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TECHNICAL REPORT NUMBER 8

A LAND USE PLAN DESIGN MODEL

VOLUME TWO MODEL TEST

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TECHNICAL REPORT

NUMBER 8

A LAND USE PLAN DESIGN MODEL
VOLUME TWO-MODEL TEST

Prepared by the

Southeastern Wisconsin Regional Planning Commission

for the

U. S. Department of Housing and Urban Development

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October 1969

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 NO. EAST AVENUE • WAUKESHA, WISCONSIN 53186 • TELEPHONE (414) 547-6721

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STATEMENT OF THE EXECUTIVE DIRECTOR

On October 28, 1966, the U. S. Department of Housing and Urban Development awarded to the Southeastern Wisconsin Regional Planning Commission a federally funded contract for the development of a mathematical model which could be used to design land use plans which would meet stated development objectives at a minimum cost. This emphasis on plan design was unusual, since mathematical model development efforts in the area of land use planning had, up until that time, been directed primarily at producing forecasts of future land use patterns rather than at producing optimal designs for such patterns.

Complete development of the land use plan design model was to be accomplished in three phases, with the results of each phase being reviewed upon completion of that phase and a decision being made by the U. S. Department of Housing and Urban Development as to whether or not to pursue the next phase of the research program. The first phase was directed at a review of the literature on land use models, the development of the design model concepts previously advanced by the Regional Planning Commission into a computer program for the execution of the design model itself, the identification of model input data requirements and means for satisfying these requirements, and the application of the model to a local area as a pilot test. The first phase was completed on December 7, 1967, and was documented in SEWRPC Technical Report No. 8, A Land Use Plan Design Model, Volume 1, Model Development, published in January 1968. Since the results of the first phase were encouraging, it was decided to proceed with the second phase.

The second phase of the work was directed at refinement of the model, with particular attention to more specifically defining the input data requirements, developing a computer program for the efficient reduction of input data, and improving the mathematical structure of the model itself. In addition, the refined model was to be tested for internal consistency and workability and applied to develop a land use plan for an actual urban region. This model-generated land use plan was to be compared with a land use plan developed for the same urban region by more conventional graphic and analytical land use planning techniques.

The second phase of the model development program was completed on October 12, 1969, and is documented in this report. The application of the land use plan design model to the preparation of a land use plan for southeastern Wisconsin, as described herein, indicates that the model can produce land use plans that are reasonable and, with certain refinements, can be developed into a flexible and useful planning tool capable of application at both the regional and community levels.

Remaining to be done in the third phase are the full development and test of the new land use plan design model algorithm proposed in this report for the model placement routine and the development of a necessary user's manual.

Respectfully submitted,

Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

This volume is the second of a series reporting on an urban planning research and demonstration project (Project No. Wis. PD-1) sponsored by the U. S. Department of Housing and Urban Development and conducted by the Southeastern Wisconsin Regional Planning Commission for the purpose of developing a land use plan design model. The first volume of this series, entitled Model Development, described the results of Phase I of the research and demonstration project. This first phase consisted of a review of the literature on land use design models, the development of design model concepts, the conversion of these concepts into the workable form of a computer program, the identification of model input data requirements and means of satisfying these requirements, and the application of the model to a local area as a pilot test to demonstrate the internal consistency and workability of the model in its computer program form.

This volume, entitled Model Test, is a report on Phase II of the research and demonstration project. This second phase consisted of a further demonstration of the conceptual soundness and internal consistency of the model and the practicality of its application, as well as of a further refinement of the model itself. The practicality of the model was demonstrated through its application to the design of a land use plan for the seven-county Southeastern Wisconsin Region and a comparison of the results of this model design to a land use plan prepared for the Region by more conventional graphic and analytic techniques.

REVIEW OF THE DESIGN MODEL CONCEPTS

As already noted, the basic purpose of the demonstration project is to develop a mathematical model to aid planners in the synthesis of, that is, the design of, community and regional land use plans. The land use plan design model is to function as an optimization model, not a forecasting model, its function being to prescribe the best land use plan which can be designed to meet stated development objectives and not to forecast future land use development that would occur with or without a land use planning effort.

Any design optimization of a system must meet the following conditions:

1. The way in which the variables of the system interact, as well as the variables themselves, must be defined.

2. A single measure of effectiveness must be determined and a set of constraints on the design solution must be specified.

3. An optimization procedure to search for the best plan satisfying the measure of effectiveness within the prescribed constraints must be formulated.

The variables defined in the land use plan design model were:

1. A set of areal cells with various locational, topographic, and soil characteristics.

2. A set of land use modules with various spatial and functional characteristics.

The interrelationships of these variables were defined as follows:

1. The modules were related to cells by module site development costs, which vary with soil characteristics.

2. The modules were interconnected by transportation, communication, and service linkages as necessary for the functioning of the modules.

The measure of effectiveness of the land use plan design model and the constraints on the design solution were specified as follows:

1. The measure of effectiveness was the minimization of total development and operational costs. These costs reflect the two types of relationships described above in that development or site costs reflect the relationship of modules to cells; that is, to the land; and the operational or linkage costs reflect the interrelationship of the modules.

2. The constraints define relationships desired in the final plan design. These constraints are of two types. They include allocation and linkage constraints designating the number of modules of each type in relation to the number of modules of all other types and indicating the required linkages between modules and resource conservation, spatial accessibility, and spatial compatibility constraints designating undesirable usage of certain types of land by certain types of modules, and spatial distance requirements between modules. The allocation and linkage constraints are expressed as input data for the model. The resource conservation, spatial accessibility, and spatial compatibility constraints are represented in the model by "dummy" site and linkage costs.[1]

The optimization procedure used in the land use plan design model involves the assignment of modules to areal cells as a result of a series of binary decisions. The model operation is initiated with a random placement of modules in the two halves of the divided design area. From this starting point model operation attempts to improve the initial placement of modules by transferring individual modules to the other half of the design area so as to minimize the combination of site costs and linkage costs. This process continues until no improved situation can be found by moving a single module from one half of the design area to the other. In the next phase of model operation, a second set of divisions is synthesized from the halves of the first division, each of the original halves now becoming a complete design area. Each module is then assigned to one of the halves resulting from the second division according to the process followed after the first division. No module assigned to a half following a division can ever be reassigned to the other half following a later division. Thus, the design area is sequentially divided in half, each half becoming a new design area, and then divided again and again with modules being assigned to halves following each division. The result is the placement of modules in areal cells such that site and linkage costs are minimized within the restrictions imposed by the design constraints.

Progress Report on Phase II

The primary purpose of Phase II of the demonstration project is to provide an evaluation of the utility of the design model as a planning tool by applying the model to the Southeastern Wisconsin Region. This application involved several major work activities:

1. The measuring and coding of soil characteristics by quarter section and watershed boundaries for the seven-county Region in order to provide the basis for determining the cost input parameters to the model. This work activity is discussed in Chapter II of this volume.

2. Investigation of data acquisition and information retrieval requirements for operational use of the urban design system in urban planning applications. This work activity is also discussed in Chapter II of this volume.

3. The preparation of auxiliary computer programs to convert forecast variables, such as population and employment, directly into module inputs for the model. This work activity allows package use of the model by planners utilizing the typical module definitions and design standards formulated in the project.

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[1] *See Volume 1, Chapter VI, for a discussion of "dummy" costs.*

4. Application of the model to the Southeastern Wisconsin Region. This work activity is discussed in Chapter IV of this volume.

5. Test and evaluation of the sensitivity of the model to imputed objectives, design standards, and cost functions. This work activity is also discussed in Chapter IV of this volume.

The remaining chapters of this volume report the results of the Phase II program of the demonstration project. In Chapter II the input information requirements of the model are defined, and the data reduction program package is described. Chapter III considers improvements in the Land Use Plan Design Model Program made during Phase II of the project. The application of the model to the Southeastern Wisconsin Region is described in Chapter IV, and Chapter V concludes with a brief discussion of the work activities to be carried out in Phase III of the demonstration project.

Chapter II

INFORMATION REQUIREMENTS AND DATA REDUCTION OPERATIONS

MODEL INFORMATION REQUIREMENTS

The information required as model input data in order to implement the land use plan design model can be grouped into five general categories: module data, soils data, cost data, division sequence data, and connectivity price data. An additional class of data, that pertaining to initial conditions, is optional as input for implementation of the model.

Module Data

Module data specify the number of each module type to be located by the design model, the area requirements of each module type, and the linkage requirements of each module type. These are derived from population and economic forecasts by means of a transformation matrix relating directly to the design standards developed for each type of module. The design standards specify the number of some types of modules required per unit of population or economic activity and the numeric relation between these primary modules and other modules. To facilitate this transformation process, auxiliary computer programs converting forecast variables directly into module inputs for the model have been prepared, based on typical module definitions formulated in Phase I and on the SEWRPC design standards.

Soils Data

The soils data identify the various soil types and their geographic distribution in the planning area. This identification and classification should be based upon those soil characteristics which significantly affect land development: soil texture, depth to water table, depth to bedrock, and slope. A classification matrix of this sort is illustrated in Table 1. Also included in the soils data is the area of each cell (in acres) covered by each soil type.

Cost Data

Cost data enter the design model in two forms: as site development costs and as linkage costs. Site development costs, the costs of constructing all facilities and necessary associated service utility lines internal to a particular module type, are derived according to the concept that at any given time construction costs will vary only with soil characteristics and conditions. Thus, only those elements of each facility with costs relating to soil types need be priced.

Linkage costs enter the model primarily in the form of a connectivity matrix. This matrix gives connectivity values (linkage costs) for connecting each module with all other modules, the values being normalized on a range of 1 to 99. It is through these connectivity values that dummy linkage costs reflecting spatial design standards are represented in the input data. Since linkages are modules in themselves, however, linkage costs also include costs of construction, the linkage site development costs, and the costs of operating the linkages.

Division Sequence Data

As a result of successive divisions, each module is placed in a cell. This process, the division sequence, requires a previous definition of the location of each cell relative to each division. For areas of uniform topography, the selected division sequence may be uniform; but for areas of nonuniform topography or major facility links, such as freeways, a division sequence which considers these natural or man-made boundaries may be of benefit. The planner has the option of selecting the division sequence, but for any sequence the location of each cell relative to each successive division must be supplied as input data in the form of a division cell list.

Table 1

SOIL CATEGORY RELATIONSHIP MATRIX

Unified Soil Classification	Slope Group[a]	Less Than 1 ft. To Water Table			1 ft. To 5 ft. To Water Table			5 ft. And Over To Water Table		
		Less than 2ft. to Bedrock	2ft.-5ft. to Bedrock	5ft. and over to Bedrock	Less than 2ft. to Bedrock	2ft.-5ft. to Bedrock	5ft. and over to Bedrock	Less than 2ft. to Bedrock	2ft.-5ft. to Bedrock	5ft. and over to Bedrock
Fine Grained Soils	A, B	1111[b]	1121	1131	1211	1221	1231	1311	1321	1331
	C_1, C_2	1112	1122	1132	1212	1222	1232	1312	1322	1332
	D_1, D_2, E, F	1113	1123	1133	1213	1223	1233	1313	1323	1333
Coarse Grained Soils	A, B	2111	2121	2131	2211	2221	2231	2311	2321	2331
	C_1, C_2	2112	2122	2132	2212	2222	2232	2312	2322	2332
	D_1, D_2, E, F	2113	2123	2133	2213	2223	2233	2313	2323	2333
Organic Soils	A, B	3111	3121	3131	3211	3221	3231	3311	3321	3331
	C_1, C_2	3112	3122	3132	3212	3222	3232	3312	3322	3332
	D_1, D_2, E, F	3113	3123	3133	3213	3223	3233	3313	3323	3333
Bedrock	A, B	---	---	---	---	---	---	4311	---	---
	C_1, C_2	---	---	---	---	---	---	4312	---	---
	D_1, D_2, E, F	---	---	---	---	---	---	4313	---	---

[a] *The percent average slope for each slope group is as follows: A equals 0.5 percent, B equals 3.5 percent, C_1 equals 7 percent, C_2 equals 10 percent, D_1 equals 13 percent, D_2 equals 17 percent, E equals 24.5 percent, F equals 37.5 percent.*

[b] *This four digit code number synthesizes four significant soil characteristics deemed requisite for cost estimation. Critical ranges of these characteristics; soil texture, depth to water table, depth to bedrock, and slope; are represented by the first, second, third, and fourth digits, respectively.*

Source: SEWRPC.

Connectivity Price Data

Connectivity prices for each division need to be provided as input data in order to allow for any unusual natural or artificial land features that would increase linkage costs between particular cells as the result of a division. The total linkage cost between any two modules after a division is then determined by multiplying the appropriate value given in the connectivity matrix by the connectivity price for that division.

Optional Data

Other data which are optional for input, depending on the purpose of the model run, are those pertaining to initial conditions of development in the planning area. In hypothetical situations or for instruction purposes, it may be desirable for the model to start from a situation of entirely undeveloped land. For practical planning application, however, it is necessary to start from an existing land use pattern. These initial conditions, then, may be included as input data.

DATA REDUCTION PROGRAMS

The user supplied input data described in the previous section must be developed into data files for use in the design model. This is done by means of a four-phase data reduction program. The detailed formats of the input, output, and file structure of the data reduction program package are shown in Tables 2, 3, and 4, respectively.

Phase 1 of the data reduction program develops the module site cost file, which shows the cost of development of each module in each cell. The data inputs for this phase are:

Soils Data	Code	Origin	Required
User Soil Inventory	UR11	User	Yes
Geographic Unit Cell Assignment	UR12	User	Yes

Table 2

DATA REDUCTION PROGRAM INPUT

Input Data	Code	Origin	Required
1. User Soil Inventory	UR11	User	Yes
2. Geographic Unit Cell Assignment	UR12	User	Yes
3. Soil Code Cross Reference	UR13	User	Yes
4. Slope Code Cross Reference	UR14	User	Yes
5. Element Site Cost Table	SR21	Supplied	Yes
6. Element Site Cost Adjustments	UR21	User	No
7. Module Element Requirements	UR22	User	Yes
8. Accessibility Annuity Factors	UR3P	User	No
9. Trip Interchanges Between Modules	UR30	User	No
10. Incremental Cost of Linkage	UR31	User	Yes
11. Module Linkage Requirements (Internal Length)	UR32	User	Yes
12. Module Span	UR33	User	Yes
13. Division Cell List	UR17	User	Yes
14. Division Connectivity Price	05	User	Yes
15. Number of Module Types in Problem	06	User	Yes
16. Module Requirements	07	User	Yes
17. Linkage Requirements	08	User	Yes
18. Initial Linkage Cost	09	User	Yes
19. Initial Conditions	00	User	No

Source: SEWRPC.

Table 3

DATA REDUCTION PROGRAM OUTPUT

1. General Information File - 4 Records

   a. 1. Division number = 1
      2. Number of divisions in problem
      3. Number of module types in problem
      4. Number of linkage types in problem

   b. Array of area requirements of each module.

   c. Array of number of each module type in problem.

   d. Array of cost per foot of each linkage type.

2. Linkage Cost File - 90 Records - 1 per Module

   Array of cost to link this module to all other modules

3. Module Site Cost File - 90 Records - 1 per Module

   Array of cost to build this module in each cell

4. Division Description File - 175 Records - 1 per Division

   1. Division number
   2. Price
   3. Division parent
   4. Parent half
   5. Number of cells this division
   6. Distance
   7. Number of cells in test
   8. Number of cells in nontest
   9. Done switch = 0

5. Cell Inventory File - 350 Records - 2 per Division

   a. Test cell inventory (Array of area of cells present in test)

   b. Nontest cell inventory (Array of areas of cells in nontest)

6. Total Placement File[a] - 175 Records - 1 per Division

   a. An array showing the number of each module type in test

   b. An array showing the number of each module type in nontest

7. Linkage Requirements File - 90 Records - 1 per Module

   An array of 30 entries. Zero indicates this linkage not required for this module. One indicates this linkage is required.

8. Module Placement File[a] - 180 Records - 2 per Module Type

   a. An array showing the number of this module type placed in each cell in test.

   b. An array showing the number of this module type placed in each cell of nontest.

9. Initial Conditions File - 90 Records - 1 per Module

   An array of 435 entries showing the number of each module type present in each cell.

[a] *Data Reduction sets this file to zeros.*

Source: SEWRPC.

Table 4

DATA REDUCTION PROGRAM DATA FILES

File XX	Number of Records	Record Size	Records Per Track	Number of Tracks	Extent Track Number
1. File 04	4	360	8	1	10 1
2. File 05	90	364	8	12	20 20
3. File 07	90	1740	2	45	40 50
4. File 08	175	36	37	5	90 10
5. File 09	350	1740	2	175	100 180
6. File 10	175	360	8	22	280 30
7. File 11	90	120	19	5	310 10
8. File 12	180	1740	2	90	320 90
9. File 00	90	1740	2	45	410 50

Source: SEWRPC.

Soil Code Cross Reference	UR13	User	Yes
Slope Code Cross Reference	UR14	User	Yes
Cost Data			
Element Site Cost Table	SR21	Supplied[1]	Yes
Element Site Cost Adjustments	UR21	User	No
Module Element Requirements	UR22	User	Yes

The first step in developing the module site cost file is to produce an index of the amount of each soil type in each cell. Module costs on each soil category are then developed by applying module element requirements to a supplied element cost table. The module site cost file is derived by applying the index of soils present in a cell to the module soil cost array. A by-product of this procedure is a file giving the area of each cell for use in Phase 2. The detailed input data format for Phase 1 is given in Table 5, and the operations procedure and flow chart are given in Table 6 and Figure 1, respectively.

Phase 2 of the data reduction program develops the cell inventory file. The data inputs for this step are:

	Code	Origin	Required
Division Cell List	UR17	User	Yes
Area of Cells		Phase 1	Yes

[1] *A procedure is included by which the user can modify the supplied element site cost table.*

Table 5
DATE REDUCTION PROGRAM INPUT
PHASE I

REQUIRED INPUT:

1. User Soil Inventory Data Cards (or Tape-Card Image Blocked 20)

   cols 1-20 User Geographic Unit
   21-30 User Soil Identification
   31-35 User Slope Identification
   36-45 Area of this Soil Type within this Geographic Unit

2. Geographic Unit Cell Cross Reference Cards

   cols 1-20 User Geographic Unit
   21-25 Cell to which this Geographic Unit is to be Assigned

3. Soil Cross Reference Cards

   cols 1-10 User Soil Identification
   11 Texture of this Soil
   1 = Fine Grained Soils
   2 = Coarse Grained Soils
   3 = Organic Soils
   4 = Bedrock
   12 Depth to Water Table for this Soil
   1 = Less than 1 Foot
   2 = 1 to 5 Feet
   3 = More than 5 Feet
   13 Depth to Bedrock for this Soil
   1 = Less than 1 Foot
   2 = 1 to 5 Feet
   3 = More than 5 Feet

4. Slope Cross Reference Cards (50 Cards)

   cols 1-5 User Slope Identification
   6 Slope Code
   1 = 0- 2%
   2 = 3- 6%
   3 = 7- 9%
   4 = 10-12%
   5 = 13-16%
   6 = 17-20%
   7 = 21-30%
   8 = 30+ %

5. Module Construction Cards

   cols 1- 5 Module Number
   6- 8 Element Number
   9-18 Units of this Element Required to Construct this Module

6. Division Cell List

   cols 3 Division Half
   6-10 Cell Number
   11-15 Division Number

Table 5 (continued)

DATA REDUCTION PROGRAM INPUT
PHASE I

OPTIONAL INPUT:

1. Factor Cards to Adjust Supplied Element Cost Tables

cols	1- 3	Element Number
	4	Operation
		x = Multiply
		+ = Add
	5-14	Factor to be Applied to Every Entry in Table

SUPPLIED INPUT:

1. Element Cost Table (Tape)

Element Number
Description
Cost of Element on Each of the 224 Soil Types

Source: *SEWRPC.*

Table 6

DATA REDUCTION PROGRAM OPERATIONS PROCEDURE
PHASE I

OPERATIONS PROCEDURE:

1. Load User Soil Inventory on Tape
   a. Program DR101-Utility Card to Tape
   b. UR11 Cards in Card Reader
   c. Output UR11 File on 181[a]
2. Sort UR11 File by User Soil Identification
   a. Program DR102
   b. Input UR11 Tape File on 181
   c. Work Area (Vol 111111-dos work pack) on 191
   d. Output Sorted UR11 on 180
3. Load User Soil Cross Reference List on Tape
   a. Program DR103
   b. UR13 Cards in Card Reader
   c. Output UR13 File on 180
4. Sort UR13 File by User Soil Identification
   a. Program DR104
   b. Input UR13 File on 180
   c. Work Area (Vol 111111-dos work pack) on 191
   d. Output Sorted UR13 on 181
5. Generate Soil Index Number
   a. Program DR105
   b. Input
      1. UR11 Sorted by User Soil Identification on 180
      2. UR13 Sorted by User Soil Identification on 181
      3. UR14 (User Slope Cross Reference Table) in Card Reader
   c. Output IR01 (Intermediate Soil Inventory) on 191 (Vol 111111-dos work)

Table 6 (continued)

DATA REDUCTION PROGRAM OPERATIONS PROCEDURE
PHASE I

6. Sort IR01 by User Geographic Unit

   a. Program DR106
   b. Input IR01 on 191
   c. Work Area (Vol 111111-dos work) on 192
   d. Output Sorted IR01 on 191

7. Load User Geographic Unit Cross Reference File on Tape

   a. Program DR101
   b. Input UR12
   c. Output UR12 Tape File on 181

8. Sort UR12 File by User Geographic Unit

   a. Program DR107
   b. Input UR12 File on 181
   c. Work Area (Vol 111111-dos work) on 191
   d. Output Sorted UR12 on 180

9. Insert Cell Number in Soil Inventory

   a. Program DR108
   b. Input
      1. IR01-Intermediate Soil Inventory-on 191
      2. User Geographic Unit Cross Reference Table on 180
   c. Output IR02 Intermediate Soil Inventory on 192 (cyl 101-198)

10. Sort IR02 by Soil Index Number within Cell Number

   a. Program DR109
   b. Input IR02 on 192 (cyl 101-198)
   c. Work area on 191
   d. Output IR02 on 192 (cyl 001-098)

11. Develop Percent of Each Soil in Each Cell

   a. Program DR110
   b. Input IR02 by Cell by Soil Index
   c. Output
      1. Percent of Each Soil in Each Cell
      2. Total Area of Each Cell (Used in Phase II)

12. Develop Module Site (Soil) Cost

   a. Program DR203
   b. Input
      1. Module Requirements (UR22)
      2. Element Cost Table
   c. Output Module Soil Cost Table

13. Develop Module Site Cost (Average Cell Placement Cost)

   a. Program DR111
   b. Input
      1. Module Soil Cost Table
      2. Percent of Each Soil in Each Cell
   c. Output Model File 07-Module Cost in Each Cell

[a]*Format of UR11 tape file is UR11 card image blocked 20. If user chooses he can reformat his existing soil inventory to the UR11 tape format and enter procedure at this point.*

Source: SEWRPC.

