat Building Industry	fiberglass boats

The BLUs classified as non-point source effluent generators included 39-41 (Agriculture), 50-54 (Misc. Rec., Public Open Space, Parks, and Vacant). The primary source from which the effluent characteristics were derived was Non-point Rural Sources of Water Pollution, Shundar Lin, Circular III, State of Illinois, Dept. of Registration and Education, Illinois State Water Survey, Urbana, 1972. Excluding BLU 41: Grazing for the moment, the process of developing the non-point source effluent characteristics for the remaining BLUs was to obtain, from Lin, one or more "bench mark" figures for each effluent parameter which fit one or more of the BLUs and then modify that figure for the remaining BLUs. Without presenting all the calculations, the basis for the "bench mark" figures are indicated by effluent parameter in the following table.

Total Coliform - basic figure derived from Yearly Mean Stream Water Quality from Agricultural run-off, free of domestic animal wastes, on a watershed of 75 acres with a stream flow of .109 cfs and a fecal coliform concentration of 10,000 cells/100ml. The derived figure of .356 E + 9 cells/acre/day was used for Parks and Public Open Space; all others estimated.

BOD - basic figure derived from the same source and conditions as Total Coliform with a concentration of 2 mg/1. The derived figure of .0156 lb/acre/day was used for Parks and Public Open Space; all others estimated.

Total Phosphates (P_2O_5) - three basic amount figures were provided by Lin as follows:

1. BLU 54: Vacant Forest - forested areas, Ohio; 0.04 lb./acre/year =0.55 E-5 lb/BLU/day
2. BLU 39: Land Crops - corn, silt loam, 8% slope; 0.5 lb./acre/year = 0.5 lb/BLU/day
3. BLU 40: Tree Crops - forested areas, Washington; 0.33 lb./acre/year = 0.083 lb/BLU/day

- all others estimated

Total Solids - two basic figures were provided by Lin based on soil loss from the Effects of Different Cropping Systems on Runoff and Erosion as follows:

1. BLUs 52, 53: Public Open Space, Vacant Grasslands - continuous bluegrass; 0.034 tons/acre/year = 0.094 lb/BLU/day
2. BLU 39: Land Crops - average figure between continuous crops and rotated crops of 5 tons/acre/year = 3333 lb/BLU/day

- all other BLUs were estimated
- Total solids was proportioned into Total Suspended Solids (TS x 60%) and Total Dissolved Solids (TS x 40%).

The effluent characteristics for BLU 41 = GRAZING were based on lbs/1000 lb beef cow/day figures provided by Lin with the addition of the runoff TSS and TDS figures. This BLU has, with the medium fertilizer policy (herd size), 600 cows on 200 acres. The base figures provided by Lin are presented in the following table.

Total Coliform - based on Yearly Mean Stream Water Quality from Agricultural Land Runoff, with 21 cows, in a watershed area of 25 acres with a stream flow of .02 cfs and a fecal coliform concentration of 30,700 cells/100 ml. The derived figure equals .428 E + 12 cells/BLU (600 cows)/day.

BOD - base figure of 1 lb/head/day

Total Phosphates - (P_2O_5) base figure of .1 lb/head/day

Total Suspended Solids - base figure (range = .5-2.0) of 1.25 lb/head/day

Total Dissolved Solids - Total solids average figure of 6.3 lb/head/day - Total Suspended Solids figure = 5.1 lb/head/day

Two additional points should be noted. First, the Total Phosphates figures listed in the BLUF print out for BLUs 48-54 show up as either 0.000 or 0.001 in many cases because the actual figures stored in the program are smaller (e.g. .000055) and the BLUF printing format provides only three digits to the left of the decimal place. (The same is true for BOD in BLUs 53, 54, and for all effluents but Coliform in BLU 44.) Second, although the effluent characteristics for the non-point source BLUs were obtained from non-point source data, the program sums and processes them as though there was an assemblage of point source BLUs in one cell (at a time).

CHAPTER III

MODEL DESCRIPTIONS - ABSTRACT

Internal Report #3 - MODEL DESCRIPTIONS - describes the assumptions, purpose, and form of the submodels contained in the simulation. After an introduction (reproduced here) comparing and contrasting WALRUS III with a generalized form of an urban model, the report is divided into six sections. Section A - Economic Algorithms - begins with an explanation of the National And State Economy (NASE) algorithm; then discusses the Salaries, Wages, and Welfare algorithm; and finally presents the remaining income generator algorithms (Industrial, Agriculture, Tourism, Retail and Service, Wholesale, and Residential). Each of the economic sub-sections has the same form: a verbal explanation, a listing of the variables, and where appropriate the major equations in FORTRAN coding. The Retail and Service Income Generator (RASIG) is presented here as an example.

Population - Migration Model

Section B of Internal Report #3 presents the Population-Migration sub-model with a verbal explanation only. The Water Models - Section C - are discussed next. This section begins with a discussion of the nature of the land use/water connection (excerpted here); presents the operation of the water quality model (excerpted here); identifies the model segmentation and various temperature, coliform death rate, etc. graphs; analyzes the parameter sensitivity of the water model; and compares model output plots with water quality sampling data. Section D - Miscellaneous Mechanical Routines - verbally identifies the various accounting mechanisms for data manipulation with the discussion of Maintaining a Dynamic Land Use File routine excerpted here.

Suggested Improvements - Section E - presents the major programatic, procedural, geographic expansion, and model additions (including a major revision to the population - migration model) improvements considered by the authors to be important to the continued use of the simulation. An Appendix - Section F - contains two reference articles used in the development of some of the algorithms.

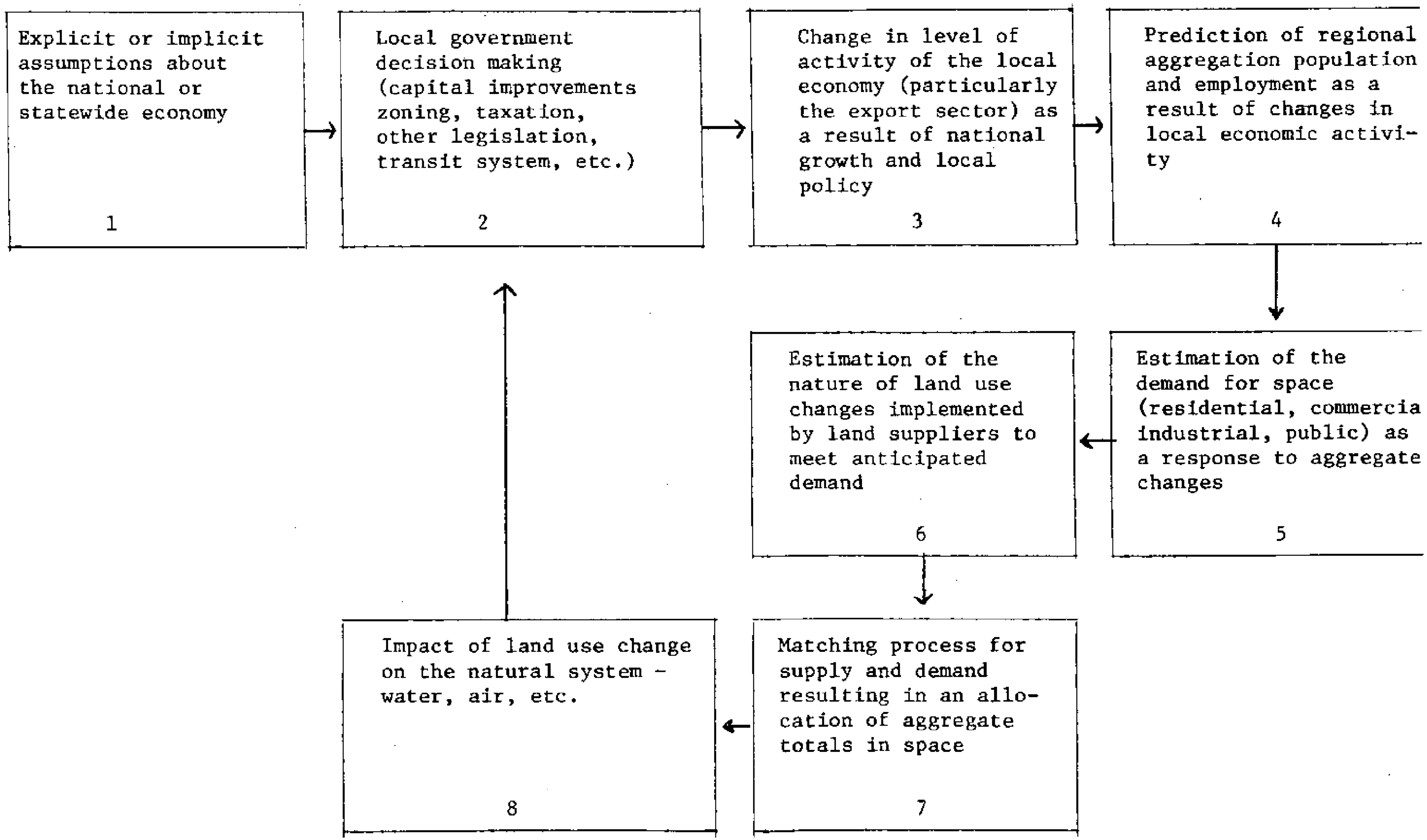
INTRODUCTION TO THE SIMULATION

After having spent considerable time reviewing a number of urban and/or regional development models, the authors concluded that most of them take on the same general structure. They differ only with respect to how much of the structure is included explicitly and then to the particulars of that inclusion. Although it would be nice to claim that WALRUS III is a unique innovation, it is more honest to acknowledge that this simulation is just another attempt at organizing the parts of the general structure in an effort to make the effectuation of that structure more workable. To more fully appreciate the WALRUS III cut at implementing an urban model, it is useful to make explicit the general structure alluded to above. After having done so, we will describe the details of our version of it - slowly and tediously.

THE GENERAL URBAN MODEL

Table 1 presents a diagram of the structure of a "typical" (or more appropriately "ideal type" in the Weberian sense) urban model.

TABLE 1. The General Urban Model



Most modellers start with some assumption about overall National growth (box 1). Failure to recognize the effect of the National economy on local affairs is equivalent to assuming no change in either the economy or other National policies that alter local development patterns. Most modellers allow for some changes in local government policies (box 2). Some actually try to simulate government decision making processes, others use governmental decisions as exogenous inputs to the model while still others incorporate the government through "gaming." The changes in the level of activity in the local economy (box 3) are often directly correlated with National economic changes; however, such complicated techniques as regional input/output modelling have been suggested to get at regional growth shares.

Aggregate employment estimations (box 4) are almost always a direct function of the level of activity in the local economy. Population predictions (box 4) are done by straight linear extrapolation, regression analysis relating population and employment, cohort survival methods, regional migration estimates or any other suitable method of guessing the unknown. The phenomenon of estimating regional aggregates independent of the allocation process is common to a great many models - a phenomenon that in some cases may not make sense.

A great deal of the simulation work done to date has focused on the allocation of the regional aggregates in space (boxes 5, 6, and 7). Micro economists, linear programmers, social physicists, students of the market place, behavioralists, etc. have all taken a shot at defining the allocation procedure. The formulation in Table 1 treats supply and demand as separate related parts of the process related through some matching procedure. Some modellers omit supply considerations (assuming that demand will generate supply), others emphasize the supply side (assuming that demand will take up whatever is provided). Whatever the allocation procedure, variables such as accessibility, neighborhood amenity, job opportunity, and capital infrastructure are usually considered important.

Finally, the modelling of natural systems (box 8) is most often done independently of the land use simulation by "technical" experts and later merged with it. Although the technical experts bemoan the inadequacy of their models, their work is generally far more suited to accurate prediction than the work of their social science counterparts.

Although Table 1 has but one feedback loop, most urban modellers attempt to capture the complexity of the system with multiple explicit and/or implicit feedback relationships. Thus, it is appropriate to interpret the feedback loop in the table as a far more complex feedback system.

All urban development models have the aura of the black box; that is, all have some form of input, some sophisticated processing of that input and some type of output. In fact, the primary difference between specific models is the selection of variables and relationships to be included in the black box and similarly, selection of variables for inputs. Anything not included as "black box" or input is automatically considered irrelevant to the modelling problem at hand. One of the most distinctive features of WALRUS III is its unusual selection of input variables and "black box material."

For the record, it is useful to identify other points of difference between urban models. Such factors as time scale (both for an iteration and for all iterations), aggregation level for key variables, selection of theoretical basis, mathematical solution techniques, parameter estimation techniques, reliance on data, and others are design issues resolved differently by different model builders. The resolution of these issues in a particular instance depends primarily on the intended purpose of the model and secondly on data availability, theoretical elegance, the requirements of a particular analytic method or the limitations of time and funding. (Unfortunately, the resolution of these issues is all too often made unconsciously out of ignorance of the importance of each of them.) In the exposition that follows, particular attention will be made to how the designers of WALRUS III resolved these issues.

WALRUS III AND THE GENERAL URBAN MODEL

The designers of WALRUS III made most of their design decisions to provide for the attainment of two goals. First and foremost, the model had to link up to a simulation of water quality in Grand Traverse Bay being done independently in another branch of the Sea Grant Program. Thus, the model had to generate effluent data from the land use configuration by summing over individual land uses and then had to supply the sums to the bay model. Many aspects of the urban system were regretfully omitted (time and funding restrictions) because of their relatively minor role in determining water quality while some items were included explicitly only because of their effect on the bay.

Second, the model was to be usable by planners and decision makers in the Traverse City region as an aid in their everyday work in the region. This more general and hard to define goal is also the more difficult to achieve. Given the funding level of the project, the design of a model that can interface with a water quality model and still be usable as a general planning tool by "non-experts" in the water field is a difficult task. (Whereas total dissolved phosphorus data may be important for water modelling, school age children data are important for capital infrastructure planning.) It is important to note that the model as it exists today does not meet this second goal. At the time of this writing, WALRUS III is a mere skeleton of the tool needed in

Traverse City; however, it is a skeleton that can be "filled out" fairly easily and made into a working model for use in that city. Many of the things that have been omitted are crucial in any attempt to achieve this second goal.

The two most striking characteristics of WALRUS III as an example of the general urban model are its excessively elaborate considerations of the operating characteristics of existing land uses and the omission of any procedure to add to the existing land use structure except by exogenous input of the operator. The first characteristic arises out of the need to generate effluents for each land use in the study area. The second arises out of the expectation that changes in the land use pattern will be generated exogenously through some gaming mechanism or other scenario generating device.

To appreciate how these two characteristics emerge from the current model, it is instructive to compare WALRUS III with the general model framework box by box. Each cycle of WALRUS III begins with some fairly elaborate bookkeeping to allow for scrutiny of the files and the exogenous addition and subtraction of land uses. (There is also ample opportunity to change many of the parameters that govern the model's behavior.) Once into the cycle, a crude algorithm for generating a national and state growth rate is executed (box 1). There is no opportunity for changes in government policy at this time although the original design of a complete WALRUS III gaming simulation called for an explicit gaming model of the government sector (box 2). The operating status of the exogenous industry (including manufacture, agriculture and tourism) is determined through three detailed algorithms generating income in each sector along with other operating characteristics (box 3). The operating status of the local retail and commercial sector is determined through two detailed algorithms (box 3). A population projection is made and total population is allocated to cells in in a population-migration model (box 4 and box 7). The income from residential land and rent structure is then determined in a separate algorithm (box 3).

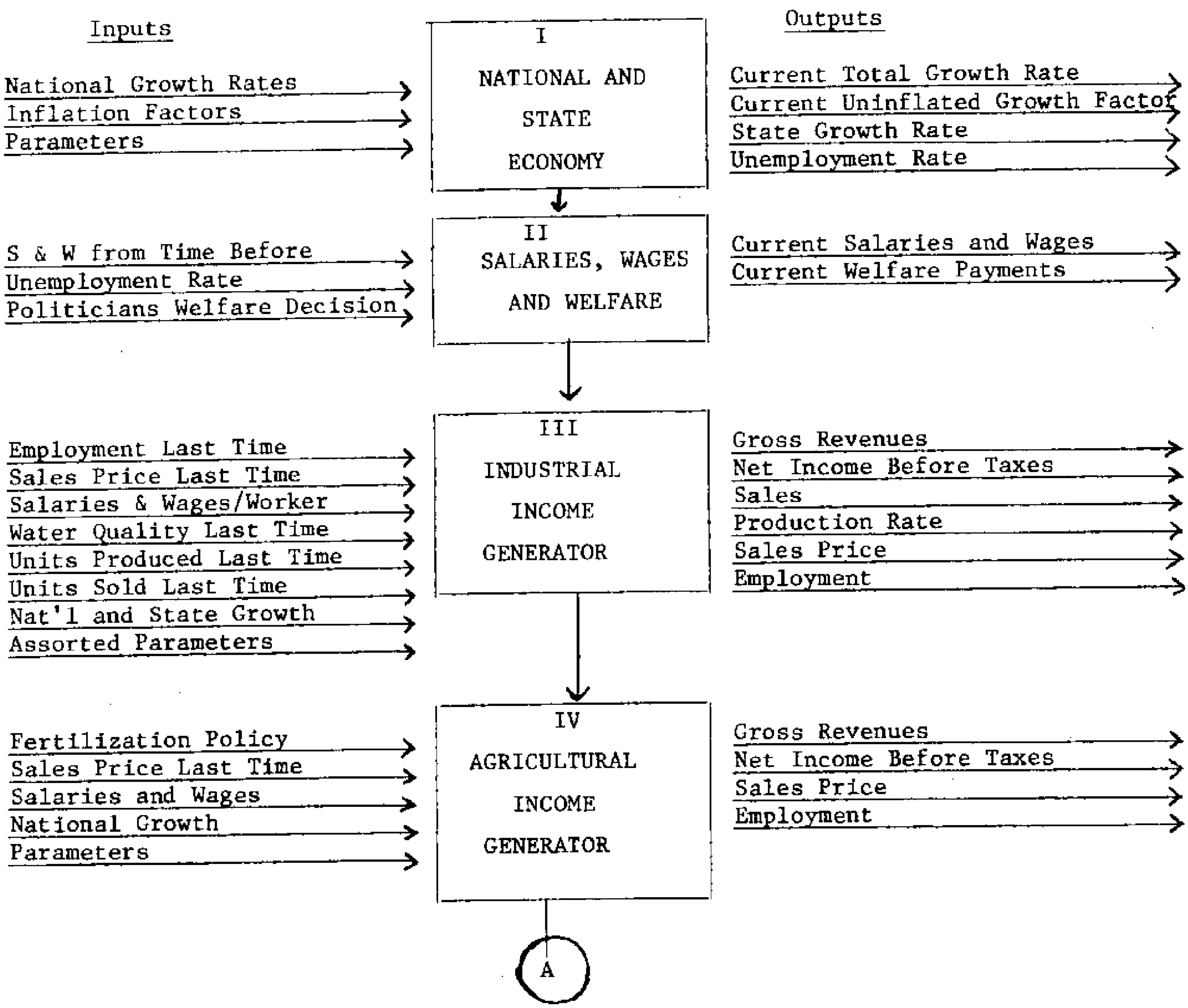
Finally, the effluents generated from operating the land uses are fed to a simulation of the Bay. A brief summary of the status of the region is printed out at the conclusion of the cycle.

