An Environmental Laboratory for the Social Sciences

U.S. Environmental Protection Agency
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Preface

The concept of a social science laboratory was another of those "buzz" words which appear to mean everything and at the same time nothing. When a group of us began to advocate such an idea for universities and colleges in late 1969; it was immediately accepted in a fuzzy sort of way. Our focus for the laboratory was to be a generalizable computer based model.

Water resource planners have been accustomed to developing and using computer models that focus to a large extent on the water subsystem of the entire river basin or regional system. This focus has been so strong that the models have not been able to deal simultaneously with a wide number of concerns that are directly or indirectly related to water resource planning, such as the effect of pollution regulations on employment of different segments of the labor force, employment by different segments of the business and government community, percent of incomes spent for various types of water uses, externalities (market values of homes, land use activity, assessed value of land, etc.) associated with water quality and use, and the financing of alternative water resource plans. In short, previous water models have not been models of an entire regional system with the water subsystem realistically interacting with all the other major subsystems.

The RIVER BASIN MODEL is a water resource model, but it is also a labor market model, a commercial allocation model, a migration-housing model, a land use and assessment model, a government operations model, and several more. It is a regional systems model. It deals with a full range of factors that impact on the water subsystem and a wide range of factors that are in turn affected by water resource planning decisions.

The RIVER BASIN MODEL deals with groups of people, corporations, and government departments as they interact with one another within a spatially defined environment. It differs from other water models in that it generates much of the data used as inputs to water models as a result of complementary processes that are a part of the regional system. For example, a typical water model might need inputs as to where industries are located, how much they earn, what their tax payments are, and how many people they employ.

In other words these are normally exogenous inputs to the model. The RIVER BASIN MODEL makes these and other factors that relate to the local water subsystem endogenously determined factors that are either human inputs or generated by computer simulations.

The RIVER BASIN MODEL recognizes that many concerns of the water resource planner may be handled only within the confines of a holistic model of the regional system. To deal with the economic, social, and governmental impacts of water resource planning calls for a model that incorporates and simulates the interaction of many subsystems other than that for water. Some of these subsystems are directly related to the water subsystem while others are related in only an indirect way. The RIVER BASIN MODEL is an attempt to represent in an operational model all of these major subsystems, and thereby place water resource planning within its realistic perspective.

Users of the model are given control over all the resources of the local area being represented. Some of the local activities withdraw water directly from the water system and return their effluent to that system (either treated or not). Most of the businesses and population of the local system use municipally supplied water which also must be withdrawn from the local water system and treated if necessary. The municipal treatment of sewage is a decision that is made in light of local considerations, such as cost, pollution levels, intergovernmental cooperation, etc.

The RIVER BASIN MODEL is oriented toward

user requirements such as generality of representation, flexibility of change, ease of inputs, and readability of output. The model provides, among other things, great detail on the quality of the local water system, the pollution generated by industrial, municipal, and water sources. It also illustrates the impact of pollution on treatment costs, health, recreation activity, and social dissatisfaction.

A wide range of decisions and their consequences may be illustrated by the model. For example, in the economic sector the impacts of response to water pollution regulations, fines, comprehensive planning, and quality of the local water system may be shown. In the social sector, the effect on leisure time of pollution, political pressure agains polluters, and loss of jobs because of plant closings can be represented. The impacts of many government decisions may be shown: comprehensive water management programs, changing utility district boundaries, intergovernmental cooperation and many more.

Operating programs of the RIVER BASIN MODEL computer package illustrate the impact that the water system has on such phenomena as housing selection, employment, time allocation and the activity patterns that result, and government budgetary activity (revenue collection and disbursement). The users of the model may make a wide range of private and public policy decisions which affect the simulations for each of these phenomena and more. The detailed and summary computer output reveals the interactions of these decisions and the collective impact they have on the environmental quality of the represented area.

The RIVER BASIN MODEL, given its present data base, does not, however, represent the workings of an actual regional system with enough accuracy to be used as a predictive device. It was built using aggregated representations of people, businesses, and government activities. Its primary purpose is to give a holistic view of the workings of a hypothetical regional system and its water subsystem and to allow its users to interact in a dynamic decision-making environment.

For nearly four years work was done on a computer-based model which could be used both for research and training purposes. When it was thought that this end was accomplished Envirometrics Inc. approached the National Science Foundation for a research grant.

Upon approval, the grant was used to test the concept of a general social science lab by having several disciplines use the same model to teach their extrant courses.

Part of this report is the result of that experiment. The story and results are told directly by each professor, except for more overall comments I made myself.

In terms of the current program of the Environmental Studies Division of EPA, the model and its availability to all represents a two-edged experiment. The first facet is related to the design and experimentation of a large scale holistic model for research. The CITY or RIVER BASIN MODEL, is somewhat unique in its size and comprehensiveness and serves as a useful starting point for such an excercise. Secondly, there are the concomitant questions of user acceptance of these large scale models. Part of our studies will document and analyze this process since the model is presently in the public domain, as is most of its documentation and is currently being distributed through a network of 10 regional centers in the U.S. and several abroad.

The general usefulness of this lab is for each reader to decide. Our thanks go to those professors who tested the laboratory concept and who present a guide for others.

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CHAPTER I

Introduction

Today, social science education is in the midst of a severe cultural lag. Its students, responding to the needs of our society, are interested in becoming active participants in the solutions of our social ills. They appear to prefer this activist role to the more traditional one of the passive scientist who studies the system from afar. Unfortunately, although our educational institutions will at least begin to prepare students for the latter, they usually do not possess techniques for preparing them for constructive participation in day to day affairs.

Possibly a partial explanation of this failing can be found in the evolved structure of the educational institutions themselves. Unfortunately, there is little for the historian and anthropologist to use to recreate the path of evolution through the ages. Consequently, we shall be forced to hypothesize the growth of this institution in Western Civilization.

When the number of people gathered together in a group or clan is small, and when the technology they have at their disposal is primitive, the society (depending on the niggardliness of nature) is usually forced to spend large amounts of its energy in matters of survival per se and therefore spends little in speculative or educational activities. The young men or women, when time comes for them to participate actively in the group's survival, are apprenticed to older members of their own sex (normally in their own kinship group) to learn by mimic the techniques they will use throughout life. It is not until the technology improves and the group's number increases, that specialization in education is able to come about.

For our convenience, let us picture this evolving rudimentary formal educational system as being divided into two distinct categories. The first, a manual-technical classification which includes a teaching of all of the skills required to support the culture in its day to day existence. In the case of teaching these skills it would appear that the more routinized the skills required and the greater the number needed to perform the operations, the more likely it is for the task to be turned over to some form of formal educational institution rather than to be apprenticed to single individuals. Subsumed under this category could be such training operations as manual trade schools, guilds, military academies, and so forth.

A second category can be broadly classified as philosophy. This group of studies was instituted to cater to the needs of the ruling and wealthy classes. Since there was little chance that the young of these groups would ever need to perform manual labor, they were taught how to govern and how to address themselves to the more abstract problems of life. Often these schools specialized in religious training or in the arts such as music and painting.

Classes in both schools were likely to be small, and the amount of accumulated tribal knowledge to be passed on to the young was relatively light. The seminar and laboratory (shop) could be widely used, resulting in a great deal of personal attention for the student. Further, secondary sources such as books were scarce so that the student could not be totally separated from everyday experience; his laboratory had to be his world—as interpreted by his teacher, of course.

As educational institutions became more crowded and as the accumulated knowledge of a society increased, the schools had to search for methods of educating its students in a more streamlined fashion. For example, many of the frescoes on the walls and ceilings of the 13th and 14th century buildings in Europe were painted by a master and his students. Such a practice is possible only if the number of students is small and the master can see to each in an apprentice fashion. For many decades we attempted to maintain this concept of master-student by separating the vast number of students seeking knowledge into undergraduate and graduate levels.

The lower level catered to its clientel through mass-produced learning situations. Only the best from this level were allowed to be taught in a tutorial sense.

Ancillary with the overcrowding of the educational sphere has been the evolution of the researcher. As more and more students demanded the benefits of an education, the demands placed on the teacher increased to provide unique tutorial discussions of the day to day environment. Further, more and more teachers discovered a continuing demand for a few of their seminars (based on their own experience and observations) to the end that there was both a desire and a demand for widespread distribution of their teaching. Soon, the dual phenomena of an expanding day to day environment and the teacher's capability of explaining it, led to the creation of a middleman, the researcher. The researcher attempted to antiseptically describe and relate a number of different environments and facets thereof to be used by the teacher and his students in place of first hand experience. In short, we evolved a body of men whose specialty is the distribution of observations of the real environment in such a fashion as to provide an artificial, but rich situation for the teacher and the student as they go about the study of philosophy.

It appears that this trend, although seemingly logically arrived at from a historical point of view, has worked to the disadvantage of the modern student. In truth, today's graduate student is the victim of both overcrowding of our educational facilities and the loss of a tutorial teacher. His teachers have taken the road of the researcher as the most rewarding and have abandoned him to read their musing rather than join in the study. Although his predecessors had the distinct advantage of practical studies under a master, he finds himself relegated to the role of the former undergraduate as his numbers have grown to a point where it is impossible for modern educational facilities to handle him as a unique individual. Since, as noted earlier, our educational institutions led the student to expect some degree of private attention and activistically oriented research as he progresses in his education, the lack of these ingredients leads to a great deal of frustration. The solution at first blush appears quite simple. All that is required is to reverse the evolutionary tendency so that the modern student can participate in real life problems under the tutelage of a guiding teacher.

Unfortunately, self-evident as such a solution might be, we are constrained by the fact that it is impossible for all of the vast number of students of social science (part of modern day philosophy) to be unleashed upon the day to day world. What is needed is an educational technique which will revert to a more personalized education and at the same time allow society to remain undisturbed by the learning process. Models of the sort described here are a step in this direction.

CHAPTER II

Brief Description of the Model

In a sense, the RIVER BASIN MODEL* is a misnomer, because if one places an emphasis on "River" it leads one to believe that the model is primarily concerned with water management. The emphasis should be placed on "River Basin", and that term should be interpreted in its broadest context as meaning a geographical area of land. Through its two major components— human interaction and computer simulation—the model represents the economic, social, and governmental activity that takes place within the geographical boundaries defined by the river basin or, more simply, by a group of contiguous counties.

The model is unlike most other simulation or human interaction models. It was not designed to accomplish any one specific purpose. Rather it was designed to let its users represent the major economic, social, and government interests that cause a regional system to function and change. As part of the functioning of this regional system, water is demanded by industries and municipal water suppliers and pollution is generated by manufacturing and commercial activities, by people, and by farm activities.

The model is a computer-assisted decision-making tool, in which a number of computer programs simulate major processes that take place in any local system such as migration, housing selection, employment, transportation, shopping patterns, the actual allocation of leisure time, and water quality determination. Users of the model provide inputs to these programs on behalf of business activities in the economic sector, government departments in the government sector, and population groups in the social sector.

*The previous version of the RIVER BASIN MODEL was known as the CITY MODEL. The RBM contains all of this model plus numerous additions. The experiments in the schools were carried out on CITY III. RBM is CITY IV.

Normally, the users of the model are assigned decision-making responsibility for businesses, population units, and government departments in a gaming format. This means that users become members of teams or decision-making units that are assigned control of:

- Economic Assets: cash, land, manufacturing plants, commercial activities, and/or residences.
- Social Assets: population units that are designated as high income, middle income, and/or low income.
- Government Assets: power of the budget, taxing and assessing authority, service responsibility, and planning power.

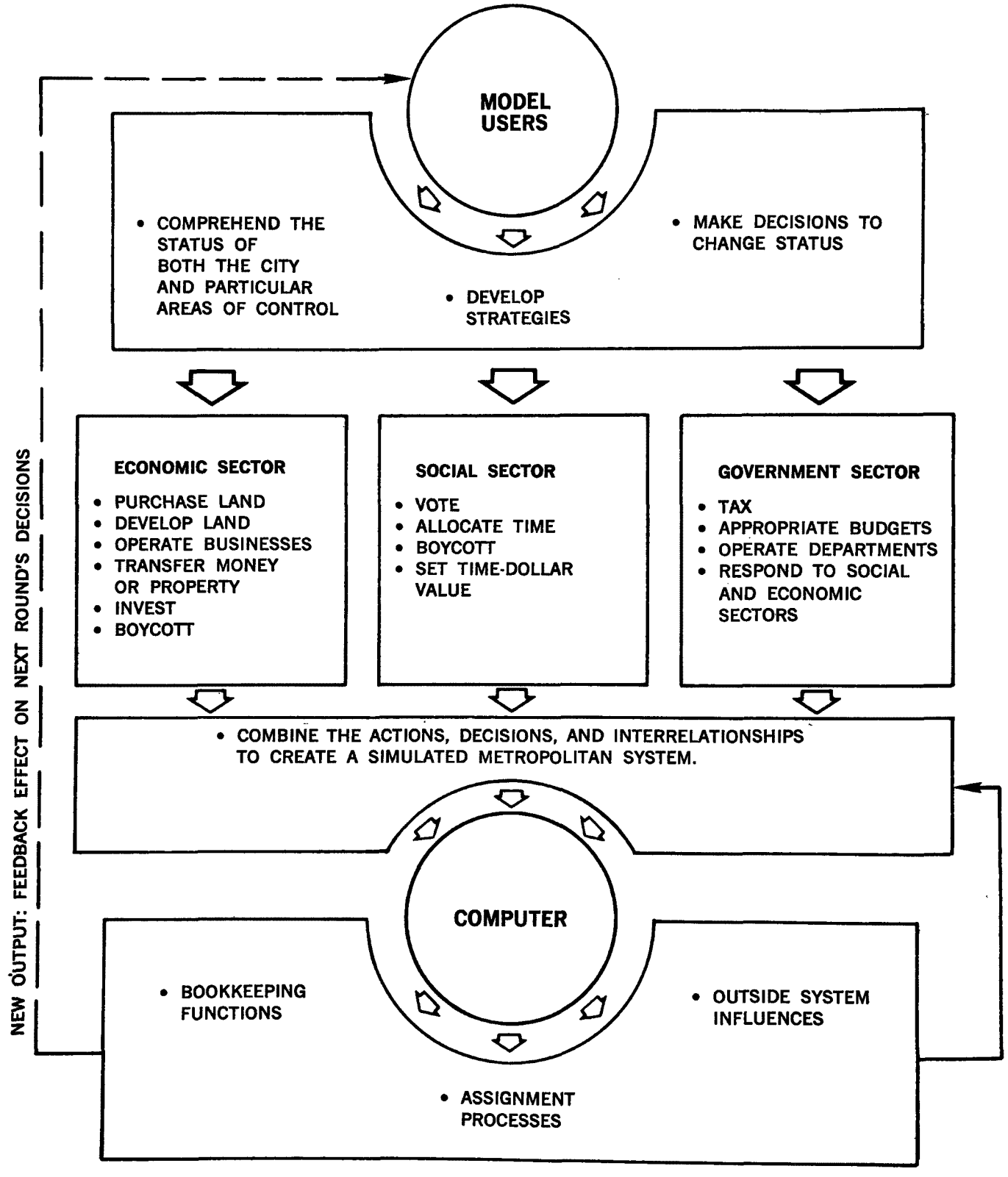
The computer print-outs in a given time period provide a detailed description of the regional area represented by the model, and the users of the model evaluate this status as individuals, as team members, and collectively to define problems, establish objectives, develop strategies, implement plans, and react to feedback from the new computer printout for the next time period. Figure 1 shows the aggregate interactions between the users and the computer portion of the model.

THE REPRESENTED AREA (THE LOCAL SYSTEM)

Since the RIVER BASIN MODEL is a holistic decision-making model for a geographical area that has been pre-loaded into the computer, the choice of the initial regional configuration to be represented is very important.

The model deals with any geographical area and many of its associated economic, social, governmental, and water resource characteristics. Many of these characteristics are represented on a grid map that measures 25 square parcels of land on a side.

Figure 1.—INTERRELATIONSHIPS IN THE MODEL



All of the 625 possible land parcels are of equal size, so the length of a parcel side determines what overall geographical size area may be represented. Or conversely, once the total area to be represented is known, the length of a parcel side may be determined.

The latter approach was used to set the initial parcel side lengths for the model. It was decided

early in the project to represent the Cuyahoga River Basin area as one of the two initial starting configurations turned over to EPA.

The Cuyahoga River Basin is located within a six county area that also happens to be continguous with the Cleveland and Akron Standard Metropolitan Statistical Areas. To fit that six county area on the 25 by 25 grid resulted in a choice of 2½ miles for the length of a parcel side for that particular load configuration. Thus each square was equated to 6.25 square miles in area.

The length of a parcel side may be changed rather easily when the model is loaded, but a realistic range of lengths would be from about .1 to 4 miles and a number of other model parameters should be simultaneously altered to correspond with the areal scale change. (See Appendix for other configurations).

Figure 2 shows a map of the economic activity represented by the model for the Cleveland-Akron area. The area is actually called RAYWID CITY in order not to mislead users of the model that a full-fledged attempt had been made to represent that actual area.

The users of the RIVER BASIN MODEL are assigned responsibility for allocating all of the major economic, social, governmental, and water resources for the local system (the area and its activities represented on the grid map) on a year to year basis. The director of the model (the person conducting the run of the model) makes a number of decisions for the major decision-makers that are outside the local system. A number of computer programs are also available to simulate part of the actions between this local system and the rest of the world.

The initial starting position will show a particular set of allocations of the local system's resources and their effects on the status of the local area. The users of the model evaluate their own particular status within the local system as well as the status of the area as a whole. They then interact with one another in a dynamic decision-making environment in which they collectively have control over the local water quality decisions that will be made, implemented, and reacted to. Some of the model users may have apparently only marginal interest in the local water quality issues because they are preoccupied with running schools, building roads, earning incomes, producing manufactured goods, building housing, and supplying local goods and services. Others may have more interest as they attempt to be elected into public office, run the planning department, collect taxes, recreate, and develop a generally pleasant environment for their new residential subdivisions. Still others might have a direct and pressing interest in the local water quantity and quality as they attempt to set and enforce water quality standards, supply municipal water, use surface water in their production process, and benefit from major water-based recreation areas.

In short, the entire local system (at a certain level of detail) is represented by the model and its users, and water decisions are placed within their realistic context of having different importance to different individuals as a function of their occupation, location, resources, and personal inclinations.

ACTIVITIES

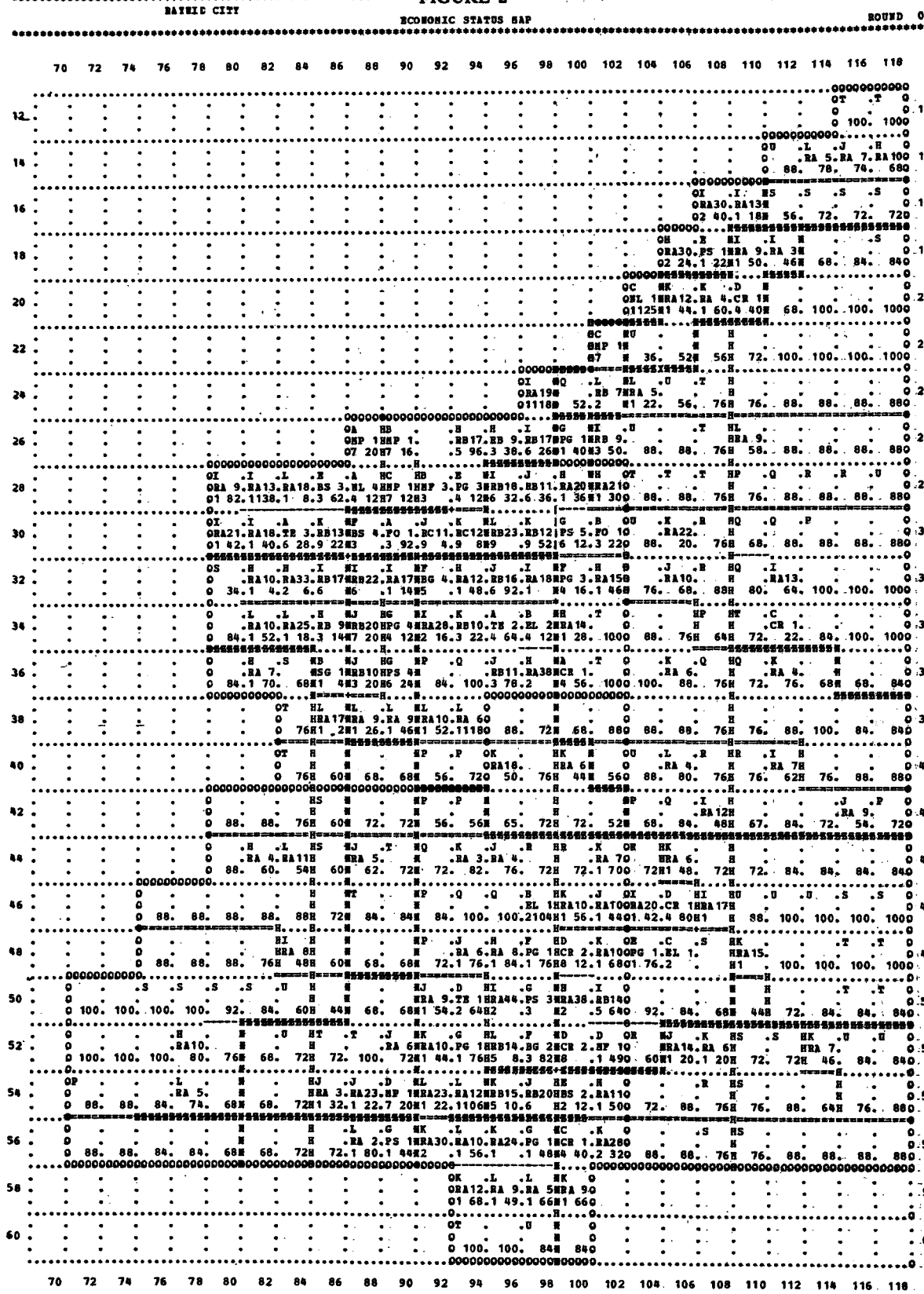
The major activities represented in the model may be divided into three major sectors (economic, social, and governmental) and one major subsector (the water component). Each of these sectors has a number of activities that interact with the activities of the other sectors.

The major economic activity is the business operation. Four broad types of businesses are represented in the model: basic industry (manufacturing mostly) that produces goods for export to national markets, service industries that supply goods and services to local system buyers, residential developers and operators who make housing available to the local population, and farming activity which often consumes the majority of the land in a region.

Figure 3 shows the detailed economic activities that fall under each of these four broad headings. The economic assets of the local system are divided up among economic teams for their management. In addition to businesses, vacant land, cash, and stock ownership may be given to teams for their use as they see fit. Teams may be set up in such a way that they are specialized (have only heavy industry, only residences, only land, etc.) or diversified (a mixture of several types of assets).

The Social Sector has one basic resource and that is people. The local system's population is divided into clusters of 500 people (or some other size if a program change is made) that are called population units (Pl's). These Pl's are further characterized by an income class (high, middle, or low), average educational level, average savings, number of registered voters, etc. Associated with income class are a number of specific characteristics such

FIGURE 2



PARCEL KEY

TOP LEFT: OWNER
TOP RIGHT: ZONING
MIDDLE: LAND USE AND LEVEL
BOTTOM LEFT: UTILITY LEVEL
BOTTOM RIGHT: % UNDEVLPD LAND

PARCEL EDGES

.. .. ROADBED
-- || TYPE 1 ROAD
== HH TYPE 2 ROAD
%% HH TYPE 3 ROAD
00 00 JURISDICTION BOUNDARY

INTERSECTIONS

+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

ZONING	LAND USE
--	ANY USE
10	ANY BUSINESS
20	HI,LI,CI
21	HI
22	LI
23	CI
30	BS,BG,BS,PG,PS
31	BS
32	BG

ZONING	USE
33	BS
34	PG
35	PS
40	RA,RB,RC
41	RA
42	RB
43	RC
50	PARKLAND

as number of workers, number of students, and many preference functions.

Social Teams are created by giving a team decision control for all the PI's of a given class on specified parcels. A good number of the actions taken by PI's during the course of a year in the local system are determined by computer allocation models, but the social teams may affect these by making time allocation, boycott, cash transfer, and vote decisions for the PI's under their control.

A significant part of the RIVER BASIN MODEL centers around how PI's function within the local system during the course of each round of play which represents one year of time in the local area.

FIGURE 3—*Economic Activities in the RIVER BASIN MODEL*

Basic Industry (sells output at markets outside the local system)
- Manufacturing (roughly equivalent to the 2-digit SIC code industries)
  - FL — Furniture and Lumber
  - SG — Stone, Clay, and Glass
  - MP — Primary Metals
  - MF — Fabricated Metals
  - NL — Nonelectrical Machinery
  - EL — Electrical Machinery
  - TE — Transportation Equipment
  - FO — Food
  - TA — Textiles, Apparel, and Leather
  - PA — Paper
  - CR — Chemical, Plastics and Rubber
- Non-Manufacturing
  - NS — National Services (such as insurance, research, etc.)

Local Commercial (sells output competitively to local system demanders)
- BG — Business Goods
- BS — Business Services
- PG — Personal Goods
- PS — Personal Services

Residential (provide housing space)
- RA — Single Family
- RB — Garden Apartments (6 times the housing space as RA housing)
- RC — High-rise Apartments (25 times the housing space as RA)

Agricultural (consume land and use varying amounts of fertilizer)
- F1 — Fruit & Nut
- F2 — Vegetable
- F3 — Other Field Crops
- F4 — Cash Grain
- F5 — Tobacco
- F6 — Cotton
- F7 — Poultry
- F8 — Dairy
- F9 — Livestock
- F10 — Ranchers
- F11 — General

Figure 4 shows the actions of PI's as they are affected by the major operating programs.

The Government Sector is comprised of decision-makers who are responsible for a wide variety of public activities: budget making (appropriations and revenues), land and building assessment, education, municipal services, transportation, planning and zoning, and utilities. The latter activity contains within it the water office that is responsible for the supply of public water. The Water Quality Office may be a part of this department or a separate agency.

FIGURE 4—*Example of How Population Units Are Affected by the Major Operating Programs of the Model.*

Major Operating Programs	Effect on Population Unit
Migration	PI's move to the local system, find and change housing within the local system, leave the local system.
Water System	Poor water quality increases dissatisfaction and high coliform count increases health costs and time lost due to illness.
Depreciation	Housing that depreciates becomes less attractive in the migration process.
Employment	PI's are assigned to full and part time jobs that maximize net income (salary minus transportation costs), employers search for best educated workers.
Transportation	PI's travel to work by the mode and route that minimizes total costs (dollar plus time), PI's travel to shopping along the minimum cost routes
School Allocation	Students of PI's are assigned to public or private schools based upon the quality of public schools.
Park Allocation	PI's are assigned to parks within a specified distance of where they live.
Time Allocation	Involuntary expenditures of leisure time are calculated as a function of the success of getting part time jobs, public adult education and the time spent on transportation.
Commercial Allocation	PI's are assigned to stores at which the total costs are minimized (price plus transportation to the store).

WATER COMPONENT

The water component is a subsector that, in a sense, cuts across the other three sectors or is a part of each. For example, some of the industrial activities in the economic sector use surface water in their production process and all other economic businesses have some need for municipally supplied water. Population units in the social sector use water as a function of their income class and the type of housing they inhabit. In the government sector, the Utility Department is responsible for supplying the municipal water needs of the residents of its jurisdiction.

Each of the surface water users requires a specified quality of water and must either treat the water they intake or purchase water from a source outside of the local system. Every water user adds some pollutants to the water it returns to the water system. If left untreated, these water discharges may lower the quality of water of the body of water into which they are dumped. Since water users and polluters are located in a geographical space, activities upstream and downstream are affected differently by the dynamically created water quality conditions.

THE RIVER BASIN MODEL AS A SYSTEMIC MODEL

The RIVER BASIN MODEL may be characterized as a systemic model. That is, it is a model of the interactive workings of the system it represents. The RIVER BASIN MODEL is not a predictive, projective, or normative model. It does not predict a future state of the area represented, although it does show the immediate status of the urban area given all the resources of the system and the policies attached to the use of those resources. Therefore, it is an impact model (one year at a time) concerned with resource allocation.

The RIVER BASIN MODEL is not a projection model because it does not extrapolate present circumstances and relationships into the future. In other words, the user of the model does not "turn it on" and generate a set of future states for the area represented. The model cycles in one year increments, and in a sense, it could be used for projection if the user made the year to year decisions for the urban area for a twenty or thirty year time period. But because of the broad scope of the model and the wide range of decisions that are based upon the results of previous decisions in the economic, social, and government sectors, this particular use of the model should not be looked on as a simple task.

Furthermore, the RIVER BASIN MODEL is not a normative or optimizing model. It will not itself generate optimal policy decisions. The model produces a thorough set of indicators and measures of the regional status at discrete points in time (the end of each year) and it is up to the user of the model to apply his own set of objective and subjective criteria to evaluate the absolute or relative quality of the environment. For example, the model will generate measures of water quality along stretches of the river, pollution dumped by various activities, local water deficiencies, poor schools, economic rates of return, housing quality, municipal services quality, social dissatisfaction, etc. and the user of the model must determine the values to be placed on these measures in the process of making policy decisions regarding the use of the regional resources in future years.

A systemic urban model such as the RIVER BASIN MODEL endeavors to represent the workings of a regional system and its major subsystems. This is done by selecting the major activities that comprise the urban system (people in households, businesses, and government agencies) and representing the actions that they pursue on a year to year basis. Population groups reside in housing, earn incomes, purchase goods and services, take part in leisure activities, utilize government and institutional services, transport themselves as they interact with activities that are spatially separated from their places of residence, and use water. Businesses purchase goods and services, hire labor, require utilities, produce output, sell output, pay taxes, invest earnings, use the transportation subsystem, use water, and generate pollutants that may be treated. Government agencies receive funds, purchase necessary goods and service, hire labor, provide service, and set policy. Most of the departments compete with the water quality office for a slice of the local budget.

CHAPTER III

Uses and Users of the Model

Broadly speaking, there are two types of users of the model when it is employed using a gaming format: the director and the players.

In each use of the model the director sets the major purpose for which the model will be employed. Usually the specific group of players he has in mind will determine his choice of the executive options, such as the starting regional configuration and any initial inputs to modify this basic configuration.

As shown in Figure 5, the director may affect the simulated region before play begins by selecting the basic configuration and making changes in it. He may also affect the year to year outside influences on the local system by, among other things, acting as the Federal and State governments with regard to granting aid and imposing regulations. For example, the director could act as an outside government that imposes rigid water quality standards. He could also act as a higher-level government that grants financial aid for the construction of waste treatment facilities, for comprehensive water resource planning, for enforcement and monitoring, etc. The following list is a sample of the executive options available to a director.

Choice of Initial Configuration: TWO CITY or RAYWID CITY

Initial Decisions:

- Change Economic Team Holdings—many possibilities.
- Change Social Team Holdings—many possibilities.
- Change Government Service Levels—give schools and/or municipal services higher or lower use indexes.
- Change Local Tax Structures—many possibilities.
- Change Salaries, Prices and/or Rents.
- Change Maintenance Levels.

To achieve:

- More or less team specialization or more or less equitable starting positions among teams.
- Create more or less neighborhood and/or single-class control.
- Make neighborhood attractiveness vary by altering the quality of public services.
- Shift to or away from dependence upon property, sales, and/or income taxes.
- Alter rates of return to economic sector or savings for social sector.
- Make area as a whole or parts of it more or less deteriorated.

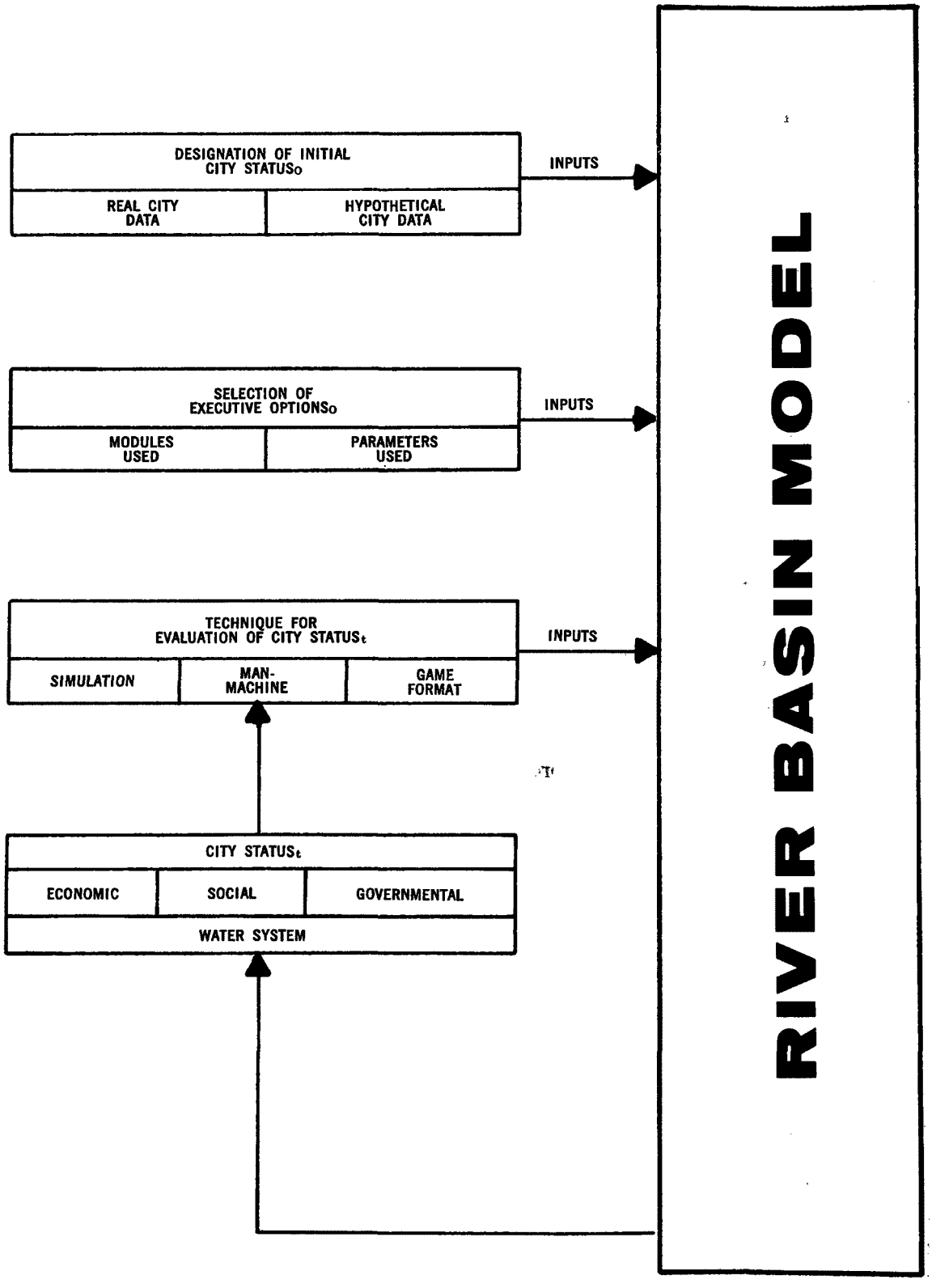
USING THE MODEL

The RIVER BASIN MODEL is a tool that has utility which is dependent upon the quantity and quality of data loaded into its files, the executive options employed by the director, and the technique used to evaluate the city status and generate inputs to the model. These three types of inputs to the model are illustrated in Figure 5.

Users will use the tool in a way that they find best suits their purposes. It is a flexible model that will take on different forms in the hands of different users. The RIVER BASIN MODEL provides a framework that is common for all regional decision-makers (much as a chemistry lab and the associated chemistry theory provide users of the lab with equal access to the facilities and accumulated knowledge). It allows the decision-maker to use this framework and the computer programs associated with it to achieve a wide range of objectives (much as the chemist may use the lab for instructional, research or production purposes).

Although the RIVER BASIN MODEL as presently developed will not satisfy every need of the decision-maker, it does allow him the opportunity to deal with a large number of regional phenomena which up to now he has not been able to deal with in a simulated and collapsed-time environment.

Figure 5.—ILLUSTRATIONS OF INITIAL AND CONTINUAL INPUTS TO THE RIVER BASIN MODEL



Users of the model are given control over all the resources of the local area being represented. Some of the local activities use the water subsystem while others do not. As a result of this, the water quantity and quality is of varying importance to the various activities represented by the model.

The RIVER BASIN MODEL is oriented toward user requirements such as generality of representation, flexibility of change, ease of inputs, and readability of output. The model provides, among other things, detail on the repercussions of various water quantity and quality levels and on the effects of water resource decisions on people and business activities. It also illustrates the impact of other decisions on the water subsystem itself.

A wide range of decisions and their consequences may be illustrated by the model. For example, in the economic sector the impacts of pollution regulation decisions may be shown. In the social sector, the effect on housing selection, employment, shopping, and leisure activities are influenced by water resource policies. The impacts of many government decisions may be shown: comprehensive planning programs, quality of life improvements, and many more.

The users of the model may make a wide range of private and public policy decisions which affect the water subsystem and others. The detailed and summary computer output reveals the interactions of these decisions and the collective impact they have on the environmental quality of the represented area. Since each cycle of the model represents the passage of a year of time in the area being represented, the model may be run for as many cycles as the users find desirable.

MODEL FEATURES

User interaction in the RIVER BASIN MODEL:

- Requires fewer model assumptions on the part of the designer than most previous models because the users provide much of the nonquantifiable relationships and inputs to the represented system.
- Allows realistic human interaction and reaction.
- Allows political repercussions associated with water resource decisions, reversal of policy, etc.
- Allows human involvement in the decision process.

The RIVER BASIN MODEL deals with:

- External Inputs—area characteristics, including the present water subsystem and quality levels.
- Internal Inputs—wide range of water resource, economic, social, and government decisions.
- Internal Outputs—changes in the resources of the individual decision-makers.
- External Outputs—changes in the area characteristics, allocations, assignments, matching of supply and demand, insufficiency of government services, and complete status of the water subsystem.

The RIVER BASIN MODEL is useful to citizens as well as planners because the model output is designed in such a way that it is comprehensive, easy to understand, and quick to retrieve. Thus, regardless of the sophistication of the user, the model will provide the necessary level of information upon which evaluations can be made and decisions can be generated.