Figure 1
DATA REDUCTION PROGRAM FLOW CHART
PHASE 1

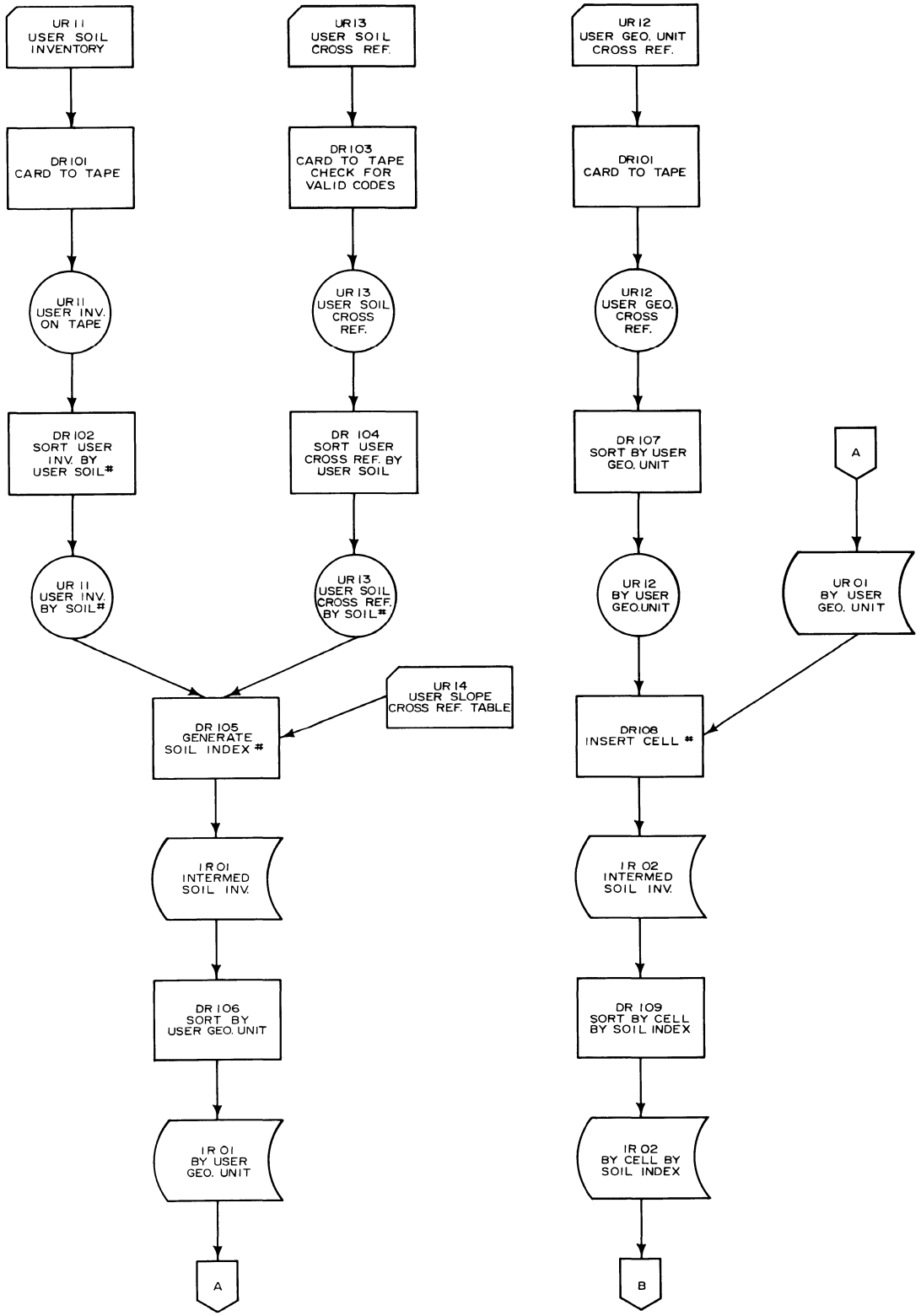
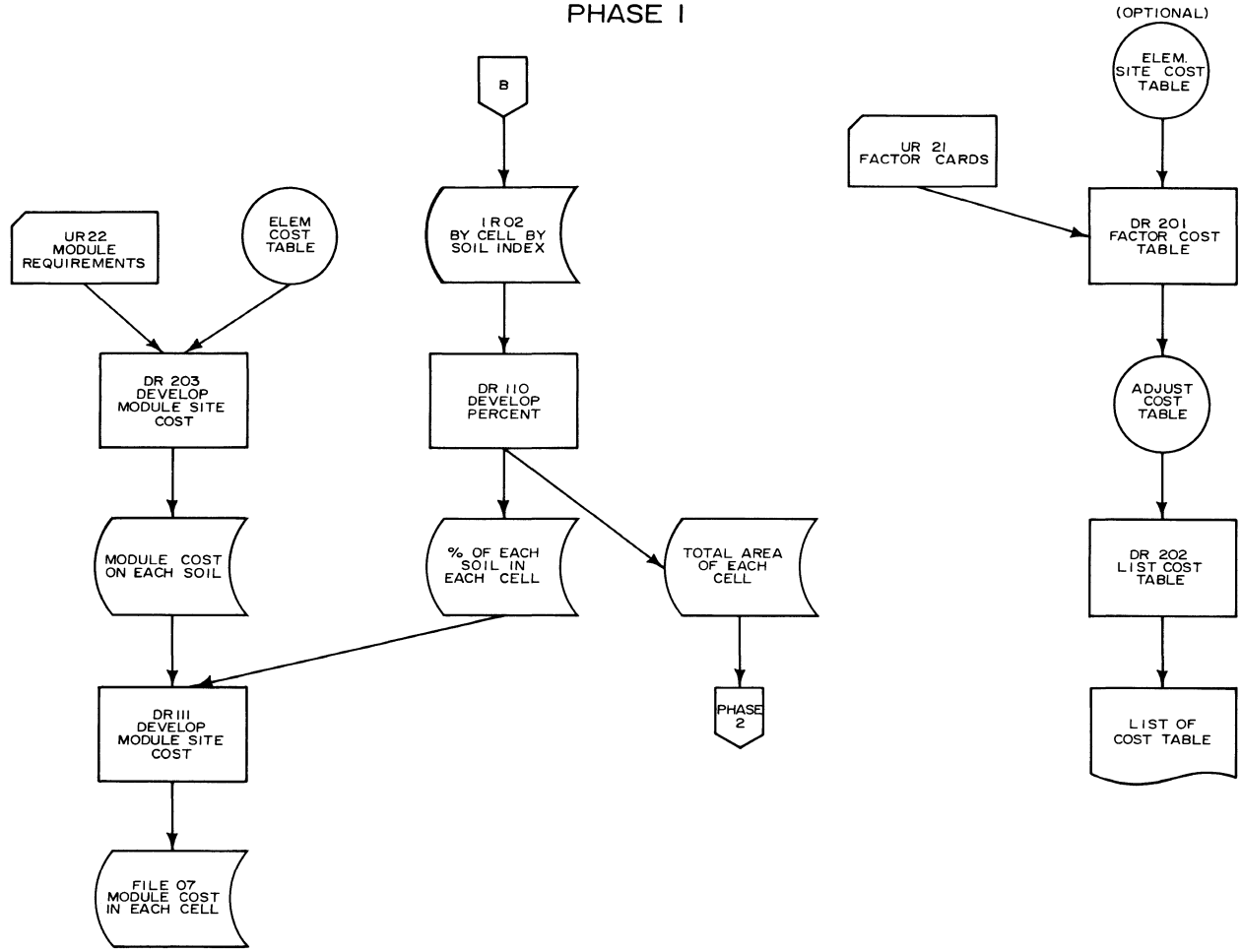


Figure 1 (continued)
DATA REDUCTION PROGRAM FLOW CHART
PHASE 1



Source: SEWRPC.

The inventory is generated by applying the division cell list to the cell areas developed in Phase 1, thus giving an inventory of all areas after each division.

The detailed inputs and operations procedure for Phase 2 are given in Tables 7 and 8, respectively; and the flow chart is given in Figure 2.

Table 7
DATA REDUCTION PROGRAM INPUT
PHASE 2

REQUIRED INPUT:

1. Division Cell List

cols 3	Division Half
6-10	Cell Number
11-15	Division Number

2. Area of Cells-Supplied from Phase 1

Source: SEWRPC.

Table 8

DATA REDUCTION PROGRAM OPERATIONS PROCEDURE

PHASE 2

OPERATIONS PROCEDURE:

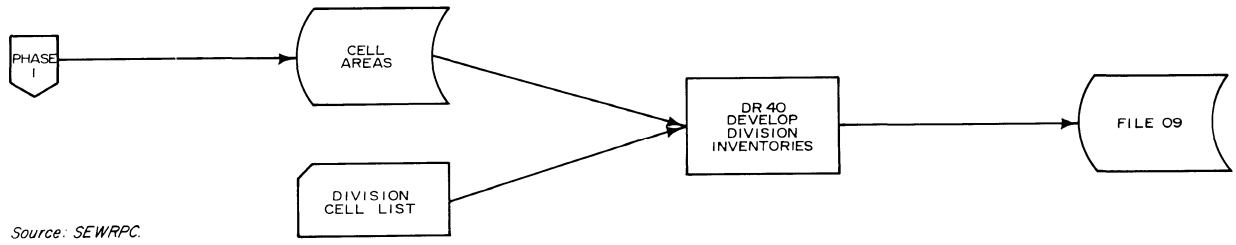
1. Create Model Input File 09-Cell Inventories
    a. Program DR210
    b. Input
        1. Division Cell List
        2. Cell Areas
    c. Output Model Input File 09

Source: SEWRPC.

Figure 2

DATA REDUCTION PROGRAM FLOW CHART

PHASE 2



Source: SEWRPC.

Phase 3 of the data reduction program produces the linkage cost file giving the incremental cost to link each module type to every other module type. The data inputs for this phase are:

Cost Data	Code	Origin	Required
Incremental Cost of Linkage	UR31	User	Yes
Module Linkage Requirements (Internal Length)	UR32	User	Yes
Module Span	UR33	User	Yes
Accessibility Annuity Factors	UR3P	User	No
Trip Interchanges Between Modules	UR30	User	No

In developing the file, the incremental cost per foot of a linkage is multiplied by the length of the linkage required in each module, thus giving the total incremental cost of linkage within each module. The total incremental cost of linkage is then expanded for all linkages in any two modules and is divided by the total span of the same two modules. An optional linkage (accessibility), developed by applying the present value of trip interchange over a given term to the number of annual trips between modules, can also be included in the linkages.

The detailed inputs and operations procedure for this phase are given in Tables 9 and 10, respectively; and the flow chart is given in Figure 3.

Table 9
DATA REDUCTION PROGRAM INPUT
PHASE 3

REQUIRED INPUT:

1. Incremental cost per foot of linkage

   cols 1- 3 Linkage Type Number
   9-18 Incremental Cost Per Foot of Linkage

2. Length of Linkage Required Internal to a Module (Distance of Separation for Accessibility)

   cols 1- 3 Linkage Type Number
   4- 8 Module Number
   9-18 Length of this Linkage Required by this Module

3. Span of Module

   cols 4- 8 Module Number
   9-18 Distance to Span this Module

OPTIONAL INPUT:[a]

1. Annuity Parameters

   cols 1- 2 Term of Annuity
   3- 6 Interest Rate (xx.xx Percent)
   7-15 Cost Per Mile Per Trip

2. Annual Number of Trips Between Modules

   cols 1- 3 Linkage Type Number
   4- 8 From Module Number
   9-13 To Module Number
   14-23 Annual Number of Trips

[a] *Used to develop accessibility cost per foot of separation as the present value of the number of foot trips at a given rate over a term.*

Source: SEWRPC.

Table 10
DATA REDUCTION PROGRAM OPERATIONS PROCEDURE
PHASE 3

OPERATIONS PROCEDURE:

1. Load UR32 File on Tape

   a. Program DR301
   b. Input UR32 File in Card Reader
   c. Output UR32 File on Tape Drive 180

2. Sort UR32 File by Linkage

   a. Program DR302
   b. Input UR32 File on 180
   c. Work Area 191 cyl 180 to 195
   d. Output UR32 File on Tape Drive 181

Table 10 (continued)

DATA REDUCTION PROGRAM OPERATIONS PROCEDURE
PHASE 3

3. Develop Total Incremental Cost of Linkage within a Module

    a. Program DR303
    b. Input

        1. Sorted UR32 File on Tape Drive 181
        2. UR31 Cards by Linkage in Card Reader
        3. Output IR31 File (Total Incremental Cost) on Tape Drive 180

4. Sort IR31 by Module

    a. Program DR304
    b. Input IR31 on Drive 180
    c. Work Area on 190 cyl 001 to 197
    d. Output IR31 on Drive 181

5. Explode Total Cost of Linkage Over All Combinations of Modules

    a. Program DR305
    b. Input IR31 by Module
    c. Output IR32 (Total Incremental Cost of Linking) on Disk

6. Explode Span of Modules Over Any Two Modules

    a. Program DR306
    b. Input UR33 Cards in Card Reader
    c. Output IR33 (Span Table) on Tape 180

7. Determine Accessibility Cost Per Foot (Optional)

    a. Program DR307
    b. Input
        1. UR3P Annuity Parameters in Card Reader
        2. UR30 Trip Interchanges between Modules
    c. Output IR34 Cost Cards

8. Calculate Total Incremental Cost Per Foot of Linking

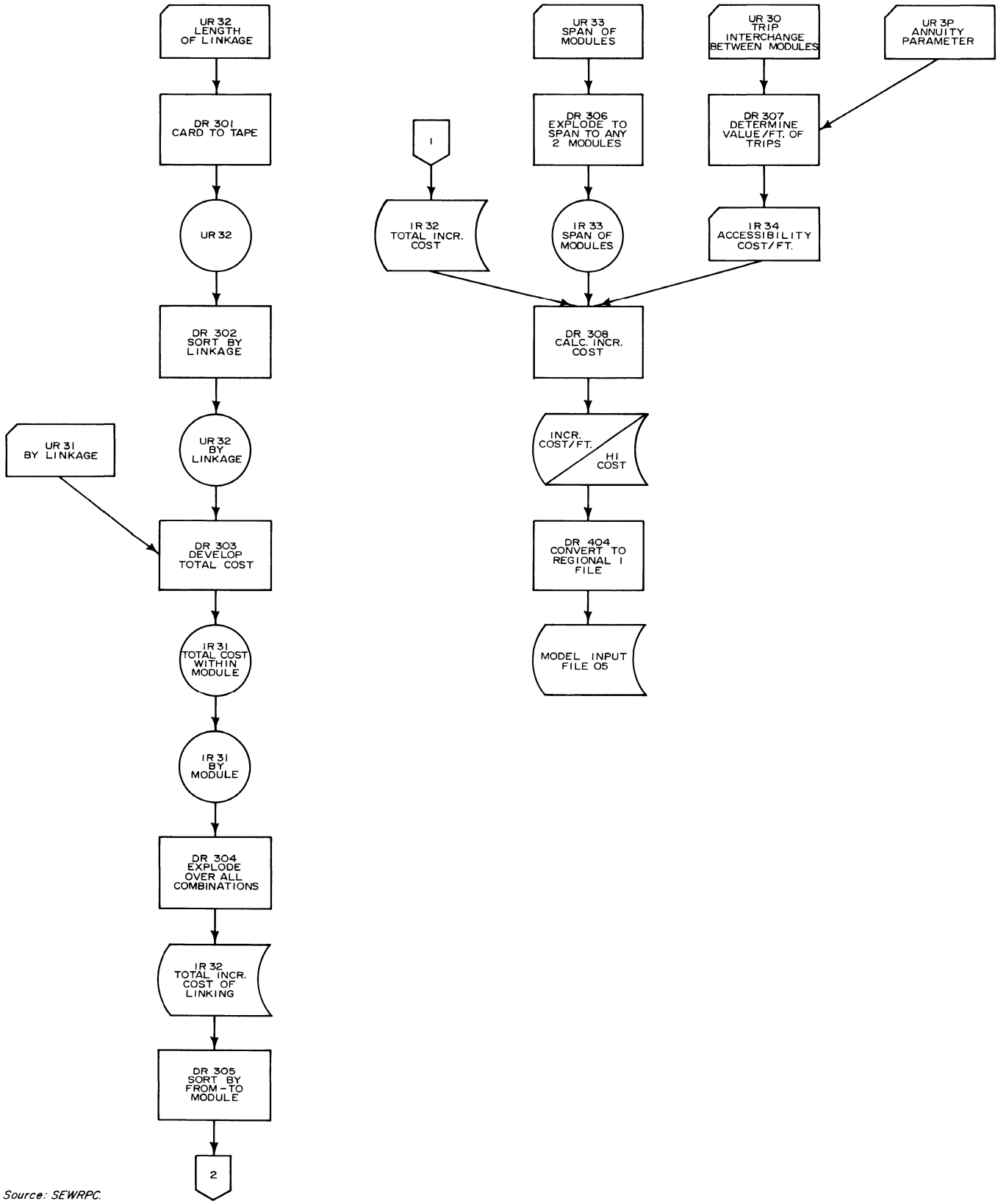
    a. Program DR308
    b. Input
        1. IR32 Total Incremental Cost of Linking
        2. IR33 Span of Modules
        3. IR34 Accessibility Cost Per Foot (Optional)
    c. Output
        1. List of Incremental Cost on Printer
        2. High Cost in Table on Printer
        3. Incremental Cost Table on Disk
        4. High Cost in Table on Disk

9. Develop Model FileII

    a. Program DR404
    b. Input Incremental Cost Table
    c. Output Model FileII

Source: SEWRPC.

Figure 3
DATA REDUCTION PROGRAM FLOW CHART
PHASE 3



Source: SEWRPC.

Phase 4 of the data reduction program transfers model run parameters to disk in a form acceptable to the design model program. In this phase the general information file, the division description file, the linkage requirements file, and the initial conditions file are prepared from the following input data:

Module Data	Code	Origin	Required
Number of Module Types in Problem	06	User	Yes
Module Requirements	07	User	Yes
Linkage Requirements	08	User	Yes
Cost Data			
Initial Linkage Cost	09	User	Yes
Division Connectivity Price	05	User	Yes
Initial Conditions	00	User	No

The detailed input and operations procedure are given in Tables 11 and 12, respectively; and the flow chart is given in Figure 4.

SUMMARY

This chapter has presented a discussion of the input data necessary for application of the land use plan design model. The data fall into five general categories: module data, soils data, cost data, division sequence data, and connectivity price data. Data pertaining to initial land development conditions may also be included, but this is not required for model operation. Before the design model can be implemented, these various inputs must be structured so as to fit the model program. This is done by means of a four-phase data reduction program which organizes the 19 inputs into nine data files. Once this process is complete, the land use plan design model becomes operational.

Table 11

DATA REDUCTION PROGRAM INPUT

PHASE 4

REQUIRED INPUT:

1. Division Description Cards

cols	6-10	Division Number
	30-35	Division Parent
	40-40	Parent Half
	43-45	Number of Cells this Division
	51-55	Distance Between Halves

2. Linkage Requirements

cols	6-10	Module Number
	22-80	30 two col Fields-1 Field Per Linkage Type
		00 Indicates this Linkage not Required
		01 Indicates this Linkage Required

3. Run Descriptors

A. Run Parameters

cols	1- 2	Constant 06
	3- 5	Number of Divisions in Problem
	6-10	Number of Module Types in Problem
	11-15	Number of Linkage Types in Problem

B. Module Requirements

cols	1- 2	Constant 07
	6-10	Module Number
	11-19	Area Required by One Module of this Type
	20-24	Number of this Type Module to be Placed

C. Linkage Costs

cols	1- 2	Constant 02
	9-10	Linkage Type Number
	11-20	Cost Per Foot of this Linkage Type

Source: SEWRPC.