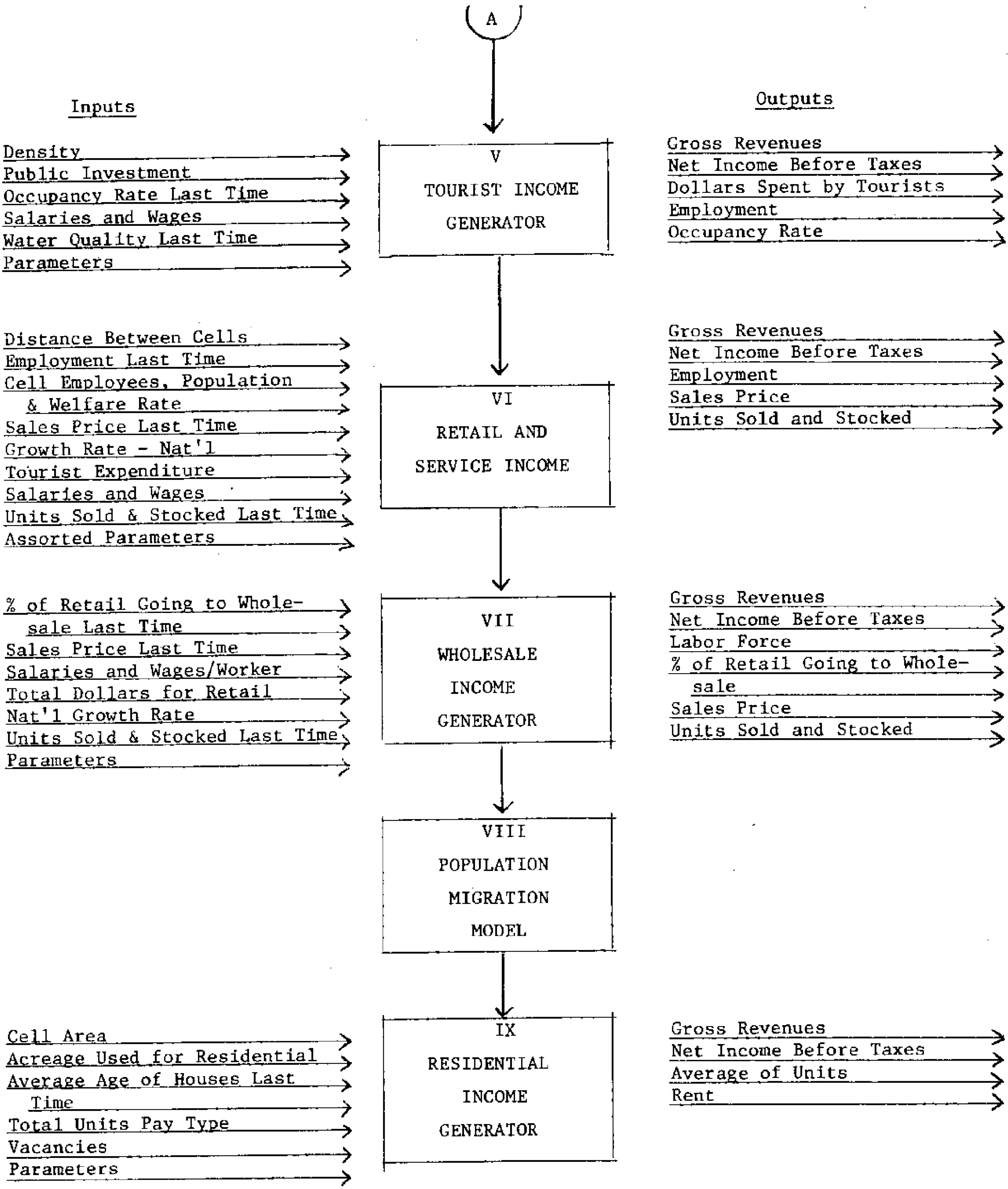
The correspondence between WALRUS III and the general model is not always obvious. For example, aggregate employment is accumulated as you proceed through the algorithms setting the operating characteristics of the various land uses. Nowhere are supply changes (changes in land use) modelled. However, it should be apparent that WALRUS III could be expanded easily to encompass all facets of the more general model. We now turn to the specifics of the model.

A. ECONOMIC SECTOR ALGORITHMS

WALRUS III concentrates on the economic sector of the community assuming that an independent method of generating land use changes exists. As originally conceived, the land use changes, the government sector and some aspects of the social sector were to be included in a gaming linkage to the simulation. The status of the economic sector was determined in the simulation. The general flow of that sector is portrayed in Table 2 - a block recursive diagram indicating the flows, inputs and outputs of the algorithms comprising the bulk of the simulation.

TABLE 2: Flow of Economic Sector Algorithms





A
Inputs
Outputs
Density
Public Investment
Occupancy Rate Last Time
Salaries and Wages
Water Quality Last Time
Parameters
V
TOURIST INCOME
GENERATOR
Gross Revenues
Net Income Before Taxes
Dollars Spent by Tourists
Employment
Occupancy Rate
Distance Between Cells
Employment Last Time
Cell Employees, Population
& Welfare Rate
Sales Price Last Time
Growth Rate - Nat'l
Tourist Expenditure
Salaries and Wages
Units Sold & Stocked Last Time
Assorted Parameters
VI
RETAIL AND
SERVICE INCOME
Gross Revenues
Net Income Before Taxes
Employment
Sales Price
Units Sold and Stocked
% of Retail Going to Whole-
sale Last Time
Sales Price Last Time
Salaries and Wages/Worker
Total Dollars for Retail
Nat'l Growth Rate
Units Sold & Stocked Last Time
Parameters
VII
WHOLESALE
INCOME
GENERATOR
Gross Revenues
Net Income Before Taxes
Labor Force
% of Retail Going to Whole-
sale
Sales Price
Units Sold and Stocked
VIII
POPULATION
MIGRATION
MODEL
Cell Area
Acreage Used for Residential
Average Age of Houses Last
Time
Total Units Pay Type
Vacancies
Parameters
IX
RESIDENTIAL
INCOME
GENERATOR
Gross Revenues
Net Income Before Taxes
Average of Units
Rent

Before describing the details of the income generating algorithms, a few comments about features common to all of them are in order. Several variables are accumulated during the pass through the income algorithms. Total jobs in the community are summed up as each employer is processed. Similarly, total cell wide income is accumulated (except for the income derived in the residential sector) as is the total salaries and wages paid out to members of the community. Most importantly, effluent data is accumulated by season and by sewer system. That is, each land use generates effluent for those days it is in operation and that effluent is dumped into ground water or one of seven possible sewer systems. Simultaneously, water usage is accumulated.

Jobs from the public sector as well as effluents are added in during a special subroutine written for just that purpose - PUBJOB. Public sector jobs do not change dynamically over time.

ECONOMIC MODEL EXCERPT:

RETAIL AND SERVICE INCOME GENERATOR

The retail and Service Income Generator (RASIG) updates the status of the nine basic land uses devoted to commercial activity. At the time of this writing, RASIG is more appropriate as a model of the retail sector than it is of the service sector. Some of the concepts such as "inventory" or "unit" are less applicable in a service business than a retail store.

The theoretical basis of RASIG parallels that of the more elegant and sophisticated academic approaches in that the rates of return reflect the market potential of a given location. The total dollars available for expenditure for each type of commercial land use is a function of expenditures by persons living in the region's hinterland, expenditures by the people making profits locally, expenditures by tourists and, finally, expenditures by people earning their living and residing in the study area. The relative strengths of localized markets in gaining a share of this money is determined by a form of gravity model. For a description of the use of a gravity model in this context see Lakshmanan and Hansen, "A Retail Market Potential Model" in the Journal of the American Institute of Planners of May, 1965.

In brief, each cell having any stores of one of the nine categories of retail and service businesses sets the operating characteristics for itself on the basis of its recent performance. The total dollars available for expenditure on this category is determined for each cell by summing over the categories described above. The potential for sales by each cell with stores is computed via a typical gravity formulation. This potential is then reconciled with the supply available in each cell by allowing cells with potential sales higher than stock to increase their sales by up to 5%.

The steps in the Retail and Service Income Generator are:

1. Impute a level of operation for each BLU on the basis of past performance.
    a. Set inventory held at start of cycle equal to last year's stock less last year's sales.
    b. Determine the new number of units purchased.
        i. Case i - If sales increased last time, purchase enough units to be able to sell as much as last year's sales plus the percentage increase from the year before.
        ii. Case ii - If sales decreased last time and some inventory was left over, purchase only enough units to be able to sell what was sold last time less half the percentage decrease from the time before.

iii. Case iii - If sales decreased last time but everything was sold (i.e., there was no underestimate in purchases last time) increase purchases to be able to sell 5% more than the last cycle.

c. Set the year's stock equal to new purchase plus inventory.

d. If this year's stock exceeds the maximum allowable for this type of establishment, cut it back to that maximum.

e. Set the new labor force as a per unit change from last year.

2. Calculate dollars community can spend for this category of retail.

a. Apply percentages by cell for this category to total available.

b. Sum up cell-wide figures.

3. Adjust sales price by percentage change in national growth.

4. Calculate unadjusted sales for each cell.

a. Calculate a measure of the size of the retail activity in each cell as a weighted average of the number of basic land use units in commercial uses in the cell. (If there are none of the type of use being processed, set the average to zero.)

b. Calculate the potential for sales in each cell.

i. If there is no retail activity of the type under consideration, set potential equal to Ø.

ii. If there is retail activity in the cell, calculate a normalizing factor which is the sum over all other cells of the size of the retail activity in those cells divided by the distance between those cells and the given cell. Potential for the given cell is then calculated by summing over the following complex quantity for all other cells: the product of the dollars for retail in the other cells multiplied by the size of the activity in the given cell divided by the distances between the other cells and the given cell with the whole quantity divided by the normalizing factor.

5. Balance potential sales with offerings.

   a. If the potential sales are up to 10% more than the number of units offered in a cell, they become actual sales.

   b. Everything over that maximum of 10% more than offered is accumulated in a "pot" for later allocation.

   c. Distribute the overall excess of sales (the "pot") to cells that offered more than their potential by selecting cells at random and allowing them to sell the amount they offered.

6. Calculate costs and income figures.

   a. Costs of doing business are new purchases multiplied by the cost per unit added to the money paid out in salaries and wages.

   b. Revenues are sales times the sales price.

   c. Net income before taxes are revenues less costs.

TABLE 10: Variables in Retail and Service Income Generator

Name	Description	Type	Unit	Where From
BTN	Net income before taxes	R	dollars	calculated
C	Matrix with number of BLUs of each type in each cell	R	--	calculated from CLUF
CODB	Costs of doing business	R	dollars	calculated
DFR	Dollars for retail expenditure by type	R	dollars	calculated
EXORET	Exogenous market area contribution to retail	R	dollars	operator
INVENT	Inventory	I	units	calculated
IRN	Index of retail type	I	--	--
IZ	Difference in cell-wide offerings for sale and demand in that cell	I	units	calculated
IZCT	Count of cells in which offerings exceed demand	I	--	calculated
LIMPRO	Limit on capacity	I	units	BLUF
MLF	Array with labor force in each cell	I	employees	calculated
MSALES	Array with sales in each cell	I	units	calculated
MSTOK	Array with stock in each cell	I	units	calculated
NDEM	Units demanded in a single cell	I	units	= SALPOT(J)/ SALPRI(K)
NEWUNS	New units purchased (later, new units sold)	I	units	calculated
NOFF	Units offered in a single cell	I	units	= MSTOK(J)
NOS(LOS)	Units sold last cycle (two cycles ago)	I	units	CLUF
NPOPC	Population by cell	I	people	ACF
NSALES (LSALES)	Units sold this cycle (last cycle)	I	units	calculated (CLUF)

Name	Description	Type	Unit	Where From
NSTOCK (LSTOCK)	Units stocked this cycle (last cycle)	I	units	calculated (CLUF)
NUDEM	The accumulator for unmet demand	I	units	calculated
REVN	Gross revenues	R	dollars	calculated
RLFPU	Labor forces per unit	R	employees	BLUF
SALPOT	Sales potential by cell	R	--	calculated
SALPRI	Sales price by retail category	R	dollars	calculated
SAWPW	Salaries and wages per worker	R	dollars	SWW
SWFR	Amount of salaries and wages for a particular retail category	R	dollars	calculated (TSAWL * XX(K))
TOTNGR	Total national growth rate	R	percent	NASE
TC2R	Tourist contribution to retail	R	dollars	TIG
TSAWL	Total salaries and wages last cycle	R	dollars	CLUF
TTINC	Total business income	R	dollars	ACF
XX	Percent of salaries and wages for retail category	R	percent	PARA
XXX	Percent of exogenous contribution to retail for each category	R	percent	PARA
YY	Percent of tourist contribution to retail for each category	R	percent	PARA
YYY	Percent of business income contributed to retail for each category	R	percent	PARA
ZTOT	Scale factor used in potential calculation	R	--	calculated
ZZ	Floor space surrogate measuring the attractive pull of a cell for shoppers	R	--	calculated
WGTS	A coefficient used to differentiate relative floor space (and therefore sales/square foot) by retail type - used to calculate ZZ	R	--	Data Statement

The equations in the Retail and Service Income Generator are more difficult to write down than those of the other modules because of the complexity of some of the summations involved therein. Therefore, at the appropriate times, FORTRAN coding will be substituted for equations.

The steps for each retail type are in a single large loop

```
DO 1000 K = 1, NRC
```

where NRC is the number of retail and service land use categories.

Steps 1 and 2 are in a sub-loop

```
DO 100 J = 1, NCS
```

where NCS is the number of cells. The equations within that sub-loop are:

```
1a)                 INVENT = LSTOCK - LSALES
 b)                 IF (SALES .LE. LOS) GO TO 65
   case i)          NEWUNS = LSALES * (1.0 + (LSALES - LOS) - INVENT
                    GO TO 75
            65      IF (INVENT .EQ. Ø) GO TO 70
  case ii)          NEWUNS = LSALES + LSALES * (1.0 + (LSALES - LOS)/2.0) - INVENT
                    GO TO 75
 case iii) 70       NEWUNS = LSALES * 1.05
           75       . . .
 c)                 MSTOK(J) = NEWUNS + INVENT
 d)                 IF (MSTOK(J) .GT. LIMPRO) MSTOK(J) = LIMPRO
                    MLF(J) = LLF * (NNUM * 1.0)/LNUM + (MSTOK(J) - LSTOCK *
                          (NNUM * 1.0/LNUM) * RLFPU + 0.999
                    MLF(J) = MLF(J) * (NIOP * 1.0/LIOP) + 0.999
2a)                 DFR(J) = SWFR/NPOPC(J) + TC2R(J) + YY(K) + EXORET
                          *XXX(K) + TTINC(J) *YYY(K)
```

b) TOTDFR(K) = TOTDFR(K) + DFR(J)

```
100     . . .
```

3) SALPRI(K) = SALPRI(K) * (1.0 + TOTNGR)

Step 4a has a loop.

4a)

```
        DO 100 J = 1, NCS
        ZZ(J) = 0.0
        IF (C(K,J) .LE. Ø) GO TO 110
        ZZ(J) = WGTS(K) * C(K,J)
110     CONTINUE
```

Step 4b has several nested loops.

4b)

```
        DO 114 I = 1,N
        ZTOT (I) = 0.0
        DO 113 J = 1,NCS
        IF (ZZ(J) .LE. Ø) GO TO 113
        ZTOT(I) = ZTOT(I) + ZZ(J)/ID(I,J) ** ALFA
113     CONTINUE
114     CONTINUE
        DO 120 J = 1, NCS
        SALPOT (J) = 0.0
        IF(ZZ(J) .LE. Ø) GO TO 120
        DO 115 I = 1,NCS
        SALPOT (J) = SALPOT(J) + (DFR(I)/(ID(I,J) ** ALFA))/ZTOT(I)
115     CONTINUE
        SALPOT (J) = SALPOT (J) * ZZ (J)
120     CONTINUE
```

Where ID(I,J) is a function returning the distance between cell I and cell J.

Steps 5a and b are enmeshed in a single loop.

```
            IZCT = Ø
            NUDEM = Ø
            DO 21Ø J = 1, NCS
            IZ(J) = 0
            NEDM = SALPOT(J)/SALPRI(K)
            NOFF = MSTOK(J)
            IF (NDEM - NOFF) 14Ø, 15Ø, 16Ø
    14Ø     IZCT = IZCT + 1
            IZ(J) = NOFF - NDEM
5a) 15Ø     MSALE(J) = NDEM
            GO TO 21Ø
    16Ø     NOFF = MSTOK(J) * 1.1Ø
            IF (NDEM - NOFF) 17Ø, 17Ø, 18Ø
5a) 17Ø     MSALE(J) = NDEM
            GO TO 200
5a) 18Ø     MSALE(J) = NOFF
5b)         NUDEM = NUDEM + NDEM - NOFF
    2ØØ     MSTOK(J) = MSALE(J)
    21Ø     CONTINUE
```

Once one of the cells that offered too many units has been selected at random, step 5c proceeds as follows:

```
5c)         IF (NUDEM .LE. IZ(J)) GO TO 27Ø
            NEWUNS = IZ(J)
            GO TO 28Ø
```

```
270     NEWUNS = NUDEM
280     NUDEM = NUDEM - NEWUNS
        MSALES(J) = MSALES(J) + NEWUNS
        MSTOK(J) = MSTOK(J) + NEWUNS
        IZ(J) = IZ(J) - NEWUNS
        IF (NUDEM .LE. 0) GO TO 300
                    .
                    .
                    .
300     CONTINUE
```

Where J is the index for the cell found and the missing steps restart the process for a different such cell.

Step 6 is in another loop.

```
            DO 330 J = 1, NCS
6a)         CODB = (MSTOK(J) - (STOCK + LSALES) * CPU + NLF(J) * SAWPW (IRN)
6b)         REVN = NSALES(J) * SALPRI(K)
6c)         BTN = REVN - CODB
```

B. POPULATION-MIGRATION MODEL

In addition to the cyclical updating of the status of basic land uses, WALRUS III performs several other functions. There is a population-migration model to grow the population and allocate households in space. The equations are not described in as much depth as were the income algorithms.

POPULATION-MIGRATION MODEL EXCERPT:

THE POPULATION-MIGRATION MODEL

Chronologically, the Population-Migration Model (POPMG) antedated the balance of WALRUS III. The conceptual formulation of the model was, therefore, the least constrained by the existence of other components. Thus, as we shall see, many of the variables generated in the balance of the program that would logically influence population allocation are not explicitly incorporated in the model as it was not known that they would be readily available at the time the concept was developed.

Furthermore, the exact nature of the entire WALRUS III simulation was barely understood at the time of concept formation - its use was ill-defined and its scope unclear. Thus the Population-Migration Model does not meet some of the needs prescribed by the uses of the model envisioned at the time of this writing.

Finally, it must be noted that the model is overly simplified when compared to the more common population allocation models described in the literature. Specifically, it treats all households on the basis of the amenities associated with those neighborhoods. At the time of its conceptual development, the major purpose of POPMG was the distribution of population so that effluents could be added to the bay.

Given this background, it is now possible to consider the model itself. The primary impetus to the model is the availability of jobs. As it assigns people to houses, POPMG also fills jobs. Its basic assumption is that unless a cell is designated as a "suburban" cell, it is attractive if and only if the people living there can find jobs close by. The only measure of the "amenities" in a cell is the capital investment constraint; that is, people will not move into a cell unless the capital investment in the cell is at a certain level. To see how all this works, let us consider the steps in the model.

1. Grow the population in the community by increasing total population by a pre-set figure under the control of the operator.
   a. Generate a random number to set growth rate according to the parameters of a normal distribution specified by the operator.
   b. Assign the increase in population to the "population to be allocated" pool.
2. Assign the stable population to each cell while placing the other households in the "population to be allocated" pool.
   a. Generate a random number representing the percentage of population in a cell to be assigned to the "population to be allocated" pool.
   b. If there are enough jobs and structures within a cell to "handle" the balance of the population (the stable population), make the assignment. Otherwise cut the stable population back to the limit set by the smaller of the two quantities (the number of people that can be employed or the number of people that can be housed). Put the remaining people in the "population to be allocated" pool.
3. Assign people to jobs in a cell if there is housing in a cell.
   a. Set capital investment constraint on.

b. Rank order cells according to job availability (consider cells that have the most job opportunities first).

c. If there are available jobs and available houses fill them with people while diminishing the "population to be allocated" pool.

d. If the pool is empty - skip to the end of the model.