The cycles of the model (each set of computer output) represent one year in the life of the area represented by the model. Users provide the evaluation of the current status of the area (in its economic, social, governmental, spatial, and water quantity and quality dimensions). Through a wide range of decision alternatives, they are able to devise strategies and implement policies in an attempt to achieve any set of goals or objectives they devise, as individuals or collectively.

These decision inputs may be generated in a simulation environment (in which a single user or group of users such as water resource planners are given control over all the resources of the local system) or in a game environment (in which individual users such as local officials, students and/or citizens are given control over various resources in the local system).

The RIVER BASIN MODEL has been designed in a modular fashion, so that new modules may be added or existing ones replaced or modified at minimal expense. This modularity means that it is relatively easy to:

- Redefine the model (change parameters and coefficients).
- Load various regions.

This modular feature of the RIVER BASIN MODEL allows it to be truly evolutionary, thus making it a framework that can continually be improved and modified for specific uses.

CHAPTER IV

Model Output

The model describes and interrelates many of the actual economic, social, and governmental activities that comprise regional areas. The metropolitan area represented by the model is described by three types of computer output: maps, tabular statistics, and indicators.

MAPS

The maps show the spatial characteristics of the represented area. The tabular output shows general information of interest to the users of the model as well as specific data concerning businesses in the economic sector, groups of people in the social sector, and government departments in the government sector. The indicators are measures such as the economic rate of return, the social dissatisfaction level, the quality of local government services, and water quality indicators.

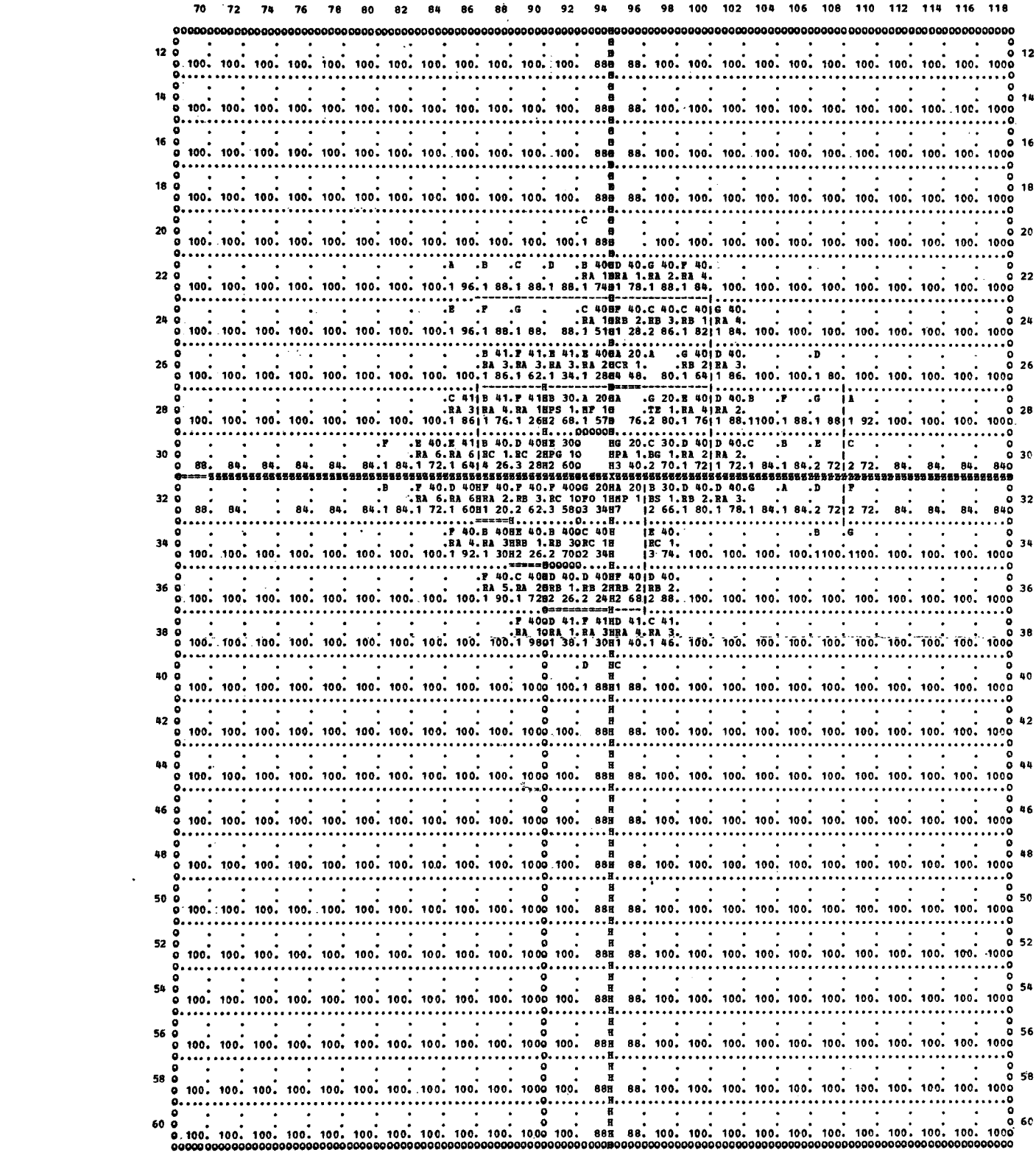
Of the dozens of maps, the Economic Status Map (Figure 6) stands out as the one of single most importance. Any represented area may be defined by spatially locating land use activities, the highway network and the water system in any desired pattern on the grid map. Although this map does not show the local water system, there are a number of maps that do.

All physical objects (industries, stores, housing, schools, government facilities, roads, rivers, and treatment plants) are located in a specified section of the regional area. Most facilities are located on parcels of land (identified by two even coordinate numbers). Roads are located (conceptually) along the boundaries (sides) of the square land parcels (identified by an even-odd or odd-even number). A road on the map actually represents all the major and minor roads that connect an origin and a destination at each end of the transportation link. Transportation terminals are located at the corners of parcels (identified by two odd-numbered coordinates).

Other local system phenomena are also spatially located. Population units are housed in residences on parcels, service districts and farms are defined in terms of contiguous parcels of land. Figure 7 is a list of the map output separated into ten categories.

FIGURE 6

TWOCITY — ECONOMIC STATUS MAP — ROUND 1



PARCEL KEY
TOP LEFT: OWNER
TOP RIGHT: ZONING
MIDDLE: LAND USE AND LEVEL
BOTTOM LEFT: UTILITY LEVEL
BOTTOM RIGHT: % UNDEVLPD LAND

PARCEL EDGES
.. .. ROADBED
-- || TYPE 1 ROAD
== HH TYPE 2 ROAD
88 HH TYPE 3 ROAD
00 00 JURISDICTION BOUNDARY

INTERSECTIONS
* TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

ZONING	LAND USE
--	ANY USE
10	ANY BUSINESS
20	HI,LI,CI
21	HI
22	LI
23	CI
30	NS,BG,BS,PG,PS
31	NS
32	BG

ZONING	USE
33	BS
34	PG
35	PS
40	RA,RB,RC
41	RA
42	RB
43	RC
50	PARKLAND

FIGURE 7—*Map Output Generated for Each Cycle of Operation*

Map Category	Map Number	Map Name
Commercial	10.1	Personal Goods Allocation Map
	10.2	Personal Services Allocation Map
	10.3	Business Commercial Allocation Map
Government Service	10.4	Municipal Service
	10.5	School Map
	10.6	Utility Map
Water System	10.7	Water Usage Map
	10.8	Water Quality Map
	10.9	Municipal Treatment
	10.10	Municipal Intake and Outflow Point Map
	10.11	Surface Water Map
	10.12	Farm Runoff Map
	10.13	River Basin Flood Plain Map
Farms	10.14	Farm Map
Property Values	10.15	Farm Assessed and Market Value Map
	10.16	Market Value Map
	10.17	Assessed Value Map
Land Use and Regulations	10.18	Economic Status Map
	10.19	Highway Map
	10.20	Planning and Zoning Map
Parks	10.21	Parkland Usage Map
Social Characteristics	10.22	Socio-Economic Distribution Map
	10.23	Demographic Map
	10.24	Social Decision-Maker Map
Physical Characteristics	10.25	Topographical Restriction Map
Government Facilities	10.26	Government Status Map

TABULAR COMPUTER OUTPUT

The economic, social, and government teams receive computer output that describes the details of the resources over which they have decision-making power. In addition to this team-specific information, general and summary statistics describing the represented area are available as common information to all teams. A list of all the tabular output is shown in Figure 8.

To provide examples of the tabular output, the following descriptions of migration and the water system are provided.

Migration

The basic population grouping in the model is the population unit (PI). A PI is designated as being a member of a socio-economic class (H, M, or L).

PI's move into, within, and out of the local system in response to available employment opportunities, housing quantity and quality, and a number of other factors. Figure 9 shows a sample of the summary migration statistics for an area and a portion of the detailed statistics.

The Migration-Housing computer routine calculates dissatisfaction (environmental and personal); develops a pool of movers comprised of the population displaced by housing demolition, a percent of the most dissatisfied, a percent of the total population (random movers), natural population growth, and the in-migrants; and moves the members of this pool into housing that has adequate capacity and quality.

A certain percentage of each income class that are either unemployed or underemployed outmigrate from the local system. Other movers who cannot find adequate local housing also become outmigrants.

Referring to Figure 9, the PI's living in the residences (or considering to live in the residences) on parcel 9422 see a health index of 50 (the higher the index the worse the situation). The time indexes are calculated only for the income classes actually living on the parcel. For example, on parcel 9422 there were PM groups living there and because of the distance and mode used to travel to work, 25 units of dissatisfaction were added to the personal index. Another 59 units were added to the index because of the amount of leisure time that was spent in involuntary pursuits.

FIGURE 8—*Tabular Output*

Output Category	Code Number	Output Name
Migration	1.1	Environmental Indexes
	1.2	Personal Indexes
	1.3	Dissatisfaction Cutoffs
	1.4	Migration Detail
	1.5	Migration Statistics
	1.6	Migration Summary
Water System	2.1	Water User Effluent Content
	2.2	River Quality During Surface Water Process
	2.3	Water User Costs and Consumption
	2.4	Coliform and Pollution Index Values
Employment	3.1	Employment Selection Information for PL Class
	3.2	Employment Selection Information for PM Class
	3.3	Employment Selection Information for PH Class
	3.4	Part-Time Work Allocation for PH Class
	3.5	Part-Time Work Allocation for PM Class
	3.6	Part-Time Work Allocation for PL Class
	3.7	Employment Summary
Commercial Allocation	4.1	Personal Goods Allocation Summary
	4.2	Personal Services Allocation Summary
	4.3	Business Goods Allocation Summary
	4.4	Business Services Allocation Summary
	4.5	Government Contracts
	4.6	Terminal Demand and Supply Table
	4.7	Terminal Allocation Map
Social Sector	5.1	Dollar Value of Time
	5.2	Social Decision-Maker Output
	5.3	Social Boycotts
Economic Sector	6.1	Farm Output
	6.2	Residence Output
	6.3	Basic Industry Output
	6.4	Commercial Output
	6.5	Economic Boycott Status
	6.6	New Construction Table
	6.7	Land Summary
	6.8	Loan Statement
	6.9	Financial Summary
Social and Economic Summaries	7.1	Number of Levels of Economic Activity Controlled by Teams
	7.2	Employment Centers
	7.3	Economic Control Summary for Teams
	7.4	Social Control Summary for Teams
	7.5	Social Control Summary Totals
	7.6	Economic Graphs for Teams
	7.7	Social Graphs for Teams
Government Detail	8.1	Assessment Report
	8.2	Water Department Reports
	8.3	Sampling Station Report: Point Source Quality
	8.4	Sampling Station Report: Ambient Quality
	8.5	Utility Department Report
	8.6	Utility Department Finances
	8.7	Municipal Services Department Report
	8.8	Municipal Services Department Finances
	8.9	Municipal Services Department Construction Table
	8.10	Planning and Zoning Department Report
	8.11	School Department Report
	8.12	School Department Finances
	8.13	School Department Construction Table
	8.14	Highway Department Finances
	8.15	Highway Department Construction Table
	8.16	Rail Company Report
	8.17	Bus Company Report
	8.18	Chairman Department Finances
	8.19	Tax Summary
	8.20	Financial Summary
Summary Statistics	9.1	Demographic and Economic Statistics

TWOCITY
PERSONAL INDEXES

FIGURE 9

ROUND 2

LOCATION	HEALTH INDEX: HS EFFECT	HEALTH INDEX: CROWDING EFFECT	HEALTH INDEX: BACTERIA EFFECT	HEALTH INDEX: TOTAL	CLASS	TRANSP. TIME	RECR.	INVOL. TIME	PERSONAL INDEX
9422	25	25	0	50	MIDDLE	25	0	59	134
9622	25	0	0	25	LOW	25	0	76	126
9822	25	0	0	25	LOW	65	0	68	158
10022	25	0	0	25	LOW	105	0	60	190

TWOCITY
ENVIRONMENTAL INDEXES

ROUND 2

LOCATION	POLLUTION INDEX	NEIGHBORHOOD INDEX: CLASS	RESIDENCE QUALITY	RENT	HS	SCHOOL	WELFARE OR TAXES	TOTAL	ENVIRONMENTAL INDEX
9422	-7	LOW	19	0	100	0	12	131	124
		MIDDLE	39	0	100	0	24	163	156
		HIGH	49	0	100	0	24	173	166
9622	-15	LOW	44	0	100	0	16	160	145
		MIDDLE	64	0	100	0	18	182	167
		HIGH	74	0	100	0	18	192	177

TWOCITY
MIGRATION DETAIL

ROUND 2

PARCEL	OWNER	TYPE	SOCIAL DECISION MAKER	NUMBER OF P'S	CLASS	QUALITY OF LIFE	NUMBER MOVED		FROM/TO PARCEL	REASON FOR MOVING	EMPLOYER
9422	G	RA 1	F	1	LOW	0	1	CAME FROM	10030	DISPLACEMENT	9828
			C	1	MIDDLE	290	1	WENT TO	10826	DISPLACEMENT	9626
9622	D	RA 1	D	2	LOW	271					
9822	G	RA 2	D	4	LOW	286	1	CAME FROM	10024	DISPLACEMENT	9630

MIGRATION BY TYPE

MIGRATION DUE TO UNEMPLOYMENT

LOW CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	4
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIDDLE CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

HIGH CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIGRATION DUE TO UNDEREMPLOYMENT

LOW CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIDDLE CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	3
JUR-2	0	0	0	2
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

HIGH CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	2
JUR-2	0	0	0	1
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIGRATION DUE TO MOBILITY

LOW CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIDDLE CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	2	3	0	0
JUR-2	1	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

HIGH CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	2	1	0	0
JUR-2	4	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIGRATION DUE TO PERSONAL DISSAT.

LOW CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	15	0	6
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIDDLE CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	6	6	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

HIGH CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	19	1	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIGRATION DUE TO DISPLACEMENT

LOW CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	1	4	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIDDLE CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	5	0	0
JUR-2	0	3	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

HIGH CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	3	0	0
JUR-2	1	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	0	0	0

MIGRATION DUE TO NATURAL GROWTH

LOW CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	2	0	0

MIDDLE CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	2	1	0	0

HIGH CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	0	3	0	0

MIGRATION DUE TO IN-MIGRATION

LOW CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	2	11	0	32

MIDDLE CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	2	0	0	0

HIGH CLASS

FROM/TO	JUR-1	JUR-2	JUR-3	OUTSIDE
JUR-1	0	0	0	0
JUR-2	0	0	0	0
JUR-3	0	0	0	0
OUTSIDE	2	0	0	0

Note that there are six items that comprise the environmental index and their contributions to that index are listed in the output. The number of population units that move to and from each residential parcel and their reasons for moving are also shown in the output.

The purpose of showing Figure 9 is not to explain how the migration process works but to illustrate that the full results of the process are illustrated on tabular computer output that can be of great assistance to the users of the model in their decision-making.

The Water System

Figure 10 shows some tabular computer output for a local system river (River 2). This output shows the location of each segment of the river, the quality rating and major pollutant, the time period in the water's passage through a parcel, the amount of each of the seven pollutant types, and the volume of the water.

Once again, it is not important that the reader fully understand this information at this time. It is illustrated here only for the purpose of showing the type of tabular computer output generated each round as part of the model operation.*

INDICATORS

The model output is also expressed in some instances by indicators. Major indicators in the economic sector are net worth for teams and rates of return on individual investments. Major indicators in the social sector are the per capita personal incomes and the quality of life indexes. Major government indicators are the service use indexes for schools, parks, and municipal services and congestion of highways. Major indicators in the local water system are the water quality ratings.

Figure 11 shows the average quality of life index for the population units (by class) controlled by a social team. Figure 12 shows the Water Quality Map for TWO CITY in Round 2.

THE RIVER BASIN MODEL AS A SET OF REGIONAL ACCOUNTS

Since the RIVER BASIN MODEL is a model of an entire regional system, there is the requirement that accounts balance within the local system. For example, every expenditure for one activity is an income for another activity. Similarly, local sales and income from services rendered are actually derived by totaling the expenditures made by the PI's or business activities for these goods and/or services. Therefore, the impact of water quality and cost decisions on the financial accounts for various population and business groups and by location can be followed over time. Not only are water usage figures calculated, but also expenditures for water, pollution treatment and fines. In short, the RIVER BASIN MODEL is a systems accounting framework as well as an integration of many market models within a spatial context.

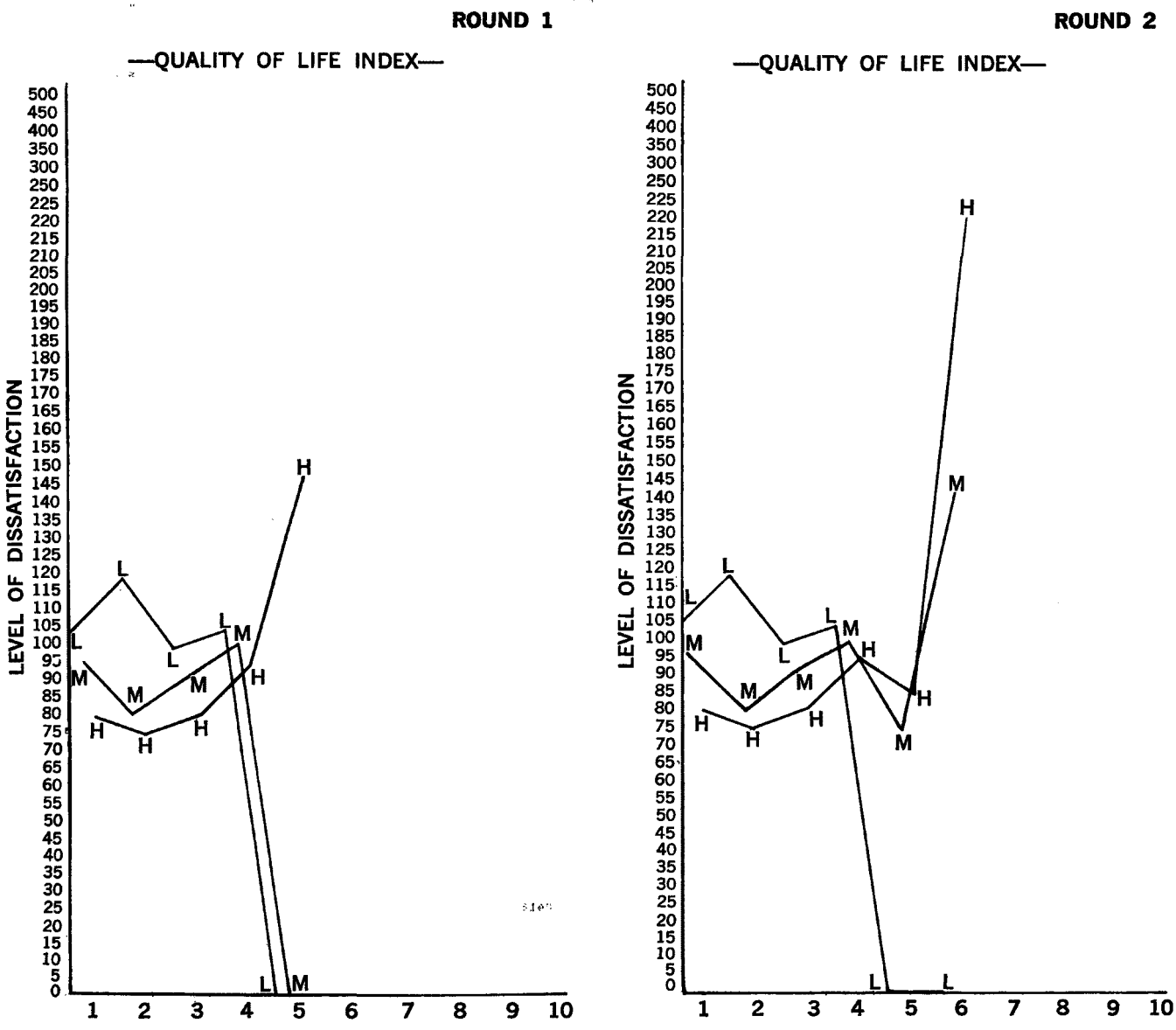
*Information of this type is presented in great detail in the fourteen manuals which accompany the model computer program.

FIGURE 10

RAYNID CITY
RIVER QUALITY DURING SURFACE WATER PROCESS: RIVER 3 ROUND 1

LOCATION	QUALITY	TIME	BOD (X 100)	CHLORIDES (X 100)	NUTRIENTS (X 100)	COLIFORM (X 100)	TEMPERATURE (X 100)	AGE OF OFS	AGE OF HLW	AMOUNT (MGDX100)
11234	10	FROM OTHER PARCELS	0	0	33615	0	0	0	0	15000
11234	10	AFTER AGING	0	0	33615	0	0	0	0	15000
11234	10	BEFORE BIO CHANGE	0	0	26668	0	0	0	0	11900
11234	10	AFTER BIO CHANGE	0	0	25051	0	0	0	0	11900
11234	91	EFFLUENT ADDED	1240004	775001	12400010	1550	12400	0	1	3100
11234	88	MOVED TO NEXT PARCEL	1240004	775001	12425061	1550	12400	0	1	15000
11236	78	AFTER AGING	1240004	775001	12425061	1550	12400	0	2	15000
11236	78	BEFORE BIO CHANGE	1240004	775001	12425061	1550	12400	0	2	15000
11236	78	AFTER BIO CHANGE	1183640	697500	11672027	1432	0	0	2	15000
11236	0	EFFLUENT ADDED	0	0	0	0	0	0	0	0
11236	88	MOVED TO NEXT PARCEL	1183640	697500	11672027	1432	0	0	2	15000
11238	78	AFTER AGING	1183640	697500	11672027	1432	0	0	3	16200
11238	78	BEFORE BIO CHANGE	1183640	697500	11672027	1432	0	0	3	16200
11238	78	AFTER BIO CHANGE	1129838	627749	10964631	1323	0	0	3	16200
11238	0	EFFLUENT ADDED	0	0	0	0	0	0	0	0
11238	88	MOVED TO NEXT PARCEL	1129838	627749	10964631	1323	0	0	3	16200
11038	88	AFTER AGING	1129838	627749	10964631	1323	0	0	4	17000
11038	88	BEFORE BIO CHANGE	1129838	627749	10964631	1323	0	0	4	17000
11038	88	AFTER BIO CHANGE	1078481	564974	10300108	1222	0	0	4	17000
11038	0	EFFLUENT ADDED	0	0	0	0	0	0	0	0
11038	88	MOVED TO NEXT PARCEL	1078481	564974	10300108	1222	0	0	4	17000
11040	88	AFTER AGING	1078481	564974	10300108	1222	0	0	5	17000
11040	88	BEFORE BIO CHANGE	1078481	564974	10300108	1222	0	0	5	17000
11040	88	AFTER BIO CHANGE	1029459	508476	9675859	1129	0	0	5	17000
11040	0	EFFLUENT ADDED	0	0	0	0	0	0	0	0
11040	88	MOVED TO NEXT PARCEL	1029459	508476	9675859	1129	0	0	5	17000
11042	63	AFTER AGING	1029459	508476	9675859	1129	0	0	0	17000
11042	63	BEFORE BIO CHANGE	1029459	508476	9675859	1129	0	0	0	17000
11042	63	AFTER BIO CHANGE	982665	457628	9089443	1043	0	0	0	17000
11042	10	EFFLUENT ADDED	0	0	180000	0	0	0	0	10000
11042	63	MOVED TO NEXT PARCEL	982665	457628	9269443	1043	0	0	0	17000
10842	63	AFTER AGING	982665	457628	9269443	1043	0	0	0	17500
10842	63	BEFORE BIO CHANGE	982665	457628	9269443	1043	0	0	0	17500
10842	63	AFTER BIO CHANGE	937998	411865	8707658	963	0	0	0	17500
10842	0	EFFLUENT ADDED	0	0	0	0	0	0	0	0
10842	63	MOVED TO NEXT PARCEL	937998	411865	8707658	963	0	0	0	17500
10642	63	AFTER AGING	937998	411865	8707658	963	0	0	0	17500
10642	63	BEFORE BIO CHANGE	937998	411865	8707658	963	0	0	0	17500
10642	63	AFTER BIO CHANGE	895361	370678	8179921	890	0	0	0	17500
10642	0	EFFLUENT ADDED	0	0	0	0	0	0	0	0
10642	63	MOVED TO NEXT PARCEL	895361	370678	8179921	890	0	0	0	17500
10644	63	AFTER AGING	895361	370678	8179921	890	0	0	0	17500
10644	63	BEFORE BIO CHANGE	895361	370678	8179921	890	0	0	0	17500
10644	63	AFTER BIO CHANGE	854662	333610	7684168	822	0	0	0	17500
10644	0	EFFLUENT ADDED	0	0	0	0	0	0	0	0
10644	63	MOVED TO NEXT PARCEL	854662	333610	7684168	822	0	0	0	17500
10646	63	AFTER AGING	854662	333610	7684168	822	0	0	0	18000
MUNICIPAL INTAKE POINT, UTILITY DISTRICT 11 1164 MGD REQUIRED										
10646	63	BEFORE BIO CHANGE	652202	254581	5863873	627	0	0	0	13736
10646	63	AFTER BIO CHANGE	622556	229122	5508486	579	0	0	0	13736
10646	91	EFFLUENT ADDED	3100002	1550000	24928000	1550	12400	0	1	7100
10646	92	MOVED TO NEXT PARCEL	3722558	1779122	30436486	2129	12400	0	1	18000
10648	92	AFTER AGING	3722558	1779122	30436486	2129	12400	0	2	18000
10648	92	BEFORE BIO CHANGE	3722558	1779122	30436486	2129	12400	0	2	18000
10648	92	AFTER BIO CHANGE	3553350	1601209	28591840	1967	0	0	2	18000
10648	81	EFFLUENT ADDED	225831	63135	77155	137	0	0	0	1164
10648	92	MOVED TO NEXT PARCEL	3779181	1664344	28668995	2104	0	0	2	18000
10448	92	AFTER AGING	3779181	1664344	28668995	2104	0	0	3	18000
10448	92	BEFORE BIO CHANGE	3779181	1664344	28668995	2104	0	0	3	18000
10448	92	AFTER BIO CHANGE	3607400	1497909	26931472	1944	0	0	3	18000
10448	0	EFFLUENT ADDED	0	0	0	0	0	0	0	0
10448	92	MOVED TO NEXT PARCEL	3607400	1497909	26931472	1944	0	0	3	18000
10248	92	AFTER AGING	3607400	1497909	26931472	1944	0	0	4	18000
10248	92	BEFORE BIO CHANGE	3607400	1497909	26931472	1944	0	0	4	18000
10248	92	AFTER BIO CHANGE	3443427	1348118	25299248	1796	0	0	4	18000
10248	0	EFFLUENT ADDED	0	0	0	0	0	0	0	0
10248	81	MOVED TO NEXT PARCEL	3443427	1348118	25299248	1796	0	0	4	18000
10048	81	AFTER AGING	3443427	1348118	25299248	1796	0	0	5	18500
10048	81	BEFORE BIO CHANGE	2289413	896316	16820576	1194	0	0	5	12300
10048	81	AFTER BIO CHANGE	2185348	806684	15801148	1103	0	0	5	12300
10048	91	EFFLUENT ADDED	2480010	1550001	24800016	3100	24800	0	1	6200
10048	92	MOVED TO NEXT PARCEL	4665358	2356685	40601164	4203	24800	0	1	18500

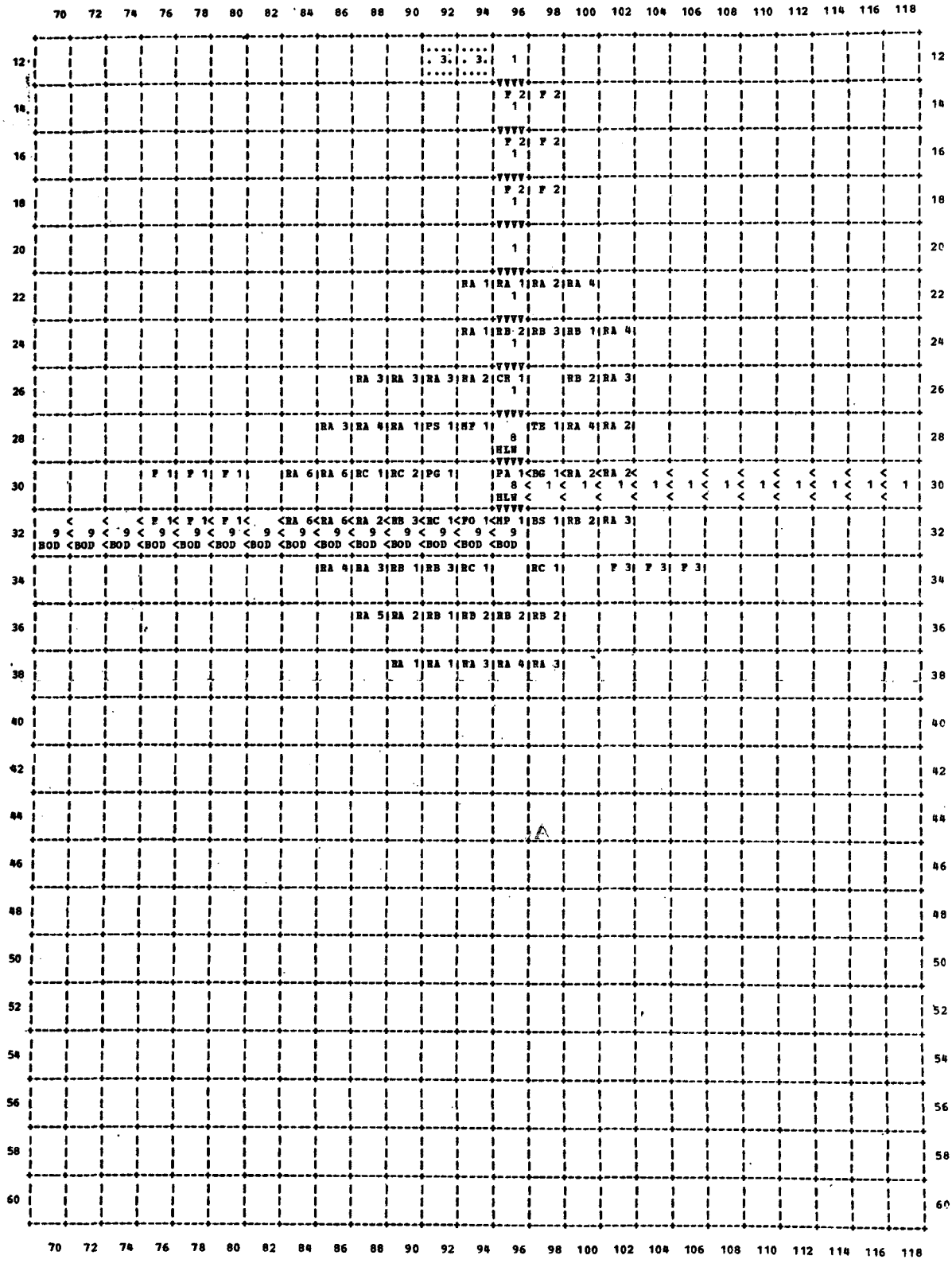
Figure 11.—SAMPLE OF QUALITY OF LIFE OUTPUT FOR POPULATION GROUPS



TWOCITY
WATER QUALITY MAP

FIGURE 12

ROUND 1



PARCELS

TOP ROW: ECONOMIC ACTIVITY TYPE
AND OPERATING LEVEL
FARM TYPE IF FARM OR PARCEL
MIDDLE ROW: SURFACE WATER QUALITY RATING
BOTTOM ROW: WORST POLLUTANT

.... LAKE PARCELS

PARCEL EDGES

>AV< DIRECTION OF FLOW

---- NO WATER FLOWING
BETWEEN PARCELS

CHAPTER V

Model Inputs

Three types of model inputs should be distinguished: initial director inputs, player inputs, and continual director inputs.

INITIAL DIRECTOR INPUTS

Some of the initial director inputs were discussed under the chapter on users of the model. Briefly, he can choose a prespecified (two at this time) starting configuration. With this configuration he may make any number of changes to alter the starting scenario. Or, he can load into the computer a starting configuration that he has fashioned out of real or hypothetical data.

The initial starting position of the model is very flexible in several ways. First, any desired initial land use pattern may be represented. Thus, a model run could begin with development ranging from a blank board to a fully occupied land area. Also, from one to fifteen separate local governments can be represented.

Second, the population classes placed into housing, rents charged at housing, prices charged at stores, salaries offered by employers, taxes charged by local governments, etc. can be set in an infinite number of patterns. For example, the five population classes could be distributed among the housing stock in such a way that there was much or little income segregation, overcrowding or under-occupancy, etc. Or any transportation subsystem configuration could be represented.

Third, the control over the economic, social, and governmental resources of the represented area can be allocated among users of the model in any way desired. For example, if a single person were using the model for research or simulation purposes, all of the economic assets could be placed under the control of a single corporation. If the model is being used for citizen participation or educational purposes, the director of the model might choose to have the resources of the community allocated in such a way that some corporations own only one type of economic activity (industry, commercial establishments, residences, or land) or several types of activities (a mix of industrial, commercial, residential, and vacant land).

The economic, social, and government sector computer output describes the details of the resources in these sectors. In addition to this specific information, general and summary statistics describing the represented area are available as information common to all the model users.

Model users provide the evaluation of the status of the area as a whole and of the individual sector resources in particular, develop goals and objectives, formulate strategies, and make decisions for the coming calendar year. All the information on the computer print-outs describes the represented area at one point in the year. All decisions that are made take effect at that time and their impact is not seen until the decisions are processed through the computer and a new status is generated for the next year.

A subset of the initial director decisions are those that relate to the local water system. The director through the load program may create a region that has any mix of water quantity and quality characteristics. For example, a region could be configured that had very low quality water and no treatment facilities at the start of play. Or an initial starting point could be developed that had all the pollution created by activities in one jurisdiction have its major detrimental effects on activities and people in a downstream jurisdiction.

PLAYER INPUTS

Players have available to them a wide number of possible formal decisions (ones that require process-

ing by the computer) and they have an infinite number of informal decision options open to them. The formal decisions available to the players are summarized in Figure 13 under the three sector headings.

A subset of the player decisions are those that relate to the local water system. Economic decision-makers may build waste treatment facilities for their industries that dump into the local water system. They may also cut back operating levels of businesses in order to reduce the pollution they generate. These two decisions do not fully indicate the impact that the water component has or may have on the specific sections of the local system because of inadequate water supply, high municipal water costs, poor surface water quality, poor transportation access caused by the absence of bridges to cross a river, etc.

FIGURE 13—*Decisions Available To Users of the Model*

1. Economic Decision-Makers
   - buy and sell land
   - set rents
   - set prices
   - set salaries
   - set maintenance levels
   - lend money
   - borrow money
   - buy and sell conservative stocks
   - buy and sell speculative stocks
   - build and demolish three types of residences, twelve types of basic industries, and four types of commercial establishments
   - contract with construction industries
   - transfer money to other economic and social and government decision-makers
   - boycott commercial establishments
   - construct chlorination, primary, secondary and tertiary effluent treatment facilities at basic industries
   - change the operating level of a business (without demolishing the building)
   - set the amount of water which is recycled at basic industries
   - construct residences which use ground water
   - operate farms
2. Social Decision-Makers
   - allocate time to extra work, education, politics and recreation
   - boycott work locations, commercial establishments, and modes of travel
   - vote for elected officials
   - set the dollar value of time travelling to work
   - transfer money to other social, economic and government decision-makers
3. Government Decision-Makers
   - grant appropriations
   - grant subsidies
   - transfer money to other government and social and economic decision-makers
   - set welfare payments
   - set tax rates
   - float bonds
   - assess land and buildings
   - buy and sell land
   - set the number of job openings in government
   - set the maintenance level of government facilities
   - set government service districts
   - request Federal-State aid
   - set the salaries offered government workers
   - build and demolish schools
   - build and demolish municipal service plants
   - contract with construction industries
   - grant contracts with local goods and services establishments for government purchases
   - set the amount of public adult education offered by the government
   - construct and demolish roads
   - construct and demolish terminals
   - zone land
   - build and demolish public institutional land uses
   - provide parkland
   - install utility service
   - set prices for utility service
   - construct and demolish utility plants
   - locate bus routes
   - buy and sell buses
   - set bus and rail fares
   - build rail lines
   - build rail stations
   - buy and sell rail rolling stock
   - locate rapid rail routes
   - set the amount of service on bus and rail routes
   - set prices for private use of publicly-provided water
   - construct and demolish primary, secondary, and tertiary sewage treatment plants
   - construct and demolish water intake treatment plants
   - locate municipal water intake points
   - locate municipal sewage outflow points
   - locate water sampling stations
   - set dam priorities
   - change a business's operating level (without demolishing the building)
   - construct and demolish bridges across rivers

Social sector decision-makers may be very much affected by the quantity and quality of water in the local system, but they make no direct water decisions. They do vote for elected officials, however, and to the extent that water issues are an important local concern, the social sector might influence water resource decision-making a great deal indirectly through the ballot box. These votes might be for water related referenda as well as for political officers.