Table 12

DATA REDUCTION PROGRAM OPERATIONS PROCEDURE

PHASE 4

OPERATIONS PROCEDURE:

1. Develop Division Description File-Model Input File08

    a. Program DR401
    b. Input Division Description Cards
    c. Output Division Description File08

2. Develop Linkage Requirements File

    a. Program DR402
    b. Input Linkage Usage Cards
    c. Output Model Input File11

3. Develop Run Parameters File

    a. Program DR403
    b. Input
        1. Run Parameters
        2. Module Requirements
        3. Linkage Costs
    c. Output Model Input File04

4. Develop Initial Conditions File

    a. Program DR405
    b. Input Initial Conditions Cards
    c. Output Model Input File00

5. Clear Model Work Files

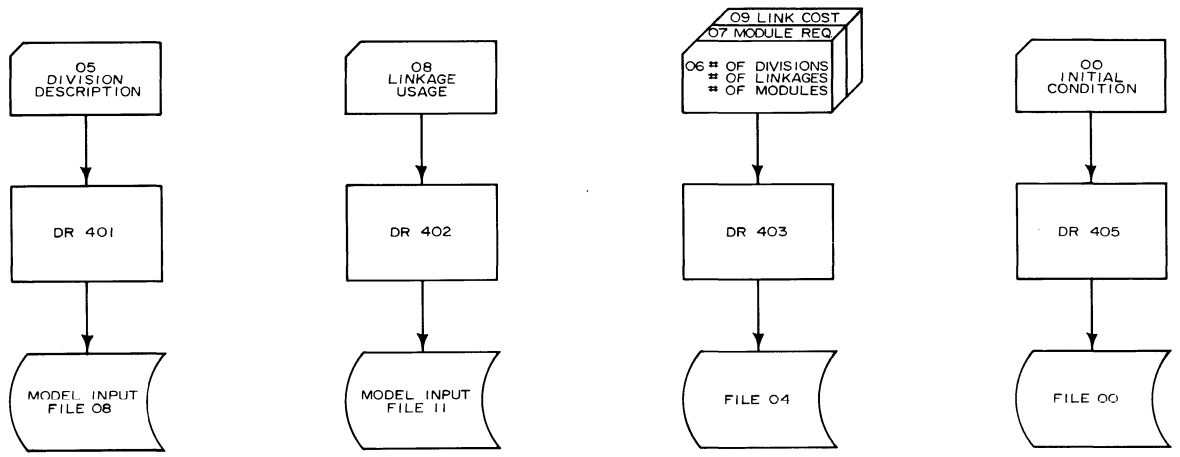
    Program CLRDSK

Source: *SEWRPC.*

Figure 4

DATA REDUCTION PROGRAM FLOW CHART

PHASE 4



Source: SEWRPC.

Chapter III

MODEL OPERATION

MODEL IMPROVEMENTS

The basic operation of the land use plan design model was described in Volume 1 of this series of reports (SEWRPC Technical Report No. 8, A Land Use Plan Design Model, Model Development). Briefly, the operation occurs in three phases: PLACECOMP II, ROUTCOMP, and MAPCOMP. The PLACECOMP II phase includes the sub-programs DVDIN, DVDSTT, and DIVIDE. DVDIN carries out the soil inventory and establishes the initial land development conditions for the design area before each division. DVDSTT makes the initial assignment of modules to the halves of the design area and calculates the initial site and linkage costs. DIVIDE, the optimization sub-program, revises these initial assignments until a least cost arrangement of modules is attained. After recording this arrangement, the model program returns to DVDIN for the next division until the division sequence has been completed. The PLACECOMP II phase is then to be followed by the ROUTCOMP phase, which locates the linkage paths required between modules while minimizing the total weighted length of the linkage system, and by the MAPCOMP phase, which provides a map of the land use plan resulting from PLACECOMP II and ROUTCOMP. At this time, however, only the PLACECOMP II phase has been implemented.

During Phase II of the Land Use Plan Design Model Project, several improvements were made in the model to make it more practicable and efficient. These improvements were:

1. Average site development costs for each module in each cell were developed to be used instead of the detailed site development costs based on the individual soil classifications in each cell. This modification was made because of difficulties in the application of the model in that some of the larger modules could not be located on the small areas of land resulting from the detailed soil classifications. It became necessary to use average site development costs for each cell in order to assure the provision of areas of land sufficient for the placement of large modules, such as low-density residential areas.

2. The model program was revised to allow for the optional input data pertaining to the initial conditions of land development in the planning area.[1] The original pilot test runs of the model started from entirely undeveloped land. In an actual planning situation, however, it is necessary to start from an existing land use pattern. The initial conditions sub-program included in the revised model program provides a means of establishing initial land development conditions at the beginning of the model run and permits the manual placement of certain modules independent of model operations.

3. The process of calculating linkage costs has been revised to eliminate unnecessary duplications. The inter-module connectivity matrix originally used in the model expresses the unit distance cost of linkages between any two modules. However, many modules may use common linkage elements, such as roads and sanitary sewer mains. Because of this the program has been modified so as to calculate the basic costs for the initial linkage elements and the incremental costs for the expansion of linkage facilities on the basis of the number and the types of elements using the linkage.

4. Actual costs for site development and linkages are now separated from dummy costs in the final print out. Since dummy costs reflect only design standards and not true monetary costs, their separation from actual costs permits the total actual cost of a plan to be determined from the final print out.

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[1] *See Chapter II for a discussion of this data input.*

5. A maximum constraint has been placed on all cells so that the land capacity of each cell cannot be violated.

6. The data reduction and design model programs have been integrated to a degree such that input data for the model need no longer be on punched cards. The data reduction outputs are now put on a disk, which then serves as direct input for the model program.

7. The DVDIN, DVDSTT, and DIVIDE sub-programs have been integrated into a single program. This eliminates some of the card handling and input-output routines previously needed.

8. The general efficiency of the program has been improved by removing certain aspects of the program which were redundant and by simplifying computational feedback loops.

None of these changes have substantially altered the basic logic of the model program but have served to improve the model in terms of workability and efficiency. Among other things, these changes have resulted in the reduction of model running time from about 12 hours to about three hours. The revised program is detailed in the flow chart presented in Appendix A.

NEW LAND USE PLAN DESIGN MODEL ALGORITHM

Although the improvements made to the data reduction and design model programs resulted in the satisfactory application of the model as described in the next chapter, it became evident upon evaluation of the model run that certain weaknesses exist in the model algorithm. The principal difficulty is the possible error inherent in the PLACECOMP II phase resulting from the fact that the placement of modules is performed by a series of binary decisions. A module placed on one half of the design area following a division cannot be moved to the other half of the original design area after a later division, even if such a change would result in reduced overall costs. The model algorithm considers only those linkage costs resulting from the latest division and not the cost of all the linkages required. Thus, the optimal plan resulting from this algorithm may not be the least cost plan.

To eliminate this source of error, a new random placement algorithm has been developed. The proposed algorithm has three steps: a Module Placement Routine, a Cost Computation Routine, and a Cost Evaluation Routine. In the Module Placement Routine, each module is assigned to an available cell by means of a random number generator program. However, if the placement of a module in a particular cell violates the site and linkage design constraints, successive random numbers will be generated until the module is located in a cell without violating any constraints. This process continues until all modules are assigned to cells. The Cost Computation Routine then calculates the site and linkage costs of the experimental plan obtained by the above process. These two steps are repeated until the required number of experimental plans has been obtained. The final land use plan is then selected through the Cost Evaluation Routine on the basis of least overall costs.

The number of experimental plans needed in order to assure the selection of a near-optimal design plan can be determined by the following equation:

$$s = 1 - (1-a)^n$$

or

$$n = \log (1-s)/\log(1-a)$$

Where n = the number of experimental plans required to obtain a plan with accuracy of "a" and probability of success of "s."

a = plan accuracy; that is, the ratio of the optimal zone[2] to the total number of possible experimental plans.

---

[2] *The optimal zone is a subset of experimental plans such that those experimental plans included in the subset have the least costs of all experimental plans.*

s = probability of success; that is, the probability that the lowest cost plan obtained by means of the algorithm will actually be among the "a" best plans represented by the optimal zone.

Table 13 gives values of "n" corresponding to selected values of "s" and "a." It should be noted that the number of experimental plans required is not a direct function of the number of possible module-cell combinations. Regardless of the size of the design area and the number of modules to be placed, the number of experimental plans required to obtain a plan within the optimal zone will not exceed 919 for even a very small optimal zone and a very high probability of success.

This proposed algorithm cannot be tested unless Phase III of the demonstration project is mounted. It is felt, however, that this algorithm, combined with the improvements made in the data reduction and design model programs, will make the land use plan design model both practicable and efficient for use in producing a near-optimal plan for any planning area.

Table 13
NUMBER OF TRIALS REQUIRED IN A MAXIMUM-SEEKING
EXPERIMENT CONDUCTED BY THE RANDOM METHOD

a	s			
	0.80	0.90	0.95	0.99
0.10	16	22	29	44
0.05	32	45	59	90
0.025	64	91	119	182
0.01	161	230	299	459
0.005	322	460	598	919

Source: Brooks, Samuel, "A Discussion of Random Methods for Seeking Maxima," Journal of Operation Research, Vol. 7, 1958.

Chapter IV

THE DESIGN MODEL PLAN FOR SOUTHEASTERN WISCONSIN

THE SOUTHEASTERN WISCONSIN REGION

The Southeastern Wisconsin Region is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Together these seven counties have a total area of 2,689 square miles, or about 5 percent of the total area of the state, and a total estimated population (1968) of 1,835,000, or about 42 percent of the total population of the state. Of the total land area, approximately 483 square miles, or about 18 percent, are presently devoted to urban land uses (1967), the remainder being devoted to rural-type land uses, such as agriculture, wetlands, and woodlands. The seven-county Region contains 153 general-purpose local units of government and encompasses all or parts of 11 major watersheds.

Geographically, the Region is bounded on the east by Lake Michigan, which provides an ample supply of fresh water for both domestic and industrial uses, as well as being an integral part of a major international transportation network. It is bounded on the south by the rapidly expanding northeastern Illinois metropolitan region and on the west and north by the fertile agricultural areas of the rest of the State of Wisconsin. Thus, the Region is located in a relatively good position for continued growth and development.

The land use plan design model was applied to the Southeastern Wisconsin Region in order to test the model's structural consistency and workability as a planning tool. For this application the Region was divided into 347 cells. The standard size of a cell was six U. S. Public Land Survey sections, (approximately six square miles), though cell size did vary from four to 18 such sections. An exception to this was Cell No. 132, which consisted of approximately 135 sections in Milwaukee County.

MODEL INPUT DATA

Model Data

A total of 2,321 modules, representing 34 module types, were supplied as input data to the model for the regional study, along with the area and linkage requirements of each module type. The number of each module type required was derived from population and economic forecasts by means of a transformation matrix reflecting the allocation design standards included in the definition of each module. The module types used and the number of each type are given in Appendix B; sample module definitions are given in Appendix C; and sample linkage requirements are given in Appendix D.

Soils Data

The basic soils data were taken from the regional soil survey that had previously been conducted by the U. S. Department of Agriculture, Soil Conservation Service, for the Southeastern Wisconsin Regional Planning Commission. This survey resulted in the identification and mapping of 585 soil types within the Region. Since many of these soils do not have characteristics differing sufficiently from other types to affect land development costs significantly, the original 585 soil classifications were reduced to 224. This reclassification, given in Table 1, Chapter II, was based upon those soil characteristics which significantly affected land development costs: soil texture, depth to water table, depth to bedrock, and topographic slope. The area of each cell covered by each of the soil categories was also defined in the soil inventory data. Examples of the data format are shown in Appendices E and F.

Cost Data

The form of the cost input data was modified to correspond to improvements made in the model program. Average development costs for each module type and cell combination were supplied as input data in place of the site development costs for every module type and soil combination. In order to avoid special and separate cost estimates for every module, data were collected for 141 basic cost elements, such as

residential foundations; sanitary sewer collection lines; and urban standard arterial thoroughfares. Since these cost elements appear in many modules, their use allows a more efficient approach to cost estimation. The data were ordered into development cost tables, giving site development costs for each cost element and soil type combination. The average development costs were then calculated for each cell on the basis of the area of the cell covered by each of the soil types and the costs of locating module elements on each of these soils. The basic cost elements and sample development cost tables are given in Appendix G.

The connectivity matrix giving the normalized cost of linking each module with any other module was also modified as input data. Model program improvements called for the replacement of this by data pertaining to basic costs for initial linkage elements and incremental costs for expansion of these linkage facilities according to the number and the kinds of modules using the linkage. Sample linkage cost data are given in Appendix H.

Division Sequence

The division sequence of the model requires a previous definition of the location of each cell relative to each successive division. This is supplied as input data for the model in the form of a division cell list. The grouping of cells defining the division sequence for model operations was based on the natural and artificial boundaries existing within the Region. The division sequence was carried through four stages for the entire Region and through five stages for selected subareas. This resulted in 20 subareas, each consisting of 15 to 20 cells. The division sequence is presented graphically on Map 1 and diagrammatically in Figure 5. The location of each cell and its relation to the final division subareas are shown on Map 2.

Connectivity Price

Connectivity prices for each division were provided as input data in order to allow for unusual natural or artificial land features that would increase linkage costs as a result of a division being made along one of these land features. The total linkage cost between any two modules is then determined by the connectivity price and the initial or incremental linkage costs. Connectivity prices are given in Appendix I.

Initial Conditions

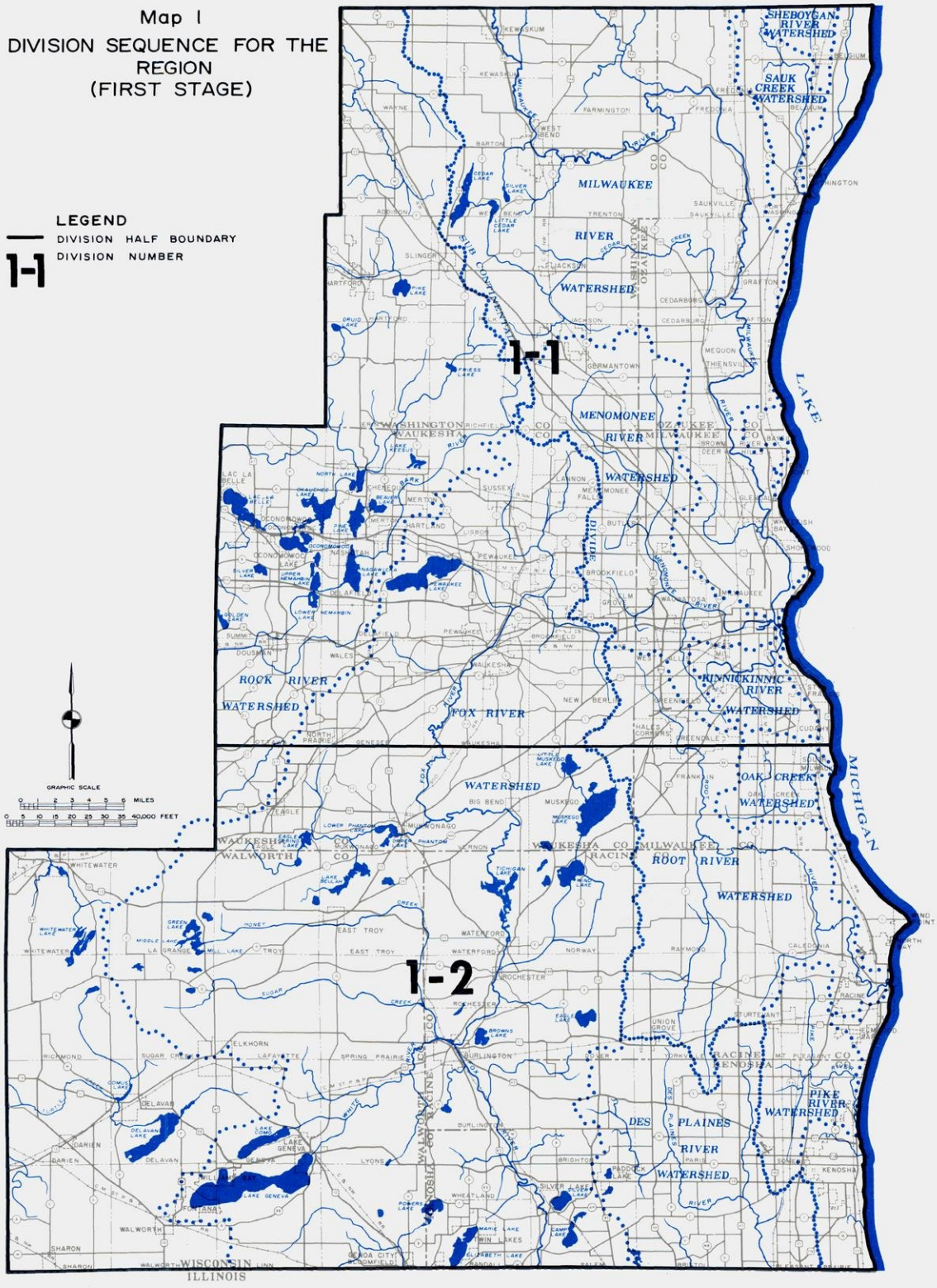
The land use pattern existing in 1963 as defined by the SEWRPC Land Use Inventory was the basis for the input data pertaining to initial conditions. The input was accomplished by locating the existing modules in their appropriate cells. The year 1963 was selected to represent initial conditions because it was also the base year for the regional land use plan prepared by more conventional techniques and thus facilitated comparison of the design model results with the latter plan. An example of the data format is given in Appendix J.

MODEL APPLICATION RESULTS

With the above model input data, the design model was applied to the Southeastern Wisconsin Region. The run located 2,278 of the 2,321 modules. The other 43 modules, all regional service facilities, were not entered in the model run so that they could be located by hand to serve the land use patterns resulting from the model application. The resulting assignment of modules to cells is shown on Map 3, along with the initial conditions entered in the model run. Map 4 shows a design plan for the Southeastern Wisconsin Region derived from the model run by locating modules within cells so that modules in adjacent cells are clustered and so that development does not infringe upon environmental corridors, except where the land area requirements of the modules exceed the available nonenvironmental corridor lands in the cell. For comparison the adopted regional land use plan, prepared utilizing conventional plan design techniques, is shown on Map 5.