4. Assign people to unoccupied houses in cells adjacent to cells with job opportunities.

a. Rank order cells according to job availability.

b. Select the cells in the two rings surrounding the cell with job opportunities. Randomize the order in which those cells in the first ring and then those in the second are considered.

c. If there are available jobs in the one cell and housing opportunities in the neighboring cell, fill those houses with people and then assign them to the jobs while diminishing the "population to be allocated" pool.

d. If the pool empties at any point, skip to the end of the model.

5. Assign people to unoccupied houses in the suburban cells.

a. Rank order cells according to job availability.

b. Locate the suburban cells nearest to the cell with job opportunities by searching through all remaining cells ring by ring (nearest ring first) and creating a list of suburban cells as they are found.

c. Loop over the list of suburban cells filling houses until either all jobs or all houses are taken. Decrease the "population to be allocated" pool simultaneously.

d. If the pool empties at any point, skip to the end of the model.

6. Repeat steps 3 through 5 with the capital investment constraint off; that is, allow people to fill areas with insufficient capital investment.

7. Overcrowd.

   a. Rank order cells according to job availability.

   b. Calculate the number of people needed to fill those jobs.

   c. If that number is less than some pre-set "overcrowd" percentage, crowd all those people into existing housing. If not, crowd at least as many people as allowed by the overcrowd percentage into the cell.

   d. Rank order all cells according to the largest change in employment from last cycle to this one.

   e. Overcrowd up to the overcrowd percentage in those cells that have not yet been crowded in step 7c.

   f. If the "population to be allocated" pool empties at any point, skip to the end.

8. Fill all remaining vacancies.

   a. Rank order cells according to the number of vacancies.

   b. Loop over all cells - cells with fewest vacancies first - assigning population to housing so as to fill all vacancies while decreasing the "population to be allocated" pool.

   c. If the pool empties, skip to the end.

9. If there are still unallocated households, signal the operator that in no way could all households be allocated and move on.

C. WATER MODELS

THE WATER CONNECTION

The first step in the water connection is the accumulation of each of five effluents - Coliform, Biological Oxygen Demand, Total Phosphates, Total Suspended Solids and Total Dissolved Solids. As the final status of each land use is recorded for posterity during the execution of the income algorithms, the quantity of each effluent generated by each land use is accumulated by cell of origin through the execution of a subroutine called CONTAM. The effluent from each cell is tallied for two seasons, summer and winter, and stored in the ACF for retrieval later in the water connection. The stored data is computed by multiplying three quantities together, the effluent rate (stored in the BLUF and measured in lbs./day), the number of units operating, and the number of days per season those units operate. In the cases of the tourism and residential basic land use units, an additional "per person" factor is also added in. If a land use is on a sewer system, the effluent is added to the cell generation destined for that sewer system; otherwise, it is passed into the ground water.

The last step in the water connection is the Steady State Modelling Program (SSMP) developed by Ray Canale and modified by Don Hineman for use in WALRUS III. The Hineman modification of SSMP sets up the basic equations for a 64 segment representation of Grand Traverse Bay; therefore, unless the flow patterns segment configuration, etc. is changed, it is unnecessary to actually run the SSMP - it is sufficient to use the intermediate set of data provided by Hineman along with changed segment loadings to generate the needed output. Thus, it is necessary to provide Hineman's version of the SSMP the quantity (in mg/day) of each of the five effluents dumped into each of the 64 segments. Furthermore, through coupled runs of the model it is possible to generate concentrations of eight contaminants in the bay with Dissolved Oxygen, Total Dissolved Phosphorus and Chlorophyll a added to the five contaminants for which effluents are accumulated. The water connection described below is the process by which total pounds per season by land cell is converted to mg/day loads for each segment.

The master subroutine governing this transition process is called WATMOD. WATMOD calls four other subroutines to perform assorted tasks in completing the connection - the fifth being the water quality model itself.

The first two of these routines, WATCAP and SEWCAP, determine the capacity of the water and sewer treatment systems respectively. During CONTAM, in addition to the accumulation of effluent, water usage and sewer usage (in volume) is also totaled up. In each routine, this total seasonal usage is reduced to an average daily usage which is compared to the capacity for each plant as stored in the Current Land Use File (CLUF). In the case of the water plant, the percentage of capacity used has no further application - it is merely reported out for user information.

Prior to calling the remaining subroutines, WATMOD places the elements describing the water system for all contaminants and both seasons in proper position. The exact meaning of these elements is known only to specialists in the use of the SSMP; however, we can give approximate interpretations based on our work here. A 64 X 64 "A-matrix" is read in containing the interaction terms between each segment of the bay and all others. (Most elements are Ø - only those elements adjacent to one another interact.) A 64 element Right Hand Side Vector is read in corresponding to the elements on the right hand side of the equals sign of the 64 simultaneous equations making up the model. Initially all elements except the two corresponding to the northern most bay segments which connect to the "larger bay" are zero. Finally, a volume vector is read in containing the volumes of the 64 segments.

WATMOD now "loops" over seasons and contaminants, thereby considering one contaminant at a time for each season. Additional parameters specific to contaminant and season must be read in. These include the reaction coefficient, three scale factors (boundary condition, loading scale and volume scale), boundary concentrations in both segments 62 and 63 (the two segments linked to the balance of the bay) and other parameters for specific contaminants (D.O. deoxygenation coefficient, D.O. saturation coefficient and a chlorophyll a coefficient).

With all the parameters in place, the third subroutine - GETEFF - is called. GETEFF converts the pounds/season/cell figures generated during the income algorithms to mg/day/segment loadings for each of the eight contaminants monitored in the bay (the five for which effluent data is accumulated plus three generated by coupled runs using the output of the primary run as input to the second level run). For the five primary runs (Coliform, BOD, Total Phosphorus and Total Suspended Solids and Total Dissolved Solids) this transformation consists of two phases - the transfer of raw effluent in the ground water to the lake and the dumping of the cleaned effluent from the sewer network. For the coupled runs (D.O., Total Dissolved Phosphorus and Chlorophyll a) a special procedure is used to generate loadings.

The two phases of the primary runs work as follows: effluent dumped into the ground water is first converted to an average daily dump by dividing by 180.0. It is then sifted through a drainage network until it reaches a water segment. For each cell the dump must pass on the way to the lake, a percentage of it is lost. (These percentages were derived in arbitrary fashion - no real data exists in the real world on the loss of contamination in ground water. They are stored in the Parameters File.) The drainage network is specified by recording in the Run-off and Water Parameters File (ROWA) the following data for each linked cell and segment: the number of cells separating the cell and segment and the percentage of that cell's effluent reaching the given segment. Effluent passed through a sewer plant (up to seven plants can operate simultaneously) is added into the segment specified for the reception of waste from the plant in the CLUF. But first, the load is converted to a daily load by dividing by 180.0 and cleansed by applying the percent removal figures for the plant also stored in the CLUF. If the capacity of the plant had been exceeded, all excess sewage is passed through to the appropriate segment untreated.

After all contributions to the effluent dump have been assigned to a segment, the loadings (now in lbs/day) are converted to milligrams/day. Also phosphate loadings are converted to phosphorus loadings by dividing by 3. Finally, pseudo boundary conditions (loads in the upriver segments of the river tributaries) are added in arbitrarily.

The special sections of GETEFF used for the coupled runs are quite simple. For D.O. no additional loadings are generated (the concentrations of BOD, however, are used in the coupled run). For Total Dissolved Phosphorus a percent of total phosphorus is assumed to be dissolved - .8 in summer and .9 in winter. For Phytoplankton, a supplemental loading is added in according to Hineman's instructions - 4000.0 mg/day in cells 14 and 24, 20000 in cell 33, 500 in cell 41, 5000 in cell 43 and 1000 in cells 47 and 50. (In summer these figures are multiplied by 10.

Once a set of loadings is complete for a contaminant in a season, the fourth subroutine is called - WQUAL, the water model itself. WQUAL sets up a set of simultaneous equations and solves them yielding resultant concentration.

Note, total suspended solids are not processed by WQUAL but are generated by a "fudge" process. A percentage of the concentration of chlorophyll a is called TSS in each cell while loadings are just dumped directly into the segments without any further mixing.

The following is a discussion of WQUAL and the loading sensitivity of the water model. For an additional reference to WQUAL, see University of Michigan Sea Grant Technical Report No. 27, Steady State Modeling Program Application Manual, by R. P. Canale and S. Nachiappen.

WATER MODELS EXCERPT:

WALRUS STEADY-STATE MODELING PROGRAM - WQUAL

The Steady-State Modeling Program (SSMP), WQUAL, was developed for use in the WALRUS III model by Don Hineman. The program is used to predict concentrations of different water quality species in the bay, which is configured into a 64 segment (compartment) model, with 52 open water segments and 12 segments representing bay tributaries. The technique used in development of this model is construction of a system of linear equations, one for each segment, representing the physical properties of the system. The designation as steady-state is strictly in reference to segment volumes, which are assumed to remain fixed over time.

The basis of the equations is presented below with a two segment example with one water quality variable.

Total volume: $V = \sum_{i=1}^{2} V_i$

Change in volume of segment i = $\dot{V}_i = \Sigma q_a - \Sigma r_s = 0$

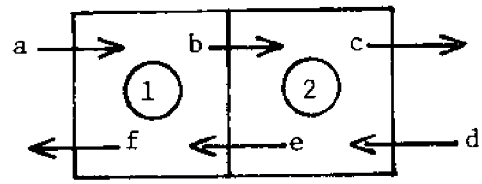
Concentration of water quality variable $dc_i = [(\Sigma q_a c_a - \Sigma r_s c_s + S_i)/v_i]\ dt$

or $v_i \dot{c}_i = \Sigma q_a c_a - \Sigma r_s c_s + S_i$

where:

- v = total volume
- v_i = volume of segment i
- $\dot{v}_i$ = change in volume of segment i (steady state = 0) with respect to time $\left(\frac{dV}{dt}\right)$
- q_a = rate of flow (a) into segment i
- r_s = rate of flow (s) out of segment i
- dC = change in concentration in segment i
- c_a = concentration of water quality variable in flow (a)
- c_s = concentration of water quality variable at flow (s)
- s_i = natural source or sink for variable in segment i
- dt = change in time
- $\dot{c}_i$ = change in concentration of water quality variable in segment i with respect to time (dc/dt)

A diagram of this model follows with arrows representing flow directions:



The precise equations, then, are:

$$V_1\dot{c}_1 = q_a c_a + q_e c_e - r_b c_b - r_f c_f + S_1$$

$$V_2\dot{c}_2 = q_b c_b + q_f c_f - r_c c_c - r_e c_e + S_2$$

These equations can be solved using any of a number of numerical techniques capable of solving systems of n simultaneous equations with n unknowns (CSMP is perhaps the most familiar computerized system).

The data requirements for the 64 segment model are somewhat extensive, in that all inter-segment flows must be provided, initial concentrations (or loadings) must be provided, and volumes of all segments estimated. A number of reaction coefficients and scaling factors are also required to account for natural source and sink conditions (S_i) and measurement scales. The data requirements are as follows:

1. A-matrix

   A 64X64 matrix with all intersegment flows contained. Since segments only flow to and from adjacent segments, most elements in this matrix are zeroes.

2. Right-hand-side vector

   The concentrations of the water quality variable for each segment are provided in this 64 x 1 vector (one vector for each water quality variable).

3. Volume vector

   This 64 x 1 vector contains the estimated volumes of each of the segments of the configuration.

4. WALRUS supplied data

   a. reaction coefficients
   b. boundary concentration scaling factor
   c. loading scale factor
   d. final concentration scaling factor

e. boundary concentrations for segments 62 and 63
f. segment loadings

Discussion of the WALRUS supplied data, particularly as these data relate to segment loadings, is presented later in this chapter. (A segment map of the bay and tributaries is included in the Internal Report.)

The SSMP algorithm follows:

1. Multiply elements 62 and 63 of right-hand side vector by the product of the corresponding boundary concentration and the boundary concentration scale factor.

2. Add to diagonal elements of A matrix the product of the volume vector, the volume scale factor, and the reaction coefficient.

3. Add to right-hand side vector the product of the loading and the loading scale factor.

4. Invert the linear system and multiply the resulting vector by the final concentration scale factor.

The computation of D.O. requires a special procedure since this system is coupled to the B.O.D. system. Hence, after B.O.D. concentrations have been calculated using the above 4 steps, D.O. is calculated in the following manner:

5. Read in
   a. D.O. saturation concentration
   b. Reaeration coefficient
   c. Deoxygenation coefficient
   d. Scale factors as above
   e. Boundary concentrations, segments 62 and 63
   f. D.O. loadings

6. Multiply elements 62 and 63 of right-hand side vector by product of corresponding boundary concentration and scale factor.

7. Add to right-hand side vector elements the following:

   (volume*reaeration coefficient*saturation concentration)
   -(volume*deoxygenation coefficient*B.O.D. Concentration
   /B.O.D. final concentration scale factor)
   + (loading*loading scale factor)

8. Add to diagonal elements of A matrix the product of the volume vector and the reaeration coefficient.

9. Invert the linear system and multiply the resulting vector by the final concentration scale factor.

The following is a summary of the required user-supplied data:

Reaction Coefficient: 0.0 for Total Phosphorus and Total Dissolved Solids; variable for Total Coliform and B.O.D. The coefficient for Coliform can be obtained from the attached curve of coliform death rate; the coefficient for BOD can be obtained from the attached temperature curve and the following formula: $K_T = K_{20*} \quad T-20$

where K_T = coefficient at temperature T

K_{20} = coefficient at 20 degrees C=0.2

= 1.04

BC Scale: 1.0 for all parameters

Loading Scale: 0.035314 for TDS, Total Phosphorus, B.O.D., and D.O.; 0.0035314 for Total Coliform

Volume scale: 1.0 for TDS, BOD, DO, and Total Coliform; 1000.0 for Total Phosphorus

Boundary Concentrations:

0.003	for Total Phosphorus
0.0	for Total Coliform
0.5	for B.O.D.
10.0	for D.O.
140.0	for TDS

Loadings: dependent upon the status of the activities as affected by the various subroutines and user input. However some loading is necessary for each of the "headwater" segments in the system (segments 33, 41, and 43)

D.O. Saturation Concentration:

$$C_S = 14.652 - 0.41022T+0.0079910T^2 - 0.00077774T^3$$

where C_S = saturation concentration

T = temperature in degrees C

D.O. Reaeration Coefficient:

$$(K_A)_T = (K_A)_{20} * 1.047^{(T-20)}$$

where $(K_A)_T$ = reaeration coefficient at temperature T

$(K_A)_{20}$ = 1.236 for stream segments (#33-44)

= 0.080 for shoreline segments (#1-4,6,7,9,10,12-17,20,21, 24,25,28,29,32,45,47,48,50,51,53,56,60,61,64)

= 0.010 for deep water segments (#5,8,11,18,19,22,23,26,27, 30,31,46,49,52,55,57,58,59,62,63)

D.O. Deoxygenation Coefficient: same as B.O.D. reaction coefficient

Use of the scale factors specified above produces the following units:

	Loading Inputs	Boundary Concentrations	Steady State Concentrations
Total Phosphorus	mg/day	mg/l (ppm)	mg/l (ppb)
Total Coliform	cells/day	cells/100 ml	cells/100 ml
T.D.S.	mg/day	mg/l	mg/l
B.O.D.	mg/day	mg/l	mg/l
D.O.	mg/day	mg/l	mg/l

D. MISCELLANEOUS MECHANICAL ROUTINES SUMMARY

As with many of the other data-bound simulations described in the literature, a large part of the initial design work is the design of the "accounting" procedure for storing, retrieving and monitoring data. With the exception of this latter category of "accounting" procedures, these are largely mechanical and are described fully in another report. They are just mentioned here to record their existence. The monitoring algorithms are described in more depth.

1. Print File Routines

   A series of routines to print out any of the data in each of the files are part of the program.

2. File Change Routine

   A routine to allow the operator to modify the contents of any of the files is a part of the program.

3. Update Land Use Routine

   A routine to enable the user to specify changes in land use exists as a part of the program.

4. Summary Table Routine

   A routine to print out a summary table at the end of each cycle is the last part of the program. A part of this summary table is a set of indices that monitor the region's performance.

MISCELLANEOUS MECHANICAL ROUTINES EXCERPT:

MAINTAINING A DYNAMIC BASIC LAND USE FILE (BLUF)

A program, DYNABLU, exists for keeping the BLUF (Basic Land Use File) current with the operational status of the Current Land Use File (CLUF). This stand-alone program is run at the completion of each cycle, using all active nonresidential land uses, with the result that BLUF is left with the characteristics of each basic land use as those characteristics currently exist in the model. Without use of this program, characteristics in BLUF will remain as initially specified, causing all subsequent additions of land uses to be entered without any reflection of current conditions. Obviously, with use of this program, subsequent additions are entered with current characteristics. The following elements are maintained dynamically:

Ret & Who	Ind	Tour	Agr	Publ	Trtmnt Plants	Description
SAW	SAW	SAW	SAW	SAW	SAW	Salaries and Wages
ILF	ILF	ILF	-	ILF	ILF	Initial Labor force
-	-	-	SALPRI	-	-	{Sales Price Units produced
-	IPROD	-	LAB(1)	-	-	{Labor Force;Fert.Policy 1
IUS	ISALES	-	LAB(2)	-	-	{Stock, Sales "t-1", Labor force; Fert.Policy 2
ISALES	-	-	LAB(3)	-	-	{Sales "t-1", Labor force fert. policy 3
-	-	ORATEL	-	-	-	occupancy rate "t-2"
-	-	ORATEN	-	-	-	occupancy rate "t-1"
ISTMZ	-	-	-	-	-	Sales "t-2"

CHAPTER IV

FILE DESCRIPTIONS - ABSTRACT

INTRODUCTION

This report - FILE DESCRIPTIONS - provides the basis for the operation and modification of the WALRUS III simulation model. In order to understand the nature of the files containing the data base and many of the parameters, the report has been divided into three sections: Accessing files (a portion of which is presented here), Structure of the files (an excerpt of the parameters file is presented here), and Operating characteristics including creation and retrieval, sequencing, restart, magnetic tape storage, and costs (excerpted here).

A. ACCESSING FILES IN THE WALRUS III PROGRAM

In an effort to maintain flexibility in shifting the WALRUS III computer program from computer to computer (it is anticipated that people not at the University of Michigan will want to use the program) all files within WALRUS III are referenced by two user supplied subroutines - one to make entries into files, the other to retrieve information from files. By adapting these subroutines to another machine, WALRUS III can be run without other modifications to the program. The two subroutines are:

FREAD - to read data already in a file, and

FWRITE - to place data into a file.

On the IBM 360/67 at the University of Michigan, these subroutines utilize the IBM FORTRAN specific "READ" and "WRITE" commands. On other computers, it will be necessary to substitute appropriate analogs to these statements within the two subroutines.

B. STRUCTURE OF WALRUS III FILES

As of the date of this writing, there are five files in the WALRUS III simulation. Each is created using the conventions for accessing files described in the preceding section. Thus, the record numbers and location within input/output buffers must be known by any user of the program. This section of the report gives the structure of each of the six working files of WALRUS III as well as a verbal description of their functions.