The Utility Department in each jurisdiction (through its Water Office) has a number of decisions that it may make. It sets the price of municipal water for different types of buyers. It may construct

intake and outflow treatment plants and locate them to best advantage taking into account water supply and quality, downstream activities, land costs, and local sentiment. It may choose where in the local water system to remove water for public consumption and where to dump the municipal wastes.

Furthermore, the water resources decision-maker may fund and locate sampling stations (ambient or point source) and set dam operating priorities (to favor recreation, flood control, and/or pollution control). Other government departments compete with the Utility Department for local citizen support and possibly for outside government financial assistance. The Highway Department is affected directly by the local water system in that it costs more to put highways across parcels that contain rivers. This higher cost represents the added expense of building bridges and tunnels.

Figure 14 shows an example of a completed team decision form and the computer "Edits" of a set of decisions for a round of the model. Since collectively the teams comprise most of the major local decision-makers of the represented area, most of the change that will take place from one round to the next will be a function of the number and type of decisions generated by the teams. The major decisions not made by the teams are those made either by computer simulators which represent the outside system impacts on the local system or by the director who may act as higher level governments or as Mother Nature and cause floods, earthquakes, and/or other forms of natural disaster.

Teams will often note that the decisions of other teams have significant effect on their own output, especially on the indicators. For example, the water quality rating for a particular section of the river might increase tremendously because of the creation of more housing with no increase in the municipal treatment facilities. Rates of return might drop because of increased local tax rates or assessments, higher maintenance costs or service charges, increased competition, etc. Or housing dissatisfaction might increase because the housing stock has deteriorated, rents have gone up, or local government services have decreased in quality.

The interactions among the various components of the urban system that cause these interrelated movements of decisions and indicators is generated

Figure 14.—SAMPLE OF INPUTS AND EDITS

INPUTS

Decision Code	Decision-Maker	a	b	c	d	e	f	g	h	i
$ OUBLD / =	A /	7012,	RB,	0,	1,	50,	60,	0,	145,	
$ OUBLD / =	E /	8430,	RA,	6,	4,	,	,	,	,	
$ FSA / =	SC1 /	2,	9030,	,	,	,	,	,	,	
$ FSA / =	SC1 /	1,	10812,	,	,	,	,	,	,	
$ TIME / =	BB /	42,	20,	0,	15,	5,	5,	,	,	
$ / =	/	,	,	,	,	,	,	,	,	

EDITS

```
$OUBLD/-A/7012,RB,0,1,50,60,0,145*      NO UTILITIES
REQUIRES LEVEL 1 UTILITY SERVICE ONLY HAS LEVEL 0


$OUBLD/=F/8430,RA,6,4*

$FSA/=SC1/2,9030*
AID REQUEST OF SC1 FOR  9030 GRANTED
```

by several major simulations contained within the computer program of the model. The model is indifferent as to how the inputs are generated. That is, the inputs could be generated as a result of a game format or by a single model user. The game format could be capitalistic and democratic in nature or socialistic.

PERIODIC DIRECTOR INPUTS

The director may act as the outside system by controlling land purchases, loans, cash transfers, exogenous employment, federal aid, the business cycle, and the effects of Mother Nature. These effects on the local system require computer inputs on the part of the director. A number of other influences he may exert on the local system and its decision-makers are handled in the gameroom and need no interface with the computer. For example, the director could impose higher government regulations on the local system in the form of water quality standards, school quality, or municipal service standards. The director could also change player assignments (switch players among several teams), make some computer information inaccessible (or acquired only at high cost), prevent or encourage team interaction by their physical placement in the gameroom, require rounds to be played in a specified amount of real clock time, or a number of other things.

Each director will find that he can affect the play a great deal and force the local system to deal with problems created by him if he wishes to exercise some of these director options. On the other hand, the director is not forced to make any of these periodic inputs. The model will continue to function without his use of these prerogative director decisions.

SUMMARY

Figure 15 summarizes the user inputs to the model. This figure shows the interaction of the user (as director or participant) of the model with the game component and with the phases of the model. First, as part of "Model Definition" the director has the option to define parts of the model (parcel size, jurisdiction boundaries, population-scale, etc.). Second, as part of the "Data Base Input" he can input two types of data—parameter values for the operating programs (for example, coefficients for migration, typical construction costs, normal units of production for industries, etc.) and the number and location of population units and activities (for example, residences and the social class of the occupants, businesses, government buildings, roads, bodies of water, etc.).

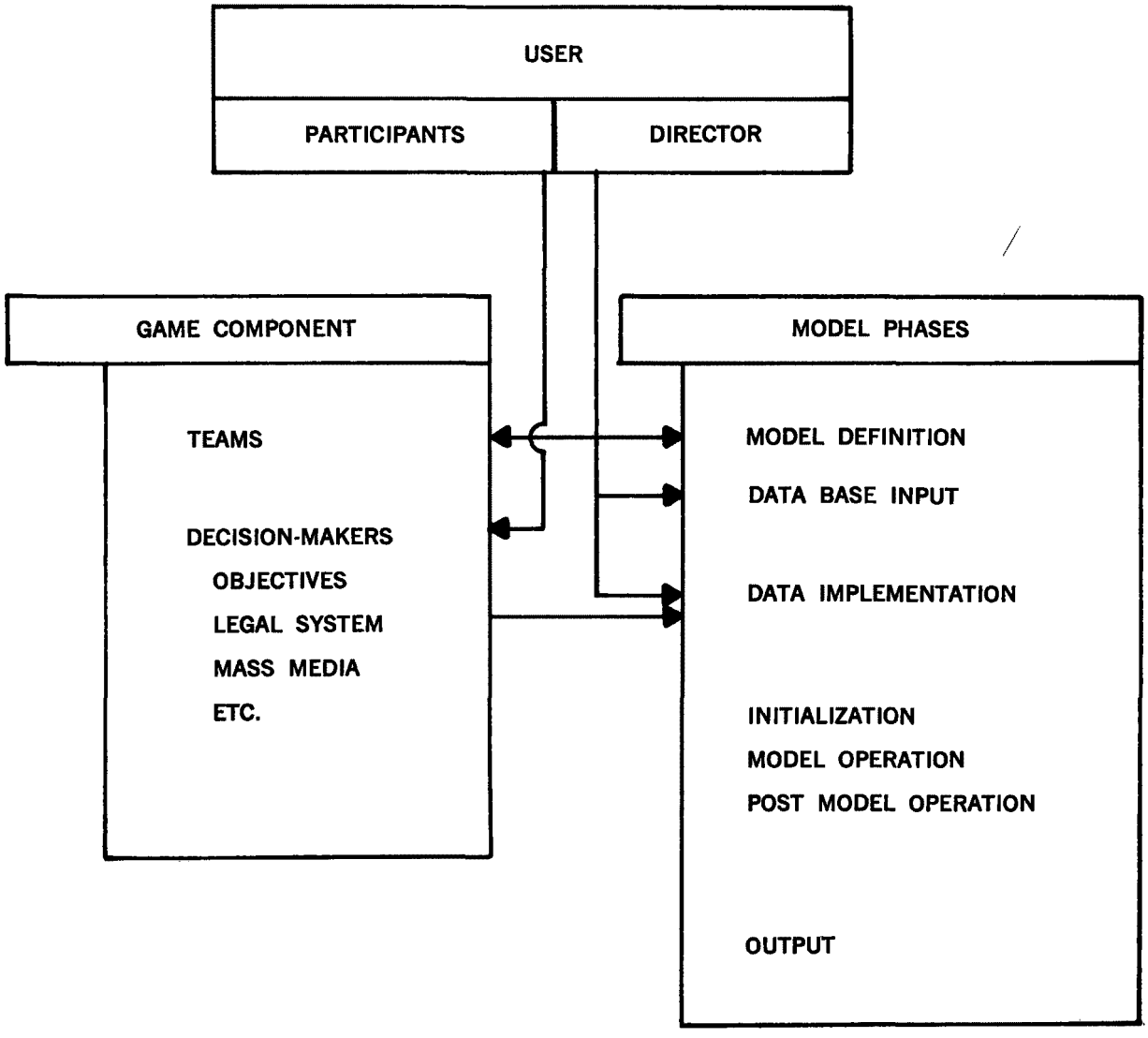
The director makes these decisions once, and they define the starting configuration of the system to be represented. The geographical scope of the region represented by the director is a function of the parcel size and the number of parcels used to represent the system. Thus, a single county or a multi-county river basin area could be represented. The director also has the option to make no decisions and instead start with one of the two prespecified hypothetical configurations.

As a third type of decision ("Teams"), the director may affect the game format by the allocation of resources to economic, social, and governmental decision-making bodies that are called teams. A final type of director influence is one that he may choose to exert any time during the operation of the model. By making inputs to the model (using the same input format as the participants), the director can control the outside system influences on the local system (federal-state aid, business cycle, federal regulations, etc.) and some local phenomena (flooding, federal employment, etc.).

The participants of the model are members of teams, and through the teams they become the decision-makers of the local system. As decision-makers, the participants establish individual and collective goals, create any needed institutions (such as a legal system, mass media, unions, etc.), evaluate the status of the local system and its constituent parts, and make decisions for the period of time represented by a cycle of the model (one year).

These decisions are input at the "Data Implementation" phase of the model, and they interact with one another and with the present status of the system to create a new status of the system. The new status is illustrated on the computer output, which then serves as the basis for new evaluation on the part of the decision-makers and a new cycle of game play.

Figure 15.—INTERACTION BETWEEN THE USER AND THE RIVER BASIN MODEL



CHAPTER VI

Explanation of the Water Component

To illustrate the interaction among the various modules that comprise the model, the water component will be described in a very brief fashion. The water component can be looked at as a module that is plugged into the other major modules of the regional model. This module could be changed without changing other parts of the model (and vice versa) as long as the links among the modules were modified accordingly. Figure 16 shows the major linkages between the water module and the other modules and sectors that comprise the RIVER BASIN MODEL.

WATER QUALITY RATINGS

In order to summarize and simplify the concept of "water quality" in the model, an index of water quality has been created. The value of this water quality index at any location in the system is determined by the concentrations of the seven pollutant categories. The higher the quality rating, the lower the quality of the water.

The average quality rating of water on a parcel is calculated each round by taking the highest index caused by any of the seven pollutants dealt with by the model. Figure 17 shows the water quality level generated by concentrations of each of the pollutants. An explanation of the table is also included in the figure.

Each parcel of land that contains surface water (lakes or rivers) has a water quality index calculated for it. The water quality rating for a parcel affects the treatment cost paid by users of that water. The quality rating also affects the pollution index, the rate of depreciation for some developments, the utility of the water, and major recreation activity. The Water Quality Map (Figure 18) shows the water quality rating for each parcel of land that has surface water, the direction of flow of rivers, the location of economic activities (including farms), and the individual pollutant responsible for the water quality rating.

WATER USE

All private economic activities require water as part of their normal operation. Some of the manufacturing activities are surface water users, and they must intake water from the parcels on which they are located. All of the other activities use municipally supplied water (except those few residences which have private water supplies).

Surface water users pay for the cost of treating the water they take from the local water system. Municipal water users pay the price charged by the Utility Department. The Utility Department must construct intake facilities and treat the water if necessary to supply the water needs of each utility district.

POLLUTION GENERATION AND MONITORING

All economic activities return their used water to the local water system. Surface water users may opt to treat all or part of the water they return to the system with one of four types of treatment. The other economic activities return their water to the water system via the outflow point of the utility district in which they reside.

The Water Office of the Utility Department may determine through the operation of sampling stations the detailed components of the water quality rating for any water parcel (the ambient water quality) or for any point source of water outflow

Figure 16.—INTERACTION BETWEEN THE WATER MOUDLE AND OTHER PARTS OF THE RIVER BASIN MODEL

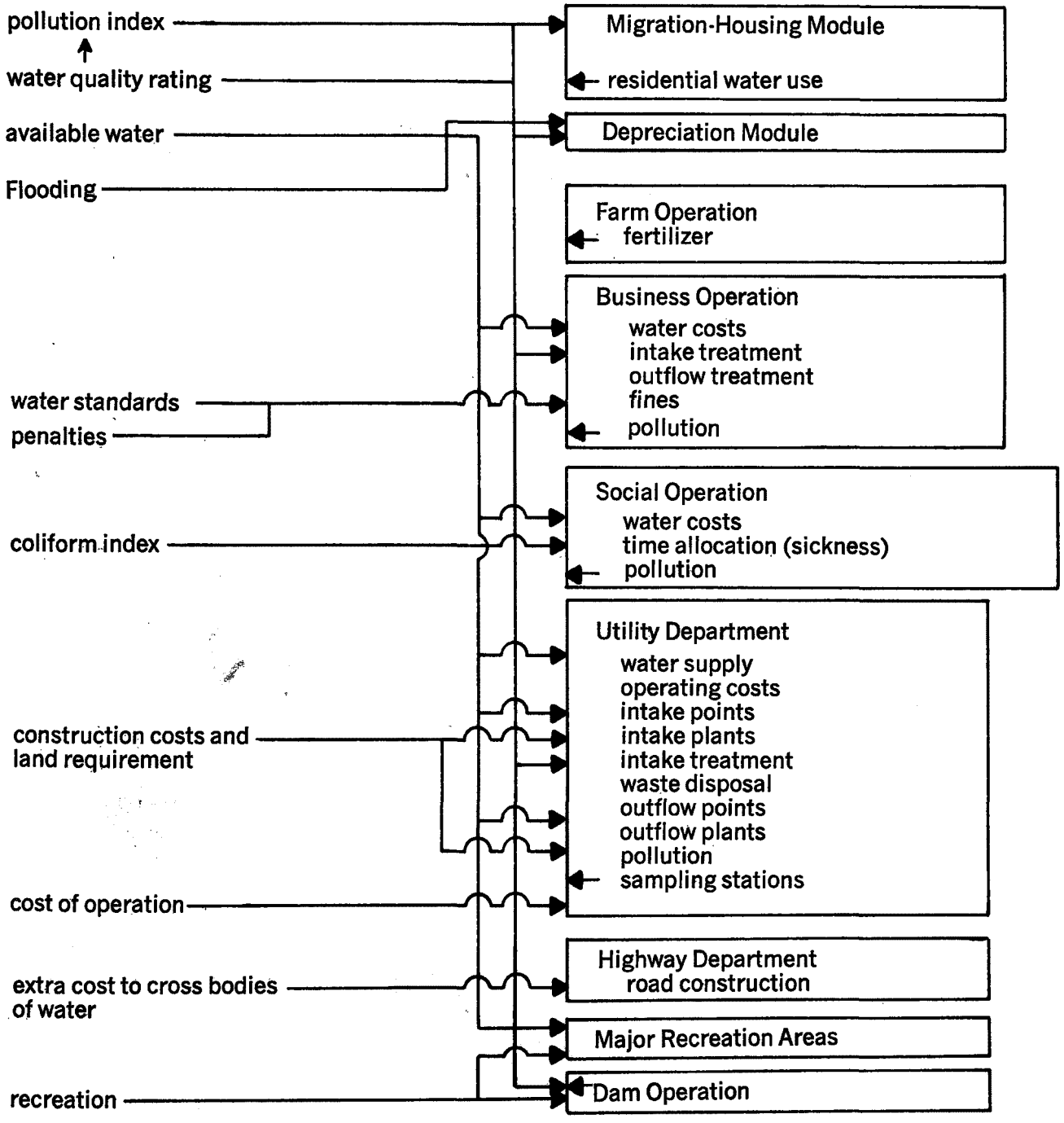


FIGURE 17—*Definition of the Nine Comprehensive Water Quality Levels*

Pollutant Types	Water Quality Levels								
	1	2	3	4	5	6	7	8	9
BOD (LBS/MG)	10	20	30	40	60	100	150	300	> 300
Chlorides (LBS/MG)	5	10	15	20	30	40	60	80	> 80
Nutrients (LBS/MG)	25	50	100	200	400	800	1600	3200	>3200
Coliform Bacteria (parts per MG)	2	6	12	20	40	70	120	160	> 160
Temperature	0	0	1	2	4	7	10	14	> 14
Oil & Floating Solids	0	0	0	0	0	>0	>0	>0	> 0
High Level Wastes	0	0	0	0	0	0	0	>0	> 0

Explanation of the Table

In order to determine the water quality level or index of given amounts of water, take the concentrations of each of the seven pollutant categories and calculate the water quality level based upon each pollutant separately. For example, a BOD concentration of 25 LBS/MG would yield an index of 3, coliform bacteria of 169 parts per MG would yield an index of 9, and the presence of oil and floating solids would allow the water quality to be no better than 6. The worst (highest) water quality index that was calculated using the pollutant types separately, is assigned to the given amount of water. If the water on parcel x had the three pollutants described above, it would be assigned water quality index of 9.

Looked at another way, water quality level 4 is attained when a body of water has concentrations of BOD that exceed 30 but fall below 41, coliform bacteria concentrations above 12 but below 21, etc.

(from surface water industries or from the municipal outflow point).

Surface water using industries and the municipal water offices may treat their water outflow to reduce its concentrations of pollutants.

EFFECTS OF THE WATER QUALITY INDEX

The Water Quality Index on a parcel of land has direct effects on the following factors:

- Treatment costs of water withdrawn from that parcel by the Water Department.
- Treatment cost of water withdrawn by an industrial surface water user on that parcel.
- The amount of personal consumption emanating from Major Recreation Areas located on or near that parcel.
- The pollution index for that parcel.

The Pollution Index is a part of the Environmental Index which is used as a basis for determining the attractiveness of a residential parcel of land for potential in-migrants. A high Pollution Index also affects the probability of population units moving away from a residential parcel.

The Health Index for a parcel of land influences the amount of money spent by population units for health services and the amount of time lost from leisure activities. It also affects the Personal Index, which in turn influences the amount of dissatisfaction experienced by population units on a parcel. The Health Index for a parcel of land is based upon the concentration of coliform bacteria in the water. This is the only case in which a single component of the water quality index is handled separately.

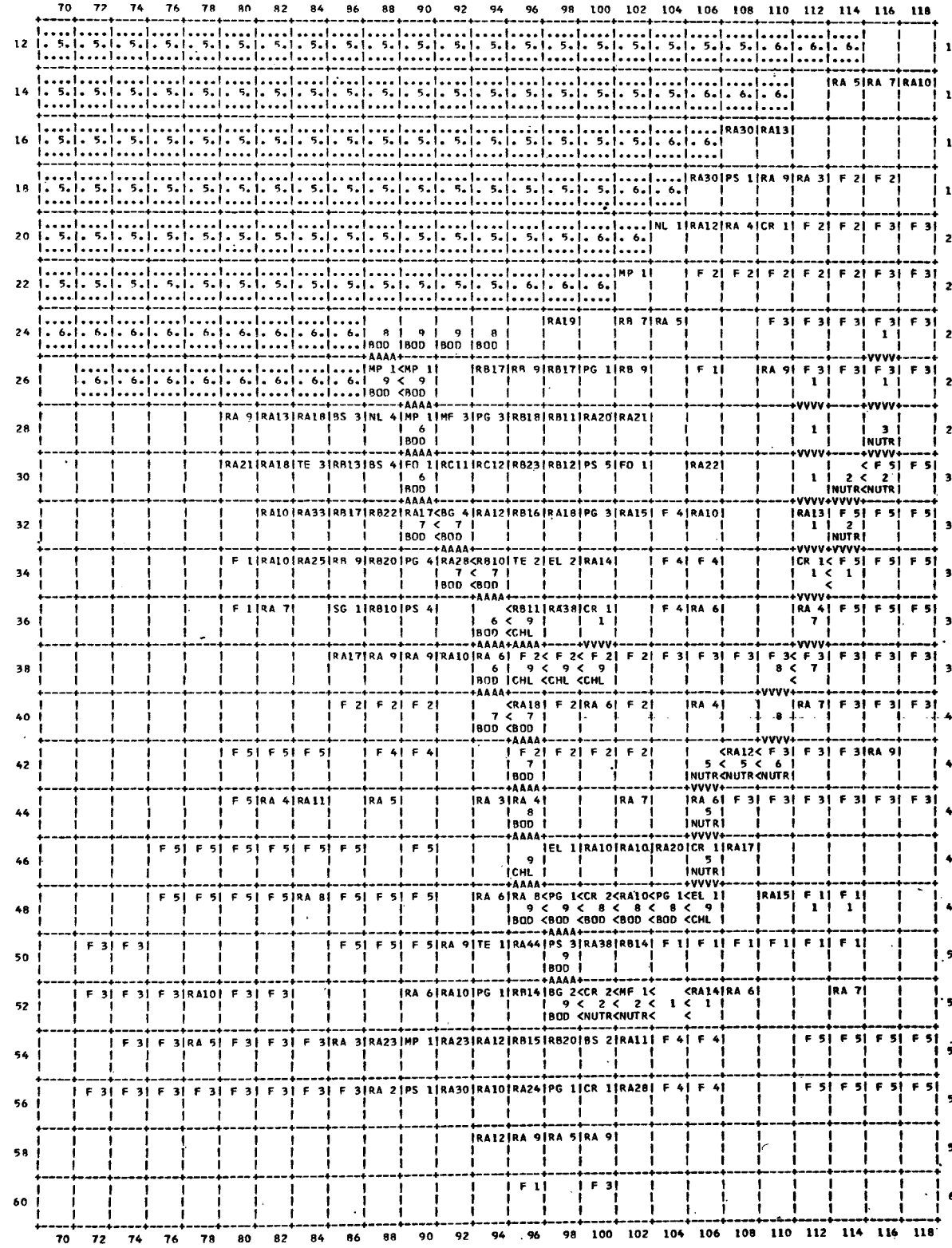
All of the dissatisfaction indexes and quality of life indexes are calculated in such a way that a high value indicates high dissatisfaction or low quality of life. In Figure 19 the components of the Quality of Life Index are illustrated. For each of the indexes, the corresponding dissatisfaction term is provided in parentheses.

Note that both of the components of the Environment Index are indexes which are based entirely upon locational quality factors outside the direct control of the social decision-makers. For example, social teams can only indirectly affect water quality, school quality and local tax rates.

The Personal Index, on the other hand, is comprised of two indexes, one of which is based on locational quality factors while the other is based upon time allocation decisions that are largely within the control of the social decision-maker.

FIGURE 18

RAYWID CITY — WATER QUALITY MAP — ROUND 0



PARCELS

TOP ROW: ECONOMIC ACTIVITY TYPE AND OPERATING LEVEL
FARM TYPE IF FARM ON PARCEL
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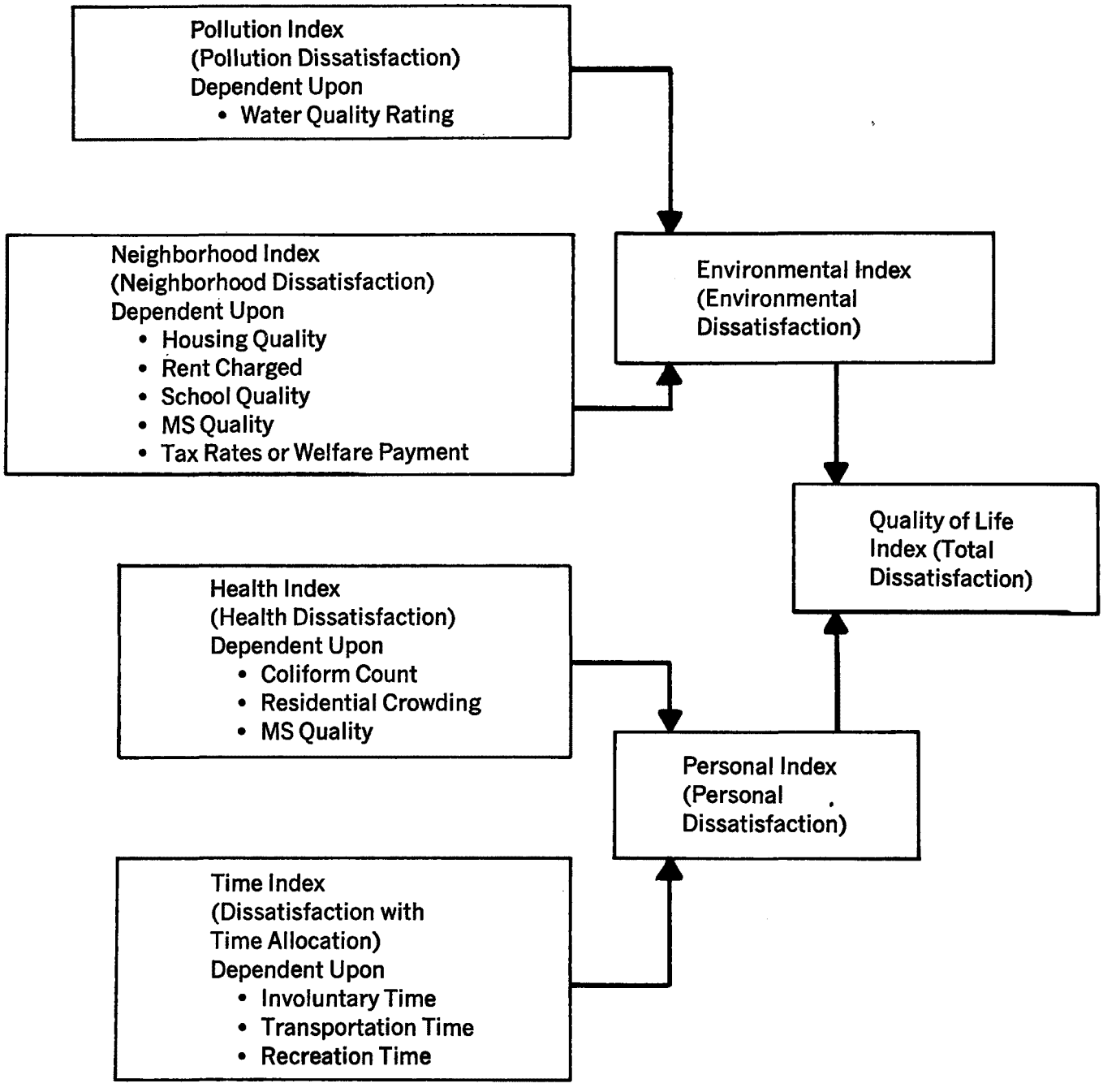
.... LAKE PARCELS

PARCEL EDGES

>AV< DIRECTION OF FLOW

---- NO WATER FLOWING BETWEEN PARCELS

Figure 19.—COMPONENTS OF THE QUALITY OF LIFE INDEX



CHAPTER VII

The Computer Programs of the RIVER BASIN MODEL

Each cycle or round of the model consists of users evaluating the status of the local system, interacting with one another, making decisions, inputing these decisions to the computer, and running the computer program to generate a new status for the local system.

Regardless of what decisions are input, the model executes the same major operating programs in the following sequence:

- Migration-Housing
- Water Quality Calculations and Effects
- Depreciation
- Employment
- Transportation
- School Allocation
- Time Allocation
- Commercial
- Bookkeeping

MIGRATION-HOUSING

The basic population grouping in the model is the population unit (PI). A PI is designated as being a member of a socio-economic class. The one thing the three classes have in common is that 500 people comprise a PI. PI's move into, within, and out of the local system in response to available employment opportunities, housing quantity and quality, and a number of other factors.

This computer routine calculates dissatisfaction (environmental and personal); develops a pool of movers comprised of the population displaced by housing demolition, a percent of the most dissatisfied, a percent of the total population (random movers), natural population growth, and the inmigrants; and moves the members of this pool into housing that has adequate capacity and quality. A certain percentage of each income class that are either unemployed or underemployed outmigrate from the local system. Other movers who cannot find adequate local housing also become outmigrants.

Water quality affects migration through the environmental dissatisfaction (housing near polluted water becomes less attractive) and through the personal dissatisfaction (bad health resulting from nearby polluted water increases the probability of moving).

WATER QUALITY CALCULATION AND EFFECTS

The water quality on each parcel of land that contains water is calculated by combining the pollution flowing into the parcel from up to three upstream sources (water from adjacent parcels) with the quantity of water on the parcel. This mixing process generates a water quality index for water on that parcel for all users on that parcel (industries, municipal water systems, and major recreation areas). That portion of the water which is not withdrawn has a certain amount of pollution disappear based upon the rate of flow of the water. All water returned to the water system on that parcel (industrial waste, municipal outflow, and farm run-off) is combined with the water not withdrawn, and a calculation of the total amount of pollution sent to the next parcel downstream.

This process is performed for each parcel of land that contains a moving body of water. The operation of industries, municipal water systems, farms, and dams affect the water quality along different stretches of a river. The water quality then affects next year's migration and this year's depreciation

and commercial activity (via major recreation areas) as indicated in the following sections.

DEPRECIATION

Buildings and roads depreciate in value and utility each year as a function of the passage of time (obsolescence), the amount of use they receive (wear and tear), and the quality of local municipal services (especially police and fire protection). Local decision makers may choose to maintain a constant value for their developments by expending the required amounts of money for maintenance. This routine depreciates all developments and calculates maintenance expenditures.

Three additional water-related factors can also contribute to the rate of annual depreciation of developments. First, industries that draw water directly from nearby water supplies have an additional depreciation that is in proportion to the water quality rating of the water they use. Second, for utility districts that have insufficient supplies of water, there is an additional depreciation that reflects above average fire damage due to inadequate water for fire fighting purposes. Third, developments may experience increased depreciation as a result of flood damage. This damage is related to the severity of the flood (input by the director), the type of building, its location in the flood plain, and the flood control priority of dams for the river basin (if there are any).

EMPLOYMENT

All Pl's in the local system compete with one another for jobs in the local labor market. Likewise, all employers compete to hire workers with the highest education levels. There are two types of employment—full-time and part-time.

The full-time employment routine assigns population units (high income first and best educated first) to full time jobs based on the assumption that workers will attempt to maximize their net salary (salary received minus transportation costs using last year's transportation cost figures). Pl's will take jobs in the next lower class if none are available in their class. The part-time employment routine assigns part-time workers (80 time units in part-time work equals one full-time job) to part-time jobs on the basis of best education first. The number of time units allocated to part-time jobs is set for each group of Pl's on a parcel by the social decision-makers. If time is allocated for part-time work, but not enough part-time jobs exist, the dissatisfaction of the Pl's is increased.

If plants that are causing water pollution are shut down or forced to curtail output, then the reduction in the required labor force will have its repercussions throughout the system. The employment routine treats the former employees of the shut down plant as unemployed at the start of the routine and assigns them to other jobs if extra jobs are available in the local system.

TRANSPORTATION

Pl's that are employed are assigned to a mode of travel and to a specific route by this computer routine. Taking the origins (homes as determined in migration) and the destinations (jobs as determined in employment) this allocator assigns workers to transportation mode and routes in an effort to minimize total transportation costs (dollar costs plus the dollar value of time spent) subject to the constraints imposed by public transit capacity, road congestion, and transportation boycotts.

Each employer may offer a unique salary; Pl's from a single parcel may be employed at several different locations, and three transportation modes (auto, bus, and rapid rail) may be considered. Government decision-makers may affect the transportation access (and thereby indirectly affect employment choices) by choosing where to build roads of different capacities, where to run bus lines, what fare to charge, and where to build and operate rapid rail service.

SCHOOL ALLOCATION

Each Pl contains a number of school age children who attend public schools, if the public schools are available and meet quality criteria that differ by income class. This routine assigns students by class (low class first) to public schools or private schools based upon school quality criteria (quality of plant and equipment, quality of teachers, and the student-teacher ratio) and capacity of the school serving their district. Population units who send their children to private schools as a result of local public school deficiencies must bear the cost of such private education.

Another school allocation routine assigns adults from PI's to public adult education programs in proportion to the amount of leisure time allocated by PI's to such programs. The local education authority provides public adult education programs by hiring teachers and using existing educational facilities. If PI's are not able to spend as much in adult public education programs as they wanted, then their personal dissatisfaction increases.

TIME ALLOCATION

For each PI grouping, time spent in transportation is deducted from a total of 100 units; then time spent in part-time employment is deducted; public adult education time is deducted; private adult education costs are determined and the time is deducted; voter registration is changed as a result of the time spent in politics and the time is deducted; and time is deducted for time spent in recreation, and consumption of PG and PS is increased above the normal amount. The remaining time is labeled "involuntary" time, which contributes to the level of dissatisfaction calculated for the following year.

COMMERCIAL

Each PI grouping must purchase units of personal goods and units of personal services each year. Establishments that sell personal goods and personal services must sell exclusively to local system demanders. These establishments compete with one another through locational advantages and by prices for a unit of goods or services sold. In the commercial routine, the purchases (normal and recreation-related) of the population groups on a parcel and residential maintenance expenditures are allocated to personal goods and personal services establishments using the criteria that establishments have a limited capacity and that shoppers attempt to minimize total costs (sale price plus transportation charges).

In a similar fashion, purchasers of business goods and business services must buy annually from BG and BS establishments. These establishments compete with one another to supply the local demand. In the commercial routine, the purchases of businesses (including personal goods and personal services establishments) for normal operation and for maintenance are allocated to business goods and business services establishments based upon the same criteria as above (an infinite-capacity outside supplier sells goods and services at prices in excess of normal local prices).

The amount of purchases from local personal goods and services establishments is affected by the normal amount of business generated by Major Recreation Areas and the present quality rating of the water bodies serving those recreation areas. Thus, consumption at local stores will rise somewhat with good water quality and fall with poor water quality. This consumption is assumed to be made by tourists from outside the local system.

BOOKKEEPING

This routine makes all the final calculations of incomes and expenditures and of indicators for use in the detailed computer output to the economic activities and teams, the social decision-makers, the government departments, and the summary statistics.

CHAPTER VIII

Summary of the RIVER BASIN MODEL Design

DESIGN ASSUMPTIONS

The basic design assumption of the model is that if the major activities that take place within a regional area are represented and related to one another, then the actual demands for water quantity and quality will result from the operation of these activities. Furthermore, the realistic way in which water resource decisions and their impacts affect the urban system can only be represented in a holistic model that incorporates public and private decision-making.

The major decision-making actors are business (the economic sector), the local population (the social sector) and public policy makers (the government sector). They interrelate with one another in a physical and institutional environment that takes into consideration spatial relationships, ties to a larger outside system, and allocates goods, services, labor, incomes, etc. by a number of market operations.

The major markets are:

- Interrelationships with the Outside System
- Migration and Housing
- Employment and Transportation
- Commercial and Transportation
- Time Allocation
- Public Goods and Services
- Allocation of Financial Resources
- Demand for and Supply of Water

The four basic building blocks of the model are business types, population units, government functions, and parcels of land. All of these factors are dealt with in a micro manner. That is, an individual population unit (representing a given number of people with loaded or derived characteristics) finds housing at a specific location, is employed by a specific employer (if in fact it is employed), shops at designated locations, etc.

BASIC BUILDING BLOCKS

Much of the design effort associated with the development of the RIVER BASIN MODEL was spent developing general and usable concepts of land parcels, business activities, population units and government functions. A general concept is required so that any area in the continental United States can be represented. The concepts must be usable in the sense that the users of the model are able to understand the basic system relationships of the model and the statistical output generated by the computer within a relatively short period of time.

Parcels of Land

The geographical area represented by the model will be comprised of land parcels. A parcel of land has the following characteristics:

- A place from which distance to other parcels is measured.
- A size (number of acres or square miles), a shape (square) and a unique identification number (pair of coordinates).
- A number of constituent percents of land.
- A single owner of the privately owned portion of the parcel.
- A single zoning classification.
- A single private land use.

All geographical areas (such as political jurisdictions, special districts, river basins, flood plains, etc.) are defined in terms of full parcels of land.

An important characteristic of the sum of all the parcels, which define the map boundaries, is that they define the geographical limits of the local system. All activities and decision-makers that are outside of the regional boundaries comprise the outside system. There may be some activities (Federal installations and state institutions) and some decision-makers (at the Federal and state level) that are physically within the boundaries of the region. These activities and their employment impacts are part of the local system, but their policy is made as part of the outside system (exogenous).

Business Activity

The RIVER BASIN MODEL contains business activity within four categories: manufacturing, commercial, residential, and farms. Within each of these categories there may be many specific business types. For example, eleven types of manufacturing may be represented, five types of commercial, three types of residences and five types of farms. Business activities must be located on parcels of land. The production function for each manufacturing and commercial business is dependent upon the quantity and quality of plant and equipment, and the amount of labor hired.

PART II

CHAPTER IX

The Research Project

To test the utility of the techniques developed in the RIVER BASIN MODEL (and its sister CITY MODEL), a study was implemented which made use of the model for educational purposes (rather than research or policy making) in a variety of disciplines and university situations.

The brief summary above should suffice to give the reader an overall impression of the model. The next chapter will focus on the meetings held with the participants.

The study design chosen consisted of picking a half dozen professors from different universities who were specialists in distinct disciplines. It was further decided that the model would be run for a full year, meaning that each professor would have an opportunity to run the model at least twice. Finally, there was an attempt made to use the model on both undergraduate and graduate classes and with varying numbers of students. The professors and universities included:

- John Sommer (Geography), Dartmouth
- Maury Selden (Urban Real Estate), American
- Philip Patterson (Urban Economics), Georgetown
- Robert Barrett (Urban Affairs), Mankato State
- Robert Dean (Urban and Regional Studies) Memphis State
- Allen Feldt* (Human Ecology) Cornell

The actual running of the model was to be carried out by Envirometrics' staffers while the conducting of the model was to be done at each university. Contact was by phone, mail, and through full participant meetings in Washington.

For the first and second meetings with the participants we met to discuss problems with the study and to try to discover methods of improving the runs. The third meeting was summarial and merely focused on wrapping up the task itself.

The discussions were carried out very informally with a representative of NSF present.[1] Following are some of the topics discussed and conclusions reached.

A. There did not appear to be any easy method of introducing the material contained in the model. We loaned the participants two film documentaries of the games produced by NBC. Further, we made available a number of slides and tried to teach the participants how to introduce the model.

As a result, the first few months of the run were a tribute to the tenacity and integrity of the professors as they stumbled and fought their way through the model with the students. The second time around was considerably easier as the professors devised their own teaching formats and personalized the introductory lectures. One professor devised his own visuals of CITY and his students produced a video tape designed to teach the model.

B. All of the participant professors had to change the reading lists assigned to their courses. They found that the syllabus used previously was no longer adequate to incorporate the breadth of subject matter covered with the Laboratory.