The design model tended to cluster the major modules so as to minimize linkage costs within the constraints of site conditions and the design standards. These clusters were located in the outlying areas of the Region so as to minimize site development costs resulting from soil and topographic conditions. In

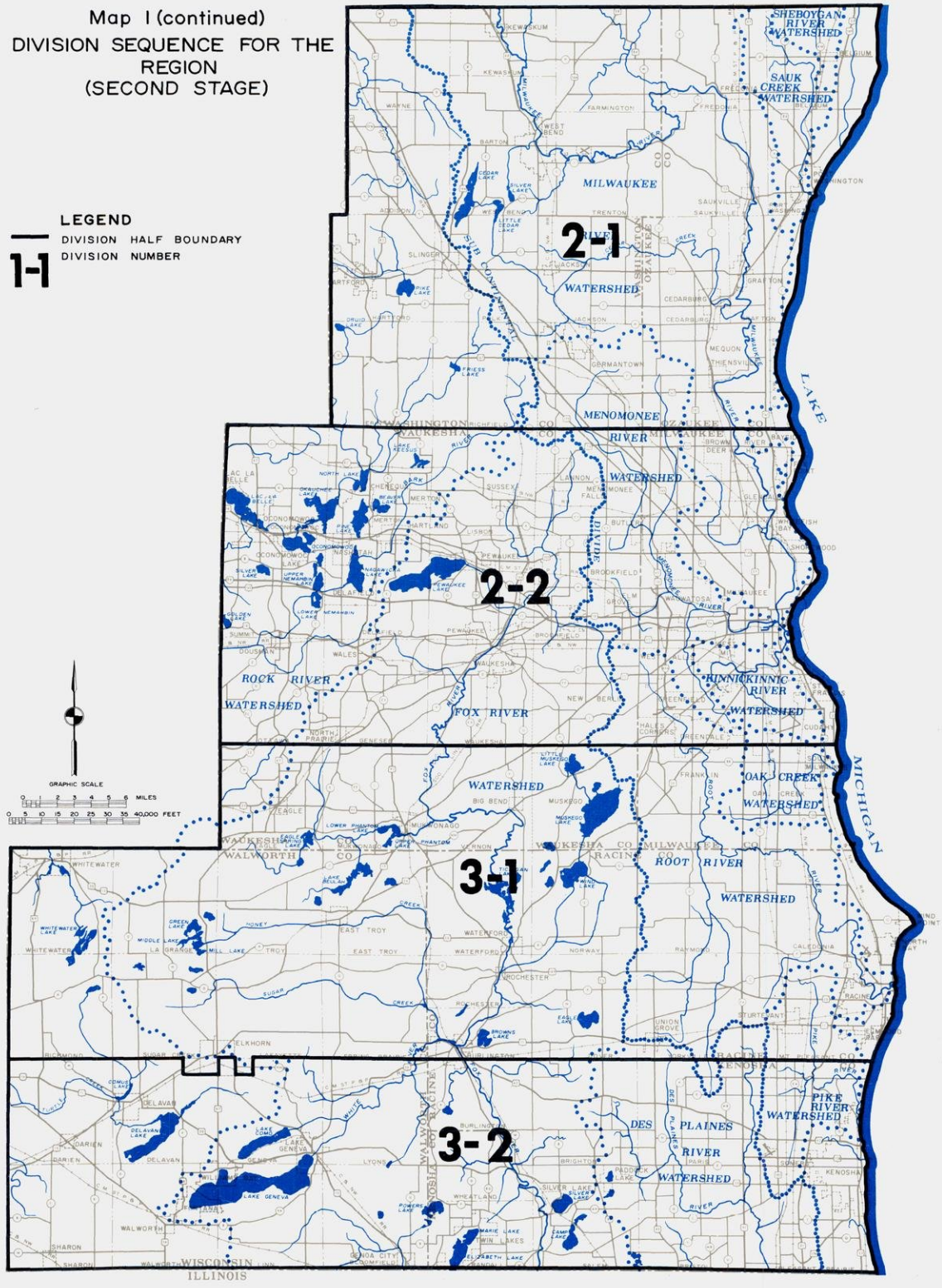
Map 1
DIVISION SEQUENCE FOR THE REGION
(FIRST STAGE)



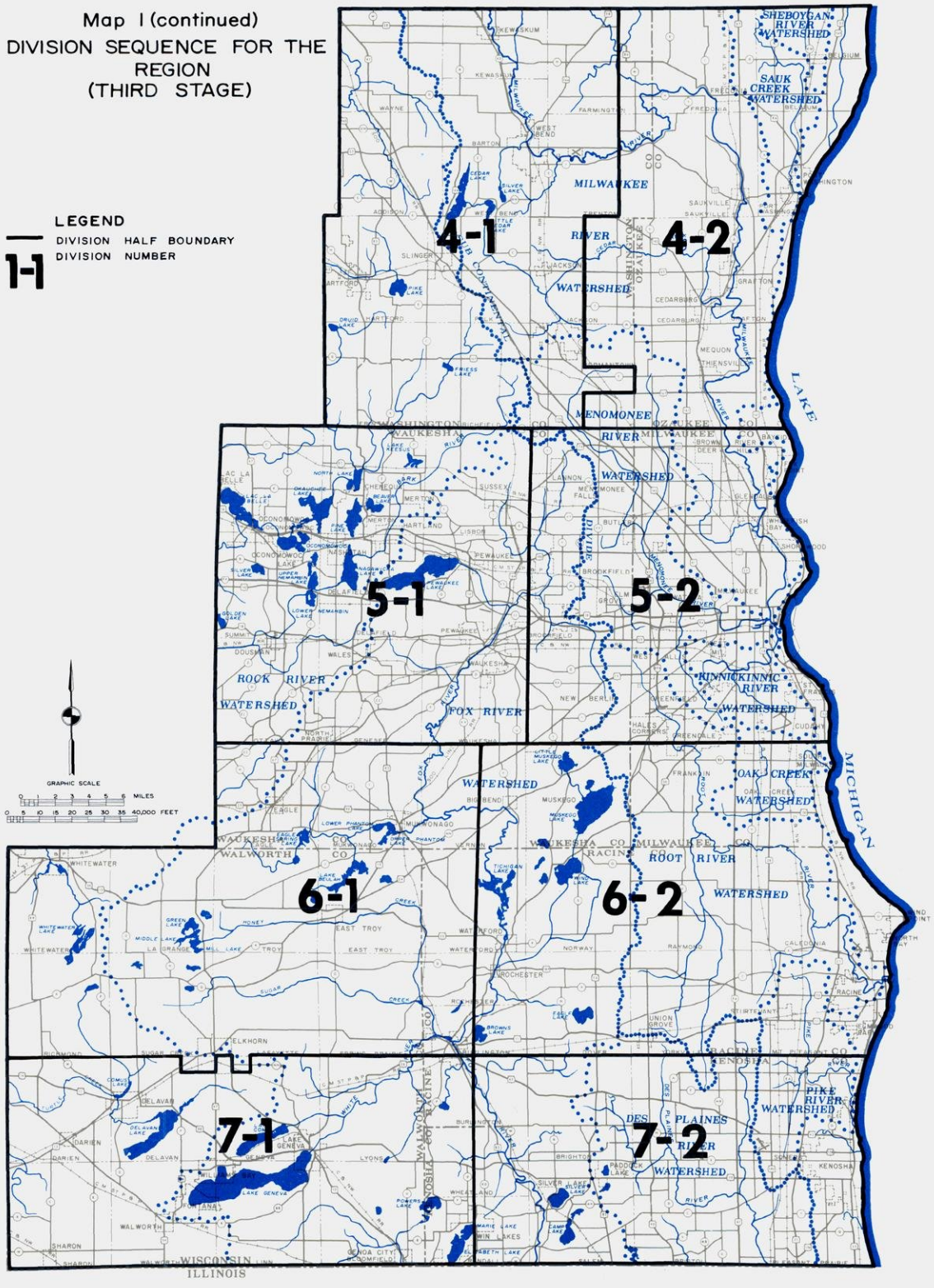
Each division half boundary encloses one or more cells. A division half is identified by a number composed of a division number followed by a dash and a division half number for each of the two halves formed by that division. Each division half then becomes a parent area, which is subsequently divided, as shown in the second, third, fourth, and fifth stages of the division sequence.

Source: *SEWRPC.*

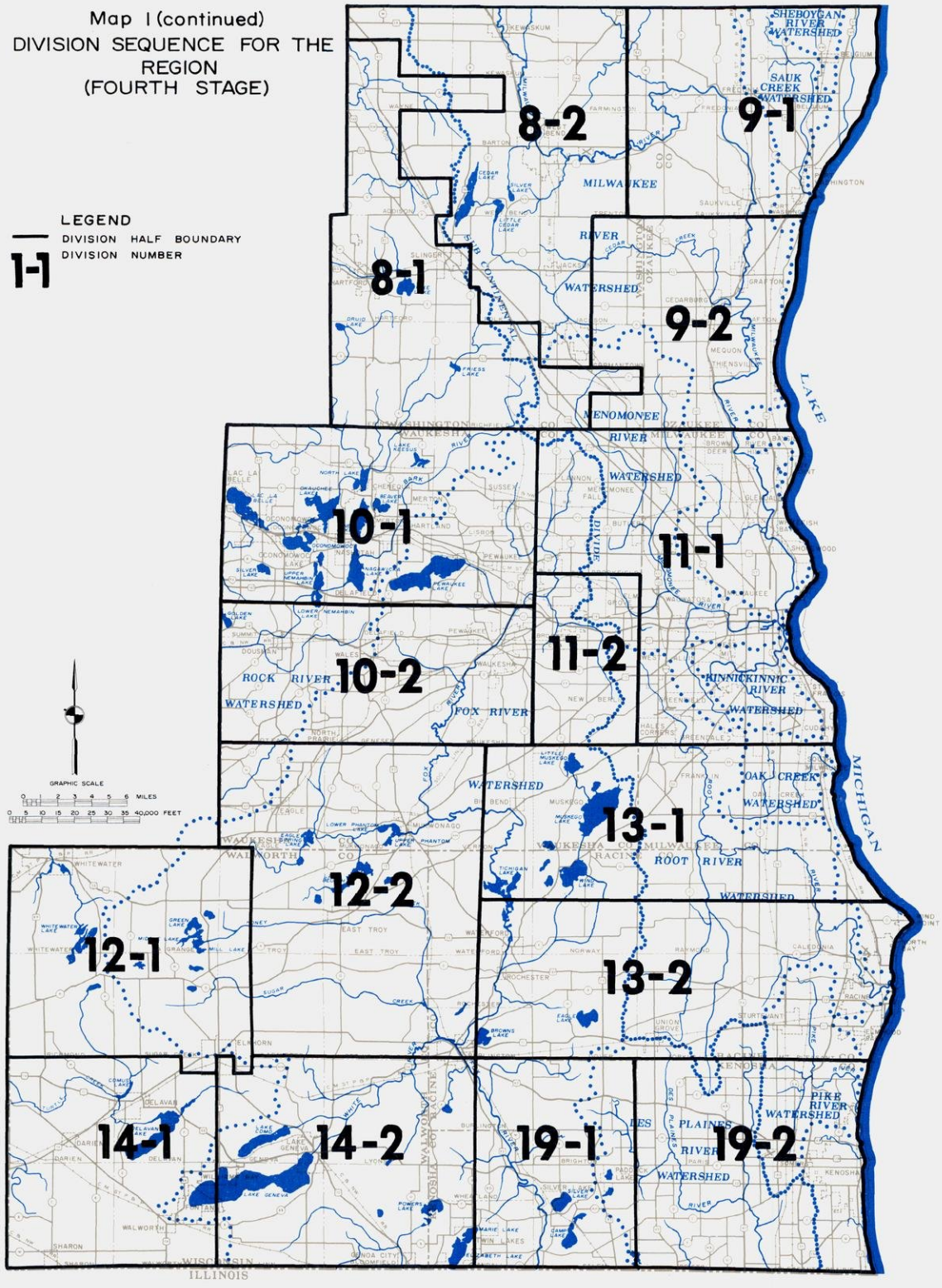
Map 1 (continued)
DIVISION SEQUENCE FOR THE REGION
(SECOND STAGE)



Map 1 (continued)
DIVISION SEQUENCE FOR THE REGION
(THIRD STAGE)



Map 1 (continued)
DIVISION SEQUENCE FOR THE REGION
(FOURTH STAGE)



Map 1 (continued)
DIVISION SEQUENCE FOR THE REGION
(FIFTH STAGE)

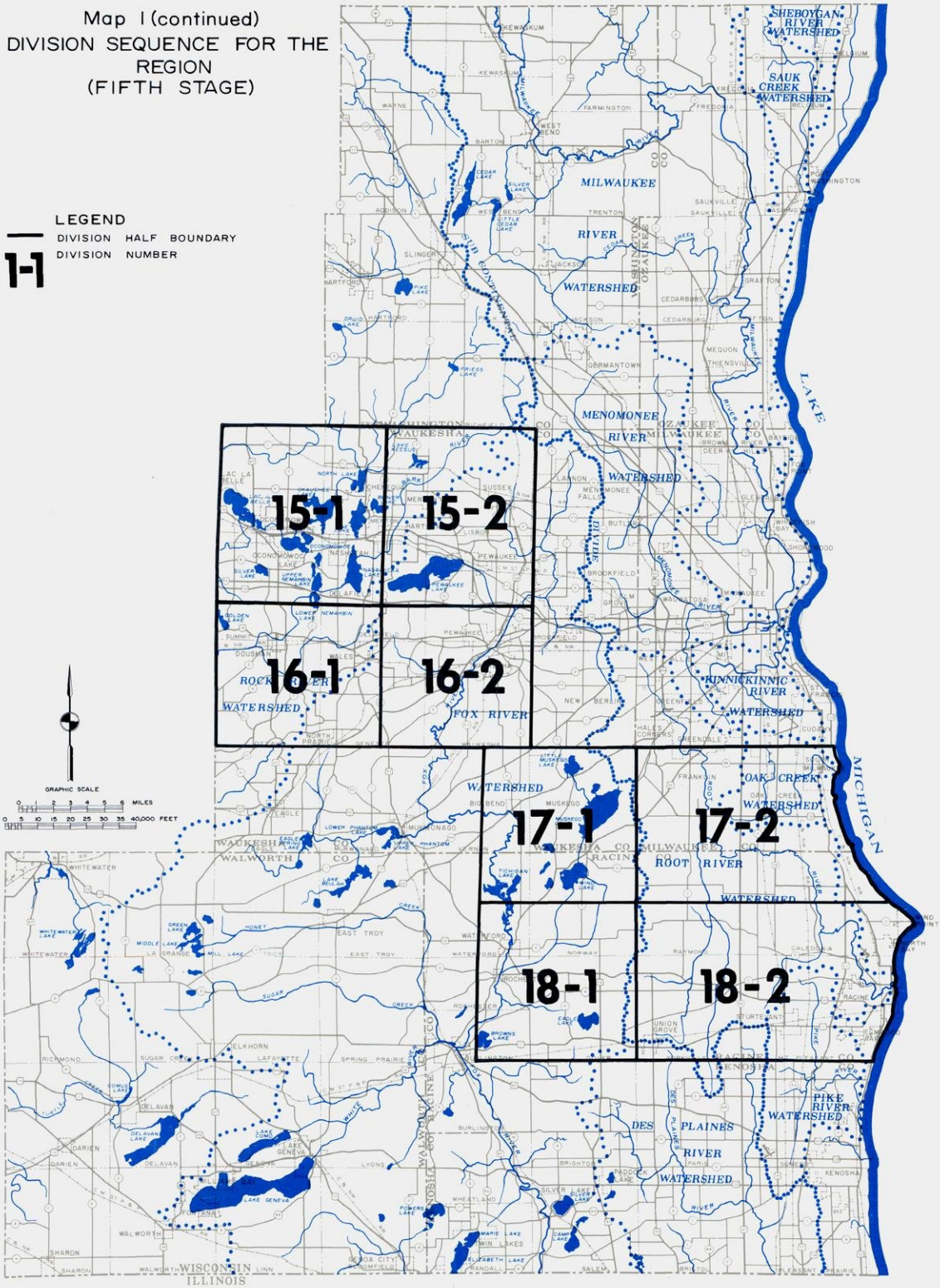
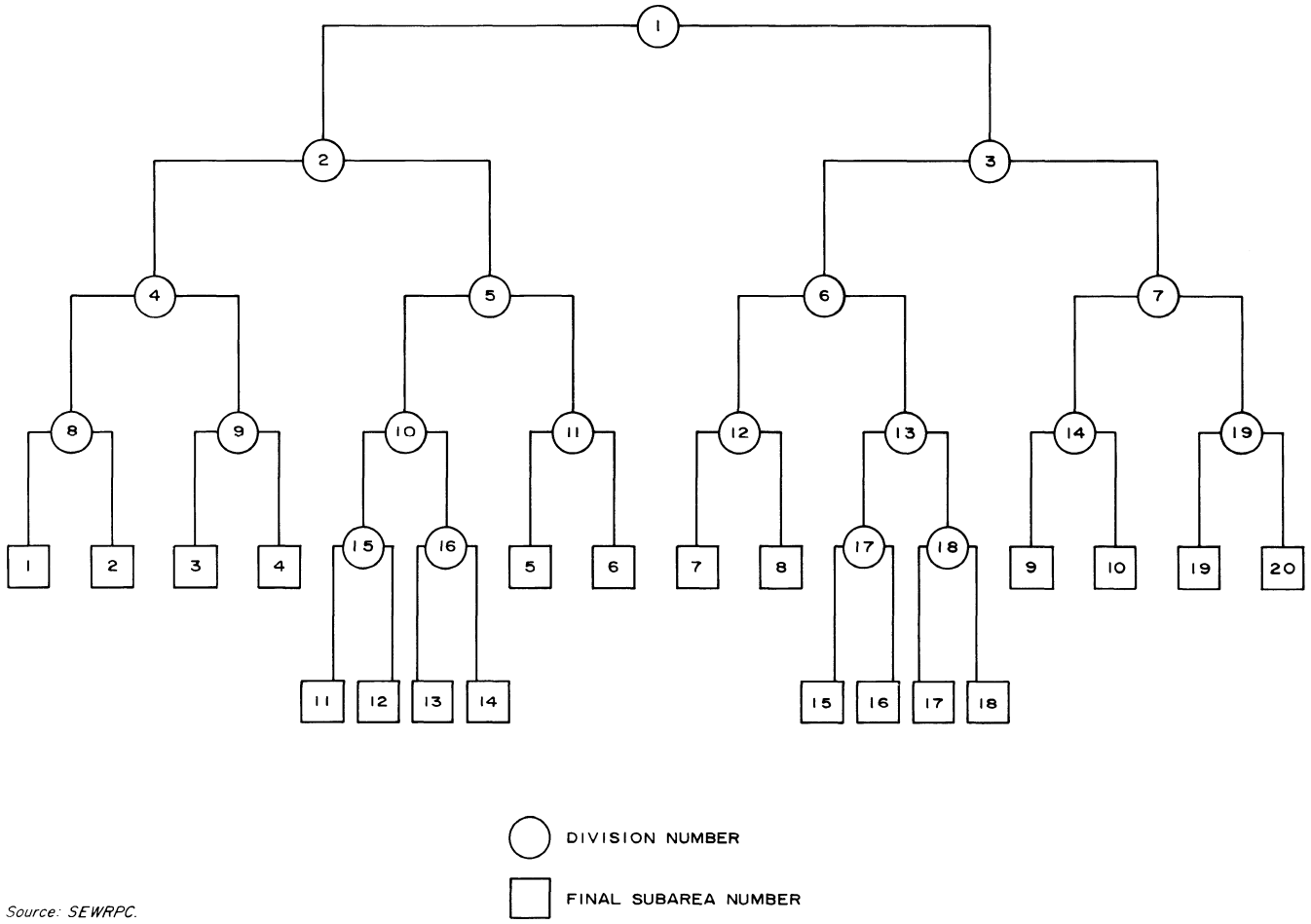


Figure 5
DIVISION SEQUENCE OF THE LAND USE PLAN DESIGN MODEL
REGIONAL APPLICATION



Source: SEWRPC.

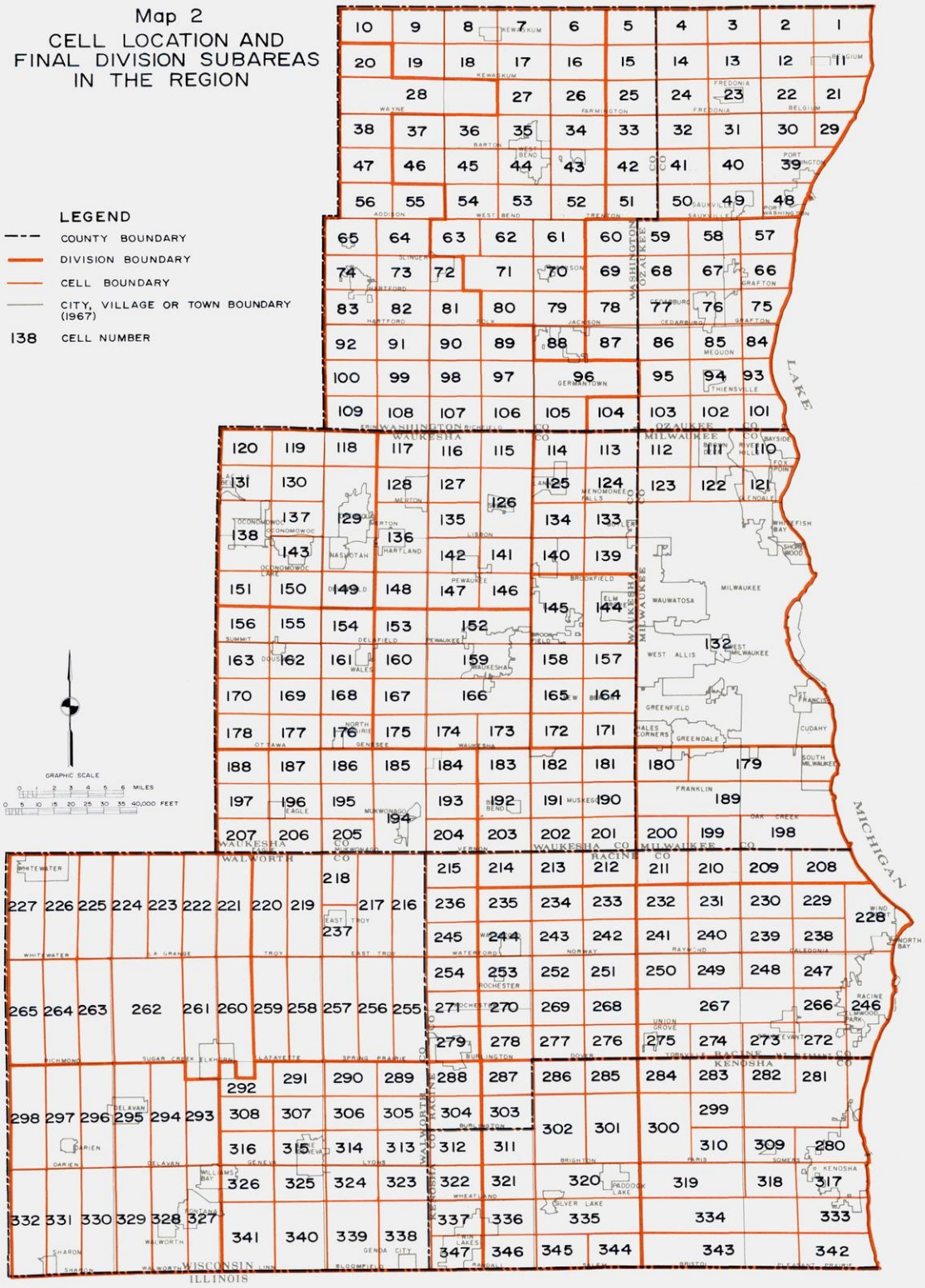
comparison the adopted regional land use plan, prepared by more conventional methods, calls for new development to be located contiguous with the major existing urban areas. While these two planning techniques may thus seem to be contradictory, a closer examination of each shows their conceptual similarity.

The design model in its entirety and the conventional planning method in part were based on the concept of minimization of costs within the constraints of the design standards. The design model is structured to function as an optimization model based on this concept. Conventional planning methods take into consideration an additional factor, however, that of the probability of implementation. This is included so that massive systems of public works are not constructed to serve a proposed land use pattern that is not likely to be implemented.