PARAMETERS FILE EXCERPT

The first file is the parameters file (PAR). As the name suggests, this file contains many of the parameters used in the simulation. By changing the values of some of these parameters, the results of the simulation change dramatically. The file has 14 records or lines, each containing a special kind of data. Each line can hold up to 25 elements. Table 1 gives the composition of each of the lines.

Table 1: The Parameters File

Record Number	Elements	Variable Name	Description
1			Values set when operator exercises various options
	1	TOTNGR	Override of preset national growth rate
	2	UNINF	Override of preset uninflated growth rate
	3	WELFP	Dollar value of welfare payment
	4	EXORET	Exogenous contribution to retail and wholesale sales
	5	CIC	Override of capital investment constraint used population migration model
	6	EXG	Override of population growth rate
	7	STDG	Override of standard deviation of population growth rate
	8	EXM	Override of stability percentage in population migration model
	9	STDM	Override of standard deviation of stability percentage
	10-25		Unused
2		/HIGHC/	Common block containing variables describing files e.g. DSRN's, record lengths, etc.
	1	NCS	Number of cells (84)
	2	NBLUS	Number of active basic land use units (55)
	3	NBRCS	Maximum allowable number of basic land use units (60)
	4	NACFS	Number of records in active cell file (224)
	5	NARCS	Maximum allowable number of records in active cell file (250)
	6	LPF	Length of all records in parameters file (25)

Record Number	Elements	Variable Name	Description
	7	LCF	Length of all records in current land use file (20)
	8	LBF	Length of all records in basic land use file (40)
	9	LRF	Length of all records in the reference file (10)
	10	NPRN	Data set reference number - parameters file (8)
	11	NBRF	Data set reference number - basic land use file (9)
	12	NREF	Data set reference number - reference file (10)
	13	NICL	Data set reference number - initial current land use file (14)
	14	NIACF	Data set reference number - initial active cell file (12)
	15	IFB	Data set reference number - file with raw "BLUF" data (19)
	16	IFC	Data set reference number - file with raw "CLUF" data (11)
	17	IFP	Data set reference number - file with raw "PAR" data (18)
	18	IFA	Data set reference number - file with raw "ACF" data (13)
	19	NROA	Data set reference number - water parameters file (7)
	20	LBR	Length of all records in the water parameters file (64)
	21	IFW	Data set reference number - file with raw data for water parameters file (17)
	22-25		Unused
3		/HIGHP/	Common block containing assorted essential variables
	1	NCYCL	Cycle number
	2-4	KDATE(3)	The date
	5	INIT	Number used by the random number generator

Record Number	Elements	Variable Name	Description
	6	KWR	Variable designed for use to trigger diagnostics during a run from a terminal (not used yet)
	7	KPR	Variable used to trigger printer diagnostics
	8	IPOUT	Logical unit number for printer (6)
	9	ITOUT	Logical unit number for terminal output (16)
	10	IOUT	Logical unit number for master output device (either 6 or 16)
	11	ITIN	Logical unit number for terminal input (15)
	12	IRIN	Logical unit number for reader input (16)
	13	IIN	Logical unit number for master input device (either 15 or 16)
	14	IOPTS	Bits are set in IOPTS to acknowledge that an operator option has been exercised - each bit corresponds to a word in record 1
	15	ICF	Data set reference number - this cycle's "ACF"
	16	IOF	Data set reference number - last cycle's "ACF"
	17	NFILE	Data set reference number - this cycle's "CLUF"
	18	LFILE	Data set reference number - last cycle's "CLUF"
	19	IFLD	Variable used to "remember" which "LUD" array is in common - current, last or initial cycle
	20-25		Unused
4			National unemployment rates
	1-11	UNEMP(11)	National unemployment rates for 11 cycles
	12-25		Unused
5			Actual growth rates
	1-11	TSGS(11)	Actual state-wide growth rates
	12-22	TNGS(11)	Actual national growth rates
	22-25		Unused
6			Pre-set national growth and inflation rates

Record Number	Elements	Variable Name	Description
	1-11	GROSN(11)	Pre-set national growth rates (subject to operator modification) for 11 cycles
	12-22	PERINF(11)	Pre-set percentages of growth due to inflation (subject to operator modification) for 11 cycles
	22-25		Unused
7			Parameters for determining expenditures on retail and service
	1-9	XX(9)	Percentages of salaries, wages and welfare spent on the nine retail and service categories
	10-18	YY(9)	Percentages of tourist expenditures spent on the nine retail and service categories
	19-25		Unused
8			Parameters used in the population-migration model
	1	XPPJ	Persons per job
	2	XPPDU	Persons per dwelling unit
	3	CIC	Capital investment constraint
	4	EXG	Population growth rate
	5	STDG	Standard deviation of growth rate
	6	EXM	Stability percentage
	7	STDM	Standard deviation of stability percentage
	8	OVPCT	Overcrowd percentage
	9-25		Unused
9			Parameters for determining expenditures on retail and service
	1-9	XXX(9)	Percentages of exogenous contribution to retail sales spent on the nine retail and service categories
	10-18	YYY(9)	Percentages of cell income spent on the nine retail and service categories
	19-25		Unused

Record Number	Elements	Variable Name	Description
10			Run-off percentages for coliform
	1-7	RATIO(7)	Percentage of coliform effluent reaching the lake from 1, 2, . . ., 7 cells away
	8-25		Unused
11			Run-off percentages for BOD
	1-7	RATIO(7)	Percentage of BOD effluent reaching the lake from 1, 2, . . ., 7 cells away
	8-25		Unused
12			Run-off percentages for total phosphorus
	1-7	RATIO(7)	percentage of total phosphorus effluents reaching the lake from 1, 2, . . ., 7 cells away
	8-25		Unused
13			Run-off percentages for total suspended solids
	1-7	RATIO(7)	Percentage of total suspended solids effluent reaching the lake from 1, 2, . . ., 7 cells away
	8-25		Unused
14			Run-off percentages for total dissolved solids
	1-7	RATIO(7)	Percentage of total dissolved solids effluent reaching the lake from 1, 2, . . ., 7 cells away
	8-25		Unused

The second file is the basic land use file (BLUF). It contains the descriptors of each of the 55 basic land uses considered in WALRUS III. These descriptors are of two kinds: parameters which remain constant (see Chapter III-D) throughout a run of WALRUS III and parameters which set the initial conditions for each of the basic land uses. The logical unit number or reference number for BLUF is "9".

BLUF is made up of 60 records. Each record has 40 4-byte words. Although many of the records are shorter than 40 words in length, errors are avoided when using FREAD and FWRITE if the full 40 word buffer is read and/or written.

The third file is the current land use file (CLUF). Information pertaining to the status of the land uses as it changes from cycle to cycle is stored in CLUF. The first ten records of CLUF are reserved for specific relevant pieces of information that must be updated and retained during each cycle. The balance of the file contains the current operating status of every land use in each cell. It is assumed that multiple occurrences of a basic land use type in a single cell are "merged" to form a single large example of that land use. Thus, a maximum of 4,620 (55 x 84) records may be used to describe the current status of the city (one record for the occurrence of each land use in each cell) although, in practice, considerably fewer records are used.

The relationship between BLUF and CLUF should be clear. BLUF holds both the parameters and initial conditions needed to describe a basic land use independent of geographical location. CLUF holds the current status of a basic land use as it is actually operating in a given cell. (The algorithms for updating the statuses of the land uses use the parameters in BLUF and the statuses preserved in CLUF in generating a new set of statuses for a "new" CLUF.) To illustrate this, all auto repair business (BLU 16) begin with the same initial sales as given in BLUF. As time passes, different auto repair businesses in different cells will sell different amounts (determined in the simulation) which are recorded in CLUF.

The fifth file is the run-off and water parameters file (ROWA). Many of the parameters required to implement Canale's model of Traverse Bay are stored in ROWA as well as the results of as many as ten seasons of "runs" of the model.

The final file contains alphanumeric names used in the computer print-out (REFRNC). Each record is 9 words in length allowing up to a 36 character title. The first 60 records are the names of the basic land use units. Records 61-224 are the names of the corresponding ACF records (see Table 12). The next 8 records are the names of the eight contaminants derived in the Canale model. The final three records are the units of the concentrations of those eight contaminants - either CELLS PER 100 MILLILITERS (COL), MILLIGRAMS PER LITER (BOD, DO, TSS and TDS) or MICROGRAMS PER LITER (TP, TDP and Chlorophyll _a_).

C. OPERATING CHARACTERISTICS

WALRUS III was designed to allow maximum operator control over parameter values, output options, and restore/restart procedures. The areas of particular interest are the restore/restart procedures. Briefly, the system operates with three different sets of files which can be classified as dynamic, previous cycle, and current cycle files. The files included are:

1. PARA - the parameters file which is a dynamic file, with values changing from cycle to cycle.
2. BLUF - the basic land use file which is dynamic, but with few changes from cycle to cycle
3. CLUF - the land use files, for which two files are specified in the design; one for previous cycle and one for current cycle.
4. ACF - the active cell files, which are also previous and current cycle files.

In actual operation, WALRUS III does not currently contain the necessary logic or file structuring to permit restarting the system from the previous cycle. Cycles must, therefore, be processed sequentially, and if restarting any cycle is required, provisions must be made for saving the above files at the conclusion of each cycle, and restoring the appropriate files before restarting the desired cycle.

Based on the restore requirement, it is obvious that the concept of previous cycle and current cycle files is basically defunct. The actual operation of the system, therefore, requires only one set of files, those from the conclusion of the previous cycle. These files then become the current files in the course of the cycle being run, and are used as input to the next cycle. Thus, the files requiring a back-up procedure are PARA, BLUF, CLUF, and ACF, with only one set of CLUF and ACF being preserved. In operation of the program, file requirements remain the same. It is therefore necessary to follow the Restart/End-of-Cycle Procedure. This procedure preserves the logic of the program as it currently exists, and fortunately, is consistent with the data manipulation procedures.

In the process of sequentially stepping through the model, however, the loss of the restart capability can create a problem if either a system failure or operator error is made. The first point of departure is where land uses may be added or subtracted (DO YOU WANT TO ADD OR SUBTRACT LAND USES?). If land uses are added or subtracted, followed by a shutdown of the system, these decisions have already been placed into the CLUF data set. Therefore, on restarting the cycle, one of two options may be taken. First, all files must be restored and then the land uses must be added or subtracted again. The second option is dependent upon not yet having reached the economic algorithm (ENTERING ECONOMIC ALGOR;...) but having concluded the process of adding and subtracting land uses. In this case, the current cycle can be restarted without restoring files, and any changes to the files need not be done again, and land uses added and subtracted <u>must not</u> be done again.

The point of no return is where the economic algorithm is entered. Once this has occurred, if there is any cause arising which terminates the cycle before completion, all files must be restored, and all changes, additions and subtractions must be re-entered.

Finally, if it is ever necessary to restart the entire cycling from cycle one, the function of the first cycle must be understood. The economic algorithms are used with a set of initial conditions. These initial conditions are not subject to operator control, and all operator-entered values are ignored. The procedure required, then, is to use the first cycle only as an initialization process, with the second cycle being the first cycle for operator-decision input.

While the conceptual framework is apparently adequate for restore/restart procedures, the logic in the program leaves the capability far from completion. As an area for future development, the restart capability and use of the current/previous files in the appropriate manner would greatly enhance the operational procedures of WALRUS III.

As an additional operational consideration, the procedure of changing static values in the Basic Land Use File (BLUF) must be reviewed. Changes in the static information in BLUF do not affect the current land use file (CLUF). Thus, if modification of removal rates of different water quality components at the sewage plant is desired, the modification of BLUF values will not result in a change for the existing records in CLUF. The change must, therefore, be made in the actual CLUF records, while any addition of the altered land use in the CLUF file will result in the new values from BLUF being used. The only method of altering values without going through the process of altering records in CLUF is to return to file creation.

OPERATING CHARACTERISTICS EXCERPT:

COSTS OF WALRUS III OPERATION

Due to the many options available in running WALRUS III, there is no clear-cut method of computing run costs. Each of the subsystems, retail and service, agriculture, wholesale, etc., provide for rather comprehensive diagnostics through no diagnostics at all, with run costs varying on the level of diagnostics. The one portion of the model with known costs is the water model, with a cost of approximately $8.00 under MTS (Michigan Terminal System) accounting structure. Normal run costs for the cycles run for Chapter VI ranged from $16.00 to $28.00 including file save procedures.

Perhaps the most costly aspect of WALRUS III is the permanent storage required for system operation. The WALRUS system requires a minimum (object program + 2 cycles) of 270 pages of MTS storage, on-line, for operation. When this storage is required over a long period of time, computing funds shrink rapidly. The calculated cost of disk storage is approximately $1/day.

In order to minimize operating costs, it would be advisable to review all diagnostic requirements before beginning a run to insure that a minimum is maintained. Further, if system inactivity is anticipated for extended periods, the file save and restoration procedures should be used, with disk space being freed when not in use.

CHAPTER V

INPUT DOCUMENTATION - ABSTRACT

This Internal Report - INPUT DOCUMENTATION - provides a discussion of the model input which produced the 1967-1978 output. The following table presents the cycle #/real-time correspondence for that time period:

Referenced Cycle #	Program Cycle #	Corresponding Year
Initial	1	June 1967
1	2	" 1968
5	6	" 1972
8	9	" 1975
11	12	" 1978

Our labeling of the first (program) cycle as "Initial" was deliberate. Briefly, certain data and values must be calculated (from the created data files) with the initial run of the program. The operator options are <u>not</u> in effect in the initial cycle. In all other cycles the following operations apply:

$$\text{OUTPUT}_t + \begin{matrix}\text{Land use changes}\\ \text{File changes}\\ \text{Operator/parameter changes}\end{matrix} + \begin{matrix}\text{Model}\\ \text{Operations}\end{matrix} = \text{OUTPUT}_{t+1}$$

Part I (1967-1975) of Internal Report #5 has the following four sections:

1. <u>Parameter Development</u> - an explanation of the values of the major parameters used in this time period (excerpted here).
2. <u>Compiled Statistics</u> - selected variables and values from the program output from this period (excerpted here in Chapter VI)
3. <u>Key to Diagnostics</u> - a listing of the sequence of the output and an explanation of the variable names (presented here in Chapter VI)
4. <u>1967-1975 Input History</u> - the actual input formats by cycle for this time period. (Cycle 7 is excerpted here).

With the omission of the "Key to Diagnostics" section, Part II (1976-1978) has a similar format for the three low-growth and high-growth scenarios.

A. PARAMETER DEVELOPMENT 1967-1975

The following discussion presents the basis for the major parameter input into the model for the nine cycles from 1967 to 1975.

A. Economic Parameters (Table I)

1. Growth Rates:

   a. Total National Growth: equals the yearly % growth in Total Gross National Product as reported in the Economic Report of the President. (TOTGRO)

   b. Uninflated growth: equals the real growth in G.N.P. and is determined by subtracting inflation from Total National Growth. (REALGRO)

2. PORN: is a determinant of Total Dollars for Wholesale. TDF Wholesale=TDF Retail x PORN. As reported in the 1967 census, TDF Wholesale was 48% of TDF retail, so PORN was 48% (.48) in the Initial Cycle. By the 1972 census, the wholesale industry had grown to 61% of TDF retail, so PORN was increased to 61% (.61). The increase was spread over the five years, with PORN growing by 2.6% (.026) each cycle. After 1972, TDR kept growing, but since we had stopped adding new wholesale units, we decided to decrease PORN in order to avoid unrealistic profit margins.

3. Exogenous Contribution (EXO) to TDF Retail: This operator input initially was $22.5 million, because the local planners felt that 1/3 of TDF Retail came from outside the community, either as Tourist dollars or Exogenous dollars. Coupled with the 13.3 million Tourist dollars, $22.5 million yielded 1/3 of the total. By 1975, our figure for the exogenous contribution had doubled, reaching $45.0 million. This increase reflects both inflation, which over the 9 years totaled 65% and a real increase. The real increase was justified because the local planners felt that more people were coming into the area than

TABLE I. Parameters for Walrus Runs

1967-1975

Cycle #

PAR.	I	1	2	3	4	5	6	7	8
TOTGRO	.059	.0965	.0745	.0526	.0746	.0916	.118	.079	.072
REALGRO	.027	.0465	.0269	-.004	.025	.0607	.062	-.023	.01
PORN	.48	.506	.532	.558	.584	.61	.61	.58	.54
EXO $ (millions)	22.5	24.5	27.4	29.8	31.7	35.0	38.5	40.5	45.0
AG WEATH BLU # 39	1.1	1.1	1.1	1.1	1.0	1.0	.9	1.0	1.0
AG WEATH BLU # 40	1.0*	1.1*	.9*	1.0*	1.0*	1.0*	.9*	1.1*	1.0*
AG WEATH BLU # 41	1.0	1.1	.9	.9	.9	1.0	1.1	1.0	1.0
TOUR WEATH	.04**	.02**	-.04**	.01**	-.02**	.01**	.00**	.04**	.03**
% TOTGRO to S & W	.8	.8	.8	.8	.8	.8	.8	.8	.8
POPGRO	2%	2%	2%	2%	2.5%	2.5%	2.2%	2.2%	2.2%
P/d.u.	3.55	3.55	3.55	3.55	3.55	3.5	3.25	3.15	3.1
P/job	2.95	2.95	2.95	2.95	2.95	2.95	2.65	2.78	2.84

* Randomly generated between .9 and 1.1

** Randomly generated between -.04 to .04

before. So the increases in the exogenous contributions were made to parallel the real increases in Total National Growth.

4. % of Total National Growth going to Salaries and Wages:
Each cycle, the average salary of each job type is increased by a percentage of the Total National Growth. Another internal report describes the rationale behind using a portion less than 100% of total growth. In short, it was believed that the increases would be closer to, although higher than, the inflation rate. We anticipated that there would be lag times which would vary from industry to industry. So, rather than using different percentages from year to year, we decided to use the average value. Over the nine years, Total growth = .85; real growth = .24; Inflation = .61; and inflation as a percentage of real growth = 72%. We chose .8 as the constant percentage of total national growth by which to increase salaries and wages.

5. Retail Demand Percentages (Table II). The % of the four portions of TDF (Total Dollars for Retail) spent on each of the 9 retail and service types changed from 1967 to 1972. Consequently, the values with which we began the initial cycle were later amended. Rather than space the changes over the five year period, we began using the 1972 distributions of retail dollars (for TSAW, TOUR, EXO, AND TINC) in 1968 so that the fluctuations in stock would have time to level off by 1972. So, the initial cycle has one set of values, while the next five years have another set. In cycle 6, the values were changed again because of the economic conditions. We felt that in times of such high inflation less would be saved. Therefore, we increased the total % spent from salaries and wages (TSAW). The percent spent on

clothing and autos was reduced, while food expenditures increased substantially. The percents were adjusted again in the next cycle, due to the economic recovery. The percentages for home furnishings, food, autos, and general merchandise all decreased, while savings increased. We simulated a big drop in the percent of profits re-invested, (TINC) due to the artificially high profits made, because of the many businesses reducing their inventory stock. In the final cycle, savings decreased slightly, as home furnishings increased to the previous level. Autos and general merchandise recaptured portions of their lost markets. We did not try to account for the "oil crisis" because of a number of reasons. First, as gas prices rose, the amount of gasoline used declined substantially. Second, auto sales also dropped sharply, leaving us no basis for determining the overall effects.

B. Tourism (Table III)

In the original Basic Land Use File, there are values for the costs of housing each of the five different tourists, and for the expenditures made by each. These values, unless changed by the operator, are held constant from cycle to cycle. Consequently, before each cycle, we entered the Basic Land Use File and manually increased each of the 10 values by the Total National Growth rate. For example, the initial cycle has each tourist of a Basic Land Use type 38 (resorts III) spent $17 in the local economy. Before cycle 1, we increased the value by 5.9% to $18.00.