C. They all found that the model ran best when the political leader was dynamic and aggressive. Also, unless the professor began to make active use of the model to demonstrate theories or to allow innovative decision-making, the students became bored because they had learned many of the mechanics of the model by the third or fourth round.

D. The students tended to take over the lab as a source of self-study. One theme became clear: there should be a central laboratory which would allow

*Due to some unexpected demands on his time, Professor Feldt was not able to fully participate.

[1] Support for this project was provided by National Science Foundation Grant Number Y008433.

students and professors continuous access to the model, regardless of course.

E. The users felt that there was a need for more information which was not provided by the model. Consequently, everyone used a form of mass media, including one or more newspapers and a video tape.

F. The model was too much for the professors to run themselves; consequently, each professor had to obtain help from the participating students or faculty or assign one of their graduate students to the project.

G. All of the users found that the model ran better the second time if a general goal or strategy for the students was pre-assigned.

H. There were a number of difficulties with misunderstood or mispunched input cards on one hand and poor turn-around on the other.

I. There was a general need for a visual of some sort to be used by the players so that they could see the impact of their decisions.

J. At the end of the first meeting, the users discovered that they had only played the game from one of an infinite number of possible starting positions. They all opted to continue with the same starting position rather than a new one, however, since they did not feel confident enough to tackle a quantum jump in complexity so early in the game. One professor did continue his city development rather than begin again.

K. The professors all ended with a feeling that use of the model would be a part of the next year's courses and that it would not be difficult to run. The amount of time that they were required to expend to learn the model was considerable. In fact, one or two said they might not have taken part in the project had they known that it would have taken so much time. However, at the end of the project, they felt that the time expenditure was well worthwhile.

L. An environmental laboratory is to remain at least at three of the schools and is to be used not only to teach students but is being spread to the local community for use in action programs and local education.

In summary, the problems with the program were all technical rather than substantive. The professors chosen did not all have prior experience with games; indeed most had never used a model. They came from a variety of disciplines and faced graduate and undergraduate students, in small as well as large numbers.

In the sections to follow are their own reports, although they were all asked to follow a similar format. In spite of the fact that the professors all started with the same introductory City (Blue City) and were asked to loosely follow a single format, the individualism which grew out of the study is most striking. This finding, like the others, is highly pleasing and helps to attest to the success of the idea of a single laboratory, which obviously can be used by different professors without placing them in a situation of artificial constraint.

The reports range in emphasis from how the professor used the laboratory, to additions which students made, and finally, to the validity and usefulness of the tool. Again, these reports stressed the richness of this technique.

CHAPTER X

Blue City on a Green Landscape: A Gaming-Simulation at Dartmouth

by John Sommer

INTRODUCTION

During the past five years there have been few teaching members of Academia who have discovered themselves to be immune to the urgent press for new, exciting, teaching innovations. This past demi-decade has thrust an entertainment-jaded student generation into the university classroom where many of them believe they have paid to be amused, as well as educated. The response of the teacher to this set of expectations has fallen somewhere between a national tragedy and a national scandal: that is, many university faculty have sought "relevance" through "podium rhetoric" or the studied adoption of the stuttering phrases of the youth culture, rather than through presentation of their philosophical justifications for the kinds of knowledge they purvey. The extensive "knowledge-shaming" and "instant-erudition" that infuses so many campuses today is unfortunate, and dangerous to the reputation of Academia as a haven for unfettered learning.

In recognition of the problem of exciting this generation of students with the quest for knowledge, and doing this without sacrificing some heavily paid-for scholarly traditions, I sought to introduce some changes in the Urban Studies and City Planning Program at Dartmouth College. As the new head of the Program in 1969 I had been made aware of the CITY I gaming-simulation developed by the individuals who later founded Envirometrics I then participated in a round of CITY I in Washington and decided that the gaming-simulation had enormous merit as an effective teaching device. For us at Dartmouth, the prospect of utilizing a gaming-simulation model to complement our urban field programs (in Boston and Montreal) seemed ideal. From this initial contact my participation in the project unfolded. I had no previous experience with modeling.

Our Urban Studies Program has more than one-hundred "concentrators" (they major in a discipline) but we have the capability of placing only about fifteen a year into an actual city environment. Some students chafed at the difficulty of "doing urban studies" in a rural area and raised some valid objections to our normal curriculum. Most of the students (largely majors in geography, political science, or sociology) take at least six courses from our program, but among these we had few offerings other than the survey and seminar type. The CITY MODEL offered us some new, valuable opportunities, and we seized them. This was done by inserting the gaming-simulation into our regular curriculum.

This report describes the experience we have had with the BLUE CITY sequence of the CITY II model during this academic year 1970-1971, where I employed the gaming-simulation in two distinct courses. Part II of this report describes the courses in which it was employed, including their structures and educational goals. Part III presents some tentative analysis of the dynamics of our play during both courses, and Part IV hazards some conclusions about the use of the CITY MODEL in undergraduate education from our experience at Dartmouth College.

COURSE DESCRIPTIONS

Modest flexibility in our curriculum and course content allowed us to employ the CITY MODEL

immediately in two courses; however some serious constraints were introduced by our short term (10 weeks), the schedule of class hours which are difficult to rupture, and the responsibility to cover certain materials in our courses which are not within the context of the CITY MODEL. These constraints, as well as the manifold possibilities, operated differently in the two courses in which the model was employed.

This portion of the report treats with Geography 10, *The City of The Future* (a freshman seminar, during the Fall), and Geography 52, *Urban Geography* (an advanced lecture course during the Spring). Students from two other courses, as well as some non-course individuals took part in the gaming simulations: during the Geography 10 rounds sixteen of Professor Frank Smallwood's students from Government 31, *Urban Government and Politics,* took part in the play. During the Winter two experimental rounds were run (and later regretted) with Geography 42, a course in theoretical geography.

Geography 10

This freshman seminar was the first I had taught and also the first college course for the sixteen men in the class. The aim of the course was to introduce these students to a seminar style of schooling as well as to the general content of urban studies. A disciplined structure was played down rather than emphasized. Some provocative readings were selected for discussion and the CITY MODEL was employed to help students act out ideas they were beginning to acquire, or had previously acquired about the city.

The course met twice a week for two hours, thereby allowing us the minimum time needed to complete a play of the model. In fact, I bargained with the students to have all of our other classes last 100 minutes if they would set aside 200 minutes whenever we ran the model. Generally, this time trade-off was successful with the freshmen, but it was somewhat less successful with the students from Government 31 who were, in effect, being excused from three, ten page book review assignments for this participation in the model. A few of these students believed the time trade-off was weighted against them despite their interest in the gaming-simulation.

The model was run six times during the term, or roughly every fourth class period. This allowed for about ten days between runs, which was good from the point of view of physical turn-around time from Envirometrics, but it was judged poor by the students, whose interest flagged while waiting for the return of the computer output. Two formal discussions of the model were scheduled during the term, not including the introduction of the model but these discussions focused more on the dynamics of the play than on the driving mechanisms of the Model. The fact that these mechanisms were not wholly accessible to us was not important during the Fall when we even failed to make full use of the information provided in the City Manual, but during the Spring this circumstance became more of a problem with the advanced students who wanted to test some hypotheses.

Students were told at the beginning of the term that their participation in the Model would count for one-quarter of their final grade. This proved to be a greatly subjective element of the grading process because it was difficult to follow what each person was doing to arrive at his interactions and decisions. This was not troubling intellectually but it did raise a question about mixing the nature of the course—particularly for the larger Geography 52 course in the Spring Term.

Geography 52

Urban Geography is a lecture course which accommodates 40–50 students. Because it is a "core curriculum" course in our Urban Studies Program almost all of the students have had at least one urban studies course before taking Geography 52. Unfortunately, only about half of the students have had a course in geography. These circumstances sometimes make for a slow "lift-off" for the course because "in-filling" is required for the non-geographers.

The course meets three times a week 9:05 a.m. to 10:20 a.m. but again I was successful in trading-off the Saturday meeting of the class for a Tuesday evening meeting from 6:30–8:00 in order to run the model; in fact we never finished a Tuesday session before 9:30 p.m., a situation that created some problems in the latter part of the term.

I have given this course a half-dozen times and the aims of the course have been to introduce urban studies students to the spatial aspects of urban phenomena, and to provide geography students an intellectual arena in which to test ideas of the spatial organization of human activities. There is some responsibility to cover certain materials in the course for the sake of both the Urban Studies Program, and

the Geography Department; therefore there is less room for experimentation than in a Freshman Seminar.

Required readings for the course were not extensive, but each student was provided with supplementary reading lists and asked to consult them regularly. Both the required and suggested readings were designed to support discrete lectures and general topics respectively. There was no assigned reading on games, simulation, or modeling, although some of the students sought references on these subjects by the end of the term, even to the point of creating some of their term projects along gaming lines. The readings, then, were not specifically designed to support the use of the CITY MODEL, but it was believed that ideas from the reading would come into play if they were perceived as useful.

The CITY MODEL was used as a supportive, "imploding" element in the Geography 52 course. My participation in the Model was greater during these rounds than those run during the Fall, but in general I remained in the role as a technical assistant, organizer, and manager. This was planned, but it would have been forced on me anyway simply by the pressure of handling the details of the Model.

Our scheduled discussions about the CITY MODEL during the Spring were more analytical and comparative than those in the Fall for the obvious reason of experience with the model as well as a more advanced group of students. These discussions were often speculative with respect to the nature of the model but frustrating because we knew that the Model would remain an "opaque substance" until we could truly subject it to experiments.

Grading participation in the Model was no less easy for Geography 52 than for Geography 10, especially since three of the forty-one students could not meet at the newly scheduled hour, but this situation was solved, in part, by introducing a new, and very exciting gaming-examination called, THE MUNIFICENT HEXAGON. Along with employment of the Model itself this examination provoked more favorable reaction among students than anything I have experienced during my teaching career.

Summary

The CITY MODEL was employed as an integral part of two distinct courses during the academic year 1970/1971. No course could be specifically designed to focus solely on the Model. Insecurity over my own abilities to direct a full model-based course, and insecurity introduced by having to rely on an outside source (Envirometrics) for the conduct of the course were too great to allow for unrestrained investment. It is my conclusion from considering the course structures of both Geography 10 and Geography 52 (in light of the goals of these courses, within the context of the Geography Department, and Urban Studies Program,) that a new course needs to be designed to employ fully the potentialities of the CITY MODEL, and other urban gaming-simulations. Such a course was designed for our summer schools 1971 and successfully operated. It is hoped that this success will carry over into our regular curriculum on an experimental basis during 1971/1972, and regularly after that. Part III that follows examines the dynamics of the use of the Blue City sequence at Dartmouth, and although there will be many points of comparison between Geography 10 and Geography 52 rounds, much of the commentary is melded observation.

THE DYNAMICS OF THE MODEL'S USE

Introduction

The introduction of the CITY MODEL is undoubtedly the most difficult aspect of its use because this is the point of ultimate ignorance of the players, most of whom have not gamed before. There is a real tension between the need to introduce the model, despite its massive and complex characteristics, and the need to allow play to proceed without the gamemaster introducing his own biases into the group of players. It is significant that players and professor alike perceived this to be the crucial point of the model's use and strived together to make it more readily understandable to later players by creating a videotape introduction. It is worthwhile discussing some aspects of the introduction of the model before proceeding to an analysis of play.

It is obvious that the gaming experience of most college students is limited, so the starting point for this kind of education is assumed to be zero. Unfortunately, after reading the *City Manual* (version of August, 1970) the student's knowledge about the model, gaming, and his role in the gaming-simulation, did not increase greatly. Two reasons account for this: first, that version of the manual was not very clear and the *errata* were numerous; second, it was difficult for the student to believe that he was required "to learn" the Manual for the purpose of a game. Specifically, that version of the Manual

desperately needed cross-referencing to speed up the student's ability to find out what he needed in discrete situations. In a few cases where *errata* existed (and were soon thereafter corrected by Envirometrics, Inc.) the most serious players became confused. Probably as important a factor was the failure of many players to familiarize themselves fully with the Manual before convening for the first play. They did their homework later, after they discovered the gaming-simulation to be a serious matter.

It was very important to employ the scenario walk-throughs provided by Envirometrics prior to our first run; now the more recently developed "Thumbnails" may give added support for the initiates. There was a great deal of fumbling in the beginning of play and some guidance and suggestion was necessary simply to inform players of what they could do.

A serious question must be raised about the "inflection state" of the model because it was discovered that the original board layout and the brief scenario provided go a long way toward determining later play and later configurations. For this reason I believe that the gamemaster should be especially careful when deriving a scenario, in order not to predicate the play. Normally the raison d'etre of the original scenario is expunged by the end of three rounds of play but there are certainly locational decisions and human interactions produced by the original scenario that linger much longer. It was discovered too that in a simulated decade of play the land use did not shift markedly, so one can assert that the original board layout had much to do with later play. This phenomenon of conservation, or pattern maintenance, was generally unruptured until "end-game phenomena" took over and players became more speculative.

The actual preparation for play at Dartmouth involved the following steps: a) an introductory lecture on the game, preceded by a reading assignment, b) display of materials, c) assigning of teams and roles. The introductory lecture involved a discussion of gaming, a description of the three sectors and their output, and a demonstration of interrelatedness in the model, using the processes of migration, employment and commerce as examples. It was explained to the players that the gamemaster could not possibly answer all of their questions and that it was incumbent upon them to work out most of their problems alone. Most of the students had read the manual (but not carefully), before the lecture and many elementary questions were asked at this session.

Following the lecture the class was made to walk around the game room (which later acquired the name, URBAN/REGION SIMULATION LABORATORY), to examine the "public information" from the first round of the game, stopping at each set of data sheets (e.g. Personal Goods materials) and discussing some kinds of interactions that were revealed in the data. This exercise never was as successful as I had hoped it would be because the players seemed to ignore much of the data that were provided them, yet persisted in asking questions for which data were available.

Teams were then assigned, largely on the basis of preference. In some cases a flip of a coin was used to assign persons whose preferences were in conflict. During the Fall Term I put an older student with a younger student, and during the Spring Term I put experienced players with inexperienced players irrespective of age or class. This strategy worked well, as evidenced by the close cooperation and friendship that developed among players. In all cases players were assured that sometime they would play a different role. This assurance was not possible to honor in all cases but a real attempt was made without any feelings being ruffled.

It was extraordinarily fortunate that we had the use of a set of rooms, particularly one large game room, for the duration of the model's use. Two walls of our main room were cork board and one was chalk board, thereby facilitating information flow. The game information could be left on the walls during the inter-play periods and the team data sheets could be kept nearby for ready consultation. A 75″ x 75″ game board was mounted on one wall and it proved to be the focus of attention in much of the play. This board, and another developed by one of the students (shown in the videotape), were used for large scale planning by each sector. During the second set of runs a new position was created—that of Boardmaster, whose main job was to provide immediate and accurate representation of changes in the configuration of the patterns displayed on the board. This player also did a landuse summary at the end of play.

Aside from the large room with movable tables and chairs, three other rooms were available most of the time and these proved useful for private meetings of the different sectors; indeed, during the second set of runs each sector was assigned a different room. One central room had two teletype

terminals tied into our computer system; these were used by players to leave messages for one another after we developed a safeguarded Message Center system.

Such were the conditions of introduction to the play and to the physical surroundings of the gaming area. Considering the lack of a true gaming center we did well to find and use these kinds of facilities which aided the introduction of the Model, as well as they facilitated play. The need for better introductory procedures was still felt early in the second set of plays, and a group of six students took on a special project of developing a videotape introduction to the model. The tape developed was technically sound and highly informative. The tape was played for more than 120 delegates who came from all over the United States to attend a *Conference on Computers in Undergraduate Curricula,* held at Dartmouth during late June. The tape was accompanied by a talk on urban gaming models, especially the CITY MODEL. The tape and talk were warmly received. The tape was also used to introduce a Summer School class to the model, and although it seemed to help launch the play it is too soon to assess the results.

Trend of Play

The trend of play differed radically from the Fall run of the model to the Spring run; the difference may be characterized as a shift from idealism to realism, from cooperation to competition, from "getting it together", to just plain "getting it". Certainly there are many reasons for this shift but I have been able to identify only three with surety. One, the model, with its pre-digested scenario became the object toward which competition was directed and students pulled together to beat the "given" system. Two, an unusually charismatic student leader was the Fall term chairman, and he chose to try to pull all elements of the city together. Three, during the Spring term we began play with the three sectors in different rooms rather than together (as was done during the Fall), and the result was heightened suspicion between sectors. In addition, by Spring Term the experienced players gravitated toward the roles of the economic sector, leaving the social sector relatively poorly staffed.

Due to some special circumstances of play the evaluation that follows is comparative, that is, over the period of four rounds the play from the Fall Term and the Spring Term were parallel rather than sequential. Due to a lost tape at the beginning of the Spring Term it was necessary to play rounds 4 through 7 over again. At first this was perceived as a problem but later it was considered an asset because it afforded the possibility of reasonable comparison of play in a way that might not otherwise have been achieved. The economic and the government sectors are formally compared here but the social sector activities are better treated in a non-formal sense because the most interesting activities of the social sector were outside the model.

Economic Sector*

Through these two comparable runs, one can discern the differences and similarities in behavior of economic sector players for each run and the underlying constant factors involved in the CITY MODEL itself. Blue City, in all respects, is a small urban area, even as of Round 7: there is only one construction company, one business goods establishment and one business services outlet. There are only two developments of each type of national industry. Even in the two personal services businesses and three personal goods outlets, these industries were plagued with recurrent overcapacity problems in the face of slack social sector demand. The housing shortage also contributed to producing a demand for personal goods and personal services that was less than it could have been. Blue City would probably have been just as well off with smaller and healthier PS and PG.

Data collection was accomplished by separating each firm into its individual business establishment components. A complicating factor was the floating of a negative 6 billion dollar loan from E to B during the Fall, 1970 Round 7. Unscrambling the resulting maze of interest payments and debt payments for each firm was quite difficult. The data was then summed on two bases—firm-wide and industry wide, giving, for example, summed results for Economic A and also for all RA. The data collected was chosen in an attempt to measure growth and profitability. For an individual business, these two factors were respectively measured by total sales/rent and net income data. For an industry of businesses, these were summed for all of a particular business over all firms. For a firm of businesses, growth and profitability were measured respectively by net worth and cash balance. The resulting data was used to calculate percentage changes to facilitate the detection of trends. The basic data was also used to compute

*Much of the economic sector evaluation was prepared by two student assistants. Bill Price and Richard Schwager.

a measure of liquidity, (total cash balance ÷ net worth). This was used to indicate the extent of ready funds on hand, an indicator of growth potential for Blue City each round. Growth, profitability, liquidity were finally compared with population by calculation of correlation coefficients between the various measures, indicating how closely related some of the phenomena were in the underlying model, and perhaps in an actual city.

Data analysis.—The actual data accumulation involved a sector-by-sector account of economic decision-makers. An account was made of the sales and net income of the teams for rounds 4 through 7 of both the original fall '70 runs (by Geography 10 and Government 31 students) and the most recent spring '71 runs (by Geography 52 students).

An unscientific grasp of the economic progress of Blue City over these four rounds can be obtained from this data. The "flow" or total economy shows a steady rise in "net income", or the value for "net worth". Among the steady improvers over time were the 30 RA units, the 10 RB units, and the 6 RC units, thus increasing gains from residential ownership. The business and industrial operations tended to be more sporadic in their earnings, reflecting their crucial necessity of frequently varying sales, susceptibility to utility-tax-extra costs changes, over-capacity, and dependence upon the mercurial social sector activities.

These four factors are intuitively observed in those firms which had sporadic gains—the one BG unit, the one CI firm, and the two HI industries. They can also be seen in the two LI and two NS establishments which had slowly increasing sales and incomes and especially in the one BS firm, the two pathetic PS units, and the three PG firms which suffered enough to lose money regularly. The CI firm's sporadic gains resulted from a periodocity of demand and occasional utilization of the outside system for construction. The PS and PG units combined $108 million deficit for New round 7 (vs.–$51 million for old) come from a distinct over-capacity, that is an ingrained underdemand for Blue City's needs, and harsh treatment by the Social Sector on whom they rely completely.

Correlations.—Venturing into this more precise analysis, it was necessary to invent some parameters to check the two Rounds' results over time. Three parameters were devised:

Profitability: (net income) ÷ (sales)
Growth: percent changes of values over time
Liquidity: (cash balance) ÷ (net worth)

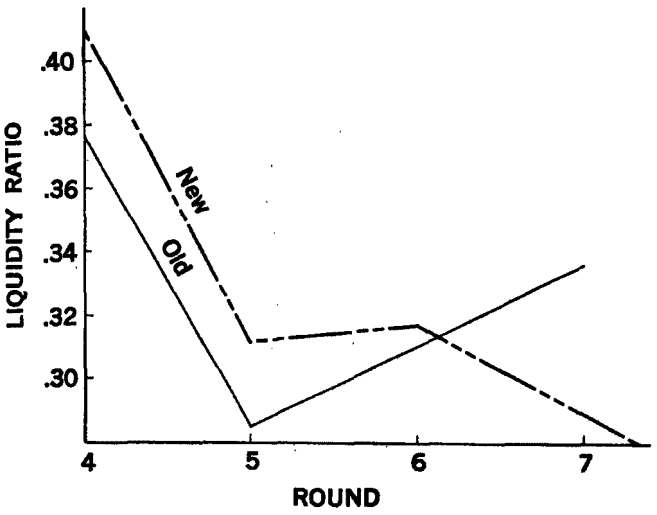
Using these parameters, clear changes and advances become noticeable.

In profitability, the ratios for individual economic activities on a year by year basis ranged from —.454 to +.357; advances and declines mirror earlier guesses. Oddly enough, the highest profits came for RA, RB, RC for both Rounds' values; the unprofitable units were for PS, PG, and BS (Old only), an indication of their ponderous natures. Low return units were the HI, LI, NS, and CI—about .1 to .2 for profitability.

In growth, different results fall out of the data. The net worth change, cash balance change, and Blue City population change were analyzed for round-to-round growth. Over the three rounds, the relative growth of Old population was greater than the growth of net worth, while the net worth in the New rounds was relatively greater than the growth of population. For the Old runs, because the growth of net worth (29%) was relatively less than the population growth (32%) production failed to keep pace with the population. Conversely, for the New runs production exceeded population narrowly, 33.5% to 33%. But the interesting growth pattern belongs to the cash balance change, important because it represents the firm's capacity to expand, improve, or build (i.e., if you have a negative cash balance, no money-requiring venture can be achieved, and economic decline is signalled). Both Rounds/Runs showed weighty declines from round 4 to 5, but Old runs' rallied to salvage an overall 13% increase; New runs were plagued with failings in the PS + PG units, which yielded an overall —5⅔% growth, or a net decline in cash balance. This single fact conveys the relative unproductivity in the New runs, and a cause for malaise in Blue City for spring '71.

In liquidity, the 3rd parameter, the resulting ratios represent the amount of funds in the net worth available for future expansion or investment. The values roughly parallel the growth and cash balance findings, such that the New runs failed to reverse the progressive decrease in liquidity over time. Both Runs fell from round 4 highs of .374 and .411 to a low at round 5, but Old grew as New fell further to .29. This "progressivity" is illustrated below. Despite the short period for examination, this drop in New's liquidity, added to its troubles with cash balances, give the nod for general economic health to the Old runs' productive capacity.

To augment these results, and to help clarify the previous findings, it was necessary to try some cor-



relation coefficients. These coefficients range from —1 to +1, with —1 representing perfect negative correlation (movement in opposite directions) and +1 representing perfect positive correlation (movement in same directions and at same degree).

The correlations of the three parameters were previously discussed. The profitability correlations for the Old vs. New Runs of rounds 4–7 revealed high correlations for: the 3 residences, the NS, LI, BS, the PG and CI firms; low correlations for: the HI and BG and PS firms. These results follow from earlier thoughts, representing similar management (i.e. decision-makers') decisions for those eight high firms, or steady rates of increase; the low firms came from industry's sporadic movement (HI and BG) plus the Social Sectors' actions (PS). In general, the 6 firms' coefficients were greater than +.9, thereby displaying a remarkable similarity in decision-making operations with respect to profitability.

The growth correlations reveal much more on Blue City's progression through the twin sets of rounds. "Net worth's" +.425 value stems from New's upturn from round 6–7 when Old hit a downturn, "Cash balance's" high +.907 stems from a similar movement in values (despite Old's consistantly higher values); "Population's" near-perfect +.99 is to be expected if the twin Runs were equal, because population increased similarly for both Runs. The "liquidity correlations" substantiate the earlier finding: the differing Runs possessed similar decreases in liquidity through round 6 (the +.99 result), but had a divergence in round 7 (thus the +.80 result).

The cross correlations represent an attempt to analyze general trends. It is with these that interesting coefficients appear. The extremely high Old "net worth" to Old "population" correlation of +.998 represents a remarkable similarity in movement and growth, while the New value of +.234 shows the dissimilar trends articulated earlier. The high negative value of —.952 for New "net worth" to New "cash balance" further shows the negative trend of the cash balance movement, while the —.53 for Old shows a mediocre relation in opposite ways. In total, these figures lead to several conclusions:

- A relative increase in the Old run liquidity and growth in cash balance points to its superior advantage in investment, building, and growth over the New run.
- High profitability correlations for almost every branch of the economy point to a general similarity of decisions and cognizance of the play of Blue City.
- Over all 4 rounds then, the Old runs enjoyed a better advantage for growth but both Runs exhibited similar decision-results, with the New runs exhibiting difficulties in its PS & PG units being the major difference; thus the New fared well with what it had, and despite a negative growth in its cash balance (which, of course restricted activity.)

Government Sector

It was agreed by almost all of the government players who had experienced roles in other sectors that the Government sector was the most demanding of their time and energy: more people to deal with (often aggregated at the end of the game period), more general responsibility in decision-making that was taken seriously, constant pressure to balance diverse interests and to project a leadership image of its own all contributed to the difficulty of play. Although this sector has the potential to be the most unstable of the three in terms of personnel it proved to be remarkably stable. In fact, once a player learned the mechanics and mores of a government role he was reluctant to relinquish it, even when the Chairman changed. Moreover, the electorate and the new Chairman were always anxious to retain most of the non-elected government officials from the previous regime. All of this suggests that politics was relatively less important to the players than technocratic management, and this attitude induced a great deal of conservancy in the play. In fact, *over a cumulative total of fifteen rounds of play the government changed hands only twice,* and it is doubtful that it would have changed a single

time without artificial outside pressure from the game director. In the elective process there was almost no trading of votes for specific policies, and, in general there was very little interest in politics. At some elections the incumbent had to be reminded to file for re-election, and in a half-dozen cases he ran unopposed and was elected unanimously.

Neither the Social Sector nor the Economic Sector put much pressure on the Government, but on the whole the Government was more responsive to the requests of the Economic Sector. There was virtually no bribery in the play. The Social Sector players were generally too lost and disorganized to pressure either sector.

In a brief student analysis of selected departments of the government where the student compared the Fall and Spring terms of play he discovered that aside from their obvious correlations with population, the rates of growth of demand for both Utilities and Municipal Services are both greater and steadier in the new play than in the old.* The graphs (Figures 20 and 21) show these rates of growth and compare them to population growth.

Figure 22 shows the tax structure in Blue City. It does not include such things as bus fares, utility billing, and bribes, which cannot be counted as part of the total picture. In both graphs, the Resident Income Tax and Property Improvement Tax share a little over 75% of the load. The general structure is, in itself, no cause for discontent, and thus remained stable through the life of the play.

Figure 23 is perhaps the most interesting of all, for it provides some insight into the inner workings and intricacies of the model. A high use-index in the school system implies that the quality of public schooling is somewhat low. Therefore it is logical that the parents of the children will put them where the quality of education is best. In the case of a high use-index, the number of children in public school will be lower. The printout numbers have been translated into percentages, where the number of children in public school is a percentage of the total number of school-age children. When the school system's use-index is high, a smaller percentage of children attend public school. The actual correlation is about —0.9.

The fluctuations of use-index in the old play and its relative calmness in the new play is directly attributable, again, to the longevity of the "superintendents of schools." A short period of "breaking in" is necessary, as shown by the new play, where conditions have been improving steadily since Round Five.

In a department by department break down for "services" for the two runs it is possible to compare the differential development of the two plays.

One may conclude from a cursory examination of the data that over the comparable four rounds there was considerable similarity in the data for government "services" of Highways, Schools, Municipal Services and Utilities. No trend emerges that cannot be explained from population increase in the Model. This suggests that the continuity of government decision making from the Fall term to the Spring term was maintained.

General Trends of Play

Observations of the extended play that was carried out by the Dartmouth group allows the following categorization of the trend of play:

Characteristic	*Rounds*
Confusion	1 and 2
Competence	3 and 4
Complacency	4 and 5
Cognition	6 and beyond

As noted above, there was general confusion for two rounds of play as the participants frantically explored the Model. This period was characterized by great frustration at the seemingly overwhelming amount of information to process and interactions to strive for. Students often pleaded for guidance and help and became angry if satisfactory advice was not forthcoming.

This period of confusion was followed by a period of relative competence in the game techniques and relative stability of play. Questions to the Director dropped off sharply and some innovations and unusual combinations began to be formulated by a few players. This situation lasted for two rounds of play and was followed by one or two rounds of bored complacency. During this period the economic sector made money, the social sector remained disorganized, and the government was not pressed from any side. There was a definite threat around rounds 4 and 5 that students would lose interest in play if no external pressures were introduced. In the Fall the social sector did induce a crisis by threat of boycotts and physical damage, but even here this suggestion came from a non-player. In the Spring Term the Director induced a crisis by asking the Envirometrics Staff for an increase in the dissatis-

*The analysis was carried out by William White.

Figure 20

OLD PLAY

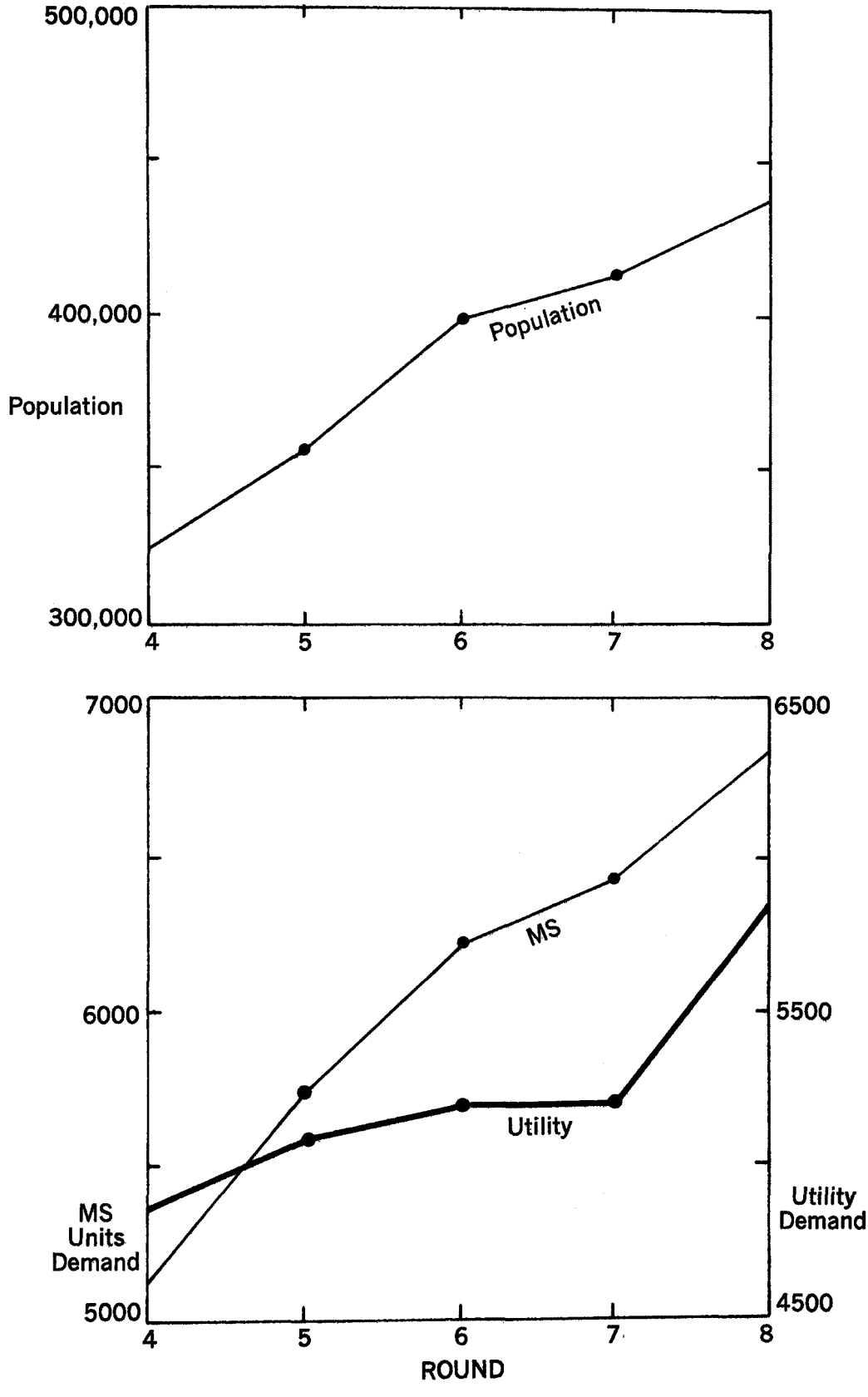


Figure 21

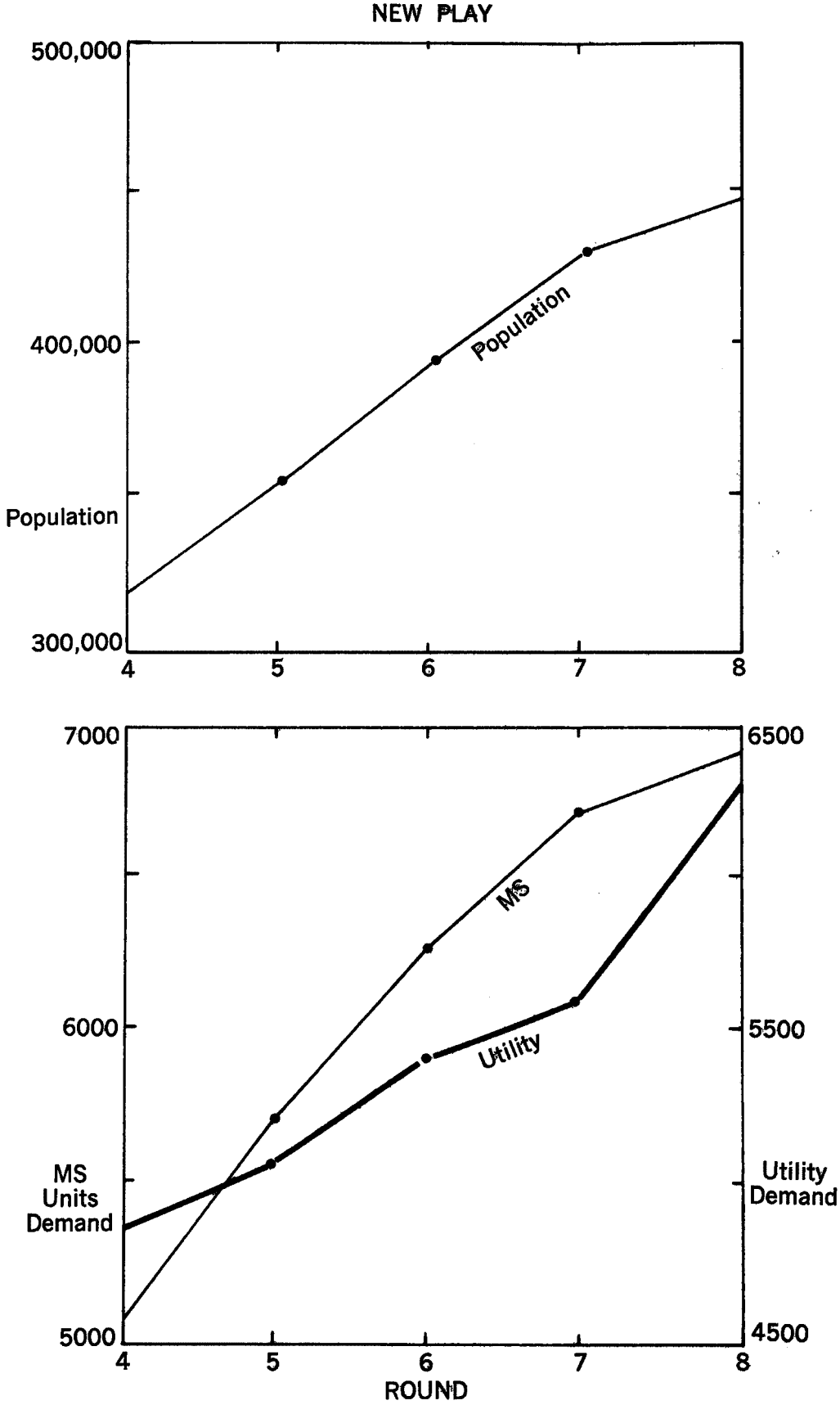

NEW PLAY
500,000
400,000
300,000
Population
Population
4
5
6
7
8
7000
6000
5000
MS
Units
Demand
6500
5500
4500
Utility
Demand
MS
Utility
4
5
6
7
8
ROUND