In the preparation of the regional land use plan by conventional techniques,[1] three alternative land use plans were developed for consideration: a Controlled Existing Trend Plan, the plan finally selected for adoption; a Corridor Plan; and a Satellite City Plan similar in concept to the design plan resulting from the model application. In the consideration of the three plans, the Satellite City Plan was ranked slightly above the Controlled Existing Trend Plan in terms of meeting the design and cost criteria, as indicated in Table 14. The Controlled Existing Trend Plan was adopted, however, on the basis of the relative plan

[1] See *SEWRPC Planning Report No. 7, Volume 1, Inventory Findings--1963; Volume 2, Forecasts and Alternative Plans--1990; and Volume 3, Recommended Regional Land Use and Transportation Plans--1990.*

Map 2
CELL LOCATION AND FINAL DIVISION SUBAREAS IN THE REGION



The subareas resulting from the division sequence are made up of cells which are similar with respect to elements of the natural resource base. Where possible, division subarea boundaries have been designated to coincide with natural or man-made barriers to development.

Source: SEWRPC.

Table 14[a]

REGIONAL LAND USE PLAN SELECTION CRITERIA

Major Group Objective Plan	Provide For A Balanced Allocation Of Land[b] Rank Order Of Group Objective = 3 Rank Order Value Of Plan[c]	Provide For An Appropriate Spatial Distribution Of Land Uses[b] Rank Order Of Group Objective = 2 Rank Order Value Of Plan[c]	Meet The Design Requirements Of the Major Land Uses[b] Rank Order Of Group Objective = 1 Rank Order Value Of Plan[c]	Plan Value	Probability Of Implementation	Final Plan Value
Controlled Existing Trend	2	3	1	13	0.6	7.8
Corridor	1	2	2	9	0.3	2.7
Satellite City	3	1	3	14	0.1	1.4

[a] *This table was derived from Table 122 in SEWRPC Planning Report No. 7, Volume 2, Forecasts and Alternative Plans--1990.*

[b] *Includes the objectives listed under this group in Appendix Table A-31, SEWRPC Planning Report No. 7, Volume 2, Forecasts and Alternative Plans--1990.*

[c] *Based on the rank order value as shown in Appendix Table A-29, SEWRPC Planning Report No. 7, Volume 2, Forecasts and Alternative Plans--1990.*

Source: SEWRPC.

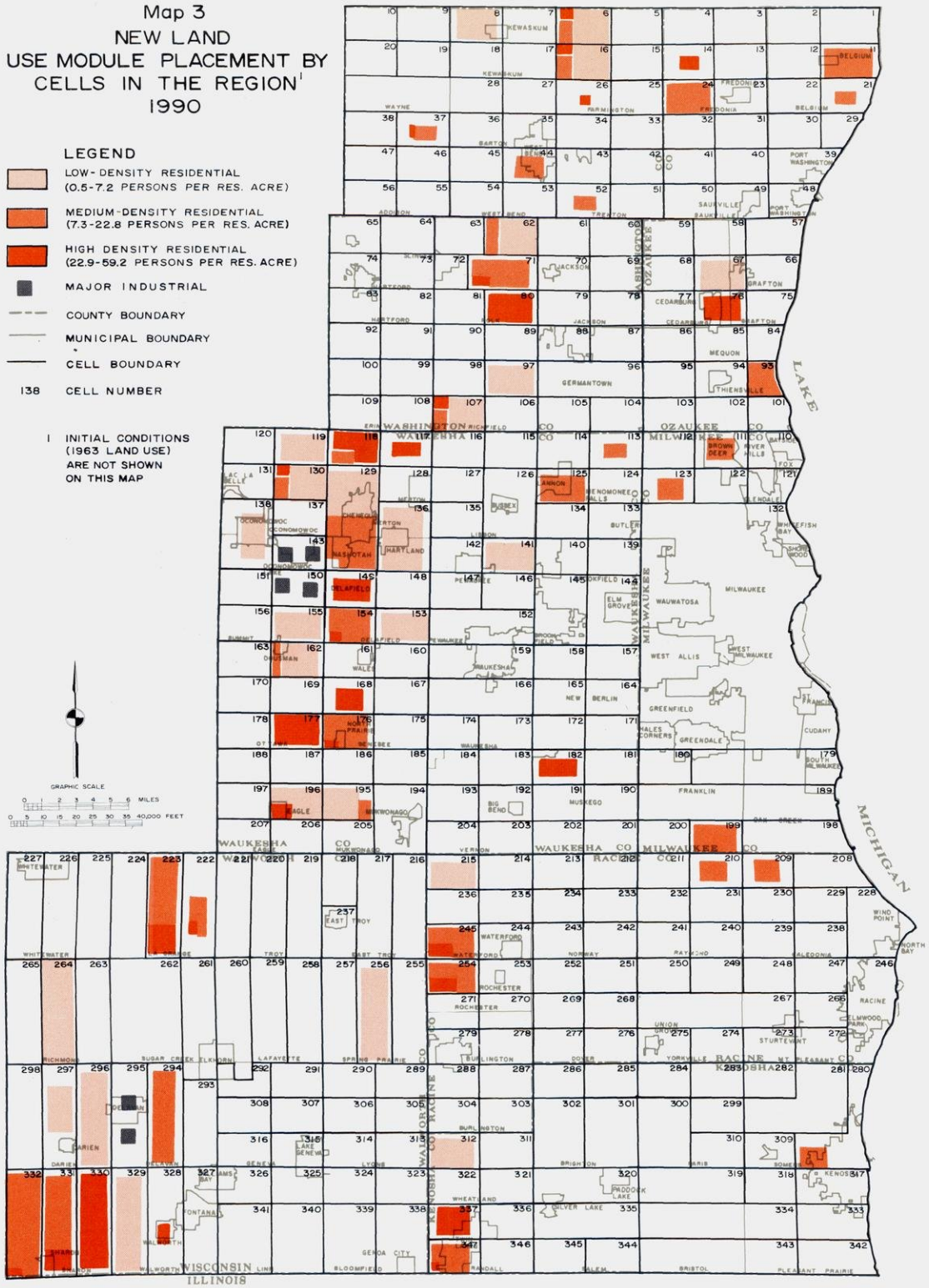
values after the probability of implementation had been included in the considerations. Thus, the application of the land use plan design model to the Southeastern Wisconsin Region resulted in findings conceptually consistent with those of the regional land use planning effort. The difference in the final plans stems from the difference in purpose of the two approaches. The conventional approach results in a plan which is feasible for implementation, whereas the design model approach results in a near-optimal plan.

MODEL EVALUATION

The work program for Phase II of the demonstration project called for the test and evaluation of the sensitivity of the model to imputed objectives, design standards, and cost functions. This was, in fact, carried out in the application of the model to the Southeastern Wisconsin Region. The model was run twice for the Region, the second run using more extensive constraints. The results of these two runs illustrate the sensitivity of the model and some of the problems encountered in the application of the model.

The model minimizes site development costs by relating these to soils. Because of this it is highly sensitive to soil condition interpretations and the resulting site development costs. Application of the design model to the Region revealed a problem relating to this fact. While the model is sensitive to comparative costs of locating a given module on various types of soil, it is not sensitive to comparative costs of putting various modules on a given type of soil. Once a module has been located on a given soil on the basis of least site development costs for that module, it is fixed and cannot be replaced by another module, even if the result would be decreased overall costs. With the present algorithm, it is thus advisable to regulate the entry of modules into the model run so that modules with high site development costs are located first. If the random algorithm is implemented, however, this problem will be eliminated entirely.

Map 3
NEW LAND
USE MODULE PLACEMENT BY
CELLS IN THE REGION[1]
1990

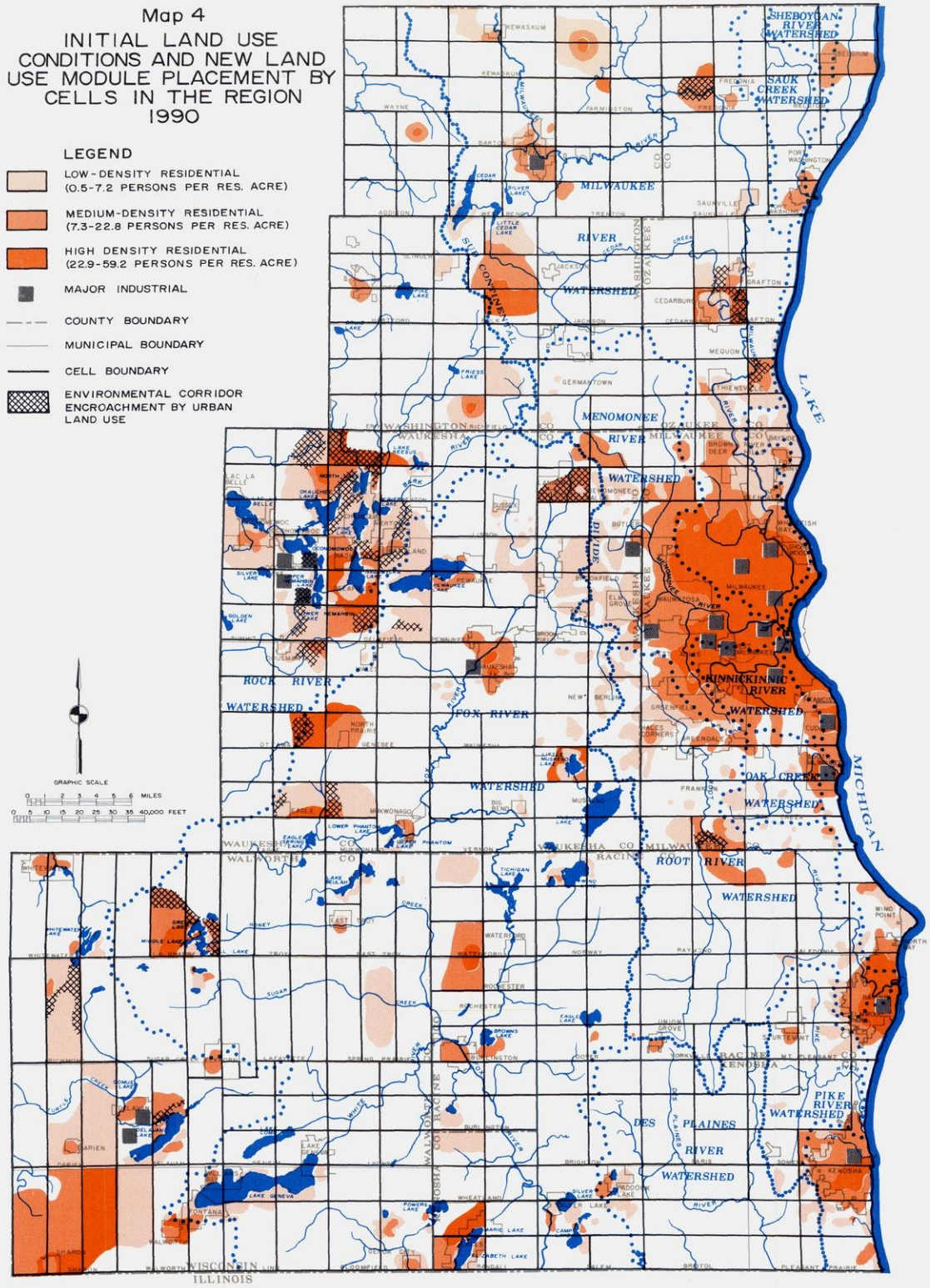


Application of the land use plan design model to the Southeastern Wisconsin Region resulted in the assignment of 2,278 new land use modules to areal cells, as shown on this map in generalized form. The primary factors determining placement of new land use modules in the plan design model are soil suitability, land and site development costs, and the location of existing land use (1963 initial conditions). No new land use modules were placed in areas which were fully developed in 1963. In order to minimize costs, the model assigned the new land use modules to those areas of the Region covered by soils well suited to urban development and having relatively low land costs.

Source: SEWRPC.

Map 4

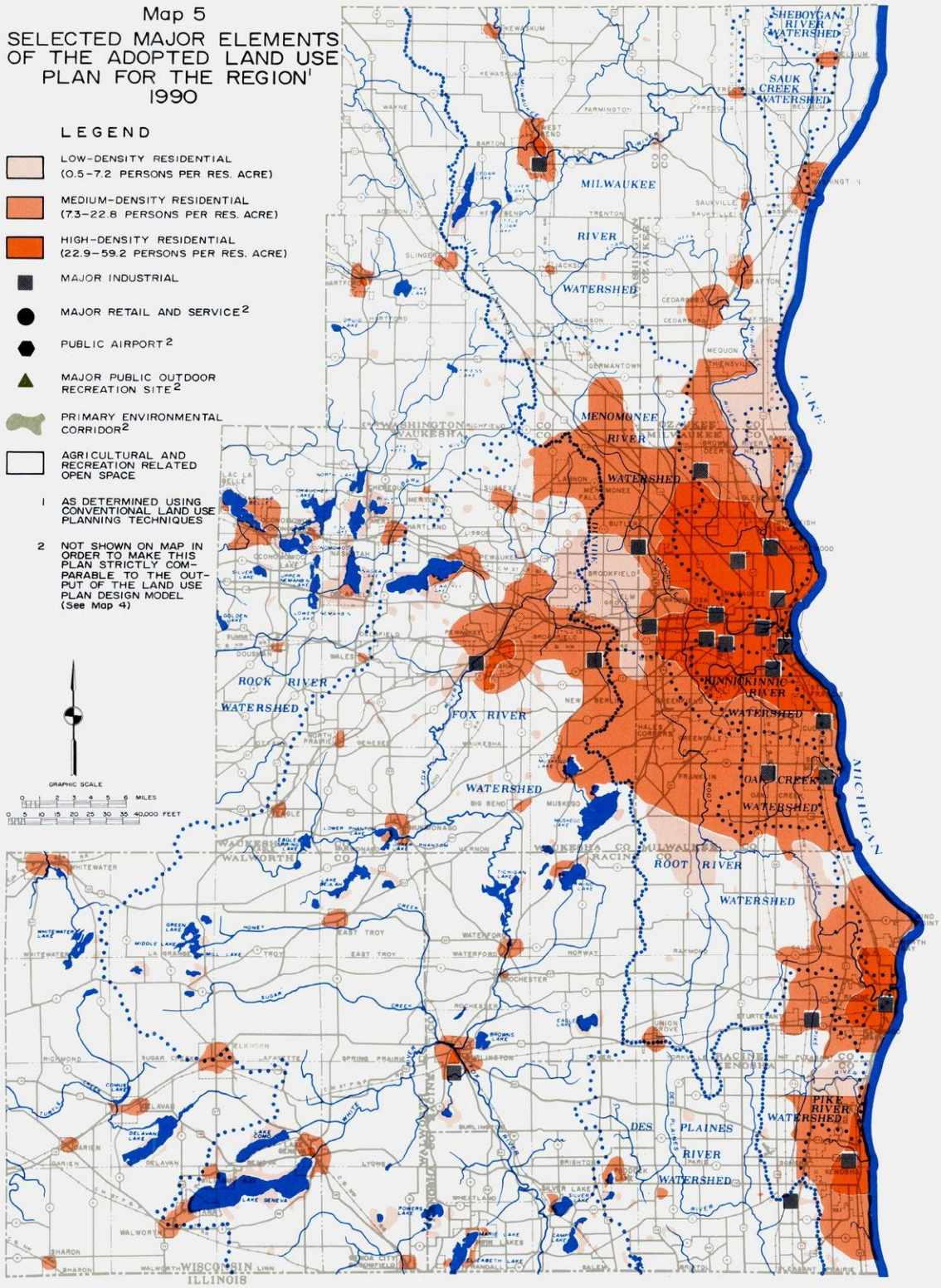
INITIAL LAND USE CONDITIONS AND NEW LAND USE MODULE PLACEMENT BY CELLS IN THE REGION 1990



This map graphically summarizes the regional land use plan produced by application of the land use plan design model. It is important to note that the model, as applied in this situation, did not have imposed upon it several significant constraints that were imposed in the preparation of the regional land use plan through conventional planning techniques. The most important of these constraints were: 1) the preservation and protection from urban development of the primary environmental corridor lands in the Region, including the significant ground water recharge area traversing the western boundary of the Region, and 2) the placement of new urban development in gravity drainage areas tributary to existing public sanitary sewage treatment facilities. The fact that these constraints were not imposed on the land use plan design model explains some of the more important differences between the land use plan as prepared by the model and the plan as prepared by conventional techniques.

Source: SEWRPC.

Map 5
SELECTED MAJOR ELEMENTS OF THE ADOPTED LAND USE PLAN FOR THE REGION[1] 1990



This map graphically summarizes the regional land use plan developed by application of conventional land use planning techniques. Those land uses, including major retail and service areas, major industrial areas, public airports, major public outdoor recreation sites, and primary environmental corridors, which, in the application of the land use plan design model, would have to be spatially distributed "by hand" after the model run, have been omitted from the map in order to make it more readily comparable to the plan produced by the model as shown on Map 4. The land use plan prepared through conventional planning techniques differs substantially from that prepared through the model technique because of the imposition of significant constraints regarding the protection and preservation of the natural resource base and public sanitary sewer service--constraints that were not built into the model.

Source: SEWRPC.

Another difficulty in applying the model was revealed by the location of the modules in relation to the environmental corridors delineated in the adopted land use plan for the Southeastern Wisconsin Region. These corridors, most of which lie along major river and stream valleys and their associated floodplains, encompass a complex of natural resources which act upon the ecology of the Region and ultimately determine the overall quality of the environment. Because of this it is imperative that all of these primary corridors be preserved and protected. Some of this corridor area, however, is also choice land for development, as evidenced by the fact that in the first run the design model tended to cluster development in the western Kettle Moraine environmental corridors.

The means of preventing undesirable development of this sort was conceived as being through dummy development costs. For areas where it is desirable to prevent development, artificially high site development costs could be entered. This was done in the second run of the model, and the resulting design was improved. Development still tended to occur in cells containing environmental corridor lands. Where the development assigned to the cell did not exceed the available non-environmental corridor lands, actual development within the cell could be adjusted through application of such land subdivision design techniques as clustering so as not to infringe upon the environmental corridor. In several cases, however, the land area requirements of the modules located in cells exceeded the available non-environmental corridor lands; and the modules were necessarily placed partially within the environmental corridor. This problem can be corrected by increasing the dummy costs, but this will also tend to prevent module placement in suitable areas of the cells. Because of this it seems advisable to exclude any lands which are to be preserved from the total area to which the model is being applied. The appropriate area and soils should be subtracted from each of the cells and only the area remaining be considered in the soil inventory and in the average development costs.

The results of the model run also showed that the model tends to cluster modules of the same type. If a sizable parcel of land appropriate for development of a certain module type exists, the model continues to locate modules of that type in the cell until the cell capacity has been reached. While this procedure may be acceptable for some module types, such as residential areas, it is not suitable for service-oriented modules.

A related problem is that service-oriented modules were frequently placed by the model in areas with few or no residential modules. An example of these related problems was the placement of nine commercial areas, seven schools, six medical centers, two branch libraries, a cemetery, a police station, a fire station, a cultural center, and six municipal halls in a single cell, which neither included nor was near any residential modules. This problem illustrates the sensitivity of the model to the design constraints. For meaningful application of the model, extensive constraints are needed, including those limiting the clustering of certain module types and those relating the placement of residential and service modules through detailed definitions of the relationships between residential module size, the population included, and the service requirements.

A final problem encountered in the model application is the treatment of initial conditions. These conditions can be included in the model run. However, once the initial conditions have been entered, they are fixed. There is presently no provision for the transition, for example, of a low-density residential area into a medium-density residential area. The desirability of this sort of transition, however, can be evaluated by comparing runs of the model made with and without the initial conditions entered.

CONCLUSIONS

Evaluation of the application of the land use plan design model to the Southeastern Wisconsin Region resulted in the following conclusions:

1. The land use plan design model produces a solution that is quite reasonable, considering the input data and the design constraints used in the application of the model to the Southeastern Wisconsin Region.

2. The greatest source of difficulty encountered in applying the model involved the use of design constraints in defining spatial relationships between modules. Because the model operation is heavily influenced by soils and related site development costs, the design constraints must be carefully enumerated in order to achieve both a desired and realistic spatial arrangement of the modules. It is this feature, then, that also makes the model a flexible tool in that the design constraints can be altered to reflect different levels of interest so that the model can be applied at both the community and regional levels.

3. A deficiency discovered in the application of the model was the possible error inherent in the model algorithm resulting from the PLACECOMP II procedure of placing modules by a series of binary decisions. The present algorithm considers only those linkage costs resulting from the latest division and not the cost of all linkages required. Thus, the resulting design plan may not be the least cost plan. To correct this a new random placement algorithm has been developed and should be tested if Phase III of the demonstration project is mounted.

In summary, the land use plan design model is workable and practicable. When the new model algorithm is implemented and the model is documented for usage by means of the User's Manual, the model will provide a flexible and useful planning tool capable of application at both the regional and community levels.

Chapter V

PHASE III PROGRAM

The original work outline for the land use plan design model development envisioned a three-phase program. Phases I and II of this program, Model Development and Model Test, have been completed and documented in published reports. The purpose of Phase III of this project is to provide final model refinements and documentation of the model in the form of a user's manual. This manual, unlike Volumes 1 and 2 of SEWRPC Technical Report No. 8, should be written in such language that an urban or regional planner unfamiliar with mathematical or computer terminology will be able to apply the model with the aid of the manual. Such documentation is essential if the basic value of the project effort is to be preserved. An important related task is the refinement of the model through implementation of the new design model algorithm previously discussed. A number of optional tasks which would increase the value of the program could also be carried out. The tasks of Phase III, then, may be considered in two categories: essential or primary tasks and optional or secondary tasks.