C. Population-Migration Model

1. Population Growth: As the parameter sheets indicate, we used various population growth rates. The reason for the changes is that the initial rate which we used, 2%, while correct for the entire county, was too low for the study area. The planners

TABLE II

RETAIL DEMAND COMPOSITION 1967 - 1972 (percents as decimals)

PAR File
TSAW - Record 7, Elements 1-9 (XX)
TOUR - Record 7, Elements 10-18 (YY)
EXO - Record 9, Elements 1-9 (XXX)
TINC - Record 9, Elements 10-18 (YYY)

				Cycle #		
BLU		i	* 1-5	6	7	8
9	TSAW	.0597	.0465	.044	→	→
	TOUR	.15	.10	→	→	→
	EXO	.0232	.02	.02	→	→
	TINC	.0517	.035	.035	.025	.035
10	TSAW	.015	.025	→	→	→
	TOUR	.25	.25	.23	→	→
	EXO	.0225	.04	→	→	→
	TINC	.0502	.054	.054	.038	.054
11	TSAW	.1493	.15	.15	.145	.15
	TOUR	-	-	-	-	-
	EXO	.1982	.20	.18	→	→
	TINC	.2125	.192	.192	.137	.192
12	TSAW	.1194	.15	.182	.17	.17
	TOUR	.10	.15	.188	→	→
	EXO	.1786	.20	.244	→	→
	TINC	.153	.136	.136	.097	.136
13	TSAW	.0299	.04	→	→	→
	TOUR	-	-	-	-	-
	EXO	.0821	.11	.1075	→	→
	TINC	-	.054	.054	.039	.054
14	TSAW	.0048	.006	→	→	→
	TOUR	-	-	-	-	-
	EXO	.0125	.01	→	→	→
	TINC	-	-	-	-	-
15	TSAW	.0517	.04	→	→	→
	TOUR	.20	.20	.19	→	→
	EXO	.0056	.02	→	→	→
	TINC	.085	.064	.064	.046	.064
16	TSAW	.22	.21	.21	.20	.2025
	TOUR	.15	→	→	→	→
	EXO	.3042	.20	.1925	→	→
	TINC	.2521	.13	.13	.093	.13
17	TSAW	.097	.0825	.08	.07	.0725
	TOUR	.15	.15	.142	→	→
	EXO	.1731	.20	.186	→	→
	TINC	.0425	.035	.035	.025	.035
TOTALS	TSAW	.7468	.75	.777	.74	.75
	TOUR	1.0	1.0	1.0	1.0	1.0
	EXO	1.0	1.0	1.0	1.0	1.0
	TINC	.85	.70	.70	.50	.70

* all entries listed in a "quickie" sub-program, as cycle 1 was run many times

TABLE III TOURIST BLUF CHANGES - 1967 - 1975

(figures in dollars)

Element 28 = cost of housing each tourist (TOUFEE)
" 29 = tourist expenditure in community (TOUR $)

Cycle #

BLU	ELEMENT	I	1	2	3	4	5	6	7	8
34	28	.57	.60	.66	.71	.75	.80	.88	.98	1.06
	29	2.00	2.12	2.32	2.50	2.63	2.82	3.08	3.44	3.71
35	28	1.61	1.70	1.87	2.01	2.11	2.27	2.48	2.77	2.99
	29	8.00	8.47	9.29	9.98	10.51	11.29	12.32	13.79	14.88
36	28	2.52	2.67	2.93	3.14	3.31	3.56	3.88	4.34	4.68
	29	13.00	13.77	15.10	16.22	17.07	18.35	20.03	22.39	24.16
37	28	2.93	3.10	3.40	3.66	3.85	4.14	4.51	5.05	5.45
	29	15.00	15.89	17.42	18.72	19.70	21.17	23.11	25.84	27.88
38	28	3.39	3.59	3.94	4.23	4.45	4.78	5.22	5.84	6.30
	29	17.00	18.00	19.74	21.21	22.33	23.99	26.19	29.28	31.59

explained that 2.2% would be a better figure, so we ran two cycles at 2.5% to make up for being too low originally. The final three cycles were run at the proper rate of 2.2%. (POPGRO)

2. Occupants/dwelling unit. Once again, we began with one figure that was later corrected. We started by using the county figure of 3.55 people per dwelling unit. After cycle 5 that figure was gradually lowered to the 3.1 figure suggested for the study area.

3. People per worker: We began by using 2.95 people/worker, or 1.2 workers/dwelling unit. We lowered the figure to 2.65, on the planner's suggestion, but generated too much unemployment - 6.4%. Since we knew that there were actually more jobs in the study area than workers, we lowered the unemployment rate to 3.8% by raising the people per worker to 2.78. In cycle 8 we made a further increase to 2.84, as unemployment dropped to 1.24%.

Water Model

Sewer Plant Efficiency: A clipping from the Traverse City Record Eagle, in 1973 told of an increase in the plant efficiency in dealing with phosphorous, with the actual addition of secondary treatment. So, in cycle 6 we made the change in the current Land Use File, raising the phosphorus pollution reduction from 25% to 85%.

Miscellaneous

1. Labor force: As explained in the "Suggested Improvements" section of the Model Descriptions Report #3, the algorithm in RASIG which adjusts the labor force of an establishment as a function of changing stock levels is currently upwardly sensitive. Small increases in stock over a period of cycles will add laborers each cycle while only a large decrease in stock will subtract laborers. While this problem affects all establishments, some are affected more than others. As reflected

in the input forms, we manually went into the CLUF (both current and last cycles) and reduced the labor force for selected establishments for the following BLU types.

Cycle #	BLU #
6	14

2. Land Use Additions: Land use additions may be entered directly from the terminal. However given the expectation that we might make multiple runs of the same cycle, files were set up containing the land use additions for each of the 1 through 8 cycles (see explanatory notes on cycle 2 input data). The entry of those files is presented below:

Cycle #	Corresponding Land Use File
1	F1967
2	F1968
3	F1969
4	F1970
5	F1971
6	F1972
7	F1973
8	F1974

A partial listing of those files follows in Table IV.

1 ********************************
2 ***
3 ** 1967
4 ***
5 ********************************

[illegible]	1	2	3	4	5	6	7
1	31	-32	1	1	0	0	0
2	1	1	15	15	0	0	8
3	1	-2	3	3	0	0	8
4	1	-3	14	14	0	0	0
5	1	4	6	6	0	0	8
6	1	-35	2	2	0	0	0
7	2	-2	16	16	0	0	8
[illegible]	2	-3	11	11	0	0	0
10	2	6	2	2	0	0	3
11	2	-34	4	4	0	0	0
11.5	10	5	2	2	0	0	8
11.7	10	3	2	2	0	0	8
11.8	2	-35	2	2	0	0	8
12	11	1	1	1	0	0	8
13	11	-2	1	1	0	0	0
14	12	1	1	1	0	0	8
15	12	-2	1	1	0	0	0
16	13	-2	1	1	0	0	0
17	15	15	1	1	0	0	8
18	20	1	1	1	0	0	8
19	20	-2	1	1	0	0	0
20	21	1	1	1	0	0	8
21	21	-2	1	1	0	0	0
22	21	16	1	1	0	0	8
23	22	2	4	4	0	0	8
24	22	-3	5	5	0	0	0
25	22	4	1	1	0	0	8
27	22	-23	1	1	0	0	0
28	22	42	2	2	0	0	8
31	30	1	1	1	0	0	8
32	30	-2	1	1	0	0	0
33	30	16	1	1	0	0	8
34	30	18	1	1	0	0	8
35	30	-44	1	1	0	0	0
36	31	2	1	1	0	0	8
37	31	-3	2	2	0	0	0
38	31	4	1	1	0	0	8
39	31	9	1	1	0	0	8
40	31	-15	1	1	0	0	0
41	31	-3	3	3	0	0	8
42	35	1	1	1	0	0	8
43	35	-2	1	1	0	0	0
44	36	2	6	6	0	0	8
45	36	-3	10	10	0	0	0
46	36	6	3	3	0	0	8
47	35	15	1	1	0	0	8
48	37	2	12	12	0	0	8
49	37	-3	8	8	0	0	0
50	37	-4	10	10	0	0	0
51	37	5	2	2	0	0	8
52	37	[illegible]	4	4	0	0	8
53	37	[illegible]	1	1	0	0	8
54	37	13	1	1	0	0	8
55	37	16	1	1	0	0	0

KEY

1. Cell number
2. NTYP - Basic land use type added or subtracted (-)
3. NNUMB - # in existence
4. NNUM - # in operation
5. NSEW - # sewered
6. NSOW - # of the sewer plant
7. NWS - # of the water source

B. 1967-1975 INPUT HISTORY

The following is an annotated reproduction of the model input for reference Cycle #7 (program cycle 8) representing the input prior to real-time June 1974 output. The corresponding output for this cycle is reproduced in Chapter VI.

```
#$CON *PRINT* HOLD ROUTE=NUBS COPIES=3
#*PRINT* ASSIGNED RECEIPT NUMBER 602207.
#$SET ECHO=OFF
#EXECUTION BEGINS

HELLO, THIS IS THE WALRUS SPEAKING

RESPOND TO ALL SIMPLE QUESTIONS WITH Y FOR YES - N FOR NO

THE CURRENT CYCLE NUMBER IS 7
DO YOU WANT TO PRINT OUT ANY FILES?
```

This is the "Current" (i.e. last cycle) data base. The program requests any file or parameter changes to this data base prior to model operation.

```
DO YOU WANT TO GET A LISTING OF THE QUANTITY OF EACH
TYPE OF BASIC LAND USE IN A GIVEN CELL?

DO YOU WANT TO CHANGE ANY FILES?
Y
TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,ROWA
TYPE NONE TO END LOOP
PAR
TYPE IN RECORD NO., ELEMENT AND TYPE (1=INT, 2=REAL)
TYPE 0 TO QUIT
RRR EE T
007 03 2
OLD ELEMENT WAS        0.1500 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.145
RRR EE T
007 04 2
OLD ELEMENT WAS        0.1820 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.17
RRR EE T
007 08 2
OLD ELEMENT WAS        0.2100 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.2
RRR EE T
007 09 2
OLD ELEMENT WAS        0.0800 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.07
RRR EE T
009 10 2
OLD ELEMENT WAS        0.0350 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.025
RRR EE T
009 11 2
OLD ELEMENT WAS        0.0540 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.038
RRR EE T
009 12 2
OLD ELEMENT WAS        0.1920 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.137
```

These entries are changes in retail demand composition in the parameter file.

```
009 13 2
OLD ELEMENT WAS       0.1360 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.097
RRR EE T
009 14 2
OLD ELEMENT WAS       0.0540 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.039
RRR EE T
009 16 2
OLD ELEMENT WAS       0.0640 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.046
RRR EE T
009 17 2
OLD ELEMENT WAS       0.1300 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.093
RRR EE T
009 18 2
OLD ELEMENT WAS       0.0350 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.025
RRR EE T
008 01 1
OLD ELEMENT WAS1093297766 TYPE IN REPLACEMENT
IIIIIIIIII

RRR EE T
008 01 1
OLD ELEMENT WAS            0 TYPE IN REPLACEMENT
IIIIIIIIII

RRR EE T
008 022
*** CHANGE ERROR ENCOUNTERED - IRET,IREC OR NO, IEL       4       8       2
MAKE LAST CHANGE AGAIN
TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,ROWA
TYPE NONE TO END LOOP
PAR
TYPE IN RECORD NO., ELEMENT AND TYPE (1=INT, 2=REAL)
TYPE 0 TO QUIT
RRR EE T
008 02 2
OLD ELEMENT WAS       3.2500 TYPE IN REPLACEMENT
RRRRRRRRRRRR
3.15
RRR EE T
008 01 2
OLD ELEMENT WAS       0.0     TYPE IN REPLACEMENT
RRRRRRRRRRRR
2.78
RRR EE T

TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,ROWA
TYPE NONE TO END LOOP
CLUF

FOR THIS CYCLE'S FILE, TYPE  CURR'
FOR LAST CYCLE'S TYPE 'LAST'
FOR INITIAL DATA, TYPE 'INIT'
CURR
```

Entries in the Parameters File for persons/job and persons/dwelling unit.

```
TYPE CELL, LAND USE, ELEMENT NO. AND TYPE (1=INT, 2=REAL)
TYPE 0 TO QUIT, OR TYPE 99 FOR FIRST TEN RECORDS
CC LU EE T
99
TYPE IN RECORD NO., ELEMENT AND TYPE (1=INT, 2=REAL)
TYPE 0 TO QUIT
RRR EE T
001 13 2
OLD ELEMENT WAS        0.6100 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.58
CC LU EE T
```

Entry to the Current CLUFF File to change PORN (% of Retail dollars to wholesale).

```
TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,ROWA
TYPE NONE TO END LOOP
CLUF

FOR THIS CYCLE'S FILE, TYPE 'CURR'
FOR LAST CYCLE'S TYPE 'LAST'
FOR INITIAL DATA, TYPE 'INIT'
LAST
TYPE CELL, LAND USE, ELEMENT NO. AND TYPE (1=INT, 2=REAL)
TYPE 0 TO QUIT, OR TYPE 99 FOR FIRST TEN RECORDS
CC LU EE T
99
TYPE IN RECORD NO., ELEMENT AND TYPE (1=INT, 2=REAL)
TYPE 0 TO QUIT
RRR EE T
001 13 2
OLD ELEMENT WAS        0.6100 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.58
CC LU EE T
```

Some change as above for Cost Cycle's PORN value.

```
TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,ROWA
TYPE NONE TO END LOOP
BLUF
TYPE IN RECORD NO., ELEMENT AND TYPE (1=INT, 2=REAL)
TYPE 0 TO QUIT
RRR EE T
034 28 2
OLD ELEMENT WAS        0.8800 TYPE IN REPLACEMENT
RRRRRRRRRRRR
.98
RRR EE T
034 2922
OLD ELEMENT WAS        3.0800 TYPE IN REPLACEMENT
RRRRRRRRRRRR
3.44
RRR EE T
035 28 2
OLD ELEMENT WAS        2.4800 TYPE IN REPLACEMENT
RRRRRRRRRRRR
2.77
RRR EE T
035 29 2
OLD ELEMENT WAS       12.3200 TYPE IN REPLACEMENT
RRRRRRRRRRRR
13.79
```

```
036 28 2
OLD ELEMENT WAS        3.8800 TYPE IN REPLACEMENT
RRRRRRRRRRRR
4.34
RRR EE T
037 29 2
OLD ELEMENT WAS       23.1100 TYPE IN REPLACEMENT
RRRRRRRRRRRR
25.34
RRR EE T
036 29 2
OLD ELEMENT WAS       20.0300 TYPE IN REPLACEMENT
RRRRRRRRRRRR
22.39
RRR EE T
037 28 2
OLD ELEMENT WAS        4.5100 TYPE IN REPLACEMENT
RRRRRRRRRRRR
5.05
RRR EE T
038 28 2
OLD ELEMENT WAS        5.2200 TYPE IN REPLACEMENT
RRRRRRRRRRRR
5.84
RRR EE T
038 29 2
OLD ELEMENT WAS        0.0    TYPE IN REPLACEMENT
RRRRRRRRRRRR
29.28
RRR EE T

TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,ROWA
TYPE NONE TO END LOOP

UNRECOGNIZABLE ENTRY - TRY AGAIN
NONE
DO YOU WANT TO PRINT OUT ANY FILES?
Y
TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,ROWA
TYPE NONE TO END LOOP
BLUF
PRINT WILL BE ON TERMINAL.  DO YOU WANT TO CHANGE?
Y
TYPE FIRST BLU NUMBER AND LAST BLU NUMBER
ALL BLU'S BETWEEN THE TWO WILL BE PRINTED
TYPE 00 TO END LOOP
FF LL
09 55

MORE BLUF?
FF LL

DO YOU WANT TO PRINT OUT ANY FILES?


DO YOU WANT TO GET A LISTING OF THE QUANTITY OF EACH
TYPE OF BASIC LAND USE IN A GIVEN CELL?

DO YOU WANT TO CHANGE ANY FILES?
```