Figure 22

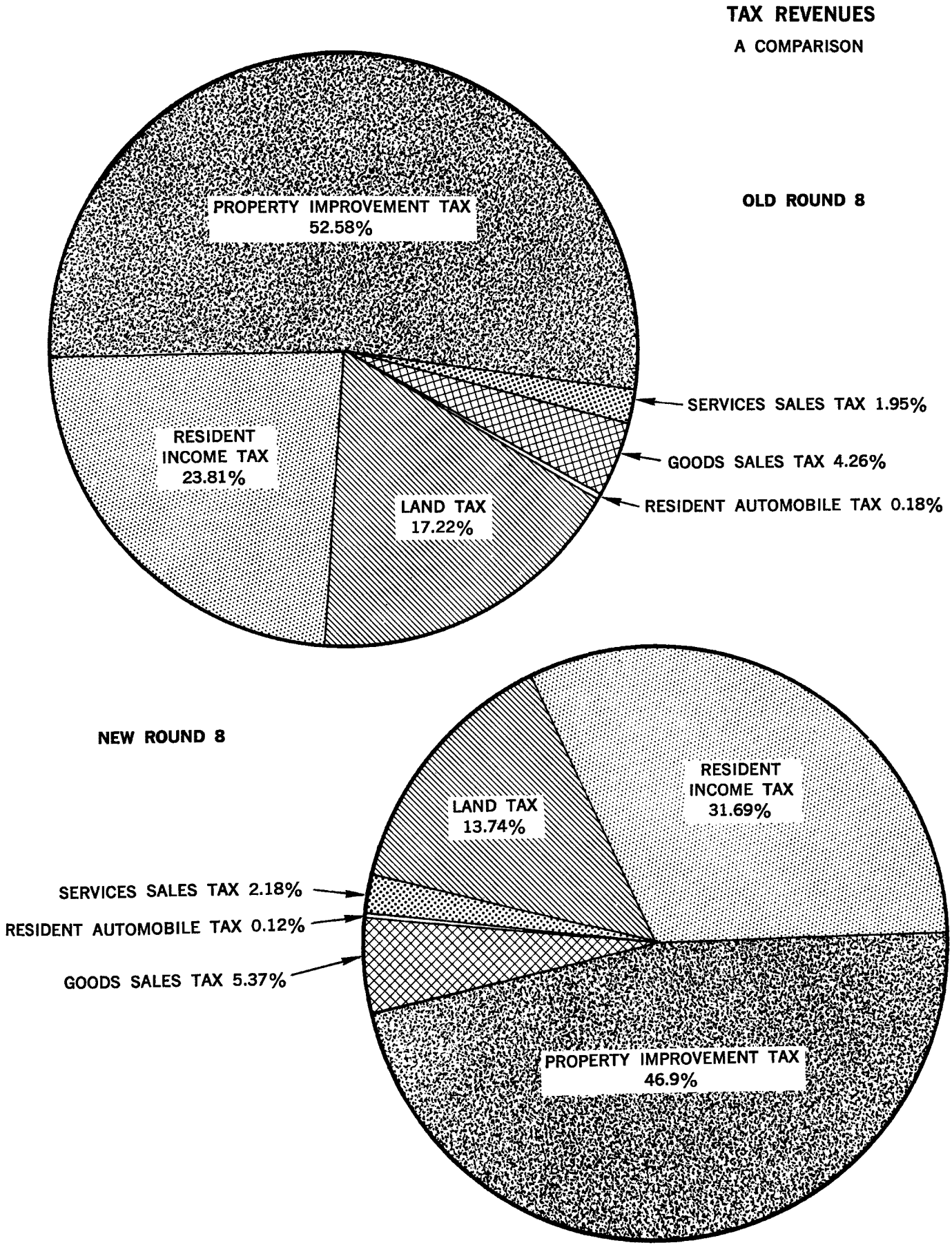
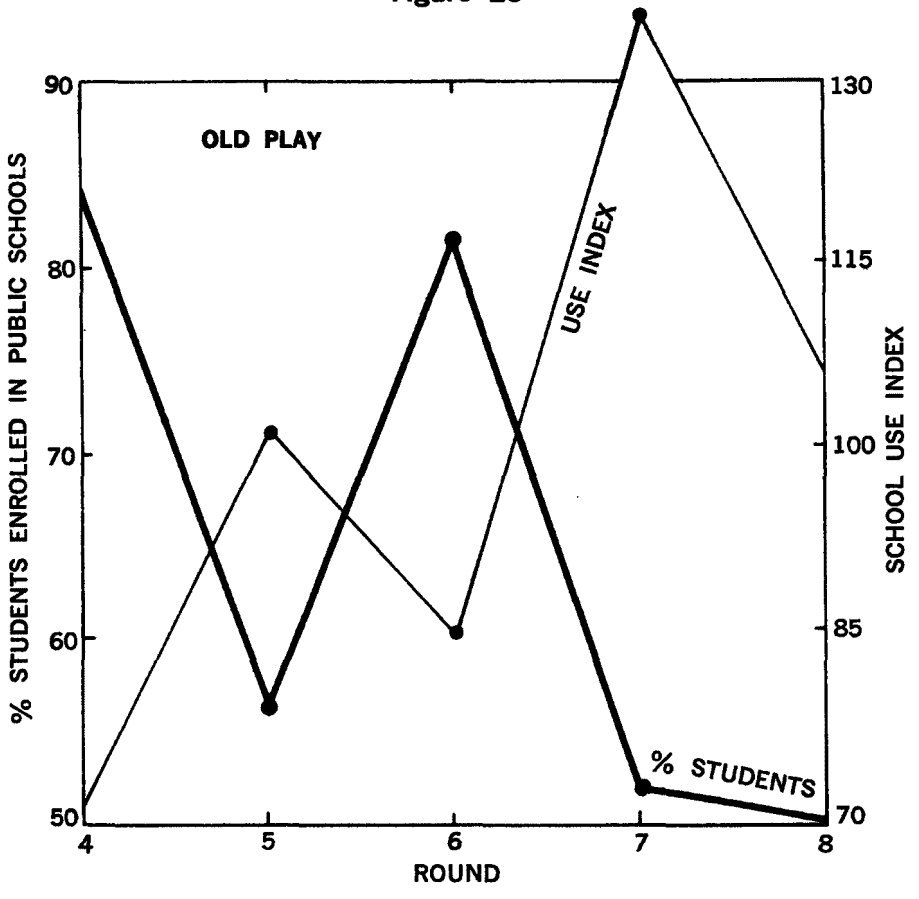

TAX REVENUES
A COMPARISON
OLD ROUND 8
PROPERTY IMPROVEMENT TAX
52.58%
RESIDENT
INCOME TAX
23.81%
LAND TAX
17.22%
SERVICES SALES TAX 1.95%
GOODS SALES TAX 4.26%
RESIDENT AUTOMOBILE TAX 0.18%
NEW ROUND 8
LAND TAX
13.74%
RESIDENT
INCOME TAX
31.69%
SERVICES SALES TAX 2.18%
RESIDENT AUTOMOBILE TAX 0.12%
GOODS SALES TAX 5.37%
PROPERTY IMPROVEMENT TAX
46.9%

Figure 23


OLD PLAY
% STUDENTS ENROLLED IN PUBLIC SCHOOLS
SCHOOL USE INDEX
USE INDEX
% STUDENTS
ROUND
90
80
70
60
50
130
115
100
85
70
4
5
6
7
8

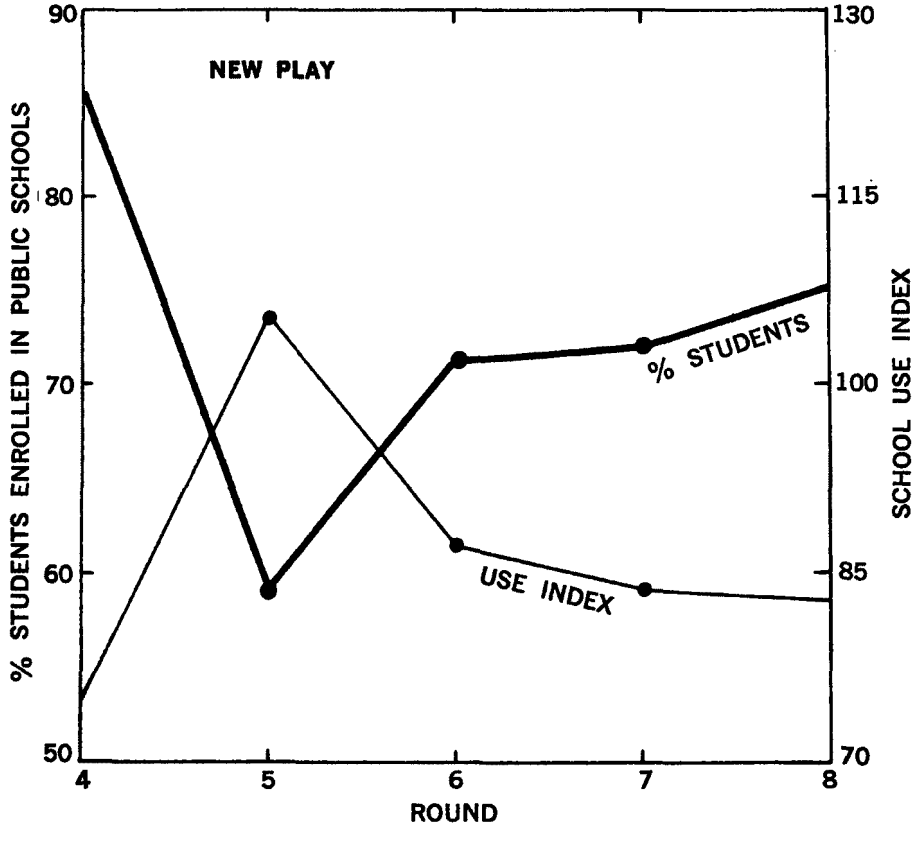

NEW PLAY
% STUDENTS ENROLLED IN PUBLIC SCHOOLS
SCHOOL USE INDEX
% STUDENTS
USE INDEX
ROUND
90
80
70
60
50
130
115
100
85
70
4
5
6
7
8

FIGURE 24

Highway	Rounds 4 Fall	4 Spring	5 Fall	5 Spring	6 Fall	6 Spring	7 Fall	7 Spring
Road Maintenance ($ Millions)	.987	1.09	1.11	1.19	1.62	1.52	1.66	1.73
Average Depreciation before Maintenance Road Type								
1	1.7	1.3	2.0	1.4	2.4	1.8	2.1	1.8
2	1.4	1.4	1.3	1.6	1.4	1.2	1.2	1.2
3	0.9	1.1	1.0	1.1	1.5	1.7	1.6	1.7
School								
Highest Use Index	91	91	200	200	91	94	92	99
Lowest Use Index	62	64	68	71	73	72	64	74
% Private Education	.164	.129	.440	.409	.234	.287	.161	.280
Unmet Adult Education Demand	2795	2775	4705	4835	705	0	0	1317
Municipal Services								
Highest MS Index	121	109	101	101	128	127	128	200
Lowest MS Index	64	59	89	89	90	96	93	200
Welfare Payment	$1200	1200	1200	1200	1200	1200	1200	1200
Total Welfare	$ 0	0	0	0	0	0	0	0
Utilities								
Highest Cost/Unit Plant	8249	7323	7589	7357	7456	7433	7998	7568
Lowest Cost/Unit Plant	7559	7197	7354	6762	6736	7399	7048	7503
Charge ($1000)	10.2	9.7	10.2	9.7	10.2	9.7	10.2	9.7

Key: Fall=Old Run
Spring=New Run

faction index and for an economic depression. The social crisis did occur but the economic crisis did not. It was the general lack of economic shortage in the model relative to the perception of possibilities by the students that contributed to complacency. Some students did not grow in their sophistication beyond the complacent stage although most of them tried to mask their lack of interest. Other students, more than half of the players, became cognizant of a wider arena for action, a greater number of possibilities, and a deeper meaning in the play of the game, all of which gave them a "second wind" that carried beyond the termination of play.

CONCLUSIONS

Some of my conclusions are implicit in the foregoing remarks, however it is worthwhile to restate them explicity:

- The experience of using the CITY MODEL has thoroughly convinced me that it is a superior learning device: when used effectively a greater percentage of a class is intellectually engaged in the gaming-simulation than is engaged in normal curricular offerings. Obviously novelty has something to do with this but it goes deeper than that in the context of contemporary, conventional academic offerings.
- The use of a complex model like Blue City requires the building of a course around it rather than leaving it on the periphery of a course. From a teaching standpoint I am no longer troubled by the prospect of making gaming-simulation the core technique in a course. I would not, however, risk the building of a regular curricular offering along these lines until I had secure access to the model on our own computer—indeed such a course would probably not pass through the curriculum committee (a necessary procedure for regular offerings at Dartmouth and most other Universities) without assurances of the Model's immediate availability.
- The instructor should build the class up to the use of the City Model by using some simpler games so that the gaming concept becomes more clearly fixed in the student's mind before play begins. This should be part of a general orientation to the Model and

should be punctuated with lectures and discussions.

- It is absolutely imperative that one or more assistants be engaged to help run the play and take care of the detailed work thereby allowing the teacher to be free to discuss ideas with the students.
- To be fully effective as a teaching device the students should be able to experiment with the model in some controlled fashion so that it passes from the realm of an engaging teaching tool into a true social science laboratory.
- The physical environment of the gaming area is very important to play. Access to several rooms which do not conflict with other classes, and the flexibility of the rooms themselves are crucial. There should be effective play; my preference is for twice information of the model. A large, up-to-date land use map is especially important.
- There must be a critical mass of players (which occurs at about twenty), to have effective play; my preference is for twice that number. There must also be an extended enough period of play (number of rounds) to allow for responsible actions to evolve. The final round should not be divulged ahead of time so that "end-game phenomena" may be avoided.
- The more different kinds of people (age, race, education level) the more interesting and fruitful the learning experience of the play.
- Bugs in the model should be corrected as soon as possible because their persistence has a deleterious effect on the play.
- The Manual should be re-evaluated and revised as ways to clarify instructions are discovered.
- Serious evaluation should be made of the influence of the starting conditions of the Model on the end result of play. This seems to be an important area for social science research.
- Continued experimental play such as that carried out by the six universities would be useful to those responsible for the development of the Model—better still would be the release of the Model to universities with the capability to experiment with it and to elaborate further its powerful teaching potential.

CHAPTER XI

American: CITY MODEL Usage for Courses in Real Estate and Urban Development Planning

*by Maury Seldin**

BACKGROUND AND DEVELOPMENT

The instructor's first experience with gaming was with CLUG in the fall of 1967, when he taught a capstone course for real estate majors in the School of Business Administration of The American University, entitled "Seminar in Real Estate Administration." The purpose of this integrating seminar was to provide the student with an opportunity to bring to bear the substantive knowledge from various courses in the solution of problems the student would be expected to face as a decision-maker.

CLUG, a manually operated Game, was comparatively simple in contrast with the computerized models such as City I and City II. Initially, the emphasis was upon analyses useful in investment decisions, for example, market analyses, valuations, and forecasts of city growth and structure.

The course next used the game "Region" which was invented during the 1967–1968 school year. "Region" handled more variables and permitted greater emphasis on analyses of local economic structure and the administration of economic environment.

One of the doctoral students playing the Game was able to clearly identify a complex set of relationships structured in the Model and tie them to the existing literature. In general, the students were able to see how the principles they had been taught were applied to real world situations, or at least to a simulation of those situations.

The students in that graduate class found the urban environment mismanaged and impeding the achievement of their objectives. To meet the problem, they applied to the public sector entrepreneurial talents previously used in the private sector. The result was a more favorable environment for their private interests and better performance by the public sector.

Based on favorable experience in graduate classes, the Game "Region" was introduced into a capstone undergraduate course. The level of undergraduate student sophistication was substantially different. That these students had a high interest in the Game but their lack of professional competence, as compared to the graduate students, was evident. The knowledge they had supposedly acquired did not come into play when they had opportunities to apply it. The undergraduates needed close instruction on the application of principles as demonstrated by the Game. The approach taken was to assign individual projects to each student which called for the analyses necessary to solve a Game problem. Thus, the student had more than an academic reason for learning or relearning a facet of the body of knowledge or the analytical technique.

The following year (1968) the graduate course used the CITY I MODEL. The next year (1969) a graduate course used the CITY II MODEL. (City I was used for an undergraduate class in the Spring of 1970.) The substance of this Chapter will be a description of the use of the CITY MODEL, with

*The author wishes to acknowledge the assistance of Robert P. Jones in the preparation of the last section of this paper.

emphasis on the experience of the graduate class in the fall of 1970 and the undergraduate class in the spring of 1971. One of the great side benefits of teaching is that the instructor learns as he teaches. The old adage "If you want to learn a course, teach it," proved to be true.

At first, the approach to instruction was to let the student get the joy of discovery as he played the model. The student would learn principles from the Game only to discover that he had previously learned them in a different form. The process taught well but slowly. In order to speed up the process, the instructor explained the model and principles early in the semester. While the mass of explanation was more than could be readily digested, it did permit the students to push deeper than they otherwise could have. As a result, questions were asked on matters not previously covered in the course. These questions turned out to be of the same nature as those the instructor was concerned with in his research. Indeed, the instructor first intended to use the Game in connection with an approach to a research problem.

Many students attempted to conceptualize the relationships brought to light by the events in the Game. They could then use their understanding of these relationships in their decision-making processes. The real world decision-maker is in the same position. except that he frequently operates under the handicap of a lack of familarity with the body of knowledge.

The major thrust of the instructor's research effort was to improve real estate and urban development decision-making on the part of real world decision-makers as well as aspiring students.

In this case the model served as a useful tool in handling complex abstractions with which the instructor had to deal. The models helped because they became progressively closer to reality, adding subsystems and providing greater detail in simulating the urban system. Thus, the instructor was able to conceptualize a process of managing the urban development system by conceptualizing the management of the subsystems and their coordination. A view of the problem of managing any subsystem had to be related to the total system. By successively working more complex models, the instructor-researcher was able to handle the more complex abstractions on an incremental basis. This provided the basis for conceptualization of a major research and demonstration project which is now under way.

That major research effort involves an approach to urban development planning which applies planning, programming, and budgeting principles to the urban development process. Of special importance are the criteria for balance in the system and methods of administration where the power to control the process is strong but fractionalized. This approach is further described in a paper entitled "Location of Residential Development."[1]

A major output of this approach is information in a form usable to decision-makers. The approach relies substantially on the power of information as it may be used to influence decision-makers and on the use of information in the political process.

The research on which the instructor is currently engaged is in the design of this system on a pilot basis for Fairfax County, Virginia. An operational system in the Game or in the real world, or both, would provide a useful teaching device not only for university students but for those who are making the decisions in the public and private sector.

A set of value judgments or biases may have been visible in the previous discussion. The value system is one which holds that the use of a market mechanism is desirable as a basic approach to economic problems. While not the sole approach, it utilizes the pursuit of self-interest to achieve community objectives. (It recognizes the important role of government in providing an environment in which a private sector can operate. It further recognizes the role of government in supplementing such activities where the results are found wanting. In addition, it recognizes the use of alternative means where the market is not workable for various reasons.) While this is no place to expound various philosophical views, the aforementioned information will be helpful to the reader in understanding the assumptions which underlie the normative economic analysis and hence the approach to business and government decision-making.

The professional mission of improving the quality of real estate and urban development decisions has led to a heavy emphasis on research concerned with improving institutional arrangements for the functioning of a free society. The particular institutional arrangements under scrutiny are those directed toward guiding market forces so that individuals pursuing their own objectives will tend to contribute

[1] Maury Seldin, "Location of Residential Development," *Papers Submitted to Subcommittee on Housing Panels on Housing Production, Housing Demands, and Developing a Suitable Living Environment,* Part I. Committee on Banking and Currency, 92nd Congress, First Session. U.S. Government Printing Office, June, 1971, pp. 243-262.

toward the community's achievement of its objectives.

Specific research by the author in the public sector areas includes the urban development information system now being developed in Fairfax County, Virginia; a recently completed demonstration project on a uniform building permit system for the Washington metropolitan area, which system would provide a data base for the aforementioned systemic approach to urban development management; also a recently completed study of the impact of the construction moratorium on the Washington metropolitan area. Other current or recent consulting includes services rendered to the Subcommittee on Housing of the House Banking and Currency Committee, and to the Office of Management and Budget, Executive Office of the President, as well as to local planning and government authorities. In the private sector, his work includes consulting for developers and coauthorship of a recent book entitled *Real Estate Investment Strategy*.

COURSE DEVELOPMENT

The real estate curriculum at The American University came into existence some twenty years ago. It started with a Real Estate Law course transferred from the Sociology Department at a time when there did not seem to be much interest in real estate and urban development. Over the next fifteen years a series of courses were developed which emphasized private sector decision-making. The sixteen real estate and urban development courses offered in 1965 for graduates and undergraduates revealed this emphasis. The capstone course, an integrating Seminar in Real Estate Administration, was added in 1965. It used case material in order to give the students an opportunity to integrate the substantive knowledge acquired in their various courses and apply this knowledge to decision-making situations. The thrust of that course was the use of analysis in the administrative process, focussing on typical real estate decisions of valuation, market analysis, location studies, particularly in the context of an administrative problem.

When CLUG was introduced in the Seminar in 1967, it was possible to use the simplified model as a basis for conducting market analyses. In the Game, the data were readily available and so the student could concentrate on methodology rather than on the time-consuming and difficult problems of gathering data. This was of significant assistance in teaching because data are not generally available for all the various kinds of analyses useful to demonstrate an understanding of the body of knowledge. "Region" provided a more realistic model and the CITY MODELS were substantial improvements in the simulation of the environment in which the decisions were being made.

As the Games were being developed, so too was the course. The emphasis changed from market analysis, valuation, location studies and the like, to analyses relating to the management of the real estate resource.

One of the great merits inherent in the study of real estate is that the resource has such distinguishing characteristics that the analysis brings into focus principles which might otherwise be clouded. Thus, the application of planning, programming and budgeting techniques to the administration of real estate development enterprise illustrates the principles of balance necessary to get from here to there. These same principles apply for the urban development process. The Game is a useful device for explaining these relationships as they apply to both business management and land use management. Once the principles of land use management are understood, the management of the urban development process may be more readily grasped.

The Seminar integrates not only the real estate decision-making from the firm-investor point of view, but also urban land decision-making knowledge from a community point of view. The relationship between the two is also subject matter for the course. While the title "Seminar in Real Estate Administration" thus has become a misnomer, the course continues to emphasize the real estate resources, albeit in a context of urban problems as well as business problems. Considerable attention is also given to the relationship between the two. While management of the urban system is considered mainly in terms of an environment in which to do business, public administrators would also find it useful in their work.

The undergraduate course entitled "Real Estate Administration" in which the Game has been used is likewise a capstone course for the undergraduate real estate major. Initially, the Game did not work as well in this course because the students did not have sufficient substantive knowledge to integrate at the level of sophistication intended for the course. Attempts to shore up this deficiency have been made first by directing the student to conduct specific

kinds of analyses with specific references to the literature. This has worked reasonably well in that the students who have a reason for wanting to understand a particular type of analysis do a good job in pursuing the knowledge. However, it has been necessary to transform the procedure into one in which more readings are programmed into the course as the Game progresses. The literature has not been designed for this purpose, and so the progress, while adequate, still leaves much room for further development.

Because of curriculum changes at the undergraduate level, a new course in urban development is to be offered in the fall of 1971 in which the Game will be utilized as a way of introducing the student to the body of knowledge. The old capstone course will go by the wayside and a new course focussing on investment decisions will take its place. The elementary course which is intended for undergraduate students of various majors in business administration focusses on the urban development process. It is anticipated that it will include the set of readings closely tied to the Game which is used as a stimulus to the student pursuing the knowledge necessary to improve his decision-making.

The differences in approach are related to the differences in student profile. On the one hand the graduate students are expected to be able to run a city efficiently and to do a good job of administering the resources which they control in the private and public sectors. At the undergraduate level, on the other hand, students are exposed to a body of knowledge whose purpose is to give them a liberal education rather than professional competency.

COURSE OBJECTIVES

The purpose of the course is to improve the quality of real estate and urban development decision-making through the use of a body of knowledge. This objective is sought through the education of students who are or may become the decision-makers. The course is designed to give them an opportunity to conduct the analysis which leads to the decisions and to see the consequences of those decisions and subsequent actions. This gaming approach is different from the term project approach in that in the Game they make the decisions and have the opportunity to implement them. They receive a feedback from their actions. In addition, other forces are constantly at work which alter the effectiveness of their programs for achieving the objective they set forth. They therefore have a learning experience in how to deal with a changing environment. The round-by-round play gives them the feedback so they get significant experience in selecting the type of analysis which is necessary to move them toward their objectives. The allocation of their time as well as of their Game resources is a critical determinant of the success they hope to achieve.

The course is designed to enable them to improve their analytical ability. It starts out geared to the developer-investor and others who are primarily concerned with individual parcels of real estate. But as the course develops, it is obvious that these decisions must be looked at in terms of what the rest of society is doing.

The resultant administrative process integrates decision-making through the various disciplines. As the Game progresses the students see that they are at sufferance of the environment in which business needs to perform its functions. They increase their involvement in the management of that environment. They apply the same administrative processes to the management of that environment. They then learn more about the relationship between business and society.

The types of analyses at the micro-level include market analysis for shopping centers which are simulated by "personal goods" and "personal service" industries. Other market analyses are used for various types of property to be developed. Appraisals need to be made for various purposes. Business and property analyses are made in order to improve profitability of the enterprises. Investment portfolio analyses are conducted. In a sense, the economic teams manage a variety of business enterprises and a portfolio of real estate resources. Unfortunately the income to business and the income to the real estate are not separated. But, the student is able to explore the application of principles which he has learned in his real estate and business administration courses. He also finds that human relations and leadership qualities become important determinants of his success.

At the macro-level the objective is to improve the student's understanding of how the system works. He does this by assuming a public role in which he does the planning and zoning or provides the transportation facilities or utilities, or he may be mayor and coordinate public sector efforts. The Game is so devised as to provide the feedback which can be

used as a measure of the quality of performance of these various public sector functions. The student then sees how the proper (effective?) functioning of government influences the proper (effective?) functioning of business, or perhaps more correctly how the improper (ineffective?) functioning of government adversely influences the proper (effective?) functioning of business.

Since the public and private interests become interwoven, the Game provides a good way of demonstrating decision-making in a society in which there is some community of interest between the public and the private. The class determines its own standards of morality. A system of ethics and law develops in a way that enables the society to function. The set of values varies with the student group, but whatever the values, they show through in the operation of the Game.

The operation of the public sector provides significant opportunities to apply analytical techniques for public decisions in much the same way analytical techniques can be used for profit-oriented decisions.

For example, a school location decision is not so different from a shopping center location decision. Experience in the Game shows that the private sector decision-makers do use that knowledge of analytical techniques for public sector decisions.

The public sector demonstrates a need for balance in the system. The balance is not only in the provision of public facilities but also in the private development of the appropriate mix of land uses.

One of the great lessons of the Game and of the course is that the urban development process may be managed by providing an environment in which the private decision-makers pursuing their own objectives respond to public sector objectives. They build where the facilities are available and at the best place to serve the markets. Since the public sector can control the locations where the facilities become available, there is an opportunity to be socially and politically, as well as economically responsive. An efficient system can be developed by developing balance.

The inefficiencies become expensive not only to the developers but to the community as a whole, so it becomes evident that it pays to have an improved analysis of the problems of managing the environment in order to achieve public objectives, whatever they may be.

In CITY MODEL the public objective decision-making is complicated by the presence of a separate social sector which is generally muted in the classes under discussion. Some development may take place in activating this sector. But the social sector receives little attention because of the small size of the class and the entrepreneurial tendencies of the students generally, as well as because of the selection of students.

COURSE STRUCTURE

One view of how best to educate a student is to let him work with a professor for several years on a one-to-one basis. This will permit guidance of his activities in reading, writing, and solving problems, real or simulated. The feedback permits close attention to individual needs. The platitudes offered at commencement time have some merit. Formal education has really just begun. Education before the degree should provide experience, knowledge and understanding that will continue to grow after graduation.

The reason for not operating a university on a one-to-one basis is that it is far too expensive. The alternative is to put students in groups and perhaps into classes and organized curricula so that a body of knowledge may be transmitted. Universities today may be "so well organized" that the student-teacher relationship has gone by the wayside in the sense of the student going to study under someone. This is less true at the graduate level than at the undergraduate level, but the problem is the same.

The Game provides an opportunity for the professor to work with each and every student on the individual students' unique problems. And while the students are grouped together in a class and live in this simulated society which, for them, is very real, they are also able to pursue their educational experience on an individual basis. Many students are uncertain about why they want to acquire the body of knowledge. Some of them will simply proceed on faith that it is really advantageous to study the discipline. The Gaming decision puts them in a situation where they know why they need to know. They are then receptive to the opportunity to seek out that understanding. And while the courses are taught with lectures explaining parts of a body of knowledge and reading material that is helpful, there is a high degree of contact in class between students and faculty and indeed among students who go on to learn from each other.

The case study approach is a halfway measure in this process. It provides a student with the oppor-

tunity to simulate situations and to discuss them. They get involved in someone else's problem. They really don't get the feedback. In the Game they are involved in their own problem. They get the feedback.

Typically, at the beginning of the semester the student writes a one-page paper outlining his goals and objectives. He then programs his activities in order to achieve his objectives. The Game provides a situation in which he may be measured against the standards he sets.

Over the past few years the instructor has experimented with various mixes of Games and other techniques. These range from building the entire course around the Game to programming the Game for one half of the course and projects for the other half. When the course was in essence all Game, the students would write many papers demonstrating how they conducted their analyses, showing detailed plans of what they were going to do, and the like. The middle ground includes a heavy lecture schedule and the use of the Game to illustrate specific points. The minimal use of the Game occurred when term papers were assigned separately from the Game. This means there were very few of the short papers in the Game, but a heavy assignment on the project. The discussion made use of the Game for the Model.

The instructor's preference depends on the objectives in view. When the purpose is to teach analytical techniques, many short papers work out best. When the goal is to develop a professional competence in some particular dimension, the term paper works well when the Game is used as a frame of reference. When the idea is to convey a general understanding of the urban system and decision-making within it, the best combination consists of the Game plus the reading and some modest papers.

FAMILIARIZATION WITH THE MODEL

The student is introduced to the Model through the use of a film, lectures, and the *City Manual.* The film shows the excerpts of a previous play of the Game and gives a brief narration of what to expect. This film is supplemented by lectures which emphasize acquiring knowledge and applying various tools of analysis in order to improve decision-making. Also, the students are requested to read the *City Manual* to familiarize themselves with its extensive technical contents.

The technical nature of CITY MODEL makes an understanding of the urban system depend upon a working knowledge of this particular Model. After the completion of one or two rounds, supplemented with staff assistance as to the operation and certain basic relationships, the majority of the students are questioned (and invited to ask questions) on how the urban system operates. The purpose of this session is to give each individual player a broader conception of his role and the roles of other players in the system. The subsequent sessions provide repeat opportunities to increase familiarity with the operation of the Model and the real urban system.

TREND OF PLAY

Armed with the technical knowledge and a simplistic view of the urban environment, the student is encouraged to develop an administrative approach utilizing the framework implicit in the planning-programming-budgeting systems approach. The student is expected to:

- Define his general *goal* which is *output oriented,*
- Identify *objectives* which indicate conditions or levels which must be obtained or maintained to successfully reach the designated *goal,*
- Draft *programs* which are designed to achieve the standards set by the various *objectives.*
- *Evaluate the programs* to determine their effectiveness (in cost/benefit terms) as compared to alternative programs.

As an example, one student's interpretation of his political role in the urban system is abstracted as follows:

POLITICAL GOAL School Department

Develop a school system comparable to the best in the nation, which will provide high quality, accessible and meaningful educational experience to the people of Blue City.

OBJECTIVE #1

Maintain the pupil/teacher ratio at less than 15/1.

Program #1

Using population growth projections, determine future student levels. Hire middle and high income teachers, at the optimum mix, to meet this demand.

Program #2

Redistrict school boundaries to better utilize existing resources.

Program #3

Construct new schools or add to existing facilities as projected. (Specific round-by-round projections are used.)

OBJECTIVE #2

Keep unmet demand for adult education at less than 10% of the total demand.

Program #1

Similar to those for OBJECTIVE #1.

It can be seen from this example that the School Department has:

- A definite goal (to be the best)
- Identified meaningful standards of performance (student/teacher ratio of 15/1 and unmet demand for adults at 10% or less)
- Determined approaches to achieve these standards (population projections, new construction, redistricting, etc.)

Some of the various types of analyses which were employed by a number of the decision-makers as described in the discussion which follows indicate that most analyses performed fall under the *Program* category.

Economic Base

Fundamental to many papers which analyzed Blue City for various reasons was the determination of why the city is growing. The recommended readings in Wilbur Thompson's *Preface to Urban Economics* had drawn attention to "export base" theory and the students were able to identify the following components of the economic base of Blue City.

Sales to the National Economy
(in millions)

Industry	*Year*			
	1	3	5	7
LI	$203	$233	$223	$234
HI	$470	$528	$530	$503
NS	$208	$215	$323	$526
	$881	$976	$1,076	$1,263

This is a useful exercise but its impact on decision-making is minimal unless it is used in conjunction with the other data.

Business Cycle

Export base analysis, since it is dependent upon sales of goods and services outside the local economy, must be supplemented by an analysis of the condition of the national economy. This provides a useful yardstick for measuring economic performance. By charting the prices paid for basic industry output, the return on investments and the interest rate on loans and bonds, the students were able to determine which phase of the business cycle they were in. Most correctly identified the downtrend of the recession. This may have been one reason for the general hesitation of investors to make large capital investments in Blue City.

Demographic Analysis

Other basic studies, important to public and private decision-makers, concerned the tracing of population growth and projecting future levels. Other trends that were investigated included: employment (total), employment distribution by industry, unemployment rates and income distribution. All these data were readily available and in a usable form but it was concealed among mountains of other figures. Here again the PPBS format guided the student to assemble only the pertinent facts and disregard peripheral information.

Housing Market Analysis

Another basic tool of the decision-makers of Blue City, important in any geographic area where dwelling units are in competition with one another as alternatives for the users of housing, was the housing market analysis. It incorporates many of the previously mentioned types of analyses: economic base, employment trends, income distribution and population analysis. An additional component of a housing market analysis is the housing stock or inventory. The magnitude of the total housing stock in terms of dwelling units, reflecting changes over time, is one of the most significant items of the reported data. In the example cited below the student goes one step further by identifying the change in distribution of the inventory by structural type.

Housing Inventory
(level of development)

TYPE OF DWELLING	YEAR		
	1	4	7 (current)
Single Family (RA)	101	115	123
Garden Apt. (RB)	24	31	37
Hi-Rise Apt. (RC)	6	6	8

Equipped with this knowledge, plus awareness of vacancy rates, rents, property values, and financial market conditions, the private developer could make a rational decision as to the advisability of a housing investment.

Appraisal

Appraisal theory was also utilized on a number of occasions to aid prospective purchasers and sellers as to the market value of particular parcels of land. The data needed for the three approaches to value were available to the student appraiser.

In the application of the cost approach:

1. An indication of the value of the land was available on the "market value of privately owned land" sheet.
2. Costs to reproduce the structure new could be obtained from the local construction industry and the outside economy.
3. The amount of physical depreciation was indicated on the individual economic output sheets.

In applying the income approach, the appraiser has:

1. Estimated the gross income by tracing the economic history of the property and analyzing anticipated changes in the environment.
2. Estimated the operating expenses in the same manner.
3. By subtraction, computed the net income before recapture (depreciation).
4. Developed or selected an acceptable method and rate for capitalizing the net income.

In applying the market data approach, the appraiser has:

1. Found similar properties in the area for which pertinent sales, rental and operating data are available.
2. Qualified the price as to terms and bona fide nature.
3. Compared the important characteristics of the subject with the corresponding characteristics of each of the comparables, by time, location, and physical factors.

The student would then select the approach which is most applicable to the subject property and determine a final valuation.

Land Use Studies

One final group of analyses began to emerge in the later rounds of the development of Blue City. Urban land studies including surveys of the intensity of land and residential development, vacant land studies, structural and environmental quality indexes, land value studies, availability of park land and general livability studies, showed that unstructured growth of the city caused numerous urban problems. In this example, intensive residential development occurred along the main western and southern arteries, causing disproportionate traffic congestion, school overcrowding, poor municipal services and general social dissatisfaction. Observing this degeneration, the zoning department initiated a comprehensive master plan for the staged growth of Blue City. This plan, coupled with the support and corresponding plans of the other departments, has insured the future life of Blue City. By proper management of the urban environment the inefficiencies due to imbalance can be minimized. No longer would the public sector blindly respond to the actions of the private sector; now the public sector would stimulate or channel growth where it deemed it most beneficial for the city as a whole.

INTERACTION OF STUDENTS

The dynamics of the Game consist of the series of analyses and decisions of the types just described and of development of interpersonal relationships leading to group action through a political and social process.

The students play the Game generally through the economic role. This often results in a minimum of student interaction early in the course because of the nature of many economic decisions. That is to say that economic decisions are viewed as beneficial only to the team making the decision. Unnecessary interrelations are thus avoided for the sake of secrecy. Most players use the guise of ignorance when talking with their peers early in the course and their limited contacts are usually attempts to acquire knowledge.

However, as the players' command over the technical content increases, so does their awareness of the necessity of a properly functioning system. The player realizes that his economic aspirations will not be achieved unless his public counterpart can create a suitable "service-rich" environment in which he can operate. One or two students generally emerge quickly with an extensive grasp of the system and its technical content and assume the role of educator. In the course last spring one student had had

previous exposure with the model and was quite familiar with its operation. In a fashion similar to the old ward politicians this student would dispense favors, in this case the patronage was in the form of technical explanations, to gain the initial respect of his constituents. Needless to say, it was a simple matter for him to insure his election to the mayoralty of the City.

As time passed, and the other players came to understand their role and the roles of others, they began to realize that the mayor, although helping the city to function, was insuring his own economic prominence at their expense. The coup d'etat was swift. The era of the ward politician had passed and with this passing came the emergence of the city-manager. The political cooperation which grew from this new regime eventually led to full appreciation of the efforts of others and opened up higher levels of discussion concerning city-wide urban problems.

CONCLUSIONS

As is taught in the Game, the conclusions drawn would be relative to objectives. If the objective is to stimulate the student to "dig," i.e., search out the knowledge he needs, then our experience indicates great success. If the objective is to convey a body of knowledge, then our experience indicates that more developmental work is needed in order to program instruction necessary to communicate the body of knowledge.

In the politics of progress, university style, any curriculum without quantitative methods, human type studies, computer usage and gaming is simply not with it. It is as much a case of fashion and politics as it is of curriculum and pedagogy. The process, even in this cynical view, does however improve the effectiveness of what universities are presumably doing.

If, as in the view expressed earlier, the best way to teach and learn is on a one-to-one basis, then the Game is a great innovation. This is so not only because there is more time on a one-to-one ratio of teacher-student where the teacher is the professor, but there is a vast increase in the amount of the one-to-one teacher-student time where the students teach each other.