PHASE III—DESCRIPTIONS AND COSTS

The descriptions and costs for the tasks which encompass Phase III of the Southeastern Wisconsin Regional Planning Commission land use plan design model development program are set forth below, and a cost summary is presented in Table 15.

1. Computer Program Improvement (Primary Task)
   Description: As a result of experience with the model in Phase II of the project, certain improvements in the data reduction and model computer programs are desirable. These improvements include the new design model algorithm, as well as the adaptation of the model for use on a small computer. Maximum Estimated Cost: $18,000.

2. User's Manual Preparation and Publication (Primary Task)
   Description: The User's Manual will provide complete instructional material in the theory of the design model, the collection and reduction of input data, the model operation, and the interpretation of model results. The Manual is estimated to consist of about 200 pages. Maximum Estimated Cost: $15,000 (500 copies).

3. User's Manual Preparation Technical Support (Primary Task)
   Description: It is recommended that if Phase III is mounted, the actual preparation and printing of the User's Manual be subcontracted. However, provision must be made for internal staff support activities by the Southeastern Wisconsin Regional Planning Commission to prepare materials, provide technical consultation, and review the manual prior to final publication. Maximum Estimated Cost: $10,000.

The following three tasks are considered optional to the completion of the project, although they would add significantly to the overall value of the project. Omission of these tasks would not, however, prevent the successful completion of the project.

1. Training Course Preparation (Secondary Task)[1]
   Description: This training course would supplement the aforementioned User's Manual by providing an audio-visual presentation of the land use plan design model and its application in planning. The User's Manual will be in itself a full explanation of the design system, but the complexity of the system and the need for extensive reference data will make the Manual a volume of substantial

[1] *If this task is applied to the project budget, a more detailed cost estimate should be prepared.*

Table 15

COST SUMMARY FOR PHASE III OF THE LAND USE PLAN DESIGN MODEL DEVELOPMENT PROGRAM

Primary Tasks	
Computer Program Improvements	$ 18,000
User's Manual Preparation	15,000
Technical Support User's Manual Preparation	10,000
Subtotal	*$ 43,000*
Secondary Tasks	
Training Course Preparation	$ 15,000
Visual Model Display Implementation	20,000
Nationwide Work Program Outline	2,000
Subtotal	*$ 37,000*
Total	**$ 80,000**

Source: SEWRPC.

size. To be a useful tool, adequate instruction in the organization and application of the Manual is necessary. To this end, it is proposed that five sound-slide presentations be included in the training package. Each slide program will provide approximately one hour of instruction and training in the SEWRPC land use plan design model operations and procedures. The programs will explain the purpose of the system, describe the functions of its components, and instruct in its application. Estimated Maximum Cost: $15,000.

a. Program 1: The proposed slide-sound training program and the performance objectives and function of Program 1 are described below.

   Performance Objectives—To develop an appreciation of the objectives of the SEWRPC Land Use Plan Design Model and to provide the vocabulary necessary to make Programs 2 through 5 fully effective.

   Function—A lecture format will be used to present an overview of the model and its applications. A brief survey of the Wisconsin PD-1 project will be followed by a demonstration of how the model can be applied. Emphasis will be placed on the practical value of the model in difficult or complex land use planning problems.

b. Programs 2 and 3: The proposed slide-sound training program and the performance objectives and function of Programs 2 and 3 are described below.

   Performance Objectives—To provide the trainee with a controlled experience in model operation and to develop: 1) a full knowledge of the model's problem-solving capabilities and 2) a comprehensive understanding of the resources and application of the User's Manual.

   Function—The trainee will be given a problem requiring use of: 1) data particular to a problem situation and 2) data, systems, and procedures incorporated in the User's Manual. The preparation of the computer input information will be worked through on a trainee-paced, step-by-step basis. Emphasis will be placed on both the need for careful preparation and the necessity of following the correct procedures. The programs will also deal with the preparation of rough data for computer data reduction.

c. Program 4: The proposed slide-sound training program and the performance objective and function of Program 4 are described below.

Performance Objective—To provide the trainee with a controlled experience in computer output analysis.

Function—The trainee will be guided through a full analysis and evaluation of the computer output from the problem developed in Program 3. By means of multiple choice questions and answers, the proposed solution will be examined for implications and alternatives. Again, heavy use of the User's Manual will be programmed into the instruction.

d. Program 5: The proposed slide-sound training program and the performance objectives and function of Program 5 are described below.

Performance Objectives—To provide the trainee with a controlled experience in the preparation of secondary computer input and to review preparation and analysis procedures.

Function—Starting with the information developed in Program 4, the trainee will be guided through the preparation of secondary computer input and the analysis of secondary output. Emphasis will be placed on firming up the trainee's understanding of the procedures and resources of the system. The User's Manual will again be used extensively.

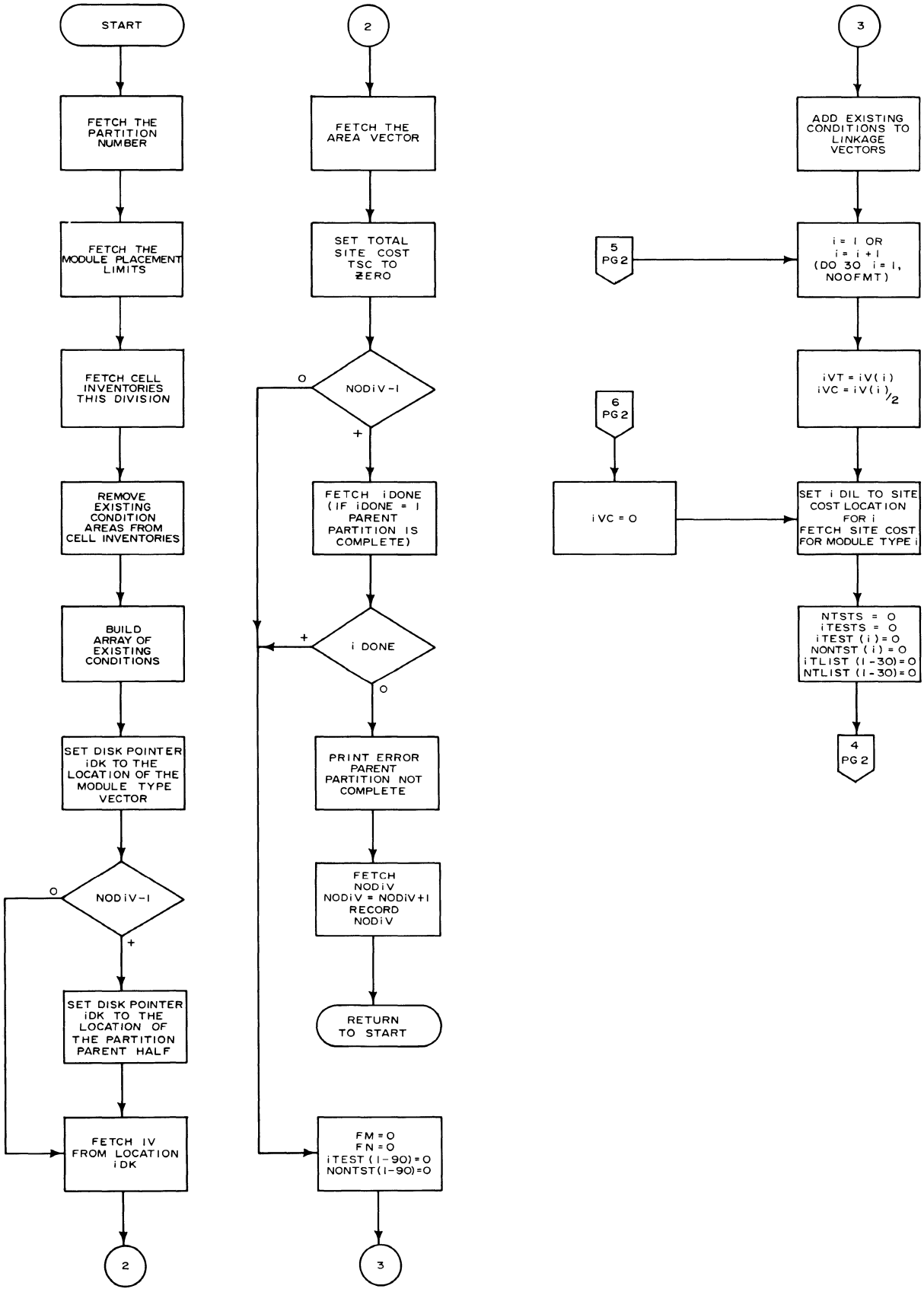
2. Visual Model Display Implementation (Secondary Task)
Description: A series of programs would be developed to visually display the operation of the land use plan design model on a cathode ray tube (CRT) display. These programs would permit the planner to visualize the plan developed by the model as it is formed and to interact with the model to modify the plan in an integrated man-machine design system. Estimated Cost: $20,000.

3. Nationwide Work Program Outline (Secondary Task)
Description: After the completion of Phase III, it would be desirable for the U. S. Department of Housing and Urban Development to initiate a national program to implement the Land Use Plan Design Model in urban planning. An outline to guide such a future program would be prepared and published. Estimated Cost: $2,000.

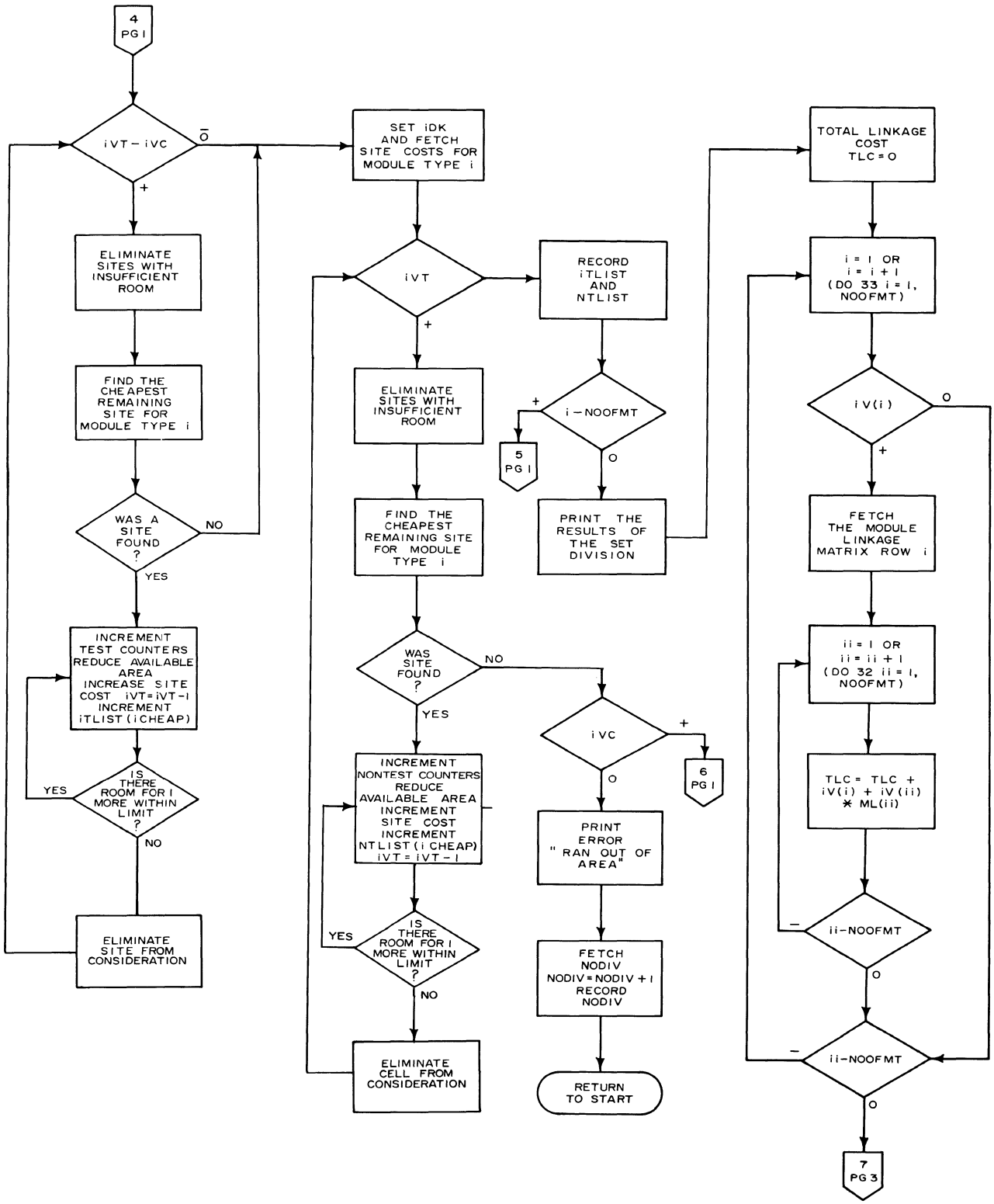
APPENDICES

Appendix A

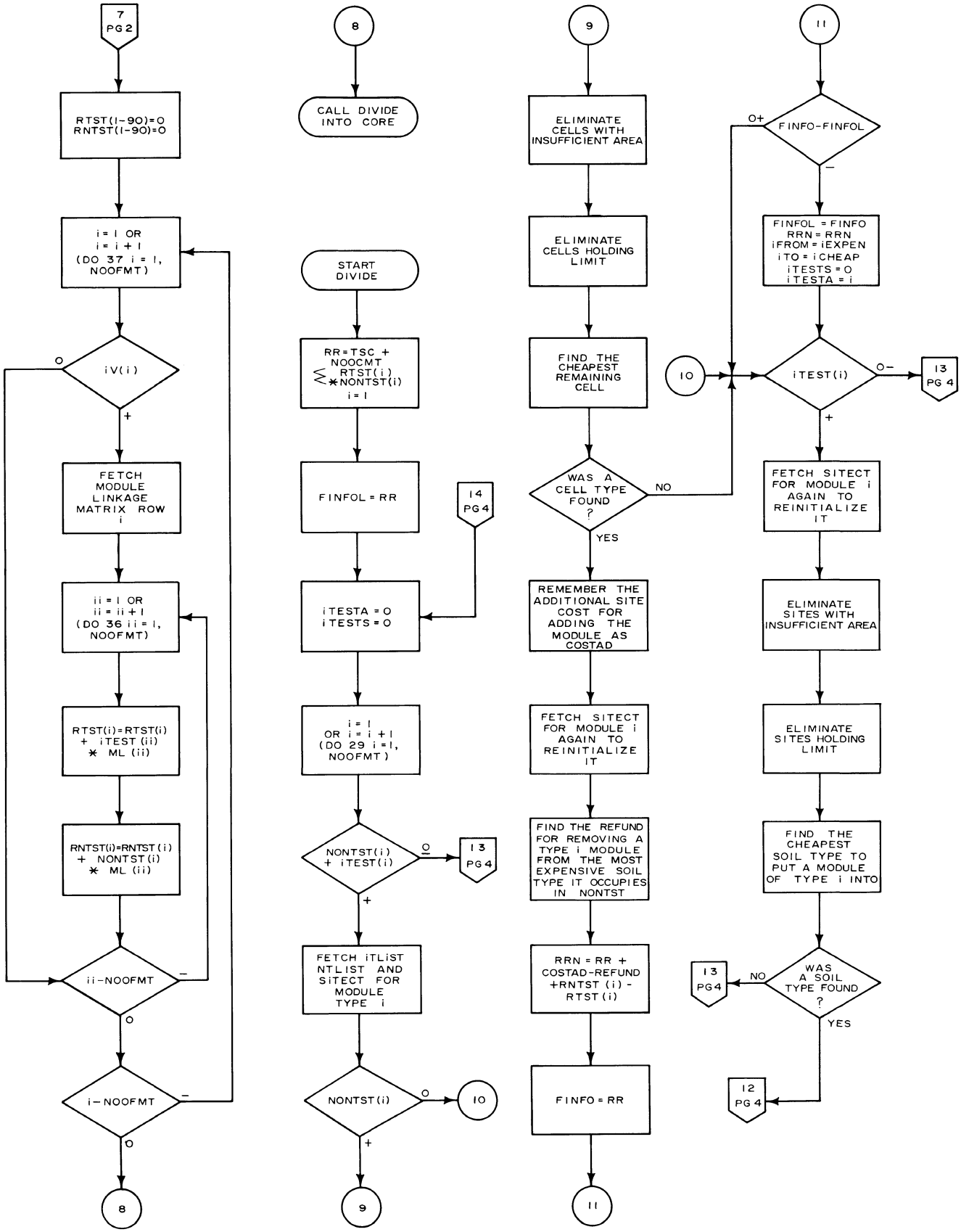
LAND USE PLAN DESIGN MODEL PROGRAM DETAILED FLOW CHART



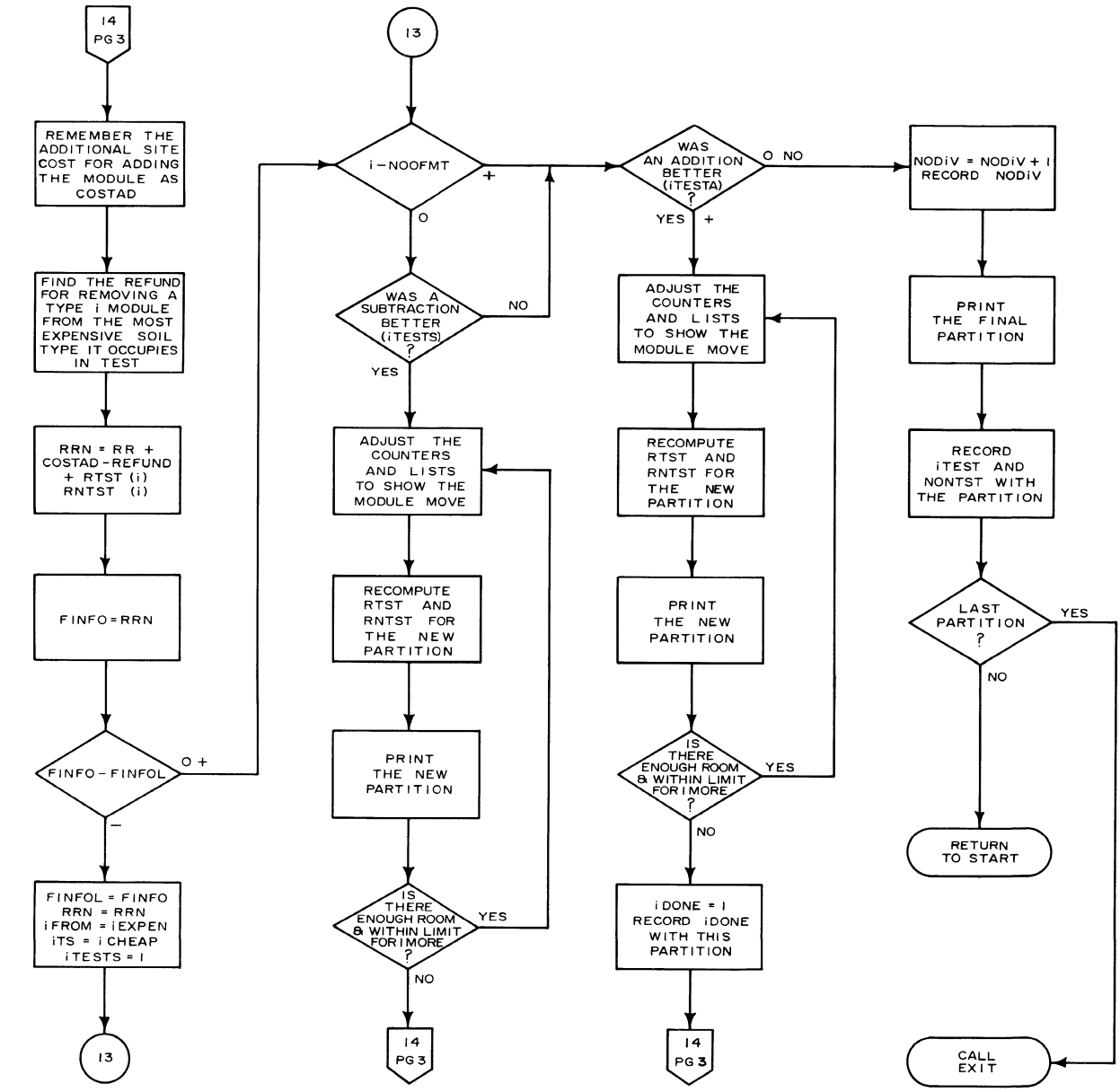
LAND USE PLAN DESIGN MODEL PROGRAM DETAILED FLOW CHART



LAND USE PLAN DESIGN MODEL PROGRAM DETAILED FLOW CHART



LAND USE PLAN DESIGN MODEL PROGRAM DETAILED FLOW CHART



Source: SEWRPC.