Entries in BLUF File to change tourist expenditures on rooms and "other" retail.


```
DO YOU WANT TO EXIT FROM THE PROGRAM?
```

```
DO YOU WANT TO RESTART THE CURRENT CYCLE?

EXOGENOUS RETAIL CONTRIBUTION WILL BE   38500000.
DO YOU WANT TO CHANGE IT?
Y
TYPE IN NEW FIGURE
$$$$$$$$$$$$
40500000.0
NAT'L GROWTH WILL BE  0.020
DO YOU WANT TO CHANGE IT?
Y
TYPE NEW RATE
RRRRR
.079
PERCENT INFLATION WILL BE  0.015
GIVING UNINF. GROWTH=  0.064
DO YOU WANT TO CHANGE IT?
Y
TYPE NEW RATE
RRRRR
-.023
CAPITAL INVESTMENT CONSTRAINT WILL BE   5.000
DO YOU WANT TO CHANGE IT?

 POP. GROWTH WILL BE   2.000 WITH ST. DEV.   1.000
STAB. CONST. WILL BE   1.000 WITH ST. DEV.   0.500
DO YOU WANT TO CHANGE IT?
Y
TYPE NEW FIGURES
RRRRRRRR RRRRRRRR RRRRRRRR RRRRRRRR
2.2       1.0       1.0        0.5
STARTING CYCLE 8
DO YOU WANT TO ADD OR SUBTRACT LAND USES?
Y
INPUT WILL BE FROM FILE - DO YOU WANT TO CHANGE?

OUTPUT WILL BE ON PRINTER - DO YOU WANT TO CHANGE?

***ERROR*** UNIT WAS REFERENCED BUT WAS NOT ASSIGNED OR DEFAULTED. CONDITI
OCCURRED DURING A FORMATTED READ ON FORTRAN UNIT 11.
11 WAS CALLED BUT NOT SPECIFIED. ENTER NAME OR "CANCEL".
F1973
LEB=255
DO YOU WANT TO PRINT OUT ANY FILES?
*OK


DO YOU WANT TO GET A LISTING OF THE QUANTITY OF EACH
TYPE OF BASIC LAND USE IN A GIVEN CELL?

DO YOU WANT TO RESTART UPDATE PROCEDURES?

TYPE 2 UNDER THE APPROPRIATE ALGORITHM CODE FOR DIAGNOSTICS
 NAS SWW IIG RIG TIG RAS WIG POP EXJ RIG
   2   2   2   2   2   2   2   2
ENTERING ECONOMIC ALGOR.: PLEASE USE REAL FORMAT F WHEN ANS. QUESTIONS
SWW ADJUST BY (1.0*TOTNGR)
DO YOU WANT TO CHANGE IT?
Y
TYPE NEW PERCENT
XXXXX
.8
```

```
ENTERING RACIG
WHICH VALUE FOR ALFA IN THE SALES POT. DETERMIN.?
SUGGESTED ONE: 1.00
%%%%%
1.0
RACIG CPU=CPU*(1.+PC*NTGR); WHAT PC?
SUGGESTED ONE: 0.1
%%%%%
1.0
WIG CPU=CPU*(1+PR*NTGR); WHAT PR?
SUGGESTED ONE: 0.8
%%%%%
1.0
10 STEPS NEEDED TO ALLOCATE POPULATION
DO YOU WANT TO RUN THROUGH THE WATER MODEL?
Y
DO YOU WANT PRINTER DIAGNOSTICS?
Y
SUMMARY INFORMATION IS ABOUT TO BE PRINTED
PRINT WILL BE ON PRINTER .  DO YOU WANT TO CHANGE?

DO YOU WANT TO PRINT OUT ANY FILES?

DO YOU WANT TO GET A LISTING OF THE QUANTITY OF EACH
TYPE OF BASIC LAND USE IN A GIVEN CELL?

Y
TYPE IN FIRST CELL AND LAST CELL
ALL CELLS BETWEEN THE TWO WILL BE PRINTED
TYPE 00 TO END LOOP
FF LL
01 34
FOR SHORT FORM TYPE 0 - FOR LONG FORM, TYPE 1
0
PRINT WILL BE ON PRINTER .  DO YOU WANT TO CHANGE?


FOR THIS CYCLE'S FILE, TYPE 'CURR'
FOR LAST CYCLE'S TYPE 'LAST'
FOR INITIAL DATA, TYPE 'INIT'
CURR
TYPE IN FIRST CELL AND LAST CELL
ALL CELLS BETWEEN THE TWO WILL BE PRINTED
TYPE 00 TO END LOOP
FF LL

DO YOU WANT TO CHANGE ANY FILES?
Y
TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,POWA
TYPE NONE TO END LOOP
NONE
DO YOU WANT TO PRINT OUT ANY FILES?
Y
TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,POWA
TYPE NONE TO END LOOP
CLUF

FOR THIS CYCLE'S FILE, TYPE 'CURR'
FOR LAST CYCLE'S TYPE 'LAST'
FOR INITIAL DATA, TYPE 'INIT'
```

```
PRINT WILL BE ON PRINTER .  DO YOU WANT TO CHANGE?
Y
TYPE CELL NUMBER AND BASIC LAND USE
TYPE 00 TO END LOOP
TYPE 98 FOR ANY OF FIRST TEN RECORDS
TYPE 99 FOR ENTIRE FILE
CC LU
98
TYPE IN APPROPRIATE RECORD NUMBER
1 = MISCELLANEOUS FIGURES FOR RETAIL AND WHOLESALE ALGORITHMS
2 = CLUF RECORD COUNTER
3 = TREATMENT PLANT INFORMATION
8 = SALARIES AND WAGES
RN
01

TOTAL S+W 0.1400E+09   WHOLESALE PRICE  936.65
DOLLARS IN RETAIL 0.1805E+09   PERCENT OF RETAIL IN LOCAL WHOLESALE 0.580
RETAIL SALES PRICES   34.14    9.29   21.78    1.30   27.26   21.45    2.34
+37.21   13.01
TOURIST EXPENDITURE IN LOCAL ECONOMY 0.2025E+08  TOURIST ROOM FEES 0.9348E+
+TOTAL WELFARE PAYMENTS 0.1456E+07

TYPE ANOTHER RECORD NUMBER OR ZERO TO MOVE ON
RN


FOR THIS CYCLE'S FILE, TYPE 'CURR'
FOR LAST CYCLE'S TYPE 'LAST'
FOR INITIAL DATA, TYPE 'INIT'

UNRECOGNIZABLE ENTRY - CURRENT CYCLE PRINTED BY DEFAULT
PRINT WILL BE ON TERMINAL.  DO YOU WANT TO CHANGE?
Y
TYPE CELL NUMBER AND BASIC LAND USE
TYPE 00 TO END LOOP
TYPE 98 FOR ANY OF FIRST TEN RECORDS
TYPE 99 FOR ENTIRE FILE
CC LU

DO YOU WANT TO PRINT OUT ANY FILES?
Y
TYPE IN FILE NAME - BLUF,CLUF,ACF,PAR,FOWA
TYPE NONE TO END LOOP
ACF

FOR THIS CYCLE'S FILE, TYPE 'CURR'
FOR LAST CYCLE'S TYPE 'LAST'
FOR INITIAL DATA, TYPE 'INIT'
CURR
PRINT WILL BE ON PRINTER .  DO YOU WANT TO CHANGE?

TYPE FIRST RECORD NUMBER AND LAST RECORD NUMBER
TYPE 00 TO END LOOP
FFF LLL
061 067
082 082

MORE ACF?
FFF LLL
```



```
MORE ACF?
FFF LLL
```

```
MORE ACF?
FFF LLL

DO YOU WANT TO PRINT OUT ANY FILES?


DO YOU WANT TO GET A LISTING OF THE QUANTITY OF EACH
TYPE OF BASIC LAND USE IN A GIVEN CELL?

DO YOU WANT TO CHANGE ANY FILES?


DO YOU WANT TO EXIT FROM THE PROGRAM?
Y
#EXECUTION TERMINATED
#$COM IF END OF CYCLE 1,3,5,7,.....
#$COM COPY NCLUF TO LCLUF AND
#$COM NACF TO LACF, OTHERWISE
#$COM COPY OPPOSITE DIRECTION (L TO N)
#$COPY -PRT *PRINT*
#$COM *PRINT* RELEASE
#*PRINT* 602207 RELEASED, 71 PAGES PER COPY
#$COPY NCL LCL/2
>"NCL" DOES NOT EXIST.
>ENTER REPLACEMENT OR "CANCEL".
?LACF
>"LCL/2" DOES NOT EXIST.
>ENTER REPLACEMENT OR "CANCEL".
?NACF
#$COPY NAC LAC/2
>"NAC" DOES NOT EXIST.
>ENTER REPLACEMENT OR "CANCEL".
?LCLUF
>"LAC/2" DOES NOT EXIST.
>ENTER REPLACEMENT OR "CANCEL".
?NCLUF
#$RUN SBVA:ERIC.O+OLIBRARY 1=NCLUF
#EXECUTION BEGINS
#EXECUTION TERMINATED
#$RUN SBVA:ERIC.O+OLIBRARY 1=LCLUF
#EXECUTION BEGINS
#EXECUTION TERMINATED
#$SET ECHO=OFF
#*PRINT* ASSIGNED RECEIPT NUMBER 602254
#EXECUTION BEGINS
#EXECUTION TERMINATED
#EXECUTION BEGINS
=FILE "PARA(21)" ... HAS BEEN SAVED
=FILE "NACF(21)" ... HAS BEEN SAVED
=FILE "NCLUF(21)" ... HAS BEEN SAVED
=FILE "BLUF(21)" ... HAS BEEN SAVED
=FILE "ROWA(21)" ... HAS BEEN SAVED
#EXECUTION TERMINATED
#SIG $
#*PRINT* 602254 RELEASED, 4 PAGES
#T905 RELEASED.
```

These procedures "save" various files allowing the WALRUS III user to "restart" from any cycle.

CHAPTER VI

OUTPUT DOCUMENTATION - ABSTRACT

The following is the sequence of the output provided for each cycle in Internal Report #6:

BLUF - except for the initial cycle, selected characteristics of the land uses represent the average of all land uses of a particular type (for the characteristic) from the last cycle.

Land Use Additions and Subtractions - land use changes for the current cycle

NASE - national and state economic parameters for the current cycle

SWW - the salaries and wage levels for each of the BLU employees

IIG - Industrial Income Generator diagnostics

AIG - Agricultural Income Generator diagnostics

TIG - Tourist Income Generator diagnostics

RASIG - Retail and Service Income Generator diagnostics

WIG - Wholesale Income Generator diagnostics

PUB - Population migration model diagnostics

WATMOD - water model loads by cell and concentrations by segment for summer and winter seasons (ONLY CERTAIN CYCLES)

SUMMARY INFORMATION - a variety of aggregate information about the study area. NOTE: if the water model has not been run for the current cycle, the values in the "Quality of Water in Selected Segments" table are garbage.

SELECTED VARIABLES - selected variables presented by cell

ACF/CLUF - a listing of the quantity of BLU's in a particular cell.

The format that follows presents a key to the variable names on the various diagnostics followed by the excerpted diagnostics for each of the Income Generators. For each of the Income Generator diagnostics the output presents (for a particular establishment type in a particular cell location) the status of the variables for the last cycle and underneath for the current cycle. Other excerpted output has been annotated where appropriate.

A table comparing the 1972 simulation output with census data is presented in the computer output section.

```
CYCLE  8 - ADDITIONS AND SUBTRACTIONS    JAN 21, 1976
CELL TYPE  NUMB  OPER  SWRD SS WS OP
   4    3     2     2     0  0  8  0
          2 UNITS OF BLU      3 HAVE BEEN CREATED IN CELL  4
  52  -33     1     1     0  0  8  0
          1 UNITS OF BLU 33 HAVE BEEN REMOVED FROM CELL 52
      THERE ARE NOW      0 UNITS
   5    2     2     2     0  0  8  0
          2 UNITS OF BLU      2 HAVE BEEN CREATED IN CELL  5
   7    3     2     2     0  0  8  0
          2 UNITS OF BLU      3 HAVE BEEN ADDED IN CELL  7
      THERE ARE NOW      3 UNITS
  11    2     3     3     0  0  8  0
          3 UNITS OF BLU      2 HAVE BEEN ADDED IN CELL 11
      THERE ARE NOW      6 UNITS
  12    2     1     1     0  0  8  0
          1 UNITS OF BLU      2 HAVE BEEN ADDED IN CELL 12
      THERE ARE NOW      5 UNITS
  13    3     4     4     0  0  8  0
          4 UNITS OF BLU      3 HAVE BEEN CREATED IN CELL 13
  13    4     3     3     0  0  8  0
          3 UNITS OF BLU      4 HAVE BEEN CREATED IN CELL 13
  14    4     3     3     0  0  8  0
          3 UNITS OF BLU      4 HAVE BEEN CREATED IN CELL 14
  15    4     1     1     0  0  8  0
          1 UNITS OF BLU      4 HAVE BEEN CREATED IN CELL 15
  18    2     2     2     0  0  8  0
          2 UNITS OF BLU      2 HAVE BEEN ADDED IN CELL 18
      THERE ARE NOW      4 UNITS
  28    3     1     1     0  0  8  0
          1 UNITS OF BLU      3 HAVE BEEN CREATED IN CELL 28
  35    4     1     1     0  0  8  0
          1 UNITS OF BLU      4 HAVE BEEN ADDED IN CELL 35
      THERE ARE NOW      3 UNITS
  36    6     2     2     0  0  8  0
          2 UNITS OF BLU      6 HAVE BEEN ADDED IN CELL 36
      THERE ARE NOW      6 UNITS
  37    6     1     1     0  0  8  0
          1 UNITS OF BLU      6 HAVE BEEN ADDED IN CELL 37
      THERE ARE NOW      8 UNITS
  40    2     3     3     0  0  8  0
          3 UNITS OF BLU      2 HAVE BEEN CREATED IN CELL 40
  60    2     1     1     0  0  8  0
          1 UNITS OF BLU      2 HAVE BEEN ADDED IN CELL 60
      THERE ARE NOW      3 UNITS
  67    3     3     3     0  0  8  0
          3 UNITS OF BLU      3 HAVE BEEN ADDED IN CELL 67
      THERE ARE NOW      6 UNITS
  68    2     1     1     0  0  8  0
          1 UNITS OF BLU      2 HAVE BEEN CREATED IN CELL 68
  70    2     1     1     0  0  8  0
          1 UNITS OF BLU      2 HAVE BEEN ADDED IN CELL 70
      THERE ARE NOW     11 UNITS
  76    4     1     1     0  0  8  0
          1 UNITS OF BLU      4 HAVE BEEN ADDED IN CELL 76
      THERE ARE NOW      3 UNITS
  80    3     3     3     0  0  8  0
          3 UNITS OF BLU      3 HAVE BEEN ADDED IN CELL 80
      THERE ARE NOW      6 UNITS
```

VARIABLE KEY

CELL = Cell reference number
TYPE = Basic Land Use (BLU) reference number
NUMB = Number of BLUs to be added or removed
OPER = Number of NUMB operating
SWRD = Number of OPER sewered
SS = Reference number of sewer system
WS = Water source
OP = Operating period (a Ø is default to operating period of the BLU type listed in the Basic Land Use file)

Variable Explanation - IIG (Industrial Income Generator)

CE	= Cell reference number
TY	= Type of establishment
IE	= Number of establishments in the cell
OP	= Number of establishments in the cell operating
SW	= Number of establishments sewered
SS	= Number of the sewer system
WS	= Water source
IOP	= Operating period in days
S	= Season of operation (1= summer, 2= winter, 3= both)
LF	= Labor force
PRODUCT	= Units produced
SALES	= Units sold
IC	= Water intake control system number
OC	= Water outflow control system number
PRICE	= Price per unit
GROSS	= Gross revenues
NET	= Net revenues
COSTS	= Water cost
EC/PIGR	= Estimated change in National economy/potential industry growth rate
PCI/FAC	= % change in sales price/used to calculate potential units sold
COPROD	= Cost of production

NAT'L GRO UNINF GRO STATE GRO NAT UNEMP CASE
-0.079 -0.023 0.099 0.043 4

*** SAW ***

(See Abstract)

SALARIES AND WAGES

```
   0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0  7781.46 8048.38
 7884.17 7830.22 8132.56 7678.20 3099.34 5351.03 8000.0812974.0912093.3012587.97
32548.3312828.8012591.4612465.7613584.3713398.4613583.5513634.5413743.9613511.74
13727.0713121.4814013.02 7701.27 6778.8612727.8013121.6613170.36 1578.53  854.95
 4816.2113815.7216865.2915978.1212843.5812907.55      0.0 13231.1812229.9110622.20
 8770.14     0.0      0.0      0.0      0.0
```

(See Abstract)

*** IIG ***

CE	TY	IE	CP	SW	SS	WS	IOP	S	LF	PRODUCT	SALES	IC	CC	PRICE	GROSS	NET	COSTS	EC/PIGR	PCI/FAC	COPROD
CE	TY	IE	CP	SW	SS	WS	IOP	S	LF	PRODUCT	SALES	IC	CC	PRICE	GROSS	NET	COSTS	EC/PIGR	PCI/FAC	COPROD
21	20	1	1	0	0	8	260	3	17	2055	2055	0	0	187.07	384426.	23089.	49.	0.131	0.029	420353.
	20	1	1	0	0	8	260	3	19	2324	2090	0	0	192.43	402184.	-18169.	0.	0.049	0.017	
32	20	1	1	1	1	1	260	3	17	2055	2055	0	0	187.07	384420.	23089.	43.	0.131	0.029	420347.
	20	1	1	1	1	1	260	3	19	2324	2090	0	0	192.43	402178.	-18169.	0.	0.049	0.017	
33	20	9	9	9	1	1	260	3	159	20952	20952	***	0	178.45	3733910.	224562.	277.	0.131	0.035	3677474.
	20	9	9	9	1	1	260	3	161	21177	21177	***	0	184.75	3912460.	234986.	0.	0.049	0.015	
39	20	2	2	2	1	1	260	3	33	4143	4143	***	0	183.19	758975.	45585.	73.	0.131	0.030	831055.
	20	2	2	2	1	1	260	3	37	4686	4686	***	0	188.68	884158.	53104.	0.	0.049	0.017	
42	20	1	1	0	0	8	260	3	17	2055	2055	0	0	187.07	384426.	23089.	49.	0.131	0.029	420353.
	20	1	1	0	0	8	260	3	19	2324	2090	0	0	192.43	402184.	-18169.	0.	0.049	0.017	
45	20	1	1	1	1	1	260	3	17	2055	2055	***	***	187.07	384420.	23089.	43.	0.131	0.029	420347.
	20	1	1	1	1	1	260	3	19	2324	2090	***	***	192.43	402178.	-18169.	0.	0.049	0.017	

THE AVERAGE NET INCOME FOR 15 ESTABLISHMENTS OF BLL 20 IS 14360.89

CE	TY	IE	CP	SW	SS	WS	IOP	S	LF	PRODUCT	SALES	IC	CC	PRICE	GROSS	NET	COSTS	EC/PIGR	PCI/FAC	COPROD
44	21	5	5	5	1	1	260	3	76	2605	2605	0	0	2322.51	6050135.	451266.	211.	0.186	0.026	5746258.
	21	5	5	5	1	1	260	3	76	2605	2605	0	0	2383.65	6209404.	463146.	0.	0.058	0.022	
53	21	1	1	1	1	1	260	3	17	521	521	0	0	2436.81	1269577.	94694.	133.	0.186	0.028	3623520.
	21	3	3	1	1	1	260	3	51	1563	1563	0	0	2505.17	3915573.	292053.	0.	0.058	0.022	

THE AVERAGE NET INCOME FOR 8 ESTABLISHMENTS OF BLL 21 IS 94399.88

CE	TY	IE	CP	SW	SS	WS	IOP	S	LF	PRODUCT	SALES	IC	CC	PRICE	GROSS	NET	COSTS	EC/PIGR	PCI/FAC	COPROD
30	22	1	1	0	0	8	260	3	25	44844	44844	0	0	50.99	2286546.	68964.	129.	0.131	0.009	2237032.
	22	1	1	0	0	8	260	3	25	44844	44844	0	0	51.44	2306601.	69569.	0.	0.049	0.022	

THE AVERAGE NET INCOME FOR 1 ESTABLISHMENTS OF BLL 22 IS 69569.00

CE	TY	IE	CP	SW	SS	WS	IOP	S	LF	PRODUCT	SALES	IC	CC	PRICE	GROSS	NET	COSTS	EC/PIGR	PCI/FAC	COPROD
23	23	4	4	0	0	8	260	3	91	49908	49908	***	0	105.20	5250483.	315349.	501.	0.131	0.013	5266009.
	23	4	4	0	0	8	260	3	96	52596	52596	***	0	106.52	5602500.	336491.	0.	0.049	0.021	
31	23	16	16	0	0	8	260	3	371	202464	202464	0	0	105.32	21323056.	1280672.	2315.	0.131	0.012	25038640.
	23	19	19	0	0	8	260	3	458	249831	249831	0	0	106.63	26638560.	1599920.	0.	0.049	0.021	
32	23	1	1	1	1	1	260	3	13	6222	6103	***	0	108.59	662717.	27658.	124.	0.131	0.029	712246.

Variable Explanation - AIG (Agricultural Income Generator)

CE	= Cell reference number
TYP	= Type of establishment
NIE	= Number of establishments in the cell
NUM	= Number of establishments in the cell operating
SEW	= Number of establishments sewered
NOS	= Number of the sewer system
WS	= Water source
IOP	= Operating period in days
S	= Season of operation (1= summer, 2= winter, 3= both)
FP	= Fertilizer policy
LF	= Labor force
PRICE	= Price per unit
GROSS	= Gross revenues
NET	= Net revenues
CRPYLD	= Crop Yield
OPER COST	= Operating Cost
WEALOC	= Local weather factor
PCF	= Price factor

*** AIG ***

PARAMS FOR TYPE 39 WEALOC 1.00 PCF 1.20

CE	TYP	MIF	NUM	SEW	NCS	WS	ICP	S	FP	LF	PRICE	GROSS	NET	CRPYLD	OPER COST
3	39	2	2	0	0	8	120	1	1	14	16.16	367850.	168559.		
	39	2	2	0	0	8	120	1	1	14	17.69	447469.	227018.	25300.	220451.
10	39	2	2	0	0	8	120	1	2	8	16.16	334409.	154661.		
	39	2	2	0	0	8	120	1	2	8	17.69	406790.	207632.	23000.	199158.
13	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
14	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
19	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
20	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
21	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
23	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
29	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
41	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
42	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
49	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
51	39	3	3	0	0	8	120	1	2	12	16.16	501614.	231992.		
	39	3	3	0	0	8	120	1	2	12	17.69	610185.	311448.	34500.	298737.
58	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
59	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
60	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
63	39	1	1	0	0	8	120	1	2	4	16.16	167205.	77331.		
	39	1	1	0	0	8	120	1	2	4	17.69	203395.	103816.	11500.	99579.
81	39	2	2	0	0	8	120	1	2	8	16.16	334409.	154661.		
	39	2	2	0	0	8	120	1	2	8	17.69	406790.	207632.	23000.	199158.