Much depends on the philosophy or assumptions, if you wish. For those that hold what some believe to be an archaic view, that the professor knows all, the student nothing, and let the students come listen, these conclusions on Game experience will be way off base. But, for those who really believe that commencement is the beginning of something, not the end, and that the educational preparation involves more of a student's learning that a professor's teaching, then the conclusion is that the Game is a great contribution in the form of providing the attractively packaged opportunity for the student to do what we believe he ought to do (attractively packaged or not).

If the waves of change in university education are following the pattern of the waves of change in other areas of human activity, be it the increase in the speed with which man travels, or his abilities to produce, control and use sound and light, or even his abilities to solve social science problems, then university education will take different forms. There is much to be done with the Game as an instructional device but there is much that has already been done with it as a learning device.

CHAPTER XII

Georgetown: CITY MODEL at Georgetown

by Philip Patterson

INTRODUCTION

Personal Background

I began an active involvement in urban economics in 1964 when I was graduate fellow to the single graduate urban course in the Economics Department at Georgetown University. Five years later, in the Spring of 1969, I began teaching the second graduate urban course to be offered in economics—The Simulation of Urban System: Econ. 484.

I have continued to teach a Spring course under that title ever since. I have however, never been a fulltime teacher at the university. The class in 1969 was held at the simulation facilities of the Washington Center for Metropolitan Studies and used the CITY I* model as a laboratory device. This first course was subsidized in part by the WCMS through the provision of free computer time, computing services and space. During the course of the semester, the Urban Systems Simulation staff (of which I was a member) at WCMS spun off and formed an independent company called Envirometrics.

The 1970 course was held at the simulation facilities of Envirometrics, and again, CITY I was used as an integral part of the laboratory seminar format. This time it was Envirometrics that subsidized the overhead costs associated with the use of the computerize model.

When the grant from the National Science Foundation was given to Envirometrics to test the use of the CITY MODEL in several different disciplines at several universities, I was very happy to participate on the part of Georgetown University. There was probably no way that I could have continued to use a computerized urban decision-making model in my course without institutional support. This was because none of the desired models could be run at the university computer center with no out-of-pocket cost.

Prior to the beginning of the 1970 course, I had been involved in designing and using urban decision-making models for about four years—first as a member of the Urban Systems Simulation staff (developers of CITY I) and then as a member of the Envirometrics staff (developers of CITY II, CITY III, and CITY MODEL). As one of the designers of the CITY MODEL and as one of the staff that had run the model on many occasions, I had many ideas about how I would like to use it. The NSF project gave me a chance to try one of the several alternatives I thought would be very beneficial to a group of students.

Course Description and Class Composition

Figure 25 shows the course syllabus. Note that no prerequisites were required and that students form other disciplines were courted. The assignments and term paper associated with the course were meant to discourage any student not willing to work on a continual basis during the entire semester.

Since the course uses a combination seminar (discussion)—laboratory (decision-making and policy-testing) approach, it was desirable to keep a small class size. After the first two classes, seven students dropped the course leaving eleven persons for the

*CITY I was funded in large part by a contract from the Office of Construction Services of the U.S. Office of Education.

rest of the semester. Undergraduates were allowed to take the course if they received permission. Several did, and the following make-up of students by rank resulted: six graduates, three undergraduates and two graduate auditors. All were economists but two: a planner with eighteen years of experience and a philosophy professor working on a master's degree in economics.

Several of the students held fulltime jobs: one as a banker, another for the U.S. Treasury Department, one student, Bob Ried, was assigned to the class as the university's fellow, which meant he was to aid in the course in any way designated by the instructor.

FIGURE 25—*Syllabus*

Economics 484: Simulation of Urban Systems
Phil Patterson
Department of Economics, Georgetown University

Prerequisites: None. Students from other disciplines are welcome.

Objectives of the course:

This seminar-laboratory course will focus on decision-making in an urban environment through the use of a computer-based gaming model. The course will deal explicitly with the major subsystems of the urban system, such as employment, transportation, migration, housing, activity systems, the provision of government services and their financing, and others.

Methods of Instruction:

The CITY MODEL, an operational simulation model will be used as the laboratory device for studying the urban system. Students will become decision-makers in a hypothetical metropolitan area. They will be able to pursue whatever objectives they wish and use whatever discipline tools they find helpful.

Assignment and Term Paper

There will be three reading reports and several other assignments of a research nature assigned during the semester. A research paper will be required that deals with a specific urban issue.

Required Texts:

1. Thompson, Wilbur R. *A Preface to Urban Economics.* Baltimore: The Johns Hopkins Press, for Resources for the Future, Inc., 1965. ($2.95 softback copy)
2. Perloff, Harvey S. and Lowdon, Wingo Jr. editors. *Issues in Urban Economics.* Baltimore: The Johns Hopkins Press, for Resources for the Future, Inc., 1968. ($5.00 softback copy)

THE COURSE

The operation of the course was strongly influenced by my previous two uses of the CITY I model in similar circumstances. There were, however, fewer changes to the purposes of the course than to the structure of the course.

Purpose of the Course

The single overriding purpose of the course was to provide the students with an opportunity to learn by being placed in a position of decision-making authority. Some of the general things to be learned were:

- The use and applicability of the box of theoretical tools they had acquired in other classes,
- The workings of a complex systems model that was designed to be a simplified reflection of the real world urban system,
- The importance of goals and norms in policy-making and in the life of any urban area,
- The competitive and cooperative nature of decisions in the economic, social and governmental sectors of any metropolitan area.

Several more specific goals of the course were to:

- Acquaint the students with some of the basic literature in urban economics.
- Provide through reading lists and class reading reports some insight into the literature in systems theory, model building, and educational games.
- Encourage original thought through the writing of a research paper on a topic of the students' choosing.
- Use the CITY MODEL as the integrating element for all the activity that took place in the course.

The last goal was of particular importance since past experience had shown that a holistic model of this type could be helpful in relating the theoretical literature to everyday urban issues and problems. In fact, my own understanding and interpretation of the literature had changed dramatically once I had become involved in designing and operating complex urban decision-making models.

Course Structure

Even though the CITY MODEL is a much more powerful tool than the CITY I model that I had used in my previous two courses, I did not depart radically from the format I would have used had I still been using CITY I. My previous two semesters convinced me to use a few strategies that I would have used regardless of the model employed.

First, start playing the game as early as possible but preceed it by the more simple manual game of CLUG (Community Land use Game).[1] The reason for starting play early is that almost any urban issue that comes up in the course can be related to the model (either to a factor contained in the model or as a factor that could be added to the "game" or to the "model").[2] The reason for starting with CLUG instead of CITY MODEL is that a few students tend to make serious mistakes based upon a misunderstanding of the model in the first or second round of play that plague them for the rest of the semester. By playing CLUG first, these students have the chance to make the mistakes, and learn from them (e.g., over-building personal goods because they do not realize that all sales must be made locally, or purchasing land at inflated prices miles away from roads or terminals).

Second, maintain a seminar atmosphere by having periodic discussion in which all students are encouraged to participate. This is to assure that each student take a stand on whatever topic the discussion deals with.

Third, allow the momentum and interests of the class to alter any pre-planned schedule for an individual class meeting. When a lively class discussion develops and it appears to be constructive, it is allowed to run its course.

A major difference between CITY I and CITY MODEL from the player viewpoint is the number of sectors. CITY I has an economic and government sector. CITY MODEL has those two plus a social sector. With CITY I, I had always had one or two person teams that played the economic and government sectors simultaneously. I decided to play CITY MODEL with one or two person teams that would play all three sectors simultaneously. But because each sector is quite complex, I opted for introducing the sectors one at a time; economic in round 1, social in round 2, and government in round 3. More will be said about this later.

THE PLAY OF THE MODEL

Overview

The model was run seven times after the receipt of Round 1 output which means that play ended with a Round 8 output. Since the model was run with teams operating Construction Industries, there was a round delay for all construction. Therefore, in the final round no construction decisions were made in order that the play would end on a stabilized basis. In Round 1 [3], only economic decisions were made. In Round 2, economic decisions and social decisions were made. The first full round of play in which the students assumed full decision-making power was Round 3. Thus, the full range of the model was available to the students for four rounds of play (Rounds 3, 4, 5, and 6).

Teams were comprised of one or two members and were matched alphabetically in the economic and social sectors (i.e., Economic Team A was also Social Team AA, etc.). Government positions were changed once (at the end of round 5), thus allowing each team to exercise two government functions.

Figure 26 shows the population growth for Georgetown [4] over the seven rounds of decision-making. The total population growth of 68 percent was quite large in terms of real life cities. This total growth over seven rounds converts to an annual rate of growth of 7.7 percent and places Georgetown up in the fast growing class of cities such as Phoenix, San Jose, Fort Lauderdale, Las Vegas, and several other cities during the decade of the sixties.

Figure 27 shows several indicators for Georgetown over the eight simulated years.

General and Departmental Indicators

Several useful city indicators that are not contained in the summary Demographic and Economic Statistics are shown in Figure 28. The indicators appear in the Figure in the same sequence as they appear in the output. For example, the first information after Edits is the details on migration. The key indicator in the Georgetown City is the in-migration, because jobs were always available in all three classes for Rounds 4, 5, and 6. It appears very

[1] Developed by Alen Feldt, now at the University of Michigan.

[2] A useful distinction can be made between the "model" and "game" components of a run of the CITY MODEL. Strictly speaking the type of inputs, the operating programs, and the computer output comprise the model. These do not change from one run to another. The starting city configuration, the allocation of assets to teams, the allocation of players to teams, the norms of the players, the institutions they create, and the win criteria they establish comprise the "game." Together they tend to be unique for each group of users of the CITY MODEL.

[3] For convention, "In Round 1" or "Round 1 decisions" will refer to decisions that were made to create a Round 2 output.

[4] The Georgetown University play of Blue City will be referred to as "Georgetown" to distinguish it from the other plays.

Figure 26.—POPULATION GROWTH IN THE CITY OF GEORGETOWN

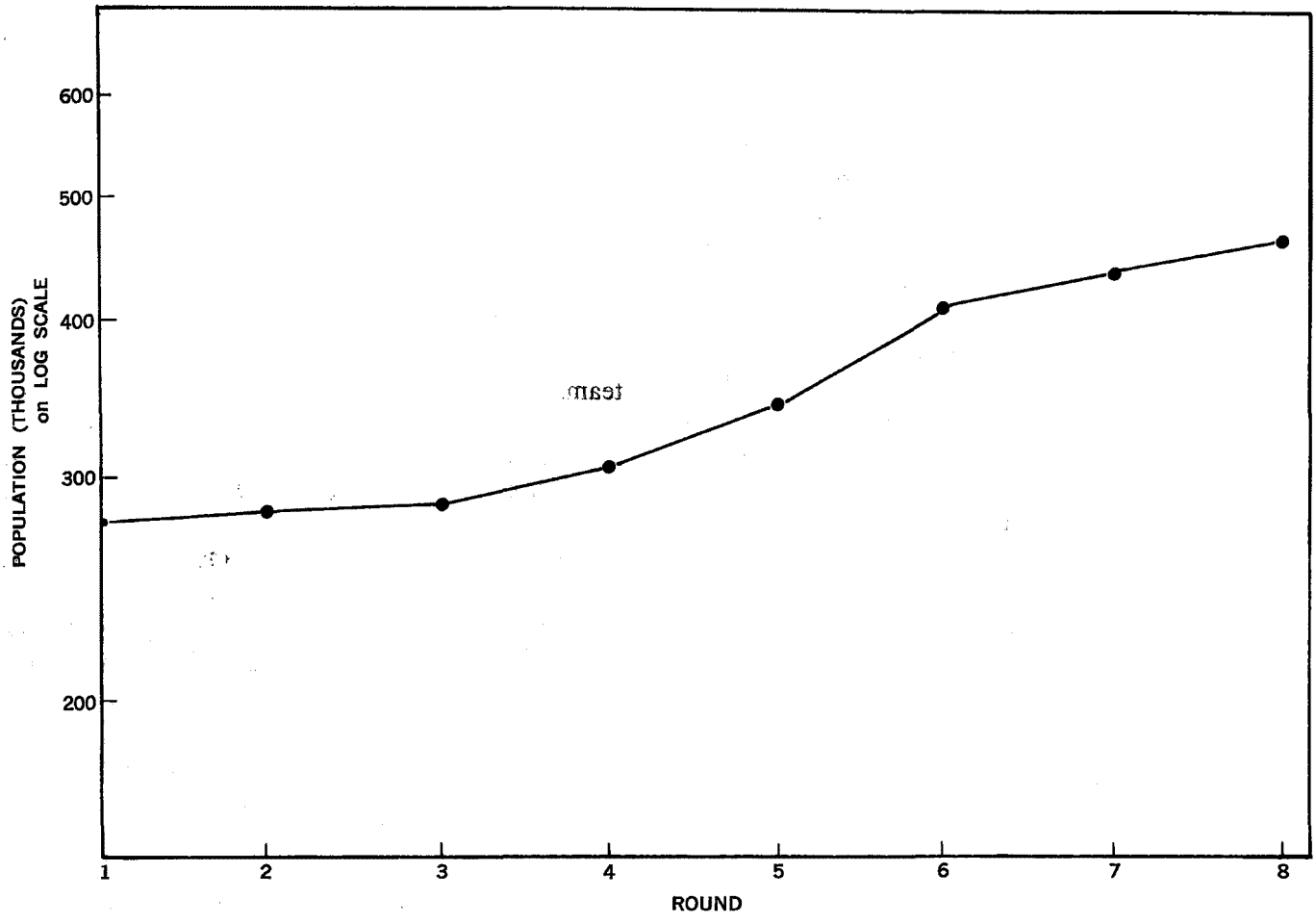


FIGURE 27—*Georgetown Indicators*

	Round							
	1	2	3	4	5	6	7	8
% Change in Population	0	2	1	7	10	19	13	
Population Per Residential Square Mile	1940	1942	1972	2127	2326	2546	2430	
Average Housing Dissatisfaction	NA	112	109	107	108	90	93	
Average Educational Level	60	57	57	57	54	59	58	
Vacancy Rate	6	3	3	3	−9	−3	2	
Employed Workers (thousands)	81.6	81.4	88.7	95.9	107.9	126.0	136.0	
Percent of Workers Earning Under $5000	38	38	37	33	36	31	34	

erratic, but this is primarily due to the amount and type of newly constructed housing. For example, in Round 5, mostly PL's moved in, and the only new housing constructed was completely occupied by Pl's. In Round 6, mostly PH's moved in, and this was because the new RC2 at 10826 was filled to over capacity by one PM and 59 PH's. Likewise, the new level of RB at 9236 was filled with 7 PH's. In other words, if housing had not been in short supply, the in-migration by round would have been even for the three classes.

A very useful indicator can be derived from the

FIGURE 28—*Indicators for the Georgetown Play, Rounds 2 through 8.*

Migration	(PI's)	Round 2	3	4	5	6	7	8
In—	PL	7	7	7	46	9	36	17
	PM	9	10	17	26	44	18	26
	PH	10	10	19	3	87	57	16
Out—	PL	0	10	3	12	12	6	17
	PM	5	12	2	2	2	3	1
	PH	14	7	1	2	1	3	4
Employment								
Average Cost of Transportation	PL	260	240	220	190	220	230	240
	PM	190	200	170	150	260	260	280
	PH	280	300	280	270	330	260	370
Average Transportation time.		5	5	5	5	5	5	6
PL unemployed		35	3	0 (82)	0 (61)	0 (70)	0 (42)	0 (54)
PM underemployed		14	0	0 (63)	0 (69)	0 (33)	0 (11)	0 (0)
PH underemployed		3	0	0 (89)	0 (110)	0 (41)	0 (0)	0 (33)
Highway								
Road Maintenance ($ million)		.824	.774	.682	2.18	1.36	1.64	1.92
	Road Type							
Average Depreciation before maintenance	1	1.1	.9	1.1	1.8	1.9	2.2	2.0
	2	1.0	1.3	1.0	1.2	1.3	1.5	1.4
	3	.9	.6	.8	2.0	2.0	2.3	2.2
Bus								
Fares ($ million)		.466	.969	1.25	1.34	1.33	1.88	.68
Current Expenditures		2.57	10.0	7.78	6.86	5.68	5.22	2.95
Fare Schedule		15¢ + 2¢	0 +5¢	0 +5¢	10¢ +5¢	10¢ +5¢	10¢ +5¢	10¢ +5¢
Passengers (1000's)		4.9	19.8	29.1	13.6	13.3	18.4	6.6
School								
High Use Index		197	185	85	47	96	88	95
Low Use Index		59	62	47	0	68	62	60
Ratio of Private/Public		.205	.186	.244	3.341	.243	.303	.352
Unmet Adult Education Demand		5085	4670	3414	8433	291	3716	4853
Municipal Services								
High MS Index		150	151	152	143	149	168	175
Low MS Index		143	143	135	121	114	114	113
Welfare Payment		$1500	$1500	$1500	$1500	$1500	$1500	$1500
Utilities								
High Cost/Unit Plant		$9704	8783	8607	8056	8271	8268	11,718
Low Cost/Unit Plant		$6926	7658	7777	7517	7106	6816	6,816
Charge ($1000)		$10	$10	$10	$9.7	$9.7	$9.7	$9.9
Revenue/Expenses		1.317	.879	1.258	.915	1.211	.755	1.230
Parks								
Population/Square Mile (in thousands)		35.4	35.8	34.3	34.2	34.2	33.3	33.0
Chairman								
Ratio of Appropriations to Taxes		1.29	1.21	.83	.74	.86	.93	.93
Auto Tax (millions of dollars)		.204	.194	.962	1.48	1.84	2.06	2.07

Employment Details. PI's by class employed by SC, MS, or BUS pay a systemwide calculated average transportation cost and take an average amount of time to go to work, since the actual cost and time cannot be derived due to the fact that there is no specified location for SC, MS, or BUS jobs.[5] Therefore, the transportation cost and time for employees of these government jobs give a useful measure of changing costs by class and over time. Since the calculated average figure takes into account other PI's that use cars, or buses (and/or rapid rail if one

[5] The SC and MS departments hire PI's and then assign them to individual SC and MS units. PI's are not hired by the individual SC and MS units.

exists), or walk to work. Thus, a declining dollar cost over time such as existed for PL's from Round 1 to Round 5, would represent such things as more bus ridership, more walking to work (Pl's working at adjacent parcels), or reduced highway congestion. In general, lower values would be beneficial to the social sector.

The average transportation costs (which are based on last round's data) reached their lowest point in Round 5, the year after bus ridership reached its maximum value. The change between Round 2 and 8 was detrimental to all but the PL Class. The average PH in Round 8 was spending 32 percent more and the average PM 47 percent more to get to work than in Round 2. The transportation sector of the local system certainly did not serve these citizens well! The average travel time to work was stable at 5 units for all the rounds except the last when it jumped to 6. Thus, the average worker was spending 20 percent more time getting to work in Round 8 than in Round 2. As city size grows, one would expect average travel costs and time to increase if offsetting improvements are not made in the transportation system, and this in exactly what happened.

Road maintenance costs increased significantly over time, and this was due primarily to more people using the same old roads. It is true that some new roads were built but the number of congested roads increased from 3 to 13 between Rounds 2 and 8.

The bus operation was a frustrating task for all three persons who tried a crack at it. Passengers peaked in Round 4, but the relative cash loss to the company was in Round 8 when expenditures exceeded fares by only 177 percent! A research paper by one of the hapless bus operators (Appendix B) presents a technique that might make the bus have a chance of turning a profit and still serve a large number of people.

The School Department started with a bad situation, in terms of disparity between the best and worst school units, and managed to make things better over time. The percentage of students going to private schools, however, increased over time and was very large in Round 5 when the local School Department experienced a wholesale exodus on the part of its teachers because of the low wages offered. The adult education program nearly met all the demand in only one year.

The Municipal Services Department started out with a system that was overcrowded and ended up with a slightly less overcrowded situation, but one that had more inequities than before. That is the worst served area was 17 percent worse and the best served area was 21 percent better off at the end of the seven rounds of decision-making. The cost to the economic sector via increased maintenance charges as the result of poor MS service must have been ignored by the entrepreneurs of the local system.

The Utility Department was improving the cost per unit at the high cost plant very nicely until the last round, when the cost per unit jumped 42 percent. The low cost plant showed a small improvement over the seven rounds. The revenue/expenditure figure is deceiving because part of the expenditures were accounted for by cash transfers to other government departments.

The population per square mile of parkland showed a small decline, which means a relative increase in the green space per capita.

Frequency of Decisions

Figure 29 shows some of the major decision categories and the number of successful and unsuccessful decisions made each round. Two conclusions are readily apparent. First, a large number of attempted decisions were declined because of procedural or substantive errors. In face, the percent of decisions rejected did not decline much over time. Also, in some cases such as housing builds in Round 6, the rejected decisions were not even submitted in the following round.

Second, the economic decisions far outweighed the government decisions, and both types far outweighed social decisions. Purchase decisions declined after peaking Round 3. Rent changes were fairly numerous, and most were increases levied by landlords in response to a seller's market. Price changes were not numerous, as one would expect given the monopoly position of most of the commercial establishments. Salary changes peaked during the rounds when labor was most scarce. The activity in maintenance decisions peaked in Rounds 2 (the first chance the teams had to improve the quality of housing) and 5 (for an unknown reason). Teams quickly realized the alternative uses of their money in outside investments. Disinvestment did occur more toward the later rounds as the national cycle declined and as local investment money became scarce. Tremendous building of businesses took place in Round 2, and much of the rest of the play centered around adjusting to meet this growth available in jobs. The housing shortage was

never sufficiently solved, but the gap opened up in Round 4 was narrowed.

In the social sector, many time allocations were made when the first opportunity in Round 3 presented itself. After change took place in the dollar values of time. More lowering of dollar values would have assisted the Bus Company in its efforts to gain maximum ridership.

All the government decisions in Rounds 2 and 3 were director inputs, made in response to needs expressed by the economic or social sectors. Appropriations were altered from year to year (unchanged appropriation levels require an annual input). Tax policy was exercised in Rounds 4, 6, and 7. Wide spread assessment changes were made in Round 4 and were coordinated with the tax policy in an attempt to intice more residential development. More residential development did take place in the following round, but the cause-effect relationship might be tenuous. Most of the other departmental activity showed little pattern other than fewer decisions over time. The one exception to this is the Planning and Zoning Department which carried out a master zoning plan in Rounds 7 and 8.

FIGURE 29—*Frequency of Decisions by Round—Georgetown**

	Round 2	3	4	5	6	7	8
Economic							
Purchases	6 [20]	37 [3]	24	25	2	12	—
Rents	15	6	11	12	8	6 [1]	6
Prices	0	0	1	1	1	1	0
Salaries	0	1	9	12 [1]	13 [1]	4	1
Maintenance	15	4	2	11	4	6	0
Invest	7	5	2	4	1	3	3
Disinvest	0	1	0	2	1	2	0
Build-Business Levels	[5]	9 [4]	1 [2]	1 [1]	1 [1]	1 [2]	—
Build-Housing Units	3	31	7 [128]	98 [58]	73 [97]	18	—
Social							
Time	—	29	15	7 [11]	3 [10]	9 [12]	0
Value	—	0	2	0	3	0	0
Government							
Appropriations	—	5	3	3	3	4	1 [1]
Taxes	—	—	4	0	3	2	0
Assessment	—	—	12 [2]	—	—	—	—
Schools	—	—	15	5 [4]	9	4	0
Municipal Services	—	—	6	6 [3]	4	1	0
Highways	—	—	17	21	5 [1]	5	—
Bus	—	4	—	11 [2]	6	106 [1]	2
Planning-Zoning	2	6	26	3	13	2 [51]	58
Utilities	[1]	8	0	6	2	6 [3]	8 [1]

*Figures in boxes are the number of decisions rejected for procedural or substantive errors. Procedural errors are coding mistakes and substantive errors are those that reflect system factors that prevent a decision from being made (e.g., lack of cash, improper zoning, lack of utilities, etc.)

The Economic Sector

Midway through the play, the students were required to calculate the rate of return on all of their properties and to trace back the rate of return for the two most profitable and the two least profitable investments. This assignment proved to be a revelation to a number of the students who were unaware of the declining profit rate that was brought about by a rash of speculative overbuilding in Round 3.

The economic sector tended to building intensively as opposed to extensively. Not many new parcels of land were developed; rather, the original undeveloped land within the initial development area was built upon. In fact, only one new parcel was used for housing, even though the population increased by 68 percent.

The Social Sector

Although the students were not active in the social sector, two major social indicators (per capita personal income and dissatisfaction index) both

improved over time. The dissatisfaction level, however, did not decline as much as in most of the other NSF cities. On the other hand, PCPI was higher in Georgetown by a large margin than in the other NSF university cities.

The Government Sector

Government activity in the Georgetown City in most of the functional areas appeared to serve the demands of the economic sector. For example, roads and utilities were placed in the places and in the amounts necessary for the planned economic development. Both of these departments showed indications of operating less efficiently over time.

The Highway Department was spending 30 cents per capita for highway maintenance in Round 1 and 42 cents per capita for maintenance in Round 8. With regard to the Utility Department, the least efficient plant had a production cost per unit of output that was 21 percent higher at the end of the eight rounds. The production costs of the most efficient plant, on the other hand, declined 2 percent.

The School Department reduced the level of inequality (ratio of use index at the most crowded school to the use index at the least crowded school) over the eight years from 3.3 to 1.6. Inequality increased with regard for municipal services, in that the inequality index went from 1.05 in Round 1 to 1.55 in Round 8. The population per square mile of parkland declined slightly from 35.4 to 33.0 over the eight rounds.

SUMMARY

Student activity in the three sectors was very uneven. Economic decisions dominated all others, and social decisions were made sparingly. This did not, however, generate an improvement in economic indicators at the expense of indicators in the other two sectors. In fact, the average rate of return on investments in the system declined over the eight rounds. This was largely due to the overbuilding that occurred midway in the play. This suggests that the students may have observed and learned more about the interaction of economic decisions in the local system than of either government or social decisions. A personal observation is that the students learn more from the model in the sections of the model that are most experimented with in a laboratory sense.

CONCLUSIONS

- The CITY MODEL provides an excellent tool around which to develop an urban economics course, an urban laboratory, or an economic decision-making seminar. A professor can focus attention on (1) tying the urban and regional economics literature to the model play, (2) allowing the students to experiment with decision-making (current policy alternatives or ones of their own design), and (3) providing the students with a chance to demonstrate their ability to use the box of economic tools that they have assembled in previous courses.

- The disadvantages of having a student play all three sectors simultaneously outweighs the advantages. The main disadvantage is that the social sector receives very little attention when a student has an option to make decisions in the other sectors. Perhaps, because of the nature of the social sector, students should never have any other responsibilities when they are playing the social sector.

Other disadvantages of playing the three sectors simultaneously are the handling of three sets of output, making decisions that cover the full scope of the model, establishing objectives in three diverse areas.

The advantages of playing all three sectors simultaneously are the educational feature of having conflicting interests, seeing the model and the city from three points of view at the same time, and playing the model with a minimum number of students.

- The CITY MODEL is a rich enough laboratory device that caution should be used as to how many complementary exercises are undertaken during the course of a single semester. I used parts of nine of the fourteen classes with game plays (two for CLUG and seven for CITY MODEL) and the remainder of the class time was devoted to discussion of readings, research papers, *Urban Dynamics,* and the play. Taken together, I feel that I attempted to cover too much ground. A number of readings were never discussed, and insufficient time was given to an analysis of the play.

- The play of a round of the model is complex and engrossing enough so that it is usually necessary to devote a full class period to play. A class session that is split between game play and any topic other than discussion of the play has a high chance of being unsatisfactory for either the play or the other exercise. On a number of occasions a class session began with a discussion of assigned readings and finished with a round of play. In each case, as stu-

dent questionnaires confirmed, the discussion was given secondary effort as students looked ahead to the play. At the same time, the play of the round did not receive the time it needed.

- The mechanics of the model are so formidable during the first two or three rounds, that once the students learn these, there is a chance of a let-down on the part of some of them. There is the danger that some of the students will feel that the purpose of playing CITY MODEL is to learn how to play it, rather than to learn by making decisions and receiving continual feedback in a hypothetical urban environment.

RECOMMENDATIONS

The recommendations will be listed under three categories of use of the CITY MODEL: those that apply to any user of the model in a classroom situation, those that apply specifically to the use of the model in an economics course, and those that apply to the type of seminar-laboratory course that I offered. These recommendations will be followed by some general suggestions concerning the use of the model.

1. Classroom Use of CITY MODEL

- Assign the social, economic, and government teams in the model (AA, A, and SC, etc.) in such a way that the students perform tasks in only one sector at a time. If there are a small number of students (less than 22) make all the gameroom teams (as opposed to the computer output or model teams) composed of one player. For example, if there are only twelve students, they would each comprise a team (numbered 1 through 12) and the gameroom team 1 might be assigned the model teams of AA and DD, team 2 might be the sum of model economic teams B and C, and team 12 might be the sum of SC and MS.

If there are more than 25 students but less than 50, it would be necessary to make some two student gameroom teams.[6]

[6] All of these recommendations are made assuming that the user starts with the Blue City configuration which has seven model economic teams, seven social teams, and from eight to eleven government teams. If one of the other starting configurations were used the number of students constituting cut off points would be different. In fact, the director who favors one man teams and has a large class might want to use the Big City configuration which has 36 distinct model teams or TriCity which has 44 distinct teams. On the other hand, a very small class might get more use out of playing Moray County which has a starting population of only 11,500 at the start of play and only about ten model teams.

- The CITY MODEL functions performed by a gameroom team should change several times during the course of the play. The ideal way to have teams assume government positions is to be elected or appointed to them. This may not be possible at the start of play or the political dynamics may never evolve, so the director must be ready to change team assignments whenever he sees the need or the benefit of doing so. Students benefit from playing several widely different functions during the course of the play.
- Have access to a graduate assistant who can handle the editing of player input forms, punch the input cards, handle the running of the output, and provide overall assistance during the run of the model. This student would very well be a member of the class. In either case, he should be well versed in the operation of the model and in the rules of the game.

This student will spend on the average about an hour editing decisions, a little bit more punching them, and whatever time is needed to input the decisions and receive output for each round of play.

- Do not attempt to cover too much ground during the course, and thereby take away time from valuable discussions of the "model" and the "game" that was played by the class. The assumptions of the model can usefully be questioned and alternative ones proposed. The goals, norms, and results generated by the game play should be fully explored and the relation between individual and collective objectives analyzed. Attempts to define the "goodness" of the final status of the city should be made.
- Do not split a class meeting between play of the model and some assignment not directly related to the play. Do not expect to get the full attention of the students during a class once output has been handed out.
- Devise several strategies for handling situations when a student or the class become let down as a result of learning the mechanics of the play or finding their function too easy to perform. If the whole class is in trouble, an outside influence such as a new state regulation setting school quality levels, utility rates, bonding, etc., might be made. Or natural disaster might strike in the form of cash drains from all economic teams or buildings being destroyed (director inputs). Or a new federal program to assist new town development might be made, creative federal aid programs might be introduced, or a federally imposed population level might be promulgated.

In the case where an individual finds the game too easy, he might be given an assignment to calculate his actual rate of return of cost-effectiveness. Or he might be given a tougher assignment. The tough assignments are Bus Company operator (have the service pay for itself through fares), Highway Department (eliminate all congestion), and Assessment Department (assess according to the best use of the land).

2. Use of CITY MODEL in an Economics Course:

- Tie the urban economics literature to the model when possible, and show where the model does not explicitly deal with elements of economic theory. In the latter case, there is a challenge to the student to devise a way for including the missing element. For example, the issue of water pollution is absent from the version of the CITY MODEL used in the NSF program. The student who is interested in this omission could devise a way for adding the water subsystem to the present urban system contained in the CITY MODEL.

- Encourage participation in the course by students from other disciplines. The model is an interdisciplinary device through which the student of economics may learn to appreciate the usefulness and limitations of his particular field of study. This learning will be aided if other students in the course have some formal background in the complementary disciplines of geography, political science, urban affairs, and sociology. Likewise, the student from the other disciplines may gain a better appreciation for the usefulness of economics.

- Assign a research paper that is closely related to the use, content, or outcome of the CITY MODEL. Student papers over a number of semesters will build up a helpful library of source material and ideas for future classes. In this way, the output from the students may be able to evolve to a larger research product than any single semester would be able to.

- Assign specific economic projects and reserve adequate time for the discussion of economic topics. The first might be accomplished with assignments to calculate the economic base of the simulated area, perform a PPBS analysis of the government, calculate rates of return for various investments, or estimate benefit/cost ratios for specific government projects. The discussions could deal with these topics in addition to such other as the place of macro and micro theory in the model, the economics of space, zero population growth policies, new town developments, model cities programs, revenue sharing, conventional intergovernmental fiscal relations, and others.

3. Use of CITY MODEL in an Urban Semi-Laboratory Course

- Have the class scheduled at such a time that the students do not have any limitations on the length of time they can stay at any one meeting. The seminar discussions that evolve or are planned should be ended by the students on a voluntary basis and not by a ring of a bell. But allow students to individually drift away at any point after the first several hours.

- Keep the class size to under 20 students so that they can easily get to know one another on a first name basis, and so that seminar-type discussions in which everyone participates are possible.

- Place strong emphasis on starting the research paper early so that discussion of the rough drafts can take place in the seminar when useful. Encourage the students to perform all of their assignments in such a way that it instructs the rest of the class and furthers the class learning experience.

SUGGESTIONS

- Make the city decision-making a long run project by having the second semester begin play where the first semester class left off. This would accomplish the dual purposes of providing the first class with an added incentive for looking at the city and their own functions in a serious way (and avoiding any end game strategies) and of giving the second class a detailed city history from which to learn the model more easily and see the reasons for the present status of the city.

- Attempt to load data into the model for a city chosen by you or your class. This could well be a class project that would not yield a usable configuration until the following semester. Making decisions for what looks like a real city may be of some benefit and the process one must go through to load a city teaches you a great deal about data availability, parameter fitting, and the model itself.

- With a very large class or with several classes, play a number of CITY MODEL configurations simultaneously and allow a few players to act as national businessmen who may invest a specified

amount of money in any of the cities, in whatever desired mix each year.

- Alter the assets of economic teams before the start of play by making some teams have only industries, other only commercial establishments, and others only residences. Team cash balances can be reduced or increased to make growth more difficult or easier.

CHAPTER XIII

Mankato State: CITY MODEL Usage in the Urban Studies Institute

by Robert Barrett

The CITY MODEL was utilized in the interdisciplinary program in Urban Studies at Mankato State College in two formal courses which I instructed and one independent study course which the students organized. This utilization during the 1970–1971 academic year was sponsored by the college and Envirometrics as part of an NSF project to test the applicability of the CITY MODEL in selected disciplines and academic institutions. The experimentation reported upon in this chapter proved to be an absorbing and rewarding experience to both the students and the instructor.

INTRODUCTION

My first experience with urban simulation came when Dr. Royce Hanson, director of the Washington Center for Metropolitan Studies, introduced me to the urban simulation lab which the Center had established under the direction of Dr. Peter House. I was afforded an opportunity to experience some "rounds" of the game and met some of the lab staff members. I became quite intrigued with the potential of the urban simulation lab to provide opportunities for theory building and concept testing in the urban studies curriculum.

My own academic training had focused first upon the sciences and then the social sciences leading to graduation from Hamline University in St. Paul with a double major in Social Science and Mathematics. When I joined the graduate program as a fellow in government and public administration at American University I was strongly interested in Political Science. My interests began to focus upon the city and its politics as I worked closely with my major advisor, Royce Hanson. These interests grew when I entered college teaching as a member of the faculty at Mankato State College, a regional institution in Southern Minnesota with an enrollment of 15,000 graduate and undergraduate students.

My early interests on the Mankato State faculty were twofold: to introduce significant opportunities within the Political Science curriculum for the study of cities and to work with sister disciplines, particularly the social sciences, to organize an interdisciplinary degree program in Urban Studies. The first interest was realized through the adoption by the Political Science Department of courses such as Urban Government, Urban Planning, Urban Administration, Urban Seminar and field study and internship experiences in the urban environment. The second interest matured into a healthy dialogue and collective action by several disciplines whereby our disciplines were married together into a B.S. and M.A. degree program for urban generalists seeking urban planning and urban management careers. More than two dozen faculty from over one dozen disciplines now cooperate on a refreshingly interdisciplinary scale to teach and research topics in Urban Studies in the Urban Studies Institute. The students in this program, numbering about 150, are upper division and graduate students whose previous experience has largely been in the social sciences. Furthermore, our students' background has typically been textbook oriented without substantial experiences within an urban environment. Consequently, our efforts to provide realistic urban learning en-

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vironments through intensive field study camps and internship work experiences found a natural learning complement in the use of the urban simulation lab.

THE COURSE

The CITY MODEL was utilized within the framework of two of the core courses of the Urban Studies curriculum. The first course was the Urban Studies Seminar which is offered to senior and graduate majors after they have completed a series of discipline based courses in the social sciences. The course is taught from an interdisciplinary approach with small enrollments (8 to 15 students) and with an emphasis upon analysis and discussion. In the seminar the class alternated use of the game with seminar meetings focused upon research and analysis of New Towns as an approach to the city as a system. The second course was Urban Government which is offered to junior/senior and graduate majors and non-majors who are interested in contemporary governmental and political problems of metropolitan areas. This lecture course generally enrolls a moderate number of students (30 to 40), and is taught from the Political Science discipline. In this course the game was alternated with conventional lectures which surveyed the standard topics of contemporary urban government. Selection of these courses for use with the CITY MODEL was largely a factor of the course schedule and the previous course work backgrounds of students enrolled in these courses. Whereas these courses had been partially redesigned at the outset, it became obvious during the conduct of these courses that not only the methods but also the objectives required serious modification. Consequently, I discovered that the usage of urban simulation required not only a rearrangement of the course syllabus but a major adjustment of the course objectives of these courses which had originally been developed to be taught with more conventional instructional techniques.

The primary objectives for the use of CITY MODEL in these courses were several. In the first instance, it was hoped that the model would afford a more multi-dimensional understanding of the city as a system. It was hoped that theory building and concept testing would be encouraged and would take place within an experimental context. For instance, concepts of decision-making and community power are capable of close observation and testing in the game dynamics. It was anticipated that the dynamics of negotiation, representation, advocacy, and related "role" activities would be meaningful and insightful experiences. A further objective was to sharpen the analytical capabilities of the class participants. Finally, the use of the game was to be tested as an effective learning experience within the established Urban Studies curriculum.