Appendix B

MODULE INPUTS FOR MODEL APPLICATION TO THE SOUTHEASTERN WISCONSIN REGION

Module Type Code	Module Description	Number of This Type of Module Required
1	Residential (low-density)	35
2	Residential (medium-density)	123
3	Residential (high-density)	262
4	Neighborhood Commercial Center (low-density)	--
5	Neighborhood Commercial Center (medium-density)	84
6	Neighborhood Commercial Center (high-density)	260
7	Community Commercial Center	37
8	Regional Commercial Center	15
9	Highway Commercial Center (partial auxiliary)	201
10	Highway Commercial Center (freeway and expressway auxiliary)	49
11	Highway Commercial Center (recreational auxiliary	201
12	Planned Industrial District (light)	20
13	Planned Industrial District (heavy)	20
14	Junior High School (public)	95
15	Junior High School (private)	61
16	Senior High School (public)	54
17	Senior High School (private)	26
18	Medical Center (short-term)	--
19	Medical Center (long-term)	22
20	Medical Center (nursing and related)	308

Module Type Code	Module Description	Number of This Type of Module Required
21	Public College	3
22	Library (regional)	--
23	Library (community)	5
24	Library (branch)	34
25	Church	--
26	Cemetery	130
27	Police Station	12
28	Fire Station	31
29	Recreational Center (community)	4
30	Recreational Center (regional)	5
31	Community Cultural Center	30
32	Regional Cultural Center (intensive)	9
33	Regional Cultural Center (extensive)	9
34	Incinerator and Sanitary Land Fill	11
35	Municipal Hall (community)	159
36	Municipal Hall (regional)	6
37	Airport (general-aviation)	--
38	Airport (commercial)	--

Source: SEWRPC

Appendix C
SAMPLE PLAN DESIGN MODULES
(MODULE DEFINITIONS)

A. MODULE TYPE: RESIDENTIAL (low-density)

DEFINITION: The module consists of a total area of 2,521.6 acres allocated to the primary and accessory land uses and facilities listed below.

1. Area: The allocation of land to the functional subcomponents of the module is:

Component	Acres
Gross area	2,521.6[1]
Building area	114.1[2]
Parking, service, access, internal vehicular, and pedestrian circulation areas	11.4[3]
Open space, side, rear, and front yards	1,922.5[4]
Arterial street right-of-way	31.7
Collector street right-of-way	19.4
Local street right-of-way	371.3
Neighborhood park and parkway	38.4
Elementary school	12.8

2. Land Use Characteristics: The primary land use of the module is single-family dwelling units and may include the following representative land use types: single-family homes on various lot sizes combined in such proportions as to average 1.2 dwelling units per net residential acre on lots averaging 185 by 200 feet, an elementary school, a neighborhood park, and facilities needed for day-to-day family life.

PURPOSE: To provide, in a cellular unit, the area necessary to house the population served by one elementary school and neighborhood park, served by an internal street system which discourages penetration of the unit by through traffic, and served by all the community facilities necessary to meet day-to-day living requirements of the family within the immediate vicinity of its dwelling unit.

DESIGN STANDARDS: The following design standards are intended to insure proper site development within the module, to provide requisite functional linkages with other modules, and to maintain a proper balance between the demands of the module and the supporting natural resource base.

[1] *This module was adapted from a 2,560-acre residential planning unit used by SEWRPC and includes all elements of the unit except the necessary neighborhood commercial area and the necessary other public and quasi-public use areas, which together total 38.4 acres and which were included in separate module types. See Appendix A, SEWRPC Planning Report No. 7, Volume 2, Forecasts and Alternative Plans--1990.*

[2] *Assuming 2,485 single-family dwelling units with an average building site of 2,000 square feet per dwelling unit.*

[3] *Assuming 200 square feet per dwelling unit.*

[4] *Assuming an average lot size of 185 by 200 feet.*

1. Intra-Module Standards

   a. The module shall include 10,560 lineal feet of arterial street right-of-way or full width equivalent constructed to rural cross section standards.[5]

   b. The module shall include 10,560 lineal feet of collector street right-of-way or full width equivalent constructed to rural cross section standards.[6]

   c. The module shall include 245,000 lineal feet of local street right-of-way or full width equivalent constructed to rural cross section standards.[7]

   d. An area of 114.1 acres shall be suitably graded for building sites.

   e. An area of 11.4 acres shall be suitably graded for off-street parking area.

   f. An area of 12.6 acres shall be suitably graded for playgrounds and playfields.

   g. An area of 110.6 acres of building foundation suitable for the appropriate structure types required shall be provided.

   h. There shall be 2,485 on-site sewage disposal units provided.

   i. Public sanitary sewage collection facilities shall be provided for the elementary school in accordance with established standards.

   j. Public water supply facilities shall be provided for the module in accordance with established standards.

   k. Gas transmission and service facilities shall be provided for the module in accordance with established standards.

   l. Electrical power transmission and service facilities shall be provided for the module in accordance with established standards.

   m. Telephone transmission and service facilities shall be provided for the module in accordance with established standards.

   n. Surface storm drainage facilities shall be provided for suitable surface drainage of 2,522 acres of land along 266,720 lineal feet of street full width equivalent.

2. Inter-Module Standards

   a. Allocation Standards

      1. One module shall be allocated in the design for each 8,200 persons residing in Residential (low-density) modules.

   b. Spatial Accessibility and Compatibility Standards

      1. The module shall be located no more than 2 miles from an arterial street linkage.

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[5] *For detailed standards, see SEWRPC Planning Guide No. 1, Land Development Guide, November 1963.*

[6] *Ibid.*

[7] *Ibid.*

2. The location of the module relative to others shall be constrained only by the optimization of combined linkage costs, site development costs, accessibility costs, and compatibility costs.

c. Resource Conservation Standards

1. The location of the module shall be constrained only by the optimization of combined site development costs, linkage costs, accessibility costs, and compatibility costs.

d. Linkage Requirements Standards

1. The module shall be connected by a rural arterial street linkage.

2. The module shall be connected by a public water supply transmission.

3. The module shall be connected by a public sewage collection line linkage.

4. The module shall be connected by a gas transmission line linkage.

5. The module shall be connected by a telephone transmission line linkage.

6. The module shall be connected by an electrical power transmission line linkage.

B. MODULE TYPE: RESIDENTIAL (medium-density)

DEFINITION: The module consists of a total area of 627.2 acres allocated to the primary and accessory land uses and facilities listed below.

1. Area: The allocation of land to the functional subcomponents of the module is:

Component	Acres
Gross area	627.2 [8]
Building area	61.7 [9]
Parking, service, access, internal vehicular, and pedestrian circulation areas	9.1 [10]
Open space, side, rear, and front yards	383.6 [11]
Arterial street right-of-way	7.9
Collector street right-of-way	9.7
Local street right-of-way	129.6

[8] *This module was adapted from a 640-acre residential planning unit used by the SEWRPC and includes all elements of the unit except the necessary neighborhood commercial area and the necessary other public and quasi-public use areas, which together total 12.8 acres and which were included in separate module types. See Table A-1 and A-2, SEWRPC Planning Report No. 7, Volume 2, Forecasts and Alternative Plans--1990. June 1966.*

[9] *Assuming 355 multi-family dwelling units with an average building size of 750 square feet per dwelling unit and 1,615 single-family units with an average building size of 1,500 square feet per dwelling unit.*

[10] *Assuming 200 square feet per dwelling unit.*

[11] *Assuming an average lot size of 85 by 125 feet.*

Neighborhood park and parkway 16.0

Elementary school 9.6

2. Land Use Characteristics: The primary land use of the module is single- and multi-family dwelling units and may include the following representative land use types: single-family and multi-family homes in such proportions as to average 4.3 dwelling units per net residential acre on lots averaging 85 x 125 feet, an elementary school, a neighborhood park, and facilities needed for day-to-day family life.

PURPOSE: To provide in a cellular unit the area necessary to house the population served by one elementary school and neighborhood park, served by an internal street system which discourages penetration of the unit by through traffic, and served by all the community facilities necessary to meet day-to-day living requirements of the family within the immediate vicinity of its dwelling unit.[12]

DESIGN STANDARDS: The following design standards are intended to insure proper site development within the module, to provide requisite functional linkages with other modules, and to maintain a proper balance between the demands of the module and the supporting natural resource base.

1. Intra-Module Standards

a. The module shall include 2,640 lineal feet of arterial street right-of-way or full width equivalent constructed to urban cross section standards.

b. The module shall include 5,280 lineal feet of collector street right-of-way or full width equivalent constructed to urban cross section standards.

c. The module shall include 94,100 lineal feet of local street right-of-way or full width equivalent constructed to urban cross section standards.

d. An area of 61.7 acres shall be suitably graded for building sites.

e. An area of 9.1 acres shall be suitably graded for off-street parking area.

f. An area of 61.7 acres of building foundation suitable for the appropriate structure types required shall be provided.

g. Public sanitary sewage collection facilities shall be provided for the module in accordance with established standards.

h. Public water supply facilities shall be provided for the module in accordance with established standards.

i. Gas transmission and service facilities shall be provided for the module in accordance with established standards.

j. Electrical power transmission and service facilities shall be provided for the module in accordance with established standards.

k. Telephone transmissions and service facilities shall be provided for the module in accordance with established standards.

l. Storm drainage facilities shall be provided for suitable surface drainage of 627 acres of land along 102,020 lineal feet of street full width equivalent.

[12] *SEWRPC Planning Report No. 7, Volume 2, Forecasts and Alternative Plans--1990, June 1966.*

2. Inter-Module Standards

a. Allocation Standards

1. One module shall be allocated in the design for each 6,500 persons residing in the Residential (medium-density) modules.

b. Spatial Accessibility and Compatibility Standards

1. The module shall be located no more than one mile from an arterial street linkage.

2. The location of the module relative to others shall be constrained only by the optimization of combined linkage costs, site development costs, accessibility costs, and compatibility costs.

c. Resource Conservation Standards

1. The module shall not be located on a major natural watershed boundary.

2. The location of the module shall be constrained only by the optimization of combined site development costs, linkage costs, accessibility costs, and compatibility costs.

d. Linkage Requirements Standards

1. The module shall be connected by an urban arterial street linkage.

2. The module shall be connected by a public water supply transmission line linkage.

3. The module shall be connected by a public sewage collection line linkage.

4. The module shall be connected by storm sewer collection line linkage.

5. The module shall be connected by a gas transmission line linkage.

6. The module shall be connected by a telephone transmission line linkage.

7. The module shall be connected by an electric power transmission line linkage.

C. MODULE TYPE: NEIGHBORHOOD COMMERCIAL CENTER (low-density)

DEFINITION: The module consists of a total area of 6.4 acres allocated to the primary and accessory land uses and facilities listed below.

1. Area: The allocation of land to the functional subcomponents of the module is:

Component	Acres
Gross area[13]	6.4[14]
Building area	1.1

[13] *This module corresponds to the 12.8 acres allocated to neighborhood commercial uses in the 2,560-acre residential planning unit used by SEWRPC; therefore, the allocation is two (6.4-acre) modules per Residential (low-density) module in the problem. Since 6.4 acres is considered a viable unit for neighborhood commercial centers, the use of two 6.4-acre modules, rather than one 12.8-acre module, allows greater flexibility in model application.*

[14] *See Appendix A, SEWRPC Planning Report No. 7, Volume 2, Forecasts and Alternative Plans--1990.*

Parking, service, access, internal vehicular, and pedestrian circulation areas . . . . . 2.9[15]

Open space, side, rear, and front yards 0.6

Arterial street right-of-way 0.9

Collector street right-of-way. 0.4

Local street right-of-way 0.5

2. Land Use Characteristics: The primary land use of the module is neighborhood commercial and may include the following representative land use types: bakeries, barbershops, bars, beauty shops, business offices, clinics, clothing stores, cocktail lounges, confectioneries, delicatessens, drug-stores, fish markets, florists, fraternities, fruit stores, gift stores, grocery stores, hardware stores, house occupations, hobby shops, lodges, meat markets, optical stores, packaged beverage stores, professional offices, restaurants, self-service and pickup laundry and dry cleaning establishments, soda fountains, sporting goods stores, supermarkets, tobacco stores, and vegetable stores.[16]

PURPOSE: To provide the area necessary to house convenience goods and service establishments needed for day-to-day living requirements of the family within the immediate vicinity of its dwelling unit.

DESIGN STANDARDS: The following design standards are intended to insure proper site development within the module, to provide requisite functional linkages with other modules, and to maintain a proper balance between the demands of the module and the supporting natural resource base.

1. Intra-Module Standards

   a. The module shall include 340 lineal feet of arterial street right-of-way or full width equivalent constructed to urban cross section standards.[17]

   b. The module shall include 150 lineal feet of collector street right-of-way or full width equivalent constructed to urban cross section standards.[18]

   c. The module shall include 340 lineal feet of local street right-of-way or full width equivalent constructed to urban cross section standards.[19]

   d. An area of 1.1 acres shall be suitably graded for building sites.

   e. An area of 2.9 acres shall be suitably graded for off-street parking area.

   f. An area of 1.1 acres of building foundation suitable for the appropriate structure types required shall be provided.

   g. Public sanitary sewage collection facilities shall be provided for the module in accordance with established standards.

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[15] *Assuming 300 square feet per 100 square feet of building area.*

[16] *These uses are listed as principal uses in the B-1 Neighborhood Business District in the Model Zoning Ordinance contained in SEWRPC Planning Guide No. 3, Zoning Guide, April 1964.*

[17] *For detailed standards, see SEWRPC Planning Guide No. 1, Land Development Guide, November 1963.*

[18] *Ibid.*

[19] *For detailed standards, see SEWRPC Planning Guide No. 1, Land Development Guide, November 1963.*

h. Public water supply facilities shall be provided for the module in accordance with established standards.

i. Gas transmission and service facilities shall be provided for the module in accordance with established standards.

j. Electrical power transmission and service facilities shall be provided for the module in accordance with established standards.

k. Telephone transmission and service facilities shall be provided for the module in accordance with established standards.

l. Surface storm drainage facilities shall be provided for suitable surface drainage of 6.4 acres of land along 830 lineal feet of street full width equivalent.

2. Inter-Module Standards

a. Allocation Standards

1. Two modules shall be allocated in the design for each Residential (low-density) module in the design.

b. Spatial Accessibility and Compatibility Standards

1. The module shall be located contiguously to a Residential (low-density) module.

2. The location of the module relative to others shall be constrained only by the optimization of combined linkage costs, site development costs, accessibility costs, and compatibility costs.

c. Resource Conservation Standards

1. The location of the module shall be constrained only by the optimization of combined site development costs, linkage costs, accessibility costs, and compatibility costs.

d. Linkage Requirements Standards

1. The module shall be connected by an urban arterial street linkage.

2. The module shall be connected by a public water supply transmission line linkage.

3. The module shall be connected by a public sewage collection line linkage.

4. The module shall be connected by a gas transmission line linkage.

5. The module shall be connected by a telephone transmission line linkage.

6. The module shall be connected by an electrical power transmission line linkage.

D. MODULE TYPE: COMMUNITY COMMERCIAL CENTER

DEFINITION: The module consists of a total area of 28.2 acres allocated to the primary and accessory land uses and facilities listed below.

1. Area: The allocation of land to the functional subcomponents of the module is:

Component	Acres
Gross area	28.2[20]
Building area	4.6
Parking, service, access, internal vehicular, and pedestrian circulation areas	18.3[21]
Open space, side, rear, and front yards	0.9
Arterial street right-of-way	3.0[22]
Collector street right-of-way	0.0
Local street right-of-way	1.4

2. Land Use Characteristics: The primary land use of the module is community commercial and may include the following representative land use types: All uses permitted in the neighborhood commercial centers and the following: appliance stores, caterers, clothing repair shops, crockery stores, electrical supply, financial institutions, food lockers, furniture stores, furniture upholstery shops, heating supply, hotels, laundry and dry-cleaning establishments employing not over seven persons, liquor stores, music stores, newspaper offices and press rooms, night clubs, office supplies, pawn shops, personal service establishments, pet shops, photographic supplies, plumbing supplies, printing, private clubs, publishing, second-hand stores, signs, trade and contractor's offices, upholsterer's shops, and variety stores.[23]

PURPOSE: To provide the area necessary to house convenience and shopper goods and service establishments which serve a larger tributary area than a Residential module but a smaller tributary area than that required to support a regional commercial module.

DESIGN STANDARDS: The following design standards are intended to insure proper site development within the module, to provide requisite functional linkages with other modules, and to maintain a proper balance between the demands of the module and the supporting natural resource base.

1. Intra-Module Standards

   a. The module shall include 990 lineal feet of arterial street right-of-way or full width equivalent constructed to urban cross section standards.[24]

   b. The module shall include 990 lineal feet of local street right-of-way or full width equivalent constructed to urban cross section standards.[25]

   c. An area of 4.6 acres shall be suitably graded for building sites.

   d. An area of 18.3 acres shall be suitably graded for off-street parking area.

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[20] *The Community Builder's Handbook, Community Builder's Council of Urban Land Institute, (Washington, D.C., 1960).*

[21] *Assuming 400 square feet per 100 square feet of building area.*

[22] *Assuming the module has access to two arterial streets.*

[23] *These uses are listed as principal uses in the B-2 Community Business District in the Model Zoning Ordinance contained in SEWRPC Planning Guide No. 3, Zoning Guide, April 1964.*

[24] *For detailed standards, see SEWRPC Planning Guide No. 1, Land Development Guide, November 1963.*

[25] *Ibid.*

e. An area of 4.6 acres of building foundation suitable for the appropriate structure types required shall be provided.

f. Public sanitary sewage collection facilities shall be provided for the module in accordance with established standards.

g. Public water supply facilities shall be provided for the module in accordance with established standards.

h. Gas transmission and service facilities shall be provided for the module in accordance with established standards.

i. Electrical power transmission and service facilities shall be provided for the module in accordance with established standards.

j. Telephone transmission and service facilities shall be provided for the module in accordance with established standards.

k. Storm drainage facilities shall be provided for suitable surface drainage of 28.2 acres of land along 1,980 lineal feet of street full width equivalent.

2. Inter-Module Standards

a. Allocation Standards

1. One module shall be allocated in the design for each 71,500 persons residing in the area for which a plan design is being prepared.

b. Spatial Accessibility and Compatibility Standards

1. The location of the module relative to others shall be constrained only by the optimization of combined linkage costs, site development costs, accessibility costs, and compatibility costs.

c. Resource Conservation Standards

1. The location of the module shall be constrained only by the optimization of combined site development costs, linkage costs, accessibility costs, and compatibility costs.

d. Linkage Requirements Standards

1. The module shall be connected by an urban arterial street linkage.

2. The module shall be connected by a public water supply transmission line linkage.

3. The module shall be connected by a public sewage collection line linkage.

4. The module shall be connected by a storm sewer collection line linkage.

5. The module shall be connected by a gas transmission line linkage.

6. The module shall be connected by a telephone transmission line linkage.

7. The module shall be connected by an electrical power transmission line linkage.

E. MODULE TYPE: SENIOR HIGH SCHOOL (public)

DEFINITION: The module consists of a total area of 45.0 acres allocated to the primary and accessory land uses and facilities listed below.

1. Area: The allocation of land to the functional subcomponents of the module is:

Component	Acres
Gross area	45.0[26]
Building area	3.6
Parking, service, access, internal vehicular, and pedestrian circulation areas	5.1
Open space, side, rear, and front yards	11.0
Arterial street right-of-way	2.1
Collector street right-of-way	1.3
Local street right-of-way	1.9
Playfields	20.0

2. Land Use Characteristics: The primary land use of the module is senior high school and may include the following representative land use types: the school classrooms and administrative building, auxiliary structures, playfield and apparatus.

PURPOSE: To provide the area necessary to house the high school facilities and related community activities, such as sports events and adult education.

DESIGN STANDARDS: The following design standards are intended to insure proper site development within the module, to provide requisite functional linkages with other modules, and to maintain a proper balance between the demands of the module and the supporting natural resource base.

1. Intra-Module Standards

a. The module shall include 700 lineal feet of arterial street right-of-way or full width equivalent constructed to urban cross section standards.[27]

b. The module shall include 700 lineal feet of collector street right-of-way or full width equivalent constructed to urban cross section standards.[28]

c. The module shall include 1,400 lineal feet of local street right-of-way or full width equivalent constructed to urban cross section standards.[29]

d. An area of 3.6 acres shall be suitably graded for building sites.

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26 *Assuming an optimal enrollment of 1,500 pupils and an allocation of 30 acres plus one additional acre per each 100 pupils.*

27 *For detailed standards, see SEWRPC Planning Guide No. 1, Land Development Guide, November 1963.*

28 *Ibid.*

29 *Ibid.*

e. An area of 5.1 acres shall be suitably graded for off-street parking area.

f. An area of 20.0 acres shall be suitably graded for a playfield.

g. An area of 3.6 acres of building foundation suitable for the appropriate structure types required shall be provided.

h. Public sanitary sewage collection facilities shall be provided for the module in accordance with established standards.

i. Public water supply facilities shall be provided for the module in accordance with established standards.

j. Gas transmission and service facilities shall be provided for the module in accordance with established standards.

k. Electrical power transmission and service facilities shall be provided for the module in accordance with established standards.

l. Telephone transmission and service facilities shall be provided for the module in accordance with established standards.

m. Storm drainage facilities shall be provided for suitable surface drainage of 45 acres of land along 2,800 lineal feet of street full width equivalent.

2. Inter-Module Standards

a. Allocation Standards

1. One module shall be allocated in the design for each 63,000 persons residing in the area for which a plan design is being prepared. [30]

b. Spatial Accessibility and Compatibility Standards

1. The location of the module relative to others shall be constrained only by the optimization of combined linkage costs, site development costs, accessibility costs, and compatibility costs.

c. Resource Conservation Standards

1. The location of the module shall be constrained only by the optimization of combined site development costs, linkage costs, accessibility costs, and compatibility costs.

d. Linkage Requirements Standards

1. The module shall be connected by an urban arterial street linkage.

2. The module shall be connected by a public water supply transmission line linkage.

3. The module shall be connected by a public sewage collection line linkage.

4. The module shall be connected by a storm sewer collection line linkage.

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[30] *Assuming 3.96 percent of the total population attends a senior high school and that 60 percent of attendants (or 2.38 percent of total population) are pupils of a public facility.*

5. The module shall be connected by a gas transmission line linkage.

6. The module shall be connected by a telephone transmission line linkage.

7. The module shall be connected by an electrical power transmission line linkage.

F. MODULE TYPE: PLANNED INDUSTRIAL DISTRICT (light)

DEFINITION: The module consists of a total area of 640 acres allocated to the primary and accessory land uses and facilities listed below.