Variable Explanation - TIG (Tourist Income Generator)

CE	= Cell reference number
TY	= Type of establishment
IE	= Number of establishments in the cell
OP	= Number of establishments in the cell operating
SW	= Number of establishments sewered
SS	= Number of the sewer system
WS	= Water source
IOP	= Operating period in days
S	= Season of Operation (1= summer, 2= winter, 3= both)
LF	= Labor force
TOUR	= Number of tourists
OCC	= Occupancy rate this cycle
OOCC	= Occupancy rate last cycle
GROSS	= Gross revenues
NET	= Net revenues
D1/D2	= Density effect last cycle/ density effect this cycle
WQ/DN	= Water quality effect last cycle/Density Effect this cycle
DPT/PRI	= Retail-service expenditure per tourist/ price for lodging
PIEFF	= Public investment effect
XCOSTS	= Extra costs due to pollution

WEATHER FACTOR FOR 34 IS 0.04

CE	TY	IE	OP	SW	SS	WS	IOP	S	LF	TOUR	CCC	CCCC	GROSS	NET	D1/D2	WQ/DN	DPT/PRI	PIEFF	XCOSTS
2	34	2	2	0	0	8	120	1	2	296	0.93	0.93	64404.	13767.	0.65	0.06	3.44		
	34	2	2	0	0	8	120	1	2	308	0.96	0.93	74158.	22535.	0.08	-0.01	2.01	-0.05	0.
27	34	2	2	0	0	8	120	1	2	300	0.94	0.94	65096.	18947.	0.77	0.06	3.44		
	34	2	2	0	0	8	120	1	2	312	0.98	0.94	74810.	22717.	0.07	0.03	2.00	-0.05	0.
62	34	6	6	0	0	8	120	1	6	846	0.89	0.89	186323.	53579.	0.25	0.06	3.44		
	34	6	5	0	0	8	120	1	6	892	0.92	0.89	215147.	65216.	0.59	-0.03	2.03	-0.05	0.
64	34	4	4	0	0	8	120	1	4	580	0.91	0.92	126309.	36723.	0.50	0.06	3.44		
	34	4	4	0	0	8	120	1	4	608	0.95	0.91	147012.	44706.	-0.06	0.00	2.01	-0.05	0.
73	34	1	1	0	0	8	120	1	1	149	0.93	0.93	32180.	9317.	0.62	0.06	3.44		
	34	1	1	0	0	8	120	1	1	154	0.97	0.93	37002.	11199.	0.11	0.02	2.00	-0.05	0.

THE AVERAGE NET INCOME FOR 15 ESTABLISHMENTS OF BLD 34 IS 11090.91

WEATHER FACTOR FOR 35 IS 0.04

CE	TY	IE	OP	SW	SS	WS	IOP	S	LF	TOUR	CCC	CCCC	GROSS	NET	D1/D2	WQ/DN	DPT/PRI	PIEFF	XCOSTS
1	35	4	4	0	0	8	180	1	8	72	0.93	0.94	101612.	18469.	0.73	0.06	13.79		
	35	4	4	0	0	8	180	1	8	76	0.97	0.93	120149.	28024.	0.02	0.02	8.78	-0.05	0.
2	35	4	4	0	0	8	180	1	8	72	0.93	0.93	105002.	21858.	0.65	0.06	13.79		
	35	4	4	0	0	8	180	1	8	76	0.96	0.93	129149.	28024.	0.08	0.01	8.78	-0.05	0.
4	35	1	1	0	0	8	180	1	2	17	0.89	0.90	24792.	4453.	0.29	0.06	13.79		
	35	1	1	0	0	8	180	1	2	18	0.93	0.89	29463.	6931.	0.00	-0.02	9.09	-0.05	0.
25	35	2	2	0	0	8	360	3	4	36	0.93	0.94	71101.	13459.	0.69	0.06	13.79		
	35	2	2	0	0	8	360	3	4	38	0.97	0.93	84002.	18993.	0.01	0.02	6.14	-0.05	0.
26	35	3	3	0	0	8	360	3	6	54	0.91	0.92	109195.	22731.	0.51	0.06	13.79		
	35	3	3	0	0	8	360	3	6	57	0.95	0.91	126003.	28490.	0.02	0.00	6.14	-0.05	0.
27	35	1	1	0	0	8	180	1	2	18	0.94	0.94	25403.	4617.	0.77	0.06	13.79		
	35	1	1	0	0	8	180	1	2	19	0.98	0.94	30037.	7006.	0.07	0.03	8.78	-0.05	0.
29	35	1	1	0	0	8	180	1	2	18	0.93	0.94	25403.	4617.	0.70	0.06	13.79		
	35	1	1	0	0	8	180	1	2	19	0.97	0.93	30037.	7006.	0.00	0.02	8.78	-0.05	0.
39	35	5	5	5	1	1	180	1	10	95	0.96	0.96	134072.	27910.	0.15	0.06	13.79		
	35	5	5	5	1	1	180	1	10	95	1.00	0.96	145430.	30274.	0.16	0.01	8.50	-0.01	0.
45	35	1	1	10	1	1	180	1	2	17	0.87	0.88	25187.	5347.	0.09	0.06	13.79		
	35	1	1	10	1	1	180	1	2	18	0.91	0.87	29463.	6931.	0.04	-0.04	9.09	-0.05	0.
53	35	4	4	1	1	1	180	1	8	72	0.94	0.94	101612.	18468.	0.70	0.06	13.79		
	35	4	4	1	1	1	180	1	8	76	0.97	0.94	120149.	28024.	0.06	0.02	8.78	-0.05	0.
62	35	4	4	0	0	8	180	1	8	68	0.89	0.89	95169.	17811.	0.25	0.06	13.79		
	35	4	4	0	0	8	180	1	8	72	0.92	0.89	117854.	27724.	0.59	-0.03	9.09	-0.05	0.
66	35	1	1	0	0	8	180	2	2	19	0.95	0.96	26814.	5582.	0.92	0.06	13.79		
	35	1	1	0	0	8	180	2	2	19	0.99	0.95	29086.	6055.	0.00	0.04	8.50	-0.05	0.
67	35	3	3	0	0	8	180	1	6	54	0.92	0.92	78752.	16394.	0.52	0.06	13.79		
	35	3	3	0	0	8	180	1	5	57	0.95	0.92	90112.	21018.	0.08	0.00	8.78	-0.05	0.
72	35	1	1	0	0	8	180	1	2	18	0.95	0.95	25403.	4617.	0.68	0.06	13.79		
	35	1	1	0	0	8	180	1	2	19	0.99	0.95	30037.	7006.	0.00	0.04	8.78	-0.05	0.
73	35	10	10	0	0	8	360	3	20	181	0.93	0.93	363583.	75771.	0.62	0.06	13.79		
	35	10	10	0	0	8	360	3	20	190	0.97	0.93	420012.	94966.	0.11	0.02	6.14	-0.05	0.
74	35	1	1	0	0	8	180	1	2	18	0.94	0.95	25403.	4617.	0.82	0.06	13.79		
	35	1	1	0	0	8	180	1	2	19	0.98	0.94	30037.	7006.	0.01	0.03	8.78	-0.05	0.
76	35	1	1	0	0	8	180	1	2	19	0.95	0.96	26814.	5582.	0.94	0.06	13.79		
	35	1	1	0	0	8	180	1	2	19	0.99	0.95	29086.	6055.	0.00	0.04	8.50	-0.05	0.
84	35	1	1	0	0	8	180	1	2	17	0.87	0.88	25637.	5347.	0.13	0.06	13.79		
	35	1	1	0	0	8	180	1	2	18	0.91	0.87	29463.	6931.	0.01	-0.04	9.09	-0.05	0.

THE AVERAGE NET INCOME FOR 48 ESTABLISHMENTS OF BLD 35 IS 7634.70

Variable Explanation - RASIG and WIG

TSAW	= Total Salaries and Wages
TOUR	= Tour Dollars Spent on Retail and Services
TINC	= Total Business Profits
EXOR	= Exogenous Contribution to Retail and Services
REL.PCT	= % of each of the above going to each Retail and Service BLU type
DFR	= Dollars for Retail generated by TSAW, TOUR, TINC, & EXO
OCELL	= Cell reference number
SALPOT	= Sales potential
ZZ	= Floor space surrogate
ZTOT	= Scale factor
CEL	= Cell reference number
TYP	= Type of establishment
NIE	= Number of establishments in the cell
NUM	= Number of establishments in the cell operating
SEW	= Number of establishments in the cell sewered
NOS	= Number of the sewer system
WS	= Water Source
IOP	= Operating period in days
S	= Season of Operation (1= summer, 2= winter, 3= both)
LF	= Labor Force
SALES	= This cycle's sales
STOCK	= Present cycle's stock
OSTC	= Previous cycle's stock
GROSS	= Total gross sales
NET	= Gross - CODB = profit
CODB	= Total cost of doing business

TSAA,TCUR,TINC,EXUE,AND REL.PCT.= 9146665.00 0.270 17381488.00 0.142 51771824.00 0.025 40499984.00 0.186

TOTAL DEP OF BLU 17 = 25441920.00

OCELL	SALPCT	DEP	ZZ	ZTCI
24	0.30E+07	0.71E+06	1.4	5.20
32	0.18E+07	0.12E+07	0.79	4.72
33	0.49E+07	0.13E+07	2.4	6.19
38	0.19E+07	0.83E+06	0.79	7.51
39	0.36E+07	0.14E+07	1.6	5.67
43	0.35E+07	0.51E+06	1.6	5.53
45	0.19E+07	0.15E+07	0.79	4.48

COST PER UNIT = 11.259 SALES PRICE = 13.609

CEL	TYP	NIE	NUM	SEW	NOS	WS	TOP	S	LF	SALES	STOCK	U STC	GROSS	NET	CODB
24	17	2	2	2	1	1	300	3	21	239142	263019	269596	2883706.	302658.	
24	17	2	2	2	1	1	300	3	19	226916	226916	239182	2951949.	519273.	2432676.
32	17	1	1	1	1	1	300	3	13	148260	148260	159499	1737502.	146561.	
32	17	1	1	1	1	1	300	3	13	134967	145000	148260	1820830.	88410.	1732420.
33	17	3	3	4	1	1	300	3	30	394352	424751	433118	4754519.	136121.	
33	17	3	3	4	1	1	300	3	30	374374	377956	394352	4870230.	726996.	4143234.
38	17	1	1	1	1	1	300	3	13	155243	155243	159449	1871693.	153072.	
38	17	1	1	1	1	1	300	3	13	146337	146337	155243	1903657.	156261.	1747436.
39	17	2	2	3	1	1	300	3	24	290694	290694	316182	3504763.	298568.	
39	17	2	2	3	1	1	300	3	24	275202	250000	290694	3580102.	131762.	3448840.
43	17	2	2	2	1	1	300	3	23	287870	290000	313352	3470715.	279267.	
43	17	2	2	2	1	1	300	3	23	271723	276165	287870	3534843.	273297.	3261546.
45	17	1	1	1	1	1	300	3	13	145869	145869	159109	1758675.	142620.	
45	17	1	1	1	1	1	300	3	13	136848	145000	145869	1780255.	47835.	1732420.

THE AVERAGE NET INCOME FOR 12 ESTABLISHMENTS OF BLU 17 IS 161944.50

TOTAL NET INCOME OF RAS FOR THIS CYCLE = 19926944.00

[illegible]

These diagnostics are from the population-migration model (See chapter III for explanation) up to the "OVERCROWD" portion (Step 7) of that model.

45	3005	0	467	0	952	4670
37	1534	42	853	0	487	4667
41	44	0	3	0	12	4667
42	36	37	35	0	11	4664
58	26	0	2	0	7	4664
42	76	19	52	0	11	4627
28	61	0	8	1	17	4627
42	36	18	53	0	11	4624
34	39	0	2	0	11	4624
42	36	17	54	0	11	4621
40	48	0	2	0	14	4621
15	119	1	51	0	37	4594
8	34	0	2	1	9	4594
15	119	0	52	0	37	4592
17	6	0	1	29	0	4592
41	43	2	16	0	13	4589
67	291	0	70	0	51	4589
51	43	1	17	0	13	4586
65	43	0	1	0	28	4586
51	43	0	18	0	13	4584
63	51	0	1	48	15	4584
19	17	0	15	0	5	4582
28	63	0	8	1	17	4582

THIRD ALLOCATION STEP

CE	PEOPLE	JOB OPP	JOBS	HOU OPP	HOUSES	UNASS POP
23	16	429	292	0	5	4192
1	437	0	8	1	136	4192
23	16	428	293	0	5	4189
27	149	0	4	0	45	4189
23	16	280	441	0	5	3777
26	892	0	133	1	282	3777
22	412	260	273	0	131	3774
1	440	0	8	0	137	3774
22	412	259	274	0	131	3771
26	895	0	133	0	283	3771

OVERCROWD

CE	PEOPLE	JOB OPP	JOBS	HOU OPP	HOUSES	UNASS POP
23	16	280	441	0	5	3771
22	432	252	281	0	131	3751
44	1547	1	742	0	395	3448
37	1706	1	994	0	487	3276
38	2292	1	938	0	710	3188
42	37	17	54	0	11	3187
31	544	0	967	0	165	3162
53	949	0	240	0	285	3117
66	171	0	118	0	52	3109
33	2293	0	1599	0	695	3000
43	1008	0	541	0	305	2952
39	1970	0	398	0	595	2959
25	283	0	137	0	86	2846
32	3575	0	1130	0	1080	2676
24	1904	0	517	0	575	2586
30	75	0	114	0	23	2563
15	124	0	57	0	37	2578
74	348	0	71	1	104	2562
36	874	0	52	0	263	2521
82	52	0	36	0	15	2519
21	210	[illegible]	50	0	[illegible]	[illegible]

*** WIG ***

TOURIST DOLLARS 0.203E+08 ARG 0.0800 PORN 0.5200 TOTAL RETAIL DOLLARS 0.180E+09
SALES PRICE = 936.647 COST PER UNIT = 789.700

TYP	NIE	NUM	SEW	NCS	WS	TCP	S	LF	SALES	STOCK	C STC	GROSS	NET						
18	1	1	0	0	8	260	3	10	1131	1158	1158	0.98E+06	0.78E+05						
18	1	1	0	0	8	260	3	10	1073	1131	1131	0.10E+07	0.39E+04	CELL	15	NEW UNITS	1104	CODB	1001570.
18	1	1	0	0	3	260	3	10	1131	1158	1158	0.98E+06	0.78E+05						
18	1	1	0	0	3	260	3	10	1073	1131	1131	0.10E+07	0.39E+04	CELL	22	NEW UNITS	1104	CODB	1001570.
18	2	2	2	1	1	260	3	19	2328	2379	2379	0.20E+07	0.16E+06						
19	2	2	2	1	1	260	3	19	2214	2328	2328	0.21E+07	0.29E+05	CELL	24	NEW UNITS	2277	CODB	2044653.
18	2	2	0	0	3	260	3	17	2183	2232	2232	0.19E+07	0.18E+06						
18	2	2	0	0	3	260	3	17	2075	2183	2183	0.19E+07	0.33E+05	CELL	30	NEW UNITS	2134	CODB	1905778.
18	8	8	0	0	3	260	3	69	9161	9356	9356	0.80E+07	0.78E+06						
18	8	8	0	0	8	260	3	69	8718	9161	9161	0.82E+07	0.20E+06	CELL	31	NEW UNITS	8966	CODB	7962686.
18	3	3	3	1	1	260	3	27	3453	3569	3569	0.30E+07	0.29E+06						
18	3	3	3	1	1	260	3	27	3322	3493	3493	0.31E+07	0.63E+05	CELL	32	NEW UNITS	3417	CODB	3048704.
18	43	43	43	1	1	260	3	361	49341	50378	50378	0.43E+08	0.43E+07						
18	43	43	43	1	1	260	3	354	46969	49341	49341	0.44E+08	0.13E+07	CELL	33	NEW UNITS	48304	CODB	42738480.
18	1	1	0	0	3	260	3	10	1131	1158	1158	0.98E+06	0.78E+05						
18	1	1	0	0	8	260	3	10	1073	1131	1131	0.10E+07	0.39E+04	CELL	36	NEW UNITS	1104	CODB	1001570.
18	7	7	0	0	8	260	3	61	7956	8166	8166	0.69E+07	0.67E+06						
18	7	7	0	0	8	260	3	60	7605	7956	7956	0.71E+07	0.17E+06	CELL	37	NEW UNITS	7826	CODB	6958636.
18	14	14	14	1	1	260	3	124	16319	16664	16664	0.14E+08	0.14E+07						
18	14	14	14	1	1	260	3	122	15532	16319	16319	0.15E+08	0.35E+06	CELL	38	NEW UNITS	15974	CODB	14197505.
18	18	18	18	1	1	260	3	155	20874	21315	21315	0.18E+08	0.18E+07						
18	18	18	18	1	1	260	3	152	19868	20874	20874	0.19E+08	0.50E+06	CELL	44	NEW UNITS	20433	CODB	18108000.
18	2	2	0	0	3	260	3	19	2328	2379	2379	0.20E+07	0.18E+06						
18	2	2	0	0	3	260	3	19	2214	2328	2328	0.21E+07	0.29E+05	CELL	46	NEW UNITS	2277	CODB	2044653.

THE NET TOTAL INCOME FOR WIG IS 2652585.00
THE AVERAGE NET INCOME FOR 102 ESTABLISHMENTS IS 26005.73

TOT WHOLESALE DOLLARS 104666416. TOT PURCHASES 114920.
*** PUB ***

This output is the loads and resultant concentrations of total coliform and B.O.D. for the summer season of cycle 7 for each of the 64 water segments. The segments are numbered sequentially in ascending order along the horizontal dimension.

COLIFORM

K	SCALE(1)	SCALE(2)	SCALE(3)
0.500900	1.00	0.003531	1.00
BC(1)	BC(2)	CSK	KAK
0.0	0.0	0.0	0.0

LOADS

0.590E+07	0.816E+12	0.103E+13	0.239E+13	0.0	0.311E+13	0.139E+13	0.0
0.135E+13	0.738E+12	0.0	0.111E+13	0.319E+13	0.518E+13	0.473E+13	0.289E+12
0.325E+12	0.0	0.0	0.363E+13	0.149E+13	0.0	0.0	0.240E+13
0.954E+12	0.0	0.0	0.858E+12	0.332E+12	0.0	0.0	0.421E+12
0.652E+12	0.673E+12	0.620E+12	0.442E+13	0.657E+13	0.160E+14	0.298E+13	0.397E+13
0.635E+13	0.0	0.396E+13	0.142E+13	0.222E+09	0.0	0.0	0.0
0.0	0.200E+15	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CONCENTRATIONS (CELLS PER 100 MILLILITERS)

0.572E+02	0.310E+02	0.366E+02	0.295E+02	0.437E+00	0.252E+02	0.357E+02	0.845E+00
0.100E+02	0.362E+02	0.988E+00	0.804E+01	0.230E+03	0.115E+03	0.164E+03	0.808E+01
0.117E+02	0.506E+00	0.134E+02	0.242E+02	0.893E+01	0.291E+00	0.551E+01	0.208E+02
0.562E+01	0.421E-01	0.608E+00	0.197E+02	0.135E+01	0.156E+00	0.438E-01	0.295E+01
0.634E+02	0.168E+03	0.266E+03	0.112E+04	0.237E+04	0.320E+04	0.123E+04	0.198E+04
0.299E+03	0.138E+03	0.405E+03	0.601E+04	0.660E+00	0.199E-01	0.115E+00	0.981E-02
0.123E+00	0.274E+02	0.235E-01	0.527E-02	0.510E-02	0.185E-02	0.312E-01	0.263E+01
0.342E-03	0.452E-03	0.161E-03	0.154E+00	0.556E-04	0.279E-04	0.198E-02	0.381E-01

B.O.D.