The course described in this chapter is the Urban Government course with an enrollment of 35 senior and graduate students majoring in Urban Studies or Political Science. The course was scheduled to meet one afternoon a week for three hours and the instructor received continuing assistance from a graduate assistant. The game was played on alternate weeks with an analytical and strategic discussion taking place during those alternate weeks when the game was not played. Figure 30 illustrates a typical two-week schedule:

FIGURE 30—*Schedule of Course Activities*

A. Week I

Time	*Activity*
30 minutes	Course assignments, general discussion.
30 minutes	Distribute results from last game round, cite highlights and trends, players record progress toward individual objectives.
30 minutes	Players analyze progress, revise role objectives, formulate strategies.
60 minutes	Players negotiate with government, economic and social sectors to maximize progress towards stated objectives.
30 minutes	Players complete decisions, write out decisions and report to game director.

B. Week II

120 minutes	Course lecture and discussion.
15 minutes	Distribute "BLUECITY GAZETTE" and "PEOPLE'S ADVOCATE".
45 minutes	Hold "town meeting" to discuss and analyze progress in game and relate game to course objectives.

The above schedule varied for purposes of the introductory session, examination periods and other related coursework. In retrospect, it would have been more advantageous to have the course meet twice weekly for two or two and one-half hours each meeting so that the participants would have shorter elapsed time intervals. In the intervals between the meetings described above the graduate assistant edited the "newspaper", prepared computer input and output, developed visual presentations and assisted the players. The players held numerous in-

formal meetings for strategy and analysis and were generally infected with a high level of interest and enthusiasm.

ORGANIZATION OF PLAYERS

At the initial class meeting the students decided who should be mayor and then self-selected their role in the social sector or economic sector. Hence, each of the students became a player in one of the three sectors.

The government sector of Blue City was structured after a commission form of local government whereby the government officials were both council members and department commissioners. The structure was devised more for the purpose of convenience relative to the limited number of players than for a desire to structure some "desirable" form of local government. The government participants were as follows: the Mayor, Transportation Commissioner, Planning and Zoning Commissioner, Education Commissioner, and the Public Works Commissioner.

The Mayor was elected by a simple majority of the class participants. Each candidate gave a platform speech indicating his or her respective objectives for Blue City as well as the intended short and long-range plans. After the election of a "liberal" mayor for the city, he then selected his staff of commissioners. The Mayor's responsibility consisted of overviewing the general administrative policies for the city as well as directing the publication of the *People's Advocate* newspaper. The *People's Advocate,* as opposed to the *Blue City Gazette,* was a government publication. It assumed the role of indicating the "accomplishments" of Blue City to the public as well as future goals and plans. It may be interesting to note that the opinions expressed in the *People's Advocate* and the *Blue City Gazette* varied considerably. The Mayor, at numerous meetings, characterized the *Blue City Gazette* in terms of "yellow journalism".

The responsibilities of each commissioner were as follows: the Transportation Commissioner assumed the role of overseeing the building, maintenance, and administrative activities of roads, bus and rail. The Planning and Zoning Commissioner was responsible for assessment and zoning activity of Blue City. The Education Commissioner was responsible for the building, maintenance and location of public, private and vocational schools. The Public Works Commissioner directed the building and maintenance of municipal services and utilities.

The Economic teams, by virtue of their assigned responsibilities, had a greater degree of influence than did the Social teams with respect to influencing the growth of Blue City. The assigned responsibilities of the Economic decision makers involved bidding on and/or purchasing land or developments; changing rents, prices, salaries and maintenance levels; transferring cash; lending, borrowing and investing capital; and building, upgrading or demolishing developments. It was found preferable to have at least two participants for each Economic team. With a limited number of participants, it was also determined that Economic teams should consist of more participants than the Social teams.

The assigned responsibilities of the Social teams involved voting, boycotting, time allocation, and setting the dollar value of time. Apart from the assigned responsibilities to the Social decision-makers from the manual, it was determined that the Social teams should have a greater degree of political influence. A simple majority of the Social decision-makers could recall the mayor and provide for the election of a new mayor, and they were also given a "veto" role through the referendum over certain bond and zoning decisions.

The *Blue City Gazette* reported statistical city data from one round to the next as well as editorialized on the activity of the Mayor and his staff. It was found that the *Gazette* afforded the class participants a vehicle for assessing the development of Blue City. The *People's Advocate* offered a basis of comparison between the statistical data as well as the Mayor's own interpretation of the data. The use of "newspapers" was found to be an effective communications link between the various sectors and also aided the student's comprehension as to "What is happening to our city?"

GAME RESULTS

At the outset of the game each of the players was required to formulate an explicit set of objectives for his sector and his role. Once during the term he revised these objectives in light of experience and changed attitudes. At the close of the term he analyzed his own rounds of play as to how well he achieved his objectives and what factors contributed to his success and failure. Likewise, he evaluated the performance of Blue City as a system and as a

learning experience. A review of the results of the student's experiences is most revealing.

In the government sector the Mayor and his Commissioners had wished to first increase the supply of jobs in construction and manufacturing to lower unemployment. One method used to accomplish the objective was to grant public subsidies to private housing construction and manufacturing industries. This objective was met in part during the last round when 80 new jobs were created. Unemployment dropped from its highest level of 8,760 workers in round three to zero unemployment in round six. This was largely attributed to new construction which offered new jobs of major impact for the unemployed.

The second objective of the government sector consisted of providing a higher standard of living for the poor. The criteria for a higher standard of living for the poor was to raise the welfare payments from $1,500/family/year to $2,500/family/year. This was done by round six which was the last round the first Mayor held office. Rounds seven, eight, and nine, however, reflect a decreased welfare payment to $1,600/family/year which was a different policy by the new Mayor in the second quarter of play.

A third objective of the Mayor was to increase the supply of housing for low income families, particularly in the northeast section of Blue City. The demographic map, however, indicated little or no increase in housing for the northeast section.

A fourth objective of the Mayor was to increase public participation by holding town meetings on local issues and by the publication of a newspaper called *The People's Advocate*. Town meetings were held during each class session. The Mayor, however, seemed to find a great deal of opposition to several issues, most of which are reported in the *Blue City Gazette*. (Examples of the newspapers are in Figures 31 and 32.) One issue of considerable debate, particularly from the Economic Sector, involved the Mayor's policy to increase welfare payments. The Economic Sector thought it more advisable to increase the quality and quantity of public utilities which would assist in the development of new construction which would provide the needed jobs. As was noter earlier, welfare payments were increased. A recall election was then held as a result of the wishes of the Economic Sector. The Mayor won reelection by three votes and he termed his victory to be a "clear mandate".

The objectives of the Commissioners of the Mayor's departments were numerous. The Transportation Commissioner wanted to increase the number of bus routes. This objective was not realized because of bureaucratic red tape and procedural errors. The Commissioner once unsuccessfully attempted to establish a bus route through a farmer's corn field. The Planning Director's objective was thwarted when agreement upon a comprehensive plan was not obtained. The Education Commissioner wanted to improve the quality of education but continually found populated areas without established school district boundaries. It was also found that the average educational level decreased from an index of 60 in round one to 57 in round six. At the same time, the student-teacher ratio increased from 14 to 15. The Commissioner of Public Works wanted to build a new utilities plant to provide for expanded construction but he forgot to transfer monies from the operating budget to the capital construction budget.

FIGURE 31

Blue City Gazette

Vol. 1 Tuesday, February 15, 1971 No. 2

MAYOR McCARTY WINS RECALL ELECTION! APPOINTMENTS REMAIN THE SAME

The "goo-goos" of BLUE CITY, in their attempt to recall the Mayor and his staff, failed in their efforts. By the vote of twenty to seven, the Mayor was retained. He was quoted as saying, "This is a clear mandate for my programs!" The Mayor, however, was four votes from losing his Supercar.

Perhaps the most devastating decision the Mayor has made is advocating additional bonding for city expenses. BLUE CITY is spending a *total of $34.09 million* this year for the *interest on bonds*. This represents almost a 50% increase in interest payments. In fact, BLUE CITY is receiving almost half off its operating capital from bonding—the other half in taxes. If the taxes were raised as this newspaper advocated, *we would not be spending the city's tax money paying for the interest on bonds*. It would not surprise this newspaper if the Mayor advocated more bonding to pay for existing bonding!

Other statistics that might be of interest to the citizens of BLUE CITY are: Total unemployment went up from 6,800 to 8,760 in proportion to an approximate increase in population (282,000 to 287,500). *Furthermore, welfare payments remained the same!* No new jobs were created. This could be attributed to a lack of new construction on the part of the Economic Decision Makers. Although construction was attempted, the economic teams either did not have the available resources needed, the level of municipal services was too low, or the decision was written incorrectly. Please refer to the computer printout (a blue X indicates the decisions that were rejected).

The Public Works Commissioner has no available revenue in his Capital Account for utilities. This, in effect, precludes any new construction for utility service. Apparently, the Mayor has not seen fit to allocate his budget accordingly.

The Transportation Commissioner failed in an attempt to build an additional road for the Nord-East section of the city.

There are, however, several enlightening statistics for BLUE CITY. First, the number of low income workers has dropped from 77,500 to 72,000. There has been an increase of medium and high income groups in the city—an increase of 6,000 and 5,000 people respectively. Also, the average dissatisfaction level went down from 112 to 108. Housing quality improved in grids 102-24, 25, and 26, owned by Economic Decision Makers "G", "A", "C" respectively. Good work!! Also, Grid 100-32 improved, and is owned by Economic Team "A".

There is overcrowding in virtually the entire city. Economic Team "D" was the only team that improved their overcrowding in Grid 100-30. Total welfare payments went up to over $1.3 million. BLUE CITY is on the brink of financial crisis. New construction is needed for new jobs which, in turn, brings in additional tax revenue. Taxes must be raised in lieu of new bonding, and the Mayor must establish a rapport with the business community.

FIGURE 32

People's Advocate

Vol. I Tuesday, January, 26, 1971

SCHOOLS SHOULD PROGRESS UNDER NEW DECENTRALIZED ADMINISTRATION

In keeping with this administration's campaign pledges, we are proud to announce the appointment of Ronald Bellfield as new BLUE CITY Commissioner of Education. Mr. Bellfield finds his new job challenging, and will bring to the office a high degree of competency, having served previously as Commissioner of Schools in New York City.

We have in this decentralization of administrative responsibility new specialized expertise for this critical field.

The policy of this journal will be to keep the public abreast of the activities which government is taking in their behalf and with their participation.

The public officials of your city took the following actions in recent weeks:
The Mayor:

1. Welfare payments were increased by $1,000 per year for each unemployed worker. This begins to give even our unemployed citizens the ability to participate in our growth and standard of living.

2. A small employee's auto tax of 1% was added to pay for welfare, transportation and utilities expansion.

Department of Transportation: (Commissioner G. Roadrummer)

1. A new bus line was established in the N.E. section to enable the mobility needed for that area's residents to take advantage of employment opportunities throughout the city. Also, this will create new opportunities for the residents of the whole city to participate in the civic affairs of the whole city.

Department of Planning, Zoning and Assessment: (Commissioner D. Snoopy)

1. Rezoned parcel 102/22 in the N.E. section of town to recreational use for the establishment of a park. *This section was completely without parks and playgrounds before this action.*

Additional tax burden for this action is not anticipated due to pending federal funding to the extent of $50,000, nearly the total cost of development.

Department of Public Utilities and Schools: (Commissioner B. Mouse)

1. Increased utilities in the R3 areas of the city to prevent rent increases for those with fixed incomes. A bond issue was floated to raise the output of the utility plant from level 2 to level 3. This should supply adequate utilities to the areas previously under-served.

2. Applied for a federal grant to provide additional teachers and renewal of the school in the N.E. section.

FUTURE PLANS:

1. A town meeting will be held January 26, at 7:30 p.m. to develop an honest assessment by citizens and government of the problems we have and possible solutions.

The Suggested Agenda:

1. Need for new City Vocational School (A committee of citizens have suggested the N.E. section)
2. Incentives needed to get overall favorable business climate established.
3. Highway improvements needed
4. Parks and recreational needs
5. General public school adequacy in BLUE CITY
6. Unemployment

Many of the objectives of the Social and Economic Sectors are mutually dependent upon one another as well as the policies of the Government. Social decision makers attempted to increase the educational level, increase employment opportunities, increase voter registration, allocate time more effectively, encourage convenient mass transportation, improve quality and construction of housing, develop additional recreational areas, encourage effective government spending, and develop a "collective spirit for decision making". With reference to the latter objective the Social decision makers were encouraged to meet collectively relative to their recently established power in having the deciding vote on bond issues and major zoning changes.

The objectives of the Economic Sector were essentially self-interest rather than public-interest oriented. The basic criteria for success was economic profit. The primary means attempted to obtain a profit was through land development and construction. The question of conflicting objectives between the Economic Sector and the Social and Government Sectors did not occur relative to the type of construction as originally thought. This could possibly be attributed to the lack of a comprehensive development plan for zoning regulation and development. The basic conflict of objectives that arose between the Economic, Social and Government Sectors was concerned with the way in which tax dollars were being spent. A priority issue of the Mayor's platform was to help the poverty groups in Blue City by increasing welfare payments. This policy took priority over providing additional utility service and large government subsidies to the Economic Sector for utility construction purposes. Without the required utility levels, additional construction was impossible. The Economic Sector argued that building construction would provide jobs for the lower income groups. The Mayor felt that the welfare payments were too low and that the additional costs of raising welfare payments to $2,500 from $1,000 should be the first priority.

Since construction and land development was one immediate economic objective, it was generally felt by the Economic Sector that this objective was not met to the degree that had been projected.

Another economic objective was to bid, buy and develop available land outside the city parameters. This effort was made in an attempt to establish a "New Town" which failed since many of the bids were too low.

Perhaps the greatest value which the CITY MODEL game possessed for the Economic Sector was the insight gained in the necessary procedures and consequential problems of spending dollars to gain a profit. New Construction required the proper zoning, capital investment, the type and availability of land, utility service, road access, and convenient mass transportation. Each step was confronted with either a conflicting or cooperative effort on the part of the Social and Government Sectors.

The Government, Economic and Social Sectors were confronted with a number of frustrations in attempting to meet their objectives. The challenge of the game which coincides with the frustrations is, in itself, a valuable learning experience. The city as a whole did improve considerably through eight years. With a total increase in population of 51%, the total increase in employed workers was 55%. There was a 65% increase in low income workers, 47% increase in middle income workers, and a 56% increase in high income workers. Through four of the eight years there was no unemployment and no welfare expenditures. With public school enrollment increasing 17% and private school enrollment increasing 68%, the average educational level declined 9%. The average number of new jobs increased 60% which reflects an expanding community. Although the city initially had an average increase of 120% for outstanding bond payments in the first four years, there were no outstanding bond payments the last four years. The increased development of Blue City was financed with a 28% increase in revenue from taxes, much of which is attributable to an increase in tax-paying population rather than any substantial increase in tax rates.

CONCLUDING OBSERVATIONS

A series of evaluations have been made of the utilization of the CITY MODEL game in our Urban Studies curriculum. In the first instance the participants conducted an evaluation of the game which is summarized below with references to advantages, disadvantages and recommendations for modifications.

PARTICIPANT REACTIONS

Advantages

Increased understanding of the role of government personnel and associated "red tape".
A better understanding of the conflicts between the government economic and social sectors in an urban environment, vying for a scarce resource and the need for public service.
The City Model Game more closely assimilates a pragmatic urban problem-solving approach than that of a "text book" approach.
Next best thing to job experience.
A situation in which one feels the general frustration involved in attempting to promote change. This necessitates better communication between interests and increases one's understanding of vested interest as well as the cause-effect relationships between government, economic, and social participants.

Disadvantages

Problems in understanding the computer language as they apply to desired decisions.
Lack of formal prerogatives in the social sector in making decisions that would have a greater consequence for the city as a whole. (This was corrected somewhat in giving the social participants new powers.)
The government sector did not establish a clear system of priorities. They reacted more toward the "outside system."
The class was made up of a relatively homogeneous group of college students rather than a representative heterogeneous group that generally live in an urban society.
The time limitation in carrying out long-range programs.

Recommendations

A need for a more graphic display of the city.
More available time should be given to play of the game with several rounds played in one day.
Initiate field trips to local units of government in order to better translate and compare the statistical data of Blue City with an actual urban situation of a similar nature.
Hold town meetings at regular intervals where all class members can participate.
Open up a means for communicating with other schools playing the City Model Game.
Provide the social sector the power to determine the need for bonding and zoning changes through a referendum. This may be a vehicle for the social decision makers to better organize and participate to a greater degree in "role playing". (This was changed for the next game.)
Provide a better understanding how specific decisions affect the "dissatisfaction index".
Concentrate on the importance of "role playing" prior to starting play of the City Model Game.

The objectives which I had suggested at an earlier point in this chapter were all capable of examination during the utilization of the game. My basic evaluation is highly positive regarding the value of the game as a learning tool. The participants demonstrated a far more sophisticated appreciation of the city at the close of the term. Many standard concepts were applied and hence tested in the game. The existence of conflict and personality became important to the players. Coalition and strategy building exercises were realistic. The frustration and delay of the "real system" became more obvious.

The analytical techniques of the students were tested and improved. The existence of the city with many dimensions and a system was demonstrable. The use of gaming improved the student/instructor relationship and provided an absorbing learning experience for the students. Considerable student initiative was demonstrated, including the continued play of the game on an independent study basis.

From our use of the game it would appear more appropriate to use the CITY MODEL in an "Urban Systems" or "Urban Simulation" course where it is the primary course method and the course can be developed around the game. It is very desirable to have the game mounted on a computer in close proximity so as to minimize the "turn around" inconvenience. The help of a graduate assistant or student assistant is imperative. I would suggest that the "intellectual payoff" of the CITY MODEL is highest within an interdisciplinary course because the game is an excellent interdisciplinary tool, whereas for students from only one discipline much of the role-playing is beyond their experience. It would appear that this tool would have greater advantage for advanced students rather than beginning students.

Based upon this experience with gaming in the Urban Studies curriculum, I have concluded that gaming can perform a valuable function within the curriculum. It is an excellent experience for students to test and hypothesize about real urban environment relationships. The dynamics of the game are very revealing. This model permits the urban social scientist to enjoy many of the laboratory experiences which prove to be of strong benefit to the Urban Studies student.

CHAPTER XIV

Memphis State: CITY MODEL Experience*

by Robert Dean

INTRODUCTION

During the spring semester of the 1970–1971 school year, a group of 16 graduate students from the Departments of Economics and Geography had both the privilege and pleasure of "playing" the CITY MODEL. With the exception of this writer, none of the students had ever participated in a simulation-gaming exercise, nor had they ever been given much exposure to the input-output media of computers (i.e., code sheets, punched cards, and computer printouts)! Despite these obstacles, the students found the interaction with the CITY MODEL a most rewarding experience and were eager to participate again in such a venture. Indeed, it was the opinion of most of the students that additional sessions with the CITY MODEL would be required if maximum benefits from the use of the Model were to be achieved. Simply put, their argument was that the more innovative uses of the Model can only occur after prolonged and extended play.

The decision to utilize the CITY MODEL as one of the principal teaching tools in the joint seminar with the Geography Department on urban problems was by no means accidental. Having used Alan Feldt's Community Land Use Game (CLUG) and Richard Duke's METROPOLIS in courses dealing with urban planning, I was well aware of the student interest and excitment in playing the roles of public and private decision makers in the urban arena. In the past, however, my experience with the use of simulation-gaming as a teaching device had been limited to undergraduate students. Moreover, I had never attempted a modeling exercise with the complexity and level of sophistication associated with the CITY MODEL. Therefore, I treated the use of the CITY MODEL as an experiment for the instructor as well as the students!

Because of my own limited experience in handling a modeling effort with the degree of complexity of the CITY MODEL, I decided to use a graduate seminar as the testing ground for the gaming experiment. I assumed (perhaps erroneously) that graduate students would more readily grasp the technical aspects of inter-acting with the CITY MODEL, and that they would be better able to make more meaningful decisions within the time span of one semester. Graduate students from both the Geography Department (the Geography Department offers a heavy concentration of courses in urban geography and planning) and the Economics Department were invited to participate in the seminar.* Because both the Geography and Economics Departments had a number of graduate students with full time jobs during the day, it was decided to hold the urban problems seminar at night. In retrospect, the decision to make the seminar available to the older, more mature graduate students was a good one. This particular group of students (roughly half the class were in this category)

*The modeling exercises could not have been carried out at Memphis State without the support of the Bureau of Business and Economic Research. In particulai, a great debt of gratitude is owed to Mr. David Gilles, a Research Assistant in the Bureau, for his untiring efforts in overseeing the modeling exercises. Without his contributions, the gaming sessions would not have been possible.

*Insofar as I can determine, this was the first experience at Memphis State in holding a joint course by departments in two different colleges. (The Economics Department is in the College of Business Administration, and the Geography Department is in the College of Arts and Sciences.)

brought first-hand knowledge of the problems confronting the Memphis Metropolitan region. Equally important, they had had some experience in dealing with these problems locally and fortunately were able to transfer their work experiences in a useful and meaningful manner to those students who had had little work experience in the "real" world.

The course was officially designated as a *Seminar in Current Economic Problems* (Economics 7190) and was offered one night a week. Traditionally, the instructor or teacher of this seminar is given a great deal of freedom and latitude in course structure, therefore it seemed to be the course best suited for experimentation with the CITY MODEL. The students agreed to meet from 6:30 to 10:30 p.m. on Wednesday evenings, even though the required number of hours of class meetings would only have called for sessions from 6:30 to 9:30 p.m. It is also worth noting that the sessions were not held in the traditional classroom setting. Instead, a group of rooms and offices adjoining the University's Regional Economics Library and the Library itself were used for the gaming sessions. The more spacious conditions were instrumental in achieving a more realistic environment for role playing in the CITY MODEL.

THE COURSE

The seminar in urban problems had three major objectives. The primary objective of the course was to improve the student's understanding of the nature and scope of such urban problems as chronic unemployment, poverty, housing shortages, crime and violence, inadequate health delivery systems, and so forth. Another important objective was to get the student to visualize the City's problems in "holistic" or "systemic" terms. In other words, the aim was to encourage students to view the activities of the City as being closely related and interdependent (e.g., an unemployment problem will exacerbate a health problem, the loss of industry and jobs in the private sector will reduce the number and quality of services offered in the public sector through reduced tax revenues, etc.). A third objective was to encourage the student to use an interdisciplinary perspective when dealing with urban problems—that is, to look at the problem not only from the viewpoint of an economist, but also from the perspective of a geographer, planner, political scientist, etc.

The CITY MODEL was essentially used to help achieve all of these objectives. Based on my previous experiences with CLUG and METROPOLIS, I found that the actual experience of dealing with a land-use problem (e.g., zoning) makes the student more sensitive to the broader concept of land use planning. Thus, it was felt that the problems of housing, unemployment, education, health, etc., would be more readily understood by the students if they were able to work on these problems at the same time they were dealing with them within the traditional classroom and academic framework. It was also felt that a simulation-game of the CITY MODEL type would enhance the student's ability to view the City as a system of interconnected activities and institutions. Indeed, many of the outputs of this particular gaming model (e.g., land use maps, economic indicator tables, etc.) are designed in such a fashion that the City can be viewed more easily as a single entity than as several separate and disparate parts.

Through proper role-placement of students with different discipline backgrounds, it was also hoped that the modeling effort would help the students to broaden their perspective to include the thoughts and ideas of other disciplines when dealing with a particular problem. In this case, the advantage of the CITY MODEL is that it encourages interaction between the various role players, thus making it possible for a certain amount of "knowledge transfer" to take place between disciplines.

The seminar in urban problems was essentially developed along three lines. First, the students were asked to read a number of books dealing with urban issues and problems. These materials were then discussed throughout the semester and in conjunction with the modeling effort. Second, the students were assigned roles in the CITY MODEL and were expected to devote a major portion of their weekly class meetings to the gaming experiment. Third, each student was asked to prepare a research paper dealing with a particular local urban problem. Each student was also asked to present his paper at one of the class meetings so that all of the students would develop a certain sensitivity towards local issues and problems at the same time they were grappling with similar types of problems in the CITY MODEL.

DYNAMICS OF PLAY

Insofar as the utilization of the CITY MODEL is concerned, certain steps were taken to minimize the students' problems in mastering the mechanics

of making decisions. One full classroom session was devoted to the discussion of the major decision-roles in the CITY MODEL as well as the many printouts and reports that result from each role player's decision inputs. During the first session, each student was assigned a particular role (i.e., social decision maker, economic decision maker, mayor, etc.) and asked to read that portion of the CITY MODEL manual dealing with his role. Using the manual as a guide, each student was also asked to fill out a decision sheet for the next class meeting and be prepared to answer questions concerning each type of decision that he(she) could make. Each student was also asked to maintain a diary on his particular decisions as well as keep a listing of any problems or criticisms he had of the gaming experiment. The diary proved to be quite useful, since both the student and instructor could review the decisions and the reasoning behind them over a number of gaming sessions. The diaries clearly revealed that as the students became more knowledgeable about their roles, they were able to make a greater number of decisions within a shorter period of time. The decisions in later rounds also appeared to be based on more information and a better understanding of their possible effects on the economic parameters of the model.

Concerning the play itself, the economic decision makers can best be described as rather conservative, cautious players. The aversion to risk-taking was especially noticeable in the early rounds when the students were quite uncertain as to the outcome of particular decisions. Insofar as I can determine, none of the economic decision makers had a "game plan." Most of the decisions in the early rounds were not made in a systematic fashion or developed in a coordinated manner. In later rounds, however, many decisions were made as a result of actions taken in earlier rounds. For example, an economic decision maker would build some housing units for rental purposes and then find they were under-utilized. He (she) would then consider building commercial or manufacturing establishments close by in order to induce more people to live in the under-utilized housing units and build up a good supply of labor. Just as likely, the procedure would be reversed, and the emphasis would be on building housing units near a previously built manufacturing plant in order to maintain an adequate supply of labor close to the plant.

Most of the economic decision makers made good profits on their business operations, although losses on particular investments were not uncommon. It was also evident that profit maximization was the primary motive for making decisions, subject, of course, to the twin constraints of risk-taking and uncertainty.

The social decision makers did not have an opportunity to exercise their voting power; therefore they spent much of their time trying to improve social conditions in the City. A few boycotts on retail establishments were attempted, but for the most part, their approach was to use "moral persuasion" on public officials and economic decision makers to change their attitudes toward problems such as poverty, poor housing, job discrimination, etc. The social decision makers did succeed in getting the mayor to establish a housing task force to investigate the poor housing conditions in the City. As we shall see shortly, this particular task force was quite instrumental in getting "slum" landlords to improve and upgrade their properties.

The public decision makers made a concerted effort to improve the welfare of the City, although the indicators used to measure economic progress do not clearly reflect the intensity of this effort. During the early rounds, the "game plan" was to obtain additional revenue to upgrade the school system and municipal services, while at the same time bring about a redistribution of the tax burden so that it would fall more heavily on the business community and to a lesser extent on the work force. Lower income residents also received a tax break through the reduction of sales taxes on goods and services while the tax on auto owners was raised in the hopes that the use of public transportation would increase.

A substantial public deficit in the early rounds, however, caused the public decision makers to modify their target objectives until the deficit was significantly reduced. By the sixth round, the deficit was under control, and the earlier effort to improve the quality of municipal services and the school system was renewed. During this round, a serious review was also made of the City's more pressing problems. As a result of this review, it was decided that more park and recreational land was needed for the City, and money was appropriated to the planning and zoning department for this purpose. Rising complaints from the social decision makers about the high tax rates on lower income residents and their deplorable housing conditions prompted the mayor to lower the residential income tax rate and the employee income tax rate. In addition, the mayor

appointed a committee to review the housing conditions in the City and provide him with recommendations concerning the proper resolution of this problem.

In the last round, an election was held, and the incumbent mayor lost to one of the economic decision makers who was dissatisfied with the higher taxes on business properties and the move towards a "socialist" form of government. Unfortunately, the new mayor did not have time to carry out his conservative policies since the gaming sessions had to be halted due to the end of the school semester!

A review of some of the economic and demographic growth trends reveals a fairly successful performance for the City's economy. Figure 31 illustrates some of these trends. Chart A and B indicate that the population increased 52 percent and employment 46 percent over the eight rounds of play. Thus, the City appears to have grown at a fairly steady rate with population at a little over 6 percent per annum and employment slightly less at 5 percent annually. The unemployment chart shows little or no unemployment from round 3 through round 7 of play, thereby indicating a full employment economy over most of the gaming sessions. Although unemployment was quite low (except for round 8), Chart C indicates that the proportion of workers earning less than $5,000 actually increased from 38 percent to 40 percent of the total work force during the gaming sessions. This is somewhat alarming, since this group of wage earners are largely unskilled and semi-skilled and are not capable of being absorbed into more capital-intensive industries (with higher wage rates) without considerable retraining and additional education.

Despite this apparent weakness in the structure of the work force, it is evident that the social welfare of the community improved considerably during the period of play. As Chart E indicates, per capita income had risen steadily during the gaming session. As of the end of the seventh round, per capita income had reached $2,000, a 17 percent increase over the base year figure. This improvement was extremely encouraging to the students, especially those that played the role of social decision maker.

With regard to certain key economic indicators, then, the City appeared to be better off at the end of the gaming sessions than at the start. It is extremely difficult, however, to single out one particular factor that contributed most to this improvement in economic well-being. Perhaps it was due to the rather conservative manner in which the public and private decision makers made decisions. Possibly it was due to the fact that the national economy was fairly strong during the gaming sessions and therefore gave added strength to the local export sector. Regardless of the causes, the students were most delighted to achieve the twin objectives of full employment and rising per capita income—a most unlikely occurrence in the real world!

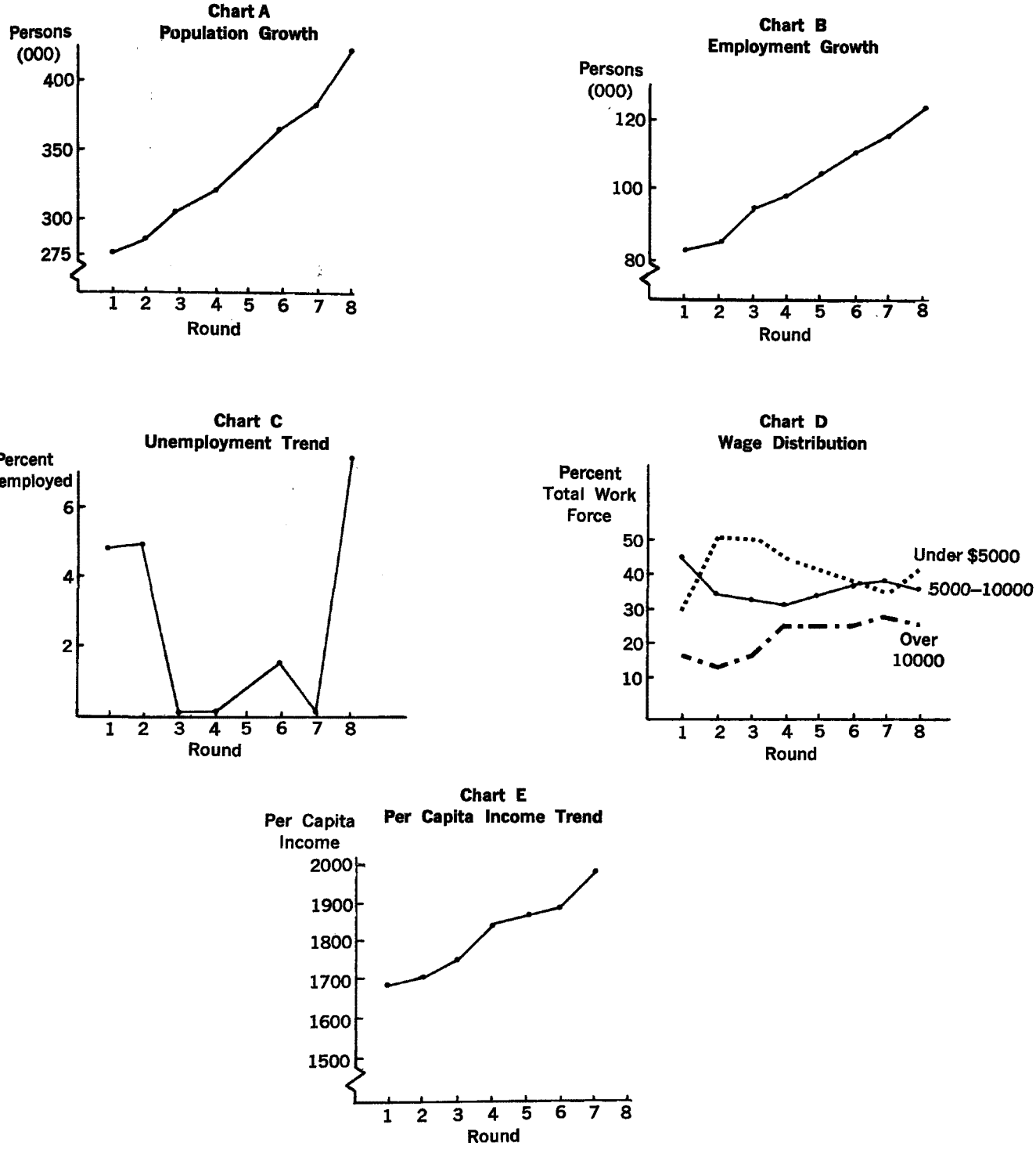
CONCLUSIONS

It should be made perfectly clear to the reader that no attempt was made to measure with precision the importance of the CITY MODEL as a learning tool. Because others have traveled this road before and have not really had much success in insolating the contributions of simulation gaming to the learning process, I find it expedient to withhold any comments on the degree of usefulness of the CITY MODEL except to say that the modeling effort was an extremely worthwhile experience in group interaction and certainly the highlight of the seminar.

In reviewing the course in more realistic terms, it is fair to say that we were moderately successful in meeting the three course objectives. Based on the results of the research papers and the class discussions that took place before and after the gaming sessions, it was clear that most of the students had a better understanding of some of the gut issues facing our cities at the end of the course than they did at the beginning. Although I cannot support this contention with empirical evidence, it seemed to me that the background readings, modeling exercises, and research papers are complementary learning activities, i.e., one reinforces the others. In this particular case, the background readings provided a basic frame of reference for the role players in the modeling effort, while the modeling effort increased the students' sensitivity and awareness towards certain urban concepts and problems. In turn, a heightened awareness of a particular problem made it easier to construct and implement a research design related to that problem.

The students also became more cognizant of the fact that the city is a system of interdependent activities, although not with the degree of sensitivity and understanding that I had hoped for. The lack of real success here, however, cannot be blamed on any inherent weakness in the CITY MODEL, but rather on the failure of the instructor to create opportunities for the students to use the Model's structural relationships to better advantage.

Figure 33.—ECONOMIC AND DEMOGRAPHIC TRENDS



The problem boils down to this: most of the students were so involved in their own roles that they had little time or interest in viewing the City as a single entity or investigating the relationships between different sectors of the economy *unless their role required them to do so.* To compensate for the students' lack of "integrating" experiences, some of the "rap" sessions concerning the modeling exercises focused attention on the concept of the City as an integrating mechanism. Another approach, and one that appeared to have greater utility, was to establish policy task forces to review a certain problem or issue. One of the more interesting task forces was the Housing Commission. This particular task force consisted of three students, and its objective was to determine the conditions of housing in the CITY

MODEL and what if anything needed to be done to improve these conditions. After a thorough analysis of maintenance levels on housing, the Housing Commission recommended that all housing in the City have at least a .50 maintenance level. The economic decision makers, of course, balked at this proposal because it would cut down on their profits and in many cases result in substantial losses in particular housing units.

Thus, the conflicting issues of economic profit and social welfare were joined, and after several hours of heated debate, the problem had still not been resolved. Eventually, a new mayor reached a compromise with the economic decision makers whereby the City would pay them subsidies to improve and rehabilitate their properties. The beauty of this particular exercise, however, lay not in the solution to the problem, but in the process through which the problem was resolved. The students on the housing task force had to view the problem of poor housing conditions as essentially a problem for the whole City to resolve, but in recommending solutions it also had to come to grips with the fact that certain groups or economic classes (e.g., slum landlords) would not benefit personally from these decisions. Because of the conflicts that result when one vested interest group stands to lose at the expense of another, most of the students gained a better appreciation for the problems of developing a citywide policy on housing standards as well as the delicate relationship between housing conditions and economic profit.

The attempt to create an interdisciplinary perspective in urban problem solving did not meet with much success. Unfortunately, the structure of the CITY MODEL does not promote this type of learning process nor does it mitigate against it. Once again, if the instructor is innovative, a number of ad hoc task forces which are multi-disciplinary in makeup can be established to consider urban problems within an interdisciplinary framework (e.g., a task force on transportation policy would include a sociologist, political scientist, geographer, planner, engineer, and an economist). However, most students—even graduate students—have not progressed to the point where they can develop on their own comprehensive solutions to a problem as complex as urban transportation; therefore, the task forces would need faculty support. In turn, this would require a team teaching effort, which was logistically not possible for this particular seminar.

Summing up, even though the objectives of the course were not completely achieved, it would be unfair to say that the CITY MODEL was mainly responsible for this lack of achievement. It should be kept in mind that this was an experiment for both the instructor and the students, and that in subsequent sessions, more effective and innovative uses of the CITY MODEL would result in higher achievement levels. As I see it, however, the main problem with the use of CITY MODEL is the inability to manipulate the key parameters of the Model (e.g., economic growth rates, social conditions, production capacities, etc.), thereby making it more flexible and susceptible to innovative approaches to urban problem-solving. In order to create this type of learning environment, the students and the instructor must know more about the inner workings of the Model itself. In turn, this calls for the computer programs that form the basis of the CITY MODEL to be housed at the college or university carrying out the modeling experiment. The location of the CITY MODEL at each participating university would also increase the frequency of interaction with the CITY MODEL. Moreover, the laborious process of mailing decisions to Washington, D.C., and then waiting a week or more for the results of these decisions tends to have a dampening effect on the students' interest and attitude towards the modeling exercise. Indeed, the most common complaint heard during the modeling experiment was Why Can't We Get the Results of Our Decisions Tomorrow? Although this is probably a universal complaint and not easily solved without terminal devices and "real time" or "shared time" computer processing capabilities, the problem of "output" delay would be less severe if handled locally.