1. Area: The allocation of land to the functional subcomponents of the module is:

Component	Acres
Gross area	640.0 [31]
Building area	157.4 [32]
Parking, service, access, internal vehicular, and pedestrian circulation areas	114.6
Open space, side, rear, and front yards	157.5
Arterial street right-of-way	7.9
Collector street right-of-way	4.8
Rail spur right-of-way	78.1 [33] [34]
Truck docks and apron	18.6 [35]
Internal circulation ways and cul-de-sacs	101.1 [36] [37]

2. Land Use Characteristics: The primary land use of the module is light industrial and may include the following representative land use types: automotive body repairs; automotive upholstery; cleaning, pressing, and dyeing establishments; commercial bakeries; commercial greenhouses; distributors; farm machinery; food locker plants; laboratories; machine shops; manufacture and bottling of nonalcholic beverages; painting; printing; publishing; storage and sale of machinery and equipment; trade and contractors' offices; warehousing; and wholesaling. Manufacture, fabrication, packing, packaging, and assembly of products from furs, glass, leather, metals, paper, plaster, plastics, textiles, and wood. Manufacture, fabrication, processing, packaging, and packing of confections; cosmetics; electrical appliances; electronic devices; food except cabbage, fish and

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31 *See SEWRPC Planning Report No. 7, Volume 2, Forecasts and Alternative Plans--1990.*

32 *See Local Planning Administration, The International City Managers Association, (Chicago 1959).*

33 *Ibid.*

34 *Assuming a railway spur right-of-way of 52 feet.*

35 *Ibid, footnote 25.*

36 *Ibid, footnote 25.*

37 *Assuming the internal circulation ways and cul-de-sacs have a right-of-way width of 50 feet.*

fish products, meat and meat products, and pea vining; instruments; jewelry; pharmaceuticals; tobacco; and toiletries.[38]

PURPOSE: To provide the area necessary to house industrial uses in an exclusive zoning district and with the economies afforded by joint use of facilities and utilities.

DESIGN STANDARDS: The following design standards are intended to insure proper site development within the module, to provide requisite functional linkages with other modules, and to maintain a proper balance between the demands of thc module and the supporting natural resource base.

1. Intra-Module Standards

a. The module shall include 2,640 lineal feet of arterial street right-of-way or full width equivalent constructed to urban cross section standards.[39]

b. The module shall include 7,920 lineal feet of collector street right-of-way or full width equivalent constructed to urban cross section standards.[40]

c. The module shall include 88,100 lineal feet of internal circulation street right-of-way or full width equivalent constructed in accordance with established standards.[41]

d. An area of 157.4 acres shall be suitably graded for building sites.

e. An area of 114.6 acres shall be suitably graded for off-street parking area.

f. An area of 18.6 acres shall be suitably graded for truck docks and apron.

g. An area of 157.4 acres of building foundation suitable for the appropriate structure types required shall be provided.

h. Public sanitary sewage collection facilities shall be provided for the module in accordance with established standards.

i. Public water supply facilities shall be provided for the module in accordance with established standards.

j. Gas transmission and service facilities shall be provided for the module in accordance with established standards.

k. Electrical power transmission and service facilities shall be provided for the module in accordance with established standards.

l. Telephone transmission and service facilities shall be provided for the module in accordance with established standards.

m. Storm drainage facilities shall be provided for suitable surface drainage of 640 acres of land along 113.8 lineal feet of street full width equivalent.

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38 *These uses are listed as principal uses of the M-1 Industrial District in the Model Zoning Ordinance contained in SEWRPC Planning Guide No. 3, Zoning Guide, April 1964. Quarrying and other mineral extraction and related uses are not included in either the Planned Industrial (light) or the Planned Industrial (heavy) modules. It is reasoned that, because of the resource orientation of extractive industries, they shall be conditional uses and subject to the established review procedure at the time of initiation of zoning appeal.*

39 *For detailed standards, see SEWRPC Planning Guide No. 1, Land Development Guide, November 1963.*

40 *Ibid.*

41 *Ibid.*

n. The module shall include 66,400 lineal feet of railway spur right-of-way or full width equivalent constructed in accordance with established standards.

2. Inter-Module Standards

a. Allocation Standards

1. One module shall be allocated in the design for each 9,100 persons employed in the area for which a plan design is being prepared.[42]

b. Spatial Accessibility and Compatibility Standards

1. The location of the module relative to others shall be constrained only by the optimization of combined linkage costs, site development costs, accessibility costs, and compatibility costs.

c. Resource Conservation Standards

1. The location of the module shall be constrained only by the optimization of combined site development costs, linkage costs, accessibility costs, and compatibility costs.

d. Linkage Requirements Standards

1. The module shall be connected by an urban arterial street linkage.

2. The module shall be connected by an urban collector street linkage.

3. The module shall be connected by a public water supply transmission line linkage.

4. The module shall be connected by a public sewage collection line linkage.

5. The module shall be connected by a storm sewer collection line linkage.

6. The module shall be connected by a gas transmission line linkage.

7. The module shall be connected by a telephone transmission line linkage.

8. The module shall be connected by a railroad main line linkage.

9. The module shall be connected by an electrical power transmission line linkage.

G. MODULE TYPE: MUNICIPAL HALL (community)

DEFINITION: The module consists of a total area of 2 acres allocated to the primary and accessory land uses and facilities listed below.

1. Area: The allocation of land to the functional subcomponents of the module is:

Component	Acres
Gross area	2.0 [43]
Building area	0.5 [44]

[42] *Assuming an allocation of 7 acres per 100 employees.*

[43] *Assuming a minimum of 2 acres is required for a viable unit.*

[44] *Assuming a need for 200 square feet of building area per employee.*

Parking, service, access, internal vehicular, and pedestrian circulation areas 0.5

Open space, side, rear, and front yards 0.4

Arterial street right-of-way 0.3

Collector street right-of-way. 0.2

Local street right-of-way 0.1

2. Land Use Characteristics: The primary land use of the module is generally municipal hall and may include the following representative land use types: city or village administrative offices and auxiliary structures.

PURPOSE: To provide the area necessary to house municipal services and administrative offices, and to centralize municipal offices where practical.

DESIGN STANDARDS: The following design standards are intended to insure proper site development within the module, to provide requisite functional linkages with other modules, and to maintain a proper balance between the demands of the module and the supporting natural resource base.

1. Intra-Module Standards

   a. The module shall include 100 lineal feet of arterial street right-of-way or full width equivalent constructed to urban cross section standards.[45]

   b. The module shall include 140 lineal feet of collector street right-of-way or full width equivalent constructed to urban cross section standards.[46]

   c. The module shall include 100 lineal feet of local street right-of-way or full width equivalent constructed to urban cross section standards.[47]

   d. An area of 0.5 acres shall be suitably graded for building sites.

   e. An area of 0.5 acres shall be suitably graded for off-street parking area.

   f. An area of 0.5 acres of building foundation suitable for the appropriate structure types required shall be provided.

   g. Public sanitary sewage collection facilities shall be provided for the module in accordance with established standards.

   h. Public water supply facilities shall be provided for the module in accordance with established standards.

   i. Gas transmission and service facilities shall be provided for the module in accordance with established standards.

   j. Electrical power transmission and service facilities shall be provided for the module in accordance with established standards.

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[45] *For detailed standards, see SEWRPC Planning Guide No. 1, Land Development Guide, November 1963.*

[46] *Ibid.*

[47] *Ibid.*

k. Telephone transmission and service facilities shall be provided for the module in accordance with established standards.

l. Storm drainage facilities shall be provided for suitable surface drainage of 2 acres of land along 340 lineal feet of street full width equivalent.

2. Inter-Module Standards

a. Allocation Standards

1. One module shall be allocated in the design for each 14,000 persons residing in each municipality[48] of the area for which a plan design is being prepared.

b. Spatial Accessibility and Compatibility Standards

1. The location of the module relative to others shall be constrained only by the optimization of combined linkage costs, site development costs, accessibility costs, and compatibility costs.

c. Resource Conservation Standards

1. The location of the module shall be constrained only by the optimization of combined site development costs, linkage costs, accessibility costs, and compatibility costs.

d. Linkage Requirements Standards

1. The module shall be connected by an urban arterial street linkage.

2. The module shall be connected by a public water supply transmission line linkage.

3. The module shall be connected by a public sewage collection line linkage.

4. The module shall be connected by a storm sewer collection line linkage.

5. The module shall be connected by a gas transmission line linkage.

6. The module shall be connected by a telephone transmission line linkage.

7. The module shall be connected by an electrical power transmission line linkage.

[48] *Assuming a need to house 7 municipal employees per 1,000 population.*

APPENDIX D

DATA REDUCTION LINKAGE REQUIREMENTS

CARD CODE 08

MODULE NO.	** 01	** 02	** 03	** 04	LINKAGES REQUIRED BY THIS MODULE 05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	** 26	** 27	** 28	** 29	** 30
1	01	00	00	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00
2	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
3	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
4	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
5	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
6	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
7	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
8	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	01	00	00	00	00	01	00	00
9	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
10	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
11	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
12	01	01	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	01	00	00	00	00	01	00	00
13	01	01	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	01	00	00	00	00	01	00	00
14	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
15	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
16	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
17	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
18	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	01	00	00	00	00	01	00	00
19	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	01	00	00	00	00	01	00	00
20	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	00	01	00	00	01	00	00
21	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
22	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
23	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
24	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
25	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
26	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00
27	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
28	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
29	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
30	01	00	00	00	00	00	00	00	00	00	00	00	00	00	01	00	01	00	00	00	00	00	00	00	00	00	00	00	00	00
31	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00
32	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	01	00	00	00	00	01	00	00
33	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00
34	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00
35	01	00	01	00	00	00	00	00	00	01	00	00	00	00	01	00	00	00	00	00	00	00	00	01	00	00	00	01	00	00

APPENDIX E
DATA REDUCTION SOIL CODE CROSS REFERENCE
CARD CODE UR13

SOIL	TEXTURE	WATER DEPTH	BEDROCK
1	1	3	1
2	1	2	3
3	1	1	1
4	1	1	3
5	1	2	3
5W	1	1	3
7	1	2	3
7W	1	2	3
9	3	1	3
10	1	2	3
10W	1	1	3
11	1	2	3
11W	1	1	3
11WR	1	2	2
11WY	1	1	3
12	2	3	3
14	2	3	3
15	2	1	3
16	1	2	3
16Z	2	3	3
18	1	3	3
18Y	1	3	3
19	1	3	3
20	2	3	3
21	1	2	3
21Y	1	2	3
22	1	2	3
23	1	2	3
24	1	2	3
26	1	2	3
27	1	2	3
27U	1	2	3
27Z	1	2	3
28	1	2	3
28Z	1	1	3
29	1	1	3

APPENDIX F
DATA REDUCTION USER SOIL INVENTORY
CARD CODE UR11

GEOGRAPHIC UNIT	SOIL	SLOPE	AREA
0123293031320000	276	3	00051
0123293031320000	277	3	00066
0123293031320000	297	3	00015
0123293031320000	298	1	00046
0123293031320000	324	1	00001
0123293031320000	332	2	00010
0123293031320000	338	1	00030
0122252627343536	21	2	00190
0122252627343536	24	2	00024
0122252627343536	31	3	00048
0122252627343536	51	2	00032
0122252627343536	53	2	00206
0122252627343536	72	3	00064
0122252627343536	214	1	00016
0122252627343536	297	5	01752
0122252627343536	298	2	00604
0122252627343536	299	2	00048
0122252627343536	326	2	00048
0122252627343536	336	3	00016
0122252627343536	340	1	00072
0122252627343536	346	1	00016
0122252627343536	450	1	00008
0122252627343536	72Y	1	00032
0122252627343536	3251	2	00136
0122252627343536	3361	2	00228
0122252627343536	346Z	1	00024
0122282930313233	80	1	00032
0122282930313233	172	5	00016
0122282930313233	203	2	00008
0122282930313233	213	1	00072
0122282930313233	217	1	00314
0122282930313233	233	2	00008
0122282930313233	266	5	00152
0122282930313233	267	4	00024
0122282930313233	297	7	01264
0122282930313233	298	1	00320

Appendix G
DEVELOPMENT COSTS

Due to its large bulk all of the development cost data prepared under Phase I of the project could not be included in this report. It may be obtained at cost by writing to:

Administrative Officer
Southeastern Wisconsin Regional
Planning Commission
P. O. Box 769
916 N. East Avenue
Waukesha, Wisconsin 53186

The complete development cost data includes unit development cost for each site development or linkage development for each of the 224 soil categories in the model test area described in this report. The 141 cost development tables are listed below. Examples of eight of these tables have been included in this appendix for illustrative purposes.

LIST OF SUMMARY TABLES

1. Airport Runways, Asphalt
2. Airport Runways, Concrete
3. Electric Power Production Plant
4. Electric Power Transmission Lines
5. Foundations, Commercial Buildings
6. Foundations, Industrial Buildings
7. Foundations, Residences (See Following Example)
8. Laterals, Storm and Sanitary Sewers and Water Lines, Earth Backfill
9. Laterals, Storm and Sanitary Sewers, Earth Backfill
10. Laterals, Storm Sewers and Water Lines, Earth Backfill
11. Laterals, Sanitary Sewers and Water Lines, Earth Backfill
12. Laterals, Storm Sewers, Earth Backfill
13. Laterals, Sanitary Sewers, Earth Backfill
14. Laterals, Water Lines, Earth Backfill
15. Laterals, Storm and Sanitary Sewers and Water Lines, Gravel Backfill
16. Laterals, Storm and Sanitary Sewers, Gravel Backfill
17. Laterals, Storm Sewers and Water Lines, Gravel Backfill
18. Laterals, Sanitary Sewers and Water Lines, Gravel Backfill
19. Laterals, Storm Sewers, Gravel Backfill
20. Laterals, Sanitary Sewers, Gravel Backfill (See Following Example)
21. Laterals, Water Lines, Gravel Backfill
22. Parking Area, Automobiles
23. Parking Area, Trucks
24. Play Area, Paved
25. Railroad, Main Line (See Following Example)
26. Railroad, Spur Line
27. Sewage Disposal Units, On Site Septic Tanks
28. Sewage Sanitary Collection Lines, 8 Inch Diameter Main Only, Earth Backfill
29. Sewage Sanitary Collection Lines, 10 Inch Diameter Main Only, Earth Backfill (See Following Example)
30. Sewage Sanitary Collection Lines, 12 Inch Diameter Main Only, Earth Backfill
31. Sewage Sanitary Collection Lines, 15 Inch Diameter Main Only, Earth Backfill

32. Sewage Sanitary Collection Lines, 18 Inch Diameter Main Only, Earth Backfill
33. Sewage Sanitary Collection Lines, 21 Inch Diameter Main Only, Earth Backfill
34. Sewage Sanitary Collection Lines, 24 Inch Diameter Main Only, Earth Backfill
35. Sewage Sanitary Collection Lines, 8 Inch Diameter Main Only, Gravel Backfill
36. Sewage Sanitary Collection Lines, 10 Inch Diameter Main Only, Gravel Backfill
37. Sewage Sanitary Collection Lines, 12 Inch Diameter Main Only, Gravel Backfill
38. Sewage Sanitary Collection Lines, 15 Inch Diameter Main Only, Gravel Backfill
39. Sewage Sanitary Collection Lines, 18 Inch Diameter Main Only, Gravel Backfill
40. Sewage Sanitary Collection Lines, 21 Inch Diameter Main Only, Gravel Backfill
41. Sewage Sanitary Collection Lines, 24 Inch Diameter Main Only, Gravel Backfill
42. Sewage Sanitary Interceptor Lines, Larger Than 24 Inch Diameter, Gravel Backfill
43. Sewage Treatment Plant
44. Site Grading, Allowable Slope 0 Percent
45. Site Grading, Allowable Slope 1 Percent
46. Site Grading, Allowable Slope 2 Percent
47. Site Grading, Allowable Slope 3 Percent
48. Site Grading, Allowable Slope 4 Percent
49. Site Grading, Allowable Slope 5 Percent
50. Site Grading, Allowable Slope 6 Percent
51. Site Grading, Allowable Slope 7 Percent (See Following Example)
52. Site Grading, Allowable Slope 8 Percent
53. Site Grading, Allowable Slope 9 Percent
54. Site Grading, Allowable Slope 10 Percent
55. Site Grading, Allowable Slope 11 Percent
56. Site Grading, Allowable Slope 12 Percent
57. Site Grading, Allowable Slope 13 Percent
58. Site Grading, Allowable Slope 14 Percent
59. Site Grading, Allowable Slope 15 Percent
60. Site Grading, Allowable Slope 16 Percent
61. Site Grading, Allowable Slope 17 Percent
62. Site Grading, Allowable Slope 18 Percent
63. Site Grading, Allowable Slope 19 Percent
64. Site Grading, Allowable Slope 20 Percent
65. Site Grading, Allowable Slope 21 Percent
66. Site Grading, Allowable Slope 22 Percent
67. Site Grading, Allowable Slope 23 Percent
68. Site Grading, Allowable Slope 24 Percent
69. Site Grading, Allowable Slope 25 Percent
70. Site Grading, Allowable Slope 26 Percent
71. Site Grading, Allowable Slope 27 Percent
72. Site Grading, Allowable Slope 28 Percent
73. Site Grading, Allowable Slope 29 Percent
74. Site Grading, Allowable Slope 30 Percent
75. Site Grading, Allowable Slope 31 Percent
76. Site Grading, Allowable Slope 32 Percent
77. Site Grading, Allowable Slope 33 Percent
78. Site Grading, Allowable Slope 34 Percent
79. Site Grading, Allowable Slope 35 Percent
80. Site Grading, Allowable Slope 36 Percent
81. Site Grading, Allowable Slope 37 Percent
82. Storm Sewer Collection Lines, 8 Inch Diameter Main Only, Earth Backfill
83. Storm Sewer Collection Lines, 10 Inch Diameter Main Only, Earth Backfill
84. Storm Sewer Collection Lines, 12 Inch Diameter Main Only, Earth Backfill
85. Storm Sewer Collection Lines, 15 Inch Diameter Main Only, Earth Backfill
86. Storm Sewer Collection Lines, 18 Inch Diameter Main Only, Earth Backfill

87. Storm Sewer Collection Lines, 21 Inch Diameter Main Only, Earth Backfill
88. Storm Sewer Collection Lines, 24 Inch Diameter Main Only, Earth Backfill
89. Storm Sewer Collection Lines, 27 Inch Diameter Main Only, Earth Backfill
90. Storm Sewer Collection Lines, 30 Inch Diameter Main Only, Earth Backfill
91. Storm Sewer Collection Lines, 36 Inch Diameter Main Only, Earth Backfill
92. Storm Sewer Collection Lines, 42 Inch Diameter Main Only, Earth Backfill
93. Storm Sewer Collection Lines, 48 Inch Diameter Main Only, Earth Backfill
94. Storm Sewer Collection Lines, 54 Inch Diameter Main Only, Earth Backfill
95. Storm Sewer Collection Lines, 8 Inch Diameter Main Only, Gravel Backfill
96. Storm Sewer Collection Lines, 10 Inch Diameter Main Only, Gravel Backfill
97. Storm Sewer Collection Lines, 12 Inch Diameter Main Only, Gravel Backfill
98. Storm Sewer Collection Lines, 15 Inch Diameter Main Only, Gravel Backfill
99. Storm Sewer Collection Lines, 18 Inch Diameter Main Only, Gravel Backfill
100. Storm Sewer Collection Lines, 21 Inch Diameter Main Only, Gravel Backfill
101. Storm Sewer Collection Lines, 24 Inch Diameter Main Only, Gravel Backfill
102. Storm Sewer Collection Lines, 27 Inch Diameter Main Only, Gravel Backfill
103. Storm Sewer Collection Lines, 30 Inch Diameter Main Only, Gravel Backfill
104. Storm Sewer Collection Lines, 36 Inch Diameter Main Only, Gravel Backfill
105. Storm Sewer Collection Lines, 42 Inch Diameter Main Only, Gravel Backfill
106. Storm Sewer Collection Lines, 48 Inch Diameter Main Only, Gravel Backfill
107. Storm Sewer Collection Lines, 54 Inch Diameter Main Only, Gravel Backfill (See Following Example)
108. Storm Drainage Ditches, Surface
109. Telephone Transmission Lines
110. Thoroughfares, Rural Freeway 8 Lane
111. Thoroughfares, Rural Freeway 6 Lane
112. Thoroughfares, Rural Freeway and Expressway 4 Lane
113. Thoroughfares, Rural Standard Arterial (See Following Example)
114. Thoroughfares, Rural Collector Street
115. Thoroughfares, Rural Local Street
116. Thoroughfares, Urban Freeway 8 Lane
117. Thoroughfares, Urban Freeway 6 Lane
118. Thoroughfares, Urban Standard Arterial
119. Thoroughfares, Urban Collector Street
120. Thoroughfares, Urban Local Street
121. Thoroughfares, Urban Alley
122. Water Transmission