K	SCALE(1)	SCALE(2)	SCALE(3)
0.152300	1.00	0.035314	1.00
BC(1)	BC(2)	CSK	KAK
0.5000	0.5000	0.0	0.0

LOADS

0.175E+04	0.666E+07	0.842E+08	0.618E+08	0.0	0.124E+08	0.510E+07	0.0
0.518E+07	0.259E+07	0.0	0.449E+07	0.232E+08	0.268E+08	0.230E+08	0.107E+07
0.140E+07	0.0	0.0	0.169E+08	0.653E+07	0.0	0.0	0.196E+08
0.397E+07	0.0	0.0	0.411E+07	0.144E+07	0.0	0.0	0.176E+07
0.771E+08	0.440E+08	0.234E+08	0.163E+09	0.266E+09	0.793E+09	0.192E+09	0.691E+09
0.580E+08	0.0	0.337E+08	0.136E+09	0.415E+05	0.0	0.0	0.0
0.0	0.800E+11	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CONCENTRATIONS (MILLIGRAMS PER LITER)

0.122E+00	0.943E-01	0.919E-01	0.563E-01	0.221E-02	0.320E-01	0.451E-01	0.272E-02
0.112E-01	0.434E-01	0.301E-02	0.796E-02	0.510E-01	0.837E-02	0.135E-01	0.108E-02
0.124E-02	0.321E-03	0.716E-02	0.269E-02	0.947E-03	0.333E-03	0.107E-02	0.219E-02
0.785E-03	0.522E-03	0.389E-03	0.127E-02	0.499E-03	0.117E-02	0.571E-03	0.667E-03
0.115E+00	0.191E+00	0.234E+00	0.567E+00	0.106E+01	0.207E+01	0.150E+01	0.282E+01
0.855E-01	0.660E-01	0.107E+00	0.657E+00	0.212E-02	0.203E-03	0.353E-03	0.926E-03
0.417E-02	0.300E+00	0.417E-03	0.222E-03	0.113E-03	0.456E-03	0.276E-02	0.769E-01
0.165E-02	0.564E-03	0.120E-02	0.124E-01	0.794E-03	0.234E-01	0.164E-01	0.670E-02

DISSOLVED OXYGEN

K	SCALE(1)	SCALE(2)	SCALE(3)
0.165700	1.00	0.035314	1.00
BC(1)	BC(2)	CSK	KAK

SUMMARY INFORMATION FOR CYCLE 8 ON JAN 21, 1976

INDICATORS OF THE ADEQUACY OF PUBLIC SERVICES

PERCENTAGE OF STREET CAPACITY UTILIZED IN EACH CELL

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	88	45	14	13	10	0	29	11	0	25	25	60	44	20	27	33	13	75	20	17
20	50	133	33	99	69	118	43	11	17	33	164	45	102	13	38	90	89	53	58	9
40	9	43	220	92	91	70	50	50	0	25	20	90	31	50	100	44	67	14	43	8
60	400	63	9	8	23	29	35	8	8	17	33	17	75	44	20	8	0	0	0	50
80	14	40	22	100																

6 CELLS ARE OVER CAPACITY

PERCENTAGES OF OTHER SERVICES UTILIZED IN EACH JURISDICTION

	TRAVERSE CITY	A.P.E.	EAST BAY	GARFIELD
FIRE AND POLICE	83.7	30.9	40.6	19.2
EDUCATION	14.4	251.6	251.6	45.7

PERCENTAGE OF CAPACITY USED IN SEWER AND WATER TREATMENT PLANTS

	1
SEWER SYSTEM	
SUMMER	22.03
WINTER	23.39
WATER SYSTEM	
SUMMER	22.36
WINTER	23.57

QUALITY OF WATER IN SELECTED SEGMENTS

	1	7	9	14	21	24	39	46
COLIFORM (CELLS PER 100 MILLILITERS)								
SUMMER	57.22	35.66	10.04	114.96	8.93	20.77	1234.19	0.02
WINTER	101.44	55.15	16.81	76.93	11.79	26.76	2043.66	0.07
B.O.D. (MILLIGRAMS PER LITER)								
SUMMER	0.12	0.05	0.01	0.01	0.00	0.00	1.50	0.00
WINTER	0.15	0.06	0.02	0.01	0.00	0.00	1.77	0.00
DISSOLVED OXYGEN (MILLIGRAMS PER LITER)								
SUMMER	9.90	9.92	9.94	9.82	9.84	9.64	9.57	9.98
WINTER	12.73	12.76	12.79	12.61	12.64	12.37	11.89	12.79
TOTAL PHOSPORUS (MICROGRAMS PER LITER)								
SUMMER	13.02	12.21	11.73	10.70	10.66	10.41	8.09	11.07
WINTER	13.22	12.33	11.83	10.72	10.70	10.45	8.11	11.13
TOT DISS PHOSPHORUS (MICROGRAMS PER LITER)								
SUMMER	6.52	5.73	5.30	4.13	4.10	3.98	6.45	4.80
WINTER	11.09	10.27	9.81	8.72	8.70	8.49	7.30	9.18
CHLOROPHYLL A (MICROGRAMS PER LITER)								
SUMMER	2.16	2.23	2.26	2.27	2.27	2.22	0.00	2.30
WINTER	882.60	909.47	924.80	922.46	924.40	900.65	0.04	946.72
TOT. SUSP. SOLIDS (MILLIGRAMS PER LITER)								
SUMMER	0.32	0.37	0.36	3.77	0.38	1.44	6.94	0.35
WINTER	132.40	136.46	138.73	140.30	138.69	135.30	4.48	142.01
TOT. DISS. SOLIDS (MILLIGRAMS PER LITER)								
SUMMER	135.37	139.08	138.93	141.43	139.51	136.28	58.55	139.99
WINTER	134.02	137.85	137.94	139.54	138.31	135.00	48.99	139.30

GENERAL INFORMATION BY JURISDICTION

	TRAVERSE CITY	A.P.E.	EAST BAY	GARFIELD	TOTAL
POPULATION	18441	5009	2760	6666	32876
DWELLING UNITS - OCCUPIED	5504	1508	836	1965	9813
DWELLING UNITS - VACANT	0	0	0	0	0
JOBS TAKEN	6441	663	576	3023	10703
GROSS RETAIL SALES	142201344.0	10870012.0	8489087.0	18896816.0	180457040.0
TOURISM CONTRIBUTION TO RET+WHO	11354568.0	3607928.0	4694455.0	596278.1	20253168.0
TOURIST EXPENDITURE FOR SPACE	5019498.0	1693167.0	2261252.0	373956.3	9347874.0
TOTAL ACREAGE	4951.1	11868.9	12521.7	17208.5	46550.2

*** THE REMAINING DATA ON LAND USE IS IN PERCENTAGES

	TRAVERSE CITY	A.P.E.	EAST BAY	GARFIELD	TOTAL
INDUSTRIAL ACREAGE	7.0	0.1	0.2	1.6	1.4

VARIABLE NO. 94: TOURIST CONTRIBUTION TO RET+REC - BY CELL

188647.19	317789.57	0.0	94679.60	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	183647.13	282970.69	175955.31	0.0	47161.80	0.0
0.0	0.0	1697422.00	0.0	0.0	0.0	0.0	0.0	5952278.00	0.0
0.0	0.0	0.0	0.0	3504868.00	0.0	0.0	0.0	0.0	0.0
0.0	0.0	2492905.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1856246.00	0.0	250982.31	0.0	47161.80	1814548.00	0.0	0.0	0.0
0.0	47161.80	1006806.81	47161.80	0.0	47161.80	0.0	0.0	0.0	0.0
0.0	0.0	0.0	44679.60						

T.C. 11354568.00 APE 3667928.00 E.B. 4094455.00 GAR. 596279.06 TOT 20253168.00

VARIABLE NO. 95: TOURIST EXPENDITURE FOR SPACE - BY CELL

120148.81	194306.84	0.0	29463.47	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	84002.31	126003.44	104847.56	0.0	30037.21	0.0
0.0	0.0	838398.58	0.0	0.0	0.0	0.0	0.0	2582984.00	0.0
0.0	0.0	0.0	0.0	1598116.00	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1130907.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	925163.19	0.0	147012.25	0.0	29085.99	831764.13	0.0	0.0	0.0
0.0	30037.21	457013.38	30037.21	0.0	29085.99	0.0	0.0	0.0	0.0
0.0	0.0	0.0	29463.48						

T.C. 5919498.00 APE 1653167.00 E.B. 2261242.00 GAR. 373956.31 TOT 9347874.00

VARIABLE NO. 100: GROSS RETAIL SALES - BY CELL

0.0	27665.63	0.0	0.0	0.0	0.0	403632.75	0.0	0.0	0.0
0.0	735608.94	54945.56	0.0	341801.31	0.0	0.0	0.0	387945.88	0.0
1942431.00	3564179.00	0.0	18621643.00	3420746.00	655695.00	0.0	191452.75	0.0	412454.38
3633611.00	15588638.00	37906384.00	0.0	52939.20	1024632.75	4910445.00	12707240.00	10023049.00	0.0
0.0	1561722.00	27091360.00	12031781.00	8281280.00	295134.88	0.0	193674.38	0.0	0.0
930745.38	0.0	3674351.00	0.0	798925.56	51936.19	43620.95	0.0	237521.00	0.0
0.0	3074527.00	0.0	0.0	0.0	32019.21	1132413.00	0.0	0.0	0.0
539924.81	103578.44	1921856.00	585238.19	0.0	0.0	0.0	0.0	0.0	0.0
44137.07	819386.50	0.0	0.0						

T.C. 142201344.00 APE 10870012.00 E.B. 8489087.00 GAR. 16896816.00 TOT 180457040.00

The cells in these tables are numbered sequentially in ascending order along the horizontal dimension.

DISTRIBUTION OF BASIC LAND USE UNITS IN CELL 35

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	10	2	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
40	1	0	0	0	0	0	8	0	0	0	0	0	4613	1472	0	0	0	0	0	0

DISTRIBUTION OF BASIC LAND USE UNITS IN CELL 36

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	0	39	1	1	0	6	0	0	0	0	1	0	1	0	1	2	0	1	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
40	0	0	0	3	0	0	10	0	0	0	0	0	6398	2592	0	0	0	0	0	0

DISTRIBUTION OF BASIC LAND USE UNITS IN CELL 37

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	0	25	23	5	4	9	0	0	2	1	4	2	3	1	2	3	0	7	0	0
20	0	0	0	0	1	3	5	2	0	0	0	2	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	19	0	0	0	0	0	4491	1664	0	0	0	0	0	0

DISTRIBUTION OF BASIC LAND USE UNITS IN CELL 38

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	0	0	47	45	1	0	0	0	2	4	4	4	39	4	4	3	1	14	0	0
20	0	0	2	4	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	2	0	5	0	0	59	0	0	0	0	9	2005	0	2360	0	0	0	0	0

DISTRIBUTION OF BASIC LAND USE UNITS IN CELL 39

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	0	4	25	22	3	3	3	0	2	5	1	2	5	1	7	6	2	0	0	2
20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	5	5	3	3	0	0
40	0	2	0	4	0	0	36	0	0	0	11	0	930	0	6600	0	0	0	0	0

DISTRIBUTION OF BASIC LAND USE UNITS IN CELL 40

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
40	1	0	0	0	0	0	11	0	0	0	0	0	4004	2976	0	0	0	0	0	0

DISTRIBUTION OF BASIC LAND USE UNITS IN CELL 41

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
40	1	0	0	0	0	0	11	0	0	0	0	0	2441	2272	17	0	0	0	0	0

DISTRIBUTION OF BASIC LAND USE UNITS IN CELL 42

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	8	1	0	0	0	0	0	0	1	0	1	0	1	0	3	3	0	0	0	1
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
40	0	0	0	0	0	0	7	0	0	0	0	0	2164	7488	53	0	0	0	0	0

DISTRIBUTION OF BASIC LAND USE UNITS IN CELL 43

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
00	0	0	0	5	17	0	0	0	0	10	34	4	14	1	19	17	2	0	0	0

TABLE VI

GROSS SALES AND ESTABLISHMENTS COMPARISON - 1972 W III RESULTS AND CENSUS DATA

	Simulation			Census	
	Gross Sales	Number of Stores	Sales Average	# Stores	Gross
BLU 9					
Study Area	$ 8,375,509	60	$ 139,592	62	$ 8,894,000
City	6,391,373	44	145,258	44	6,424,000
Remainder	1,984,136	16	124,009	18	2,208,000
BLU 10					
Study Area	9,515,774	67	142,026	77	11,079,000
City	7,402,212	51	145,141	51	8,871,000
Remainder	2,113,562	16	132,098	26	2,208,000
BLU 11					
Study Area	28,717,101	115	249,714	128	33,065,000
City	21,972,815	81	271,269	81	22,094,000
Remainder	6,744,286	34	198,361	47	10,971,000
BLU 12					
Study Area	29,639,002	56	529,268	68	31,975,000
City	22,511,854	41	549,070	41	28,407,000
Remainder	7,127,148	15	475,143	27	3,568,000
BLU 13					
Study Area	9,712,940	168	57,815	184	10,265,000
City	8,277,148	140	59,122	140	9,165,000
Remainder	1,435,792	28	51,278	44	1,867,000
BLU 14					
Study Area	1,021,412	34	30,041	38	1,079,000
City	624,549	18	34,697	18	461,000
Remainder	396,863	16	24,803	20	618,000
BLU 15					
Study Area	9,965,177	161	61,896	201	11,032,000
City	8,265,171	130	63,578	130	9,165,000
Remainder	1,700,006	31	54,839	71	1,867,000
BLU 16					
Study Area	36,200,757	133	272,186	134	38,588,000
City	25,414,071	87	292,116	87	30,075,000
Remainder	10,786,686	46	234,493	47	8,513,000
BLU 17					
Study Area = City	19,491,433	12	1,624,286	12	19,294,000

CHAPTER VII

PROGRAM LISTING INTRODUCTION

Internal Report #7 is a listing in FORTRAN coding of the WALRUS III program excluding data files. All programs, initial data files, intermediate data files, and cycle land use changes and additions have also been stored on magnetic tape. The tape was created using University of Michigan file save program (*FS). If the tape is incompatible with other system requirements, facilities exist at the University for copying the tape into the desired format. Copies of the tape are available at cost from the Michigan Sea Grant Program. The following table provides a listing of the subroutines in the program.

SUBROUTINE NAMES, DEFINITIONS, & ORDER FOR PROGRAM LISTING

NASE	National and State Economy
SWW	Salaries, Wages and Welfare
PUBJOB	In the absence of more complete algorithms for the Public Sector, it is necessary to accumulate jobs and contaminants for Public Land Uses
WIG	Wholesale Income Generator
AIG	Agricultural Income Generator
TIG	Tourist Income Generator
RIG	Residential Income Generator
IIC	Industrial Income Generator
RASIG	Retail and service Income Generator
RASIG 1	Fill C Matrix - Numer of Units of BLU types by Cell
RASIG 2	Set Initial Supply and Demand Conditions
RASIG 3	Calculate Unadjusted Sales by Area
RASIG 4	Balance Potential Sales with Offering
ADJCS	This Routine Selects and Rank Orders Randomly Cells from the First and Second Ring Around a Given Cell -I-
SUBCS	This Routine Locates and Orders Suburban Cells
SHUFF	This Routine Increments Population, Jobs and Dwelling Units Whenever Conditions are Such that Those Increments are Legal
POPMG	Population-Migration Model For WALRUS III
CALCCI	Calculate Dollars of Capital Investment in Each Cell
CHPMP	Check for Changes in Population-Migration Params
WATCAP	Determines and stores the Water System Capacities for Final Summary Printout
BASLOD	Real*4 Load
STOEFF	Store Effluents in File
GETEFF	Program Converts Cell Effluent to Segment Loadings for Second Order Runs (D.O., Phytoplankton - loadings are also set)
SEWCAP	Determines and Stores in Common the Volume of Sewage Treated in Each of 7 Sewer Systems on the Average Day
WQUAL	Actual Run of Canale's Model
WATMOD	Set Up Parameters and Run Water Model
MKPARA	Create the Parameters File
MKBLUF	This Routine Reads Data for Storage in BLUF
MCLUF	Create the Current Land Use File
MCRI	Routine Completes Initialization of CLUF Record 1
MKACF	This Routine Sums Over CLUF Entries to Arrive at Cell Totals Needed as Input to the Economic Algorithms
MKACF2	This Routine Reads into ACF Those Variables that Are Initialized Without Summing Over CLUF
MKROWA	Create the File of Water Parameters
MAIN	Main reference program
ERRI	Error Message Routine - Inconsistency Within CLUF
CONTAM	Increment Contaminant Levels
EXJOB	Account for Jobs Left Unfilled by POPMIG
ECOALG	Master Routine for Calling Economic Algorithms
RIGRT	Calculate Rent
IIGCW	Water Cost
CONEFF	Convert Effluent Data for Fertilization Policy
CHFILE	Perpetrate an External Change in a File
NEWEL	Get a New Element for One of the Records in a File
WCHFILE	Subroutine Asks For a File Name and Returns a Code for Each Possible Response. Input Can Be From Terminal or Batch.
ROUTCH	Change Print Route- Only Called When Using a Terminal
PRIFIL	Routine Calls the Print File Routines
GFN	Ask User if He Wants Current or Last Cycle's Files
SETOPT	Allow User to Set Options
CACCHE	Calculate Adequacy of Public Services
PAGOUT	Print Out Single Page of Summary Data
BLUPRI	Ask for a Print of Number of BLUS in a Cell
PRPARA	Print Parameters File
PCLUF	Print the Current Land Use File
PRNBLS	This Routine Prints the Number of Basic Land Use Units in Each Cell
PCLUF2	Routine to Print the First 10 Records of CLUF
PBLUF	Print the Basic Land Use File
PRACF	This Routine Prints and Record of the ACF File
PRROWA	Print Out Water Model Data-ROWA-
UNIFO	Subroutine generates a uniformly distributed random variable between IA and IB
NORML	Subroutine generates normal variates of mean EX and Standard deviation STDX
CO2CE	Converts a set of cell coordinates -KX,KY- into a cell # -I-
CE2CO	Converts a cell number -I- into Cell coordinates -KX,KY-
SORTI	Shell sort for descending order(largest number first) - Intege
SORTR	Shell sort for descending order(largest number first) - Real
BLU2TY	Look-up routine returning supertype and sub-supertype
LUKBLU	Look-up routine relating BLU, sub-supertypw, and supertype
CE2JUR	Returns jurisdiction given a cell number
IBYJUR	Returns jurisd. totals given an integer variable
RBYJUR	Returns jurisd. totals given a real variable
FILSET	Set correct file numbers
FREAD	Reads data from a disk data file
FWRITE	Writes data into a disk data file
GETLUD	Gets the proper "LUD" in common
SETIO	Sets input/output devices for CREDES
PLACHK	Checks if addition to a cell with sewer or water system is in a cell permitted for that system
ADDLU	Adds more BLU's to an existing land use in a cell
ACCHGE	Changes acreage totals
CRELU	Creates a new land use
ACCHEK	Checks that acreage totals are correct
CREDES	Adds or destroys land uses
CHKRTE	Performs routine safety checks and jump to correct operation
SUBLU	Subtracts BLU's from an existing land use
DYNABLU	Provides for the updating of selected BLU characteristics to those of an average value