There is also a need to feed local demographic and economic statistics into the CITY MODEL so that students can actually work on problems that are both important and extremely familiar to them. This can best be done by transferring the CITY MODEL to the local university or college carrying out the modeling experiment.*

The other criticisms that we have of the CITY MODEL are minor in nature and mostly have to do with the mechanics of "playing the game." The majority of the students felt that the player's manual

*At Memphis State, we would like to load 1970 Memphis block and tract data on population and housing into the CITY MODEL, develop local population and land use growth patterns, and in general operate the Model as a replicate of the local development process.

was overly complex, and that the sections dealing with individual roles should also include decision input formats, the procedure for making decisions, and those computer printouts most important to a particular role (decision maker). Another frequently heard complaint was the inability to go to one source or computer printout sheet for needed data. Although this is not possible to achieve under the present reporting system, some additional consideration should be given to the data needs of each role player and whether or not more realistic data combinations can be developed. For example, it would be extremely useful for the player operating the bus company to have the geographical locations of the labor force and the work sites combined on one printout sheet. There was also a strong feeling among the students that the social decision makers were quite limited in the number and types of decisions they could make, and that this particular role should be either expanded greatly or dropped completely in favor of new roles that emphasize the activities of agencies dealing with health and welfare problems.

As indicated above, however, these criticisms do not materially detract from the basic strengths of the CITY MODEL. Indeed, our interest in CITY MODEL is very high, and we are anxiously looking forward to continued interaction with the Model during the next school year.

CHAPTER XV

Conclusion

CITY MODEL was designed to be a non-scoring game. It was to be as difficult to compare one outcome with another as is the case with real life cities. This conceptualization of the outcomes of the model meant that an objective comparison of the status of the model generated from different plays was not expected, because each of the users was free to decide his own criteria for the "best" or desirable city.

However, to partially satisfy the very natural urge to compare the model runs, the data in Figure 34 was prepared.

The five university plays are compared in terms of four types of measures: 1) population (size, composition, and growth), 2) land use (amount and value), 3) business and personal income and employment, and 4) government finance (annual taxes and debt structure). These measures do not provide a comprehensive set of indicators, but they do provide a feeling for the trends that developed during the various plays.

With regard to population growth, it is interesting to note that the greatest total growth was associated with those plays in which the middle income (PM) population class became the larger part of the total distribution. For example, in the Georgetown play (where the total population growth was largest), the PM class grew to be 38 percent of the population while in the Mankato and Memphis plays (with the least total population growth) the percentage of PM's declined compared with the starting position.

In all the plays, the reliance or greater assessments on developments compared with those for land persisted. The residential developers lagged behind local demand (as is indicated by the housing vacancy rate) in all the plays except for American where the professor (in a real estate course) placed emphasis on the students' making development plans and justifications.

The business income measures indicate that Heavy Industry maintained its dominance over the other forms of basic industry except in the case of Dartmouth. With regard to second place in the basic industry importance, National Services lost out to Light Industry in every play except American. This is a little bit surprising since the National Services industry is the most footloose form of basic industry and it has the least requirements for transportation access and utility service.

All the plays developed a positive balance of trade. The large differences among the five plays are explained by the composition of the basic industries in each city and the success that each city had in stemming the purchase of goods and services from the outside system by providing adequate local supply.

The income distribution is related somewhat to the population distribution by class, but even more so the general level of salaries in the five different plays. The Georgetown play showed the largest percentage of workers receiving over $10,000 per year in salaries.

The cost of government increased above the base year in all of the plays, but the different schools selected quite different strategies for financing these increases from tax payments and from bonds. Dartmouth struck a good balance and attained both a low annual tax payment per capita and a low annual bond payment per capita.

Meanwhile, American traded high bond payments for low tax payments, while Memphis traded high tax payments for low bond payments.

It should be made clear that these differences among the various plays and the many other differences that are not reflected by these measures were generated by the users of the model as they strove to achieve their own unique set of individual and collective objectives. Furthermore, the influence of the game director on these differing measures could

FIGURE 34—*Comparative Measures for the Five University Plays of Blue City*

	Base Year (Round 1)	Round 8 Data				Memphis State (Round 7)
		American	Dartmouth	Georgetown	Mankato	
1. *Population*						
Total Population	275,500	428,000	448,500	462,500	418,000	374,500
% Change from Base Year	—	55	63	68	52	36
Percent of Population						
Low Income	27	27	26	24	27	28
Middle Income	36	34	37	38	35	34
High Income	37	39	37	38	38	38
2. *Land Use*						
Number of Parcels with Development	41	51	50	52	47	46
Population Density per Parcel	440	684	717	740	668	599
Total Assessed Value of Land (millions)	$166	273	279	259	194	177
Total Assessed Value of Developments (millions)	$450	852	950	1,149	667	527
Housing Vacancy Rate (negative indicates overcrowding)	6%	6%	—2%	0	—4%	—5%
3. *Income*						
Sales to National Economy (millions)						
Heavy Industry	469.9	532.9	501.7	723.4	620.2	494.0
Light Industry	203.0	473.8	539.3	565.8	438.3	304.9
National Services	207.9	572.0	223.1	457.6	205.9	298.9
Balance of Trade (millions)	(17.1)	478.6	175.5	647.8	356.8	268.1
Total Employed	81,600	133,160	139,560	131,480	126,920	116,840
Unemployed (percent)	4.90	0	0	0	2.16	0
Welfare Recipients	4,200	0	0	0	2,800	0
Income Distribution (% Under $5,000/$5-10,000/Over $10,000)	38/43/17	36/34/28	37/35/28	35/32/31	36/35/28	35/37/26
4. *Finance*						
Taxes Per Capita ($)	184.34	230.09	203.15	258.95	271.37	372.89
Bond Payment Per Capita ($)	46.20	127.59	16.68	6.90	107.61	10.49
Total Annual Bond Payment ($million)	12.7	54.6	7.5	3.2	45.0	3.9

have been large or small depending upon the impact that his structuring of the play had upon the students.

OBJECTIVES OF THE STUDY

The original objectives of the study were multifold:

- To illustrate that the laboratory so desperately needed by the social scientist to illustrate theoretical concepts and to test "what if" questions would best be served by a computer simulation model.
- To demonstrate that such a simulation, by compressing both time and space could make complicated patterns of interrelationships understandable to students and researchers in the field of urban development.
- To refine a single comprehensive simulation for teaching. This simulation, by holistically revealing economic, social, and political variables in a metropolitan area, was assumed to make courses more meaningful to a student than have more traditional methods.
- To adapt the CITY MODEL to extensive classroom use in interdisciplinary or other social science courses in urban affairs and analysis so that it could be used:

  as the basic teaching device in a course, or as a means of illustrating specific principles or relationships.

It appears that these objectives were met by the project.

FINDINGS AND RECOMMENDATIONS

Following is a summary of the findings and recommendations of the NSF sponsored use of the model:

- It is possible to use the RIVER BASIN-CITY MODEL to teach a variety of social science subjects. This fact is true regardless

of class size or whether the participants are graduates or undergraduates.

- The presence of a social science laboratory in an on-going curriculum requires substantial changes in course context or the addition of a new course.
- The inclusion of a laboratory cannot be done without some help from a colleague or a graduate student. Further, the decision to use the tool will require a considerable time and effort expenditure on the part of the professors using it.
- Unanimously, the tool was considered a valuable addition to the conventional discipline courses. This finding was affirmed by both the professors and the students.
- The model must be installed on the campus for really effective use. This would mean that the model could be more fully utilized and that the faculty and students could experiment with it.

In summary, the experiment indicated that the social sciences are now ready to use a computer assisted laboratory to teach their subjects. However, this laboratory must be packaged better and made available to local universities and colleges so that they may carry on individual experimentation as part of their normal educational programs. The results of the study showed the success of the use of the model as a pedagogical device but also showed the difficulty of trying to service its use from a single centralized location.

APPENDIX A

Scenarios

Many starting configurations may be developed by the users of the RIVER BASIC MODEL by making initial round input or loading a data base. Two pre-configured regional river basin areas were developed as part of the EPA project and are presently available to the user of the RIVER BASIN MODEL. These areas are called TWO CITY and RAYWID CITY, and their characteristics are compared in Figure A-1.

FIGURE A-1—*Local System Comparisons of TWO CITY and RAYWID CITY*

	TWO CITY	RAYWID CITY
Land Area (square miles)	3906	2519
Parcels of Land	625	403
Number of Political Jurisdictions	2	3
Total Population	275,500	2,508,000
Percent Distribution by Class		
High Income	37	31
Middle Income	36	34
Low Income	27	35
Percent of Workers Earning Under $5000	33	36
Total Assessed Value of Land and Developments (millions)	$12,733	$26,296
Average Quality of Life Index	69	117
Average Education Level	59	49
Unemployment Rate	7.5%	13.7%
Workers Receiving Unemployment	12,800	127,240
Student-Teacher Ratio	7	6
Percent of Students Enrolled in Private School	30	13
Features of the Water Component		
Miles of River	87.5	130
Number of Rivers	3	7
Types of Polluters		
Surface Water Industries	4	14
Municipal Outflow Points	2	11
Farms Contributing to Runoff	3	8
Total Sewered Population (thousands)	276	2,508

The director or players might have a preference for one of these two basic starting positions because of the number of players, types of problems represented, or complexity of the local system. It should be kept in mind that these scenarios and the starting positions may be modified very easily by the director making decisions before the play begins. In this way a large number of initial starting positions are available just from these two basic configurations.

The director should be sure to modify the scenario he uses if he makes any modifications in the starting position. The director should also feel free to change the format of the scenario to provide more or less information on the local system. For example, more information could be presented on the components of the quality of life indicators or less information could be presented on the relative status of the economic teams.

The director can derive alternative scenarios by carefully reviewing the Round 1 output before it is distributed to the players. Figure A-2 shows some of the computer output sections (those circled) that are most helpful in developing a verbal description of the local system.

A general note about relative wages and outside system costs should be made for the two basic starting configurations. Average salaries are 37 percent greater in RAYWID CITY than in TWO CITY For example, the average salary for high income workers in TWO CITY is $10,000, whereas it is $13,700 in RAYWID CITY. The price paid for purchases from the outside system (for BG, BS, PG, and PS) are also higher in RAYWID CITY than in TWO CITY. For example, an outside system unit of BG sells for $130,000 in TWO CITY and for $150,000 in RAYWID CITY. These salary and price differences are explained by the fact that data for TWO CITY is based upon an average hypothetical region in the U.S. in 1960. The data for RAYWID was derived from 1960 information for the Cleveland-Akron areas. Salaries tended to be higher in the Cleveland-Akron area than in the U.S. as a whole.

FIGURE A-2—*Selected Computer Output That Is Most Helpful in Developing a Verbal Scenario*

RIVER BASIN MODEL OUTPUT

1. Migration	1.1 Environmental Indexes
	1.2 Personal Indexes
	1.3 Dissatisfaction Cutoffs
	1.4 Migration Detail
	1.5 Migration Statistics
	1.6 Migration Summary
2. Water System	2.1 Water User Effluent Content
	2.2 River Quality During Surface Water Process
	2.3 Water User Costs and Consumption
	2.4 Coliform and Pollution Index Values
3. Employment	3.1 Employment Selection Information for PL Class
	3.2 Employment Selection Information for PM Class
	3.3 Employment Selection Information for PH Class
	3.4 Part-Time Work Allocation for PH Class
	3.5 Part-Time Work Allocation for PM Class
	3.6 Part-Time Work Allocation for PL Class
	3.7 Employment Summary
4. Commercial Allocation	4.1 Personal Goods Allocation Summary
	4.2 Personal Services Allocation Summary
	4.3 Business Goods Allocation Summary
	4.4 Business Services Allocation Summary
	4.5 Government Contracts
	4.6 Terminal Demand and Supply Table
	4.7 Terminal Allocation Map
5. Social Sector	5.1 Dollar Value of Time
	5.2 Social Decision-Maker Output
	5.3 Social Boycotts
6. Economic Sector	6.1 Farm Output
	6.2 Residence Output
	6.3 Basic Industry Output
	6.4 Commercial Output
	6.5 Economic Boycott Status
	6.6 New Construction Table
	6.7 Land Summary
	6.8 Loan Statement
	6.9 Financial Summary
7. Social and Economic Summaries	7.1 Number of Levels of Economic Activity Controlled by Teams
	7.2 Employment Centers
	7.3 Economic Control Summary for Teams
	7.4 Social Control Summary for Teams
	7.5 Social Control Summary Totals
	7.6 Economic Graphs for Teams
	7.7 Social Graphs for Teams
8. Government Detail	8.1 Assessment Report
	8.2 Water Department Reports
	8.3 Sampling Station Report: Point Source Quality
	8.4 Sampling Station Report: Ambient Quality
	8.5 Utility Department Report
	8.6 Utility Department Finances
	8.7 Municipal Services Department Report
	8.8 Municipal Services Department Finances
	8.9 Municipal Services Department Construction Table
	8.10 Planning and Zoning Department Report
	8.11 School Department Report
	8.12 School Department Finances
	8.13 School Department Construction Table
	8.14 Highway Department Finances
	8.15 Highway Department Construction Table
	8.16 Rail Company Report
	8.17 Bus Company Report
	8.18 Chairman Department Finances
	8.19 Tax Summary
	8.20 Financial Summary

FIGURE A–2—*Selected Computer Output That Is Most Helpful in Developing a Verbal Scenario*—Continued

9. Summary Statistics	9.1 Demographic and Economic Statistics
10. Maps	10.1 Personal Goods Allocation Map
	10.2 Personal Services Allocation Map
	10.3 Business Commercial Allocation Map
	10.4 Municipal Services Map
	10.5 School Map
	10.6 Utility Map
	10.7 Water Usage Map
	10.8 Water Quality Map
	10.9 Municipal Treatment
	10.10 Municipal Intake and Outflow Point Map
	10.11 Surface Water Map
	10.12 Farm Runoff Map
	10.13 River Basin Flood Plain Map
	10.14 Farm Map
	10.15 Farm Assessed and Market Value Map
	10.16 Market Value Map
	10.17 Assessed Value Map
	10.18 Economic Status Map
	10.19 Highway Map
	10.20 Planning and Zoning Map
	10.21 Parkland Usage Map
	10.22 Socio-Economic Distribution Map
	10.23 Demographic Map
	10.24 Social Decision-Maker Map
	10.25 Topographical Restriction Map
	10.26 Government Status Map

RAYWID CITY SCENARIO

RAYWID CITY is a three county regional area with a population of about 2.5 million. There are a number of manufacturing establishments, farms, and municipal sewer systems that contribute to the pollution of the major river that runs through the region. This local river system has a basin area that comprises about half of the land area in the three counties. Along with high unemployment, poor water service, housing shortages, and inadequate municipal services, the polluted river looms as one of the several major problems facing the regional area.

Figure A–3 shows a map of the regional area encompassed by RAYWID CITY. Note that the upper portion of the map is a lake and that some parcels of land on the left-hand side are not considered part of the local system.

Figure A–4 shows the population distribution by the three income classes for the three political jurisdictions that comprise RAYWID CITY. Jurisdiction 1 clearly has the largest population. It is also the residence for the majority of the unemployed workers. The region is experiencing very high unemployment (16 percent) and all of this is concentrated in the low income groups. The middle and high income groups are experiencing some employment difficulties (underemployment) in that a number of population units have been forced to take jobs at salaries below the level they would normally earn.

All of the very high density housing is in Jurisdiction 1, where this type of housing makes up nearly half of the supply. In both Jurisdiction 2 and 3, single family housing is dominant and all of the multiple family housing is of a low density nature.

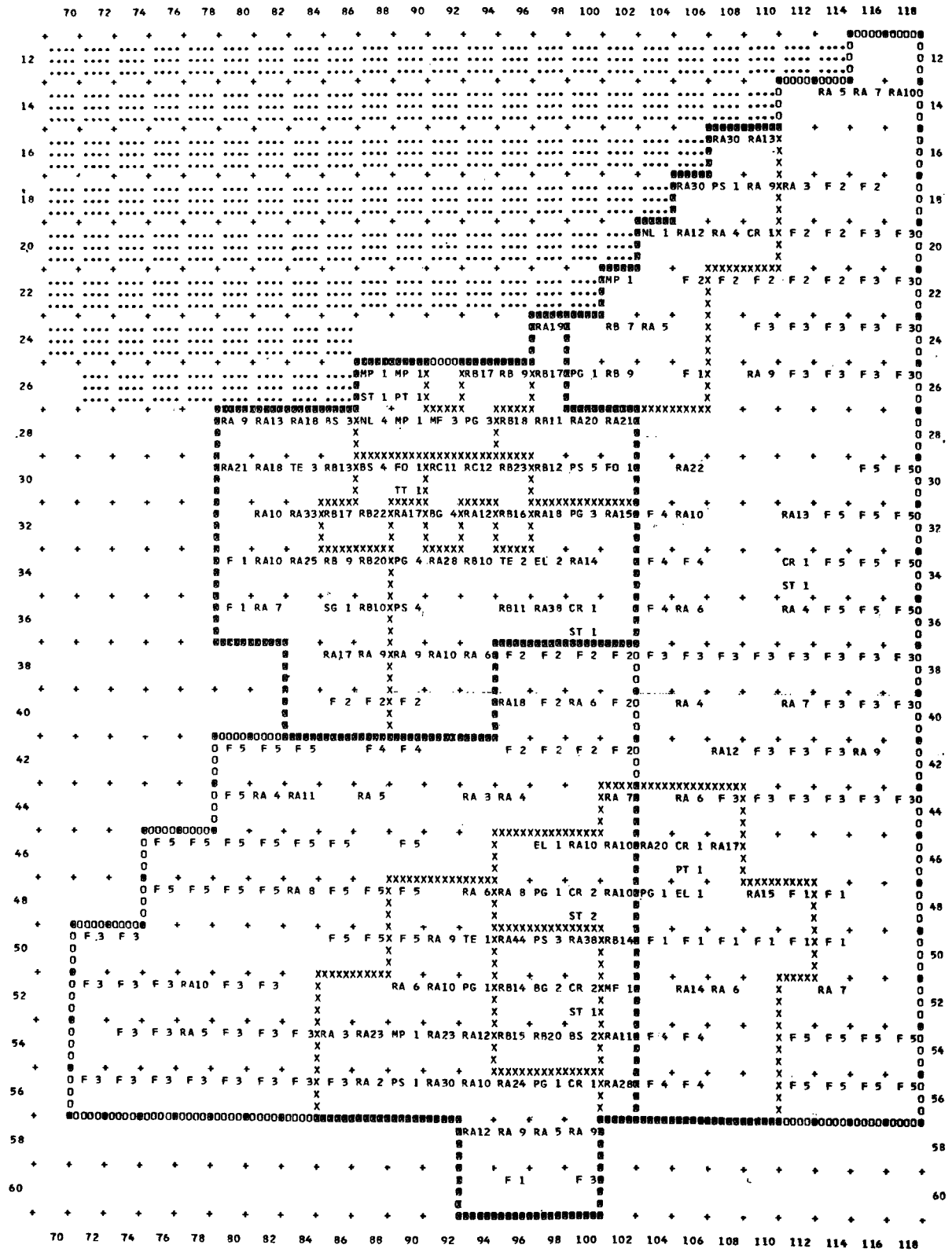
Figure A–5 shows the allocation of social decision-making power among the nine teams that comprise the social sector. Note that teams are specialized. That is, teams initially have control over only one income class. Team AA controls the largest percentage of high income population units in Jurisdiction 1, while team CC controls the majority of PH's in Jurisdiction 3. Other obvious power blocks are team DD's control of middle income units in Jurisdiction 1 and team II's control of low income units in Jurisdiction 2.

The Economy

The economic assets of the region are quite widely distributed among 23 economic teams. Each of these teams is very specialized at the start of play as

FIGURE A-3

RAYWID CITY — WATER USAGE MAP — ROUND 0



PARCELS

TOP ROW: ECONOMIC ACTIVITY TYPE AND OPERATING LEVEL
MIDDLE ROW: (FOR BASIC INDUSTRIES) PERCENT OF WATER RECYCLED
BOTTOM ROW: (FOR BASIC INDUSTRIES) EFFLUENT TREATMENT TYPE AND LEVEL

PARCEL EDGES

XX XX UTILITY DISTRICT BOUNDARY
OO OO JURISDICTION BOUNDARY
BOTH

****
**** LAKE PARCELS
****

FIGURE A–4—*Characteristics for the Jurisdictions of RAYWID CITY*

	Jurisdiction 1	2	3	Total
Population	1,662,500	564,500	281,000	2,508,000
Percent				
High Income	30	32	35	31
Middle Income	35	34	30	34
Low Income	35	34	35	35
Unemployment	129,000	5,800	0	134,800
(Percent)	(24)	(7)	(0)	(16)
Underemployment				
High Income	NA	NA	NA	17,880
Middle Income	NA	NA	NA	75,040
Housing Types (Percents)				
Single Family	17	53	76	32
Multiple Family	83	47	24	68
High Density	20	0	0	10
Percent of Students Attending Private Schools	14	2	35	13
Student-Teacher Ratio in Public Schools	13	6	17	12

FIGURE A–5—*RAYWID CITY Social Control Summary*

	Jurisdiction 1			Jurisdiction 2			Jurisdiction 3		
TEAM	PH	PM	PL	PH	PM	PL	PH	PM	PL
AA	441	0	0	50	0	0	23	0	0
BB	293	0	0	150	0	0	43	0	0
CC	280	0	0	156	0	0	128	0	0
DD	0	514	0	0	153	0	0	0	0
EE	0	336	0	0	70	0	0	84	0
FF	0	298	0	0	162	0	0	85	0
GG	0	0	450	0	0	49	0	0	76
HH	0	0	413	0	0	79	0	0	43
II	0	0	300	0	0	261	0	0	80

	PH	PM	PL
Typical Salary per Worker	$13,700	$6,850	$3,425
Typical Salary per Pl	$1,644,000	$1,096,000	$685,000

figure A–6 indicates. Teams A through D control only manufacturing industries. Each team has control of at least one plant that is contributing large amounts of pollution to the local river system. All of team A's industries are in Jurisdiction 1, while team D owns no industry there. Teams E, F, and G control only commercial establishments.

Teams H through L control the residences in the region, with each team having specialties. For example, team J owns only multiple-family units in Jurisdiction 1 and teams I and K control most of the housing supply in Jurisdiction 3.

Ownership of the seventeen large farms in the region is divided among teams M and N. Team M has control of eight farms, all of which contribute runoff pollution (from fertilizer use) to the local river system. None of team N's farms have runoff into the local river.

There are six realtor teams that own nothing but land at the start of play. The undeveloped land (36

FIGURE A–6—*Economic Team Assets in RAYWID CITY*

Economic Teams	Establishments (Parcel locations)	Assets (Billions)	Cash (Millions)
Industrial Teams			
A	6	7.9	97
B	6	5.9	200
C	6	4.2	0
D	7	7.1	163
Commercial Teams			
E	5	.69	0
F	5	1.82	256
G	8	1.02	0
Landlords			
H	19	1.24	67
I	25	1.97	127
J	19	2.11	103
K	26	1.82	87
L	23	.95	55
Farmers	(Farms)		
M	8	NA	1.5
N	9	N	1.5
Realtors		(millions)	
P	13	112	0
Q	12	109	0
R	11	96	.63
S	21	131	0
T	21	154	0
U	15	102	.59
Bankers			
O			1.5
V			717
W			717

parcels) that is within the river basin is divided among teams P, Q and R. The undeveloped local land (57 parcels) not within the river basin is divided among teams S, T, and U. Teams O, V, and W are banker teams, in that they own nothing but cash at the start of play.

The national business cycle is in an upswing period, and local basic industries are enjoying above average prices on the goods that they produce and sell to outside markets. Typical prices for heavy industry products were 5 percent above normal and those for light industry were 4 percent above normal.

As noted in Figure A–5, the typical salaries for high income workers is $13,700 and, therefore, the typical salary per PH is $1,644,000. The PM and PL typicals are as indicated in Figure RC–3.

The Public Sector

The governments in the three jurisdictions are similar in structure, but they are quite different in size. For example, Jurisdiction 1 has six times the population, over eight times the local tax revenue, 2.5 times as many school districts, 3.5 times as many MS districts, and three times as many utility districts as Jurisdiction 3. Figure A–7 shows some of the government features for each of the jurisdictions.

FIGURE A–7—*Government Sector Comparisons in RAYWID CITY*

	Jurisdiction 1	2	3
Population	1,662,500	564,500	281,000
Tax Revenue (millions)	$889	$342	$105
Welfare Payment per Unemployed Worker	$2500	$2200	$1900
Expenditures (millions)			
Municipal Services	$218	$89	$45
Schools	$215	$100	$43
Congested Highway Links	13	2	0
Worst School Use Index	144	40	112
Number of School Districts	10	6	4
Number of MS Districts	14	8	4
Average MS Use Index	143	128	179
Worst MS Use Index	196	188	263
Highest Operating Cost UT District	$8371	$8270	$8816
Number of Utility Districts	6	3	2
Government Teams	7	7	7

The Local Water System

As Figure A–8 shows, the local system water quality is very poor. The worst water is quality level 9. The rural county (Jurisdiction 3) has the most parcels with good water, whereas Jurisdiction 2 has 10 of its 15 parcels with river water in the very worst water quality category. Six of the major surface water industries have no effluent treatment whatsoever. This is contributing to many of the local system water quality problems. All of the municipal water districts are treating their effluents, but the eight that have only secondary treatment are causing part of the pollution problem.

FIGURE A–8—*Water System Comparisons—RAYWID CITY*

	Jurisdiction 1	2	3	Total
Parcel of Water Quality				
1	1	2	16	19
2	—		—	—
3	—	—	—	—
4	—	—	—	—
5	—	—	—	—
6	—	—	5	5
7	4	—	2	6
8	5	3	2	10
9	3	10	2	15
Surface Water Industries with				
Tertiary Treatment	1	—	—	1
Secondary Treatment	2	2	1	5
Primary Treatment	1	—	1	2
No Treatment	2	2	2	6
Municipal Outflow Treatment				
Tertiary	2	1		3
Secondary	4	2	2	8
Primary				—
None				—

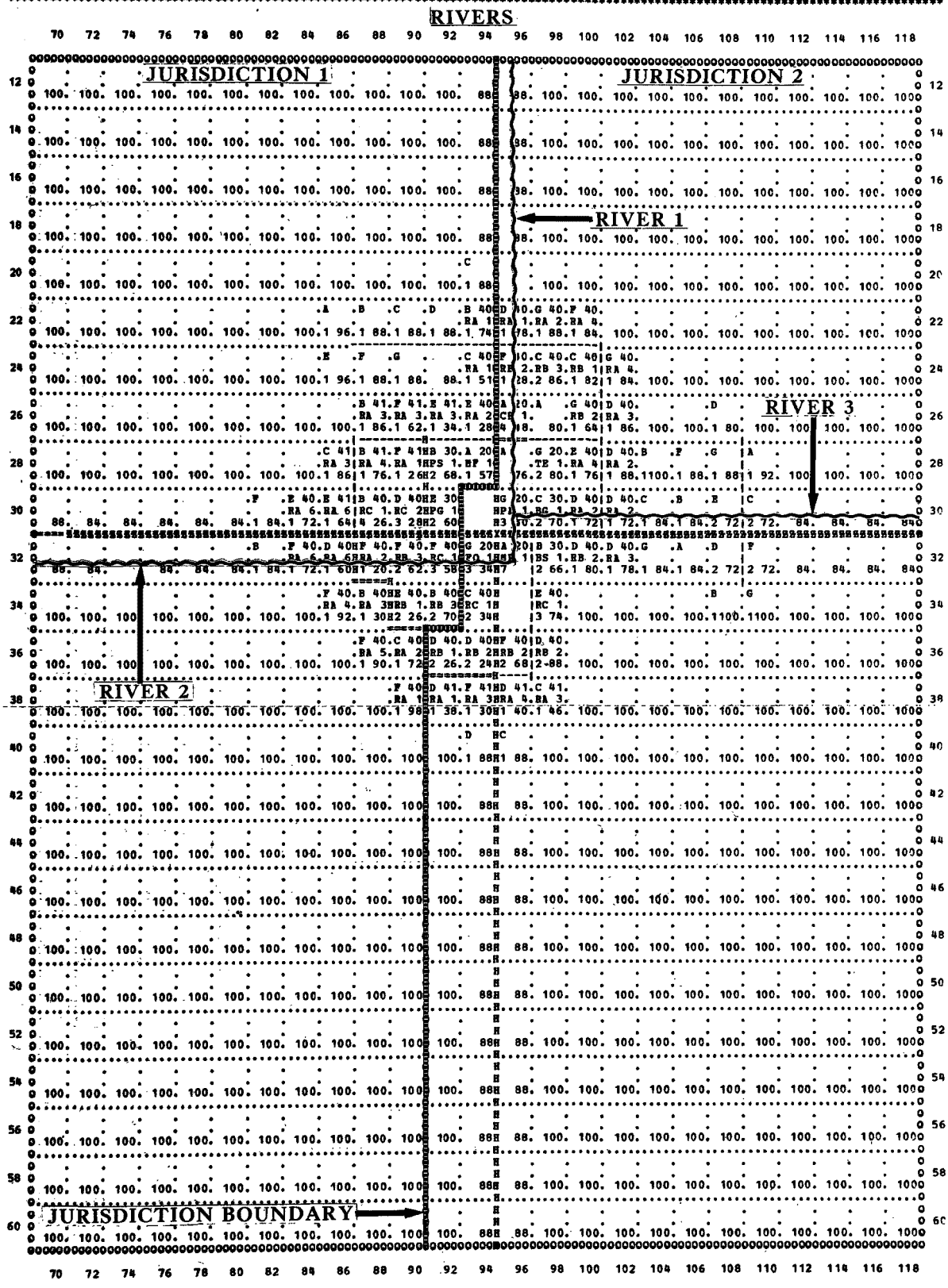
TWO CITY SCENARIO

TWO CITY is a regional river basin area containing two political jurisdictions with a population of about 275,000. There are a number of manufacturing establishments, farms and municipal sewer systems that contribute to the pollution of the major rivers that run through the region. Along with poor water service, housing deficiencies and inadequate municipal services, the polluted river looms as one of the several major problems facing the regional area.

The Economic Status Map (Figure A–9) shows the regional area encompassed by TWO CITY. All the local system population and land use activity is

FIGURE A - 9

TWOCITY — ECONOMIC STATUS MAP — ROUND 1



PARCEL KEY
TOP LEFT: OWNER
TOP RIGHT: ZONING
MIDDLE: LAND USE AND LEVEL
BOTTOM LEFT: UTILITY LEVEL
BOTTOM RIGHT: % UNDEVLPD LAND

PARCEL EDGES
.. .. ROADBED
-- || TYPE 1 ROAD
== HH TYPE 2 ROAD
SS HH TYPE 3 ROAD
QQ QQ JURISDICTION BOUNDARY

INTERSECTIONS
+ TYPE 1 TERMINAL
X TYPE 2 TERMINAL
* TYPE 3 TERMINAL

ZONING	LAND USE
--	ANY USE
10	ANY BUSINESS
20	HI,LI,CI
21	HI
22	LI
23	CI
30	BS,BG,BS,PG,PS
31	BS
32	BG

ZONING	USE
33	BS
34	PG
35	PS
40	RA,RB,RC
41	RA
42	RB
43	RC
50	PARKLAND

concentrated in the center of the region. The jurisdictional boundary runs from north to south and separates Jurisdiction 1 (on the west side) from Jurisdiction 2. There are three sections of river that flow through the region. Note that rivers flow through the centers of parcels.

Figure A–10 shows the population distribution by the three income classes for the two political jurisdictions that comprise TWO CITY. Jurisdiction 2 has a larger rate of unemployment and all of this is concentrated in the low income groups. The middle and high income groups are experiencing some employment difficulties (under-employment) in that a number of workers are forced to take jobs at salaries below the level they would normally earn.

FIGURE A–10—*Characteristics for the Jurisdiction of TWO CITY*

	Jurisdictions 1	2	Total
Population	126,000	149,500	275,500
High Income (%)	49	28	37
Middle Income (%)	51	23	36
Low Income (%)	0	49	27
Unemployment	0	6,400	6,400
Percent	0	13.0	7.5
Underemployed Workers (number)			
High Income	NA	NA	1,200
Middle Income	NA	NA	3,360
Housing Vacancy Rate	—8	—9	—8
Housing Types (Percents)			
Single Family	31	20	25
Multiple Family	69	80	75
High Density	50	26	38

Housing is in short supply in both jurisdictions. Most of the very high density housing is in Jurisdiction 1, where this type of housing makes up half of the supply. In Jurisdiction 2, low density multiple-family housing is dominant.

The public school system in Jurisdiction 2 is not serving the population well, in that a large number of the children attend private schools.

Figure A–11 shows the allocation of the social decision-making power among the seven teams that comprise the social sector. Note that teams are specialized. That is, teams (with the exception of CC and GG) initially have control over only one income class. Team AA controls the largest percentage of middle income population units in Jurisdiction 1 and DD controls all of the PL's in the local system. Another obvious power block is team FF's control of middle income units in Jurisdiction 2.

FIGURE A–11—*TWO CITY Social Control Summary*

Team	Jurisdiction 1 PH	PM	PL	Jurisdiction 2 PH	PM	PL
AA	0	106	0	0	0	0
BB	46	0	0	0	0	0
CC	0	22	0	26	0	0
DD	0	0	0	0	0	147
EE	45	0	0	13	0	0
FF	0	0	0	0	61	0
GG	33	0	0	43	9	0
Typical Salary per Worker		$10,000			$5,000	$2,500
Typical Salary per Pl		$1,200,000			$800,000	$500,000

The Economy

The economic assets of the region are distributed among seven economic teams. Each of these teams is fairly specialized at the start of play as Figure A–12 indicates. Teams A and G control all of the manufacturing industries. Both teams have control of at least one plant that is contributing large amounts of pollution to the local river system. All the large polluting manufacturing plants are located in Jurisdiction 2, but the detrimental effects of their water borne wastes are felt primarily in Jurisdiction 1. The commercial establishments in the local system are under the control of only three teams.

FIGURE A-12—*Economic Team Assets in TWO CITY*

	Teams A	B	C	D	E	F	G
Industrial Parcels	3						3
Commercial Parcels		2	1		1		
Residential Parcels		6	7	14	7	13	3
Undeveloped Parcels	5	5	5	4	2	4	4
Assets (billions)	2.5	.63	1.47	.94	.65	.87	2.0
Cash (millions)	268	68	145	91	66	102	254

Six of the seven teams control residences in the region. Ownership of the three small farms in the region is in the hands of Team A. All the farms contribute runoff pollution (from fertilizer use) to the local river system.

The national business cycle is in an upswing period, and local basic industries are enjoying above average prices on the goods that they produce and sell to outside markets. Typical prices for heavy industry products were 5 percent above normal and those for light industry were 4 percent above normal.

The Public Sector

The governments in the two jurisdictions are similar in structure, but they are quite different in service levels. For example, Jurisdiction 2 has a slightly larger population, and it has a substantially larger local tax revenue. Figure A–13 shows some of the government features for each of the jurisdictions. Note that all of the highway congestion and the worst school use indexes are in Jurisdiction 2. Jurisdiction 1, however, has a far worse average MS use index.

FIGURE A–13—*Government Sector Comparisons in TWO CITY*

	Jurisdiction 1	Jurisdiction 2
Population	126,000	149,500
Tax Revenue (millions)	62.6	82.9
Welfare Payment per Unemployed Worker	$1,500	$1,600
Current Expenditures (millions)		
Municipal Services	11.1	26.5
Schools	25.5	17.5
Congested Highway Links	0	2
Worst School Use Index	72	144
Number of School Districts	2	2
Number of MS Districts	1	2
Average MS Use Index	111	200
Worst MS Use Index	111	200
Highest Operating Cost UT District	$7,900	$6,801
Number of Utility Districts	1	1

The Local Water System

As Figure A–14 shows, the local system water quality is very poor in Jurisdiction 1, even though that jurisdiction has no major industrial polluters within its boundaries. Level 9 water quality is the worst water quality rating and all of Jurisdiction 1's water is of this quality. The solution to the local system's water quality problems will require cooperation among the local political jurisdictions.

FIGURE A–14—*Water System Comparisons—TWO CITY*

	Jurisdiction 1	Jurisdiction 2	Total
Parcels of Water Quality			
1 (best	—	19	19
2	—	—	—
3	—	—	—
4	—	—	—
5	—	—	—
6	—	—	—
7	—	—	—
8	—	3	3
9 (worst)	12	1	13
Surface Water			
Industries with			
Tertiary Treatment	—	1	1
Secondary Treatment	—	1	1
Primary Treatment	—	1	1
No Treatment	—	1	1
Municipal Outflow Treatment	—	—	—
Tertiary	—	—	—
Secondary	1	1	2
Primary	—	—	—
None	—	—	—

APPENDIX B

River Basin Manuals

The RIVER BASIN MODEL is described for player and directer use in fourteen (14) separately bound manuals. Each manual has a "161100 FRU 12/71" prefix. The final digits in each manual code number are the identifying numbers for the specific manuals. They are:

The RVER BASIN MODEL:

1. An Overview (109 p. — $1.00) 16110 FRU 12/71-1
2. Director's Guide (229 p. — $1.75) 16110 FRU 12/71-2
3. Economic Sector (151 p. — $1.25)
4. Social Sector (117 p. — $1.25)
5. Chairman and Council (80 p. — $.70)
6. Assessment Department (83 p. — $.75)
7. School Department (94 p. — $1.00)
8. Municipal Services Department (93 p. — $1.00)
9. Utility Department (129 p. — $1.25)
10. Highway Department (104 p. — $1.00)
11. Planning and Zoning Department (81 p. — $.75)
12. Computer Output (246 p. — $2.00)
13. The Social Science Laboratory (271 p. — $2.00)
14. Transportation Departments (94 p. — $1.00)

These volumes are attainable from the U.S. Government Printing Office at the indicated prices and from the National Technical Information Service, Springfield, Virginia 22151.

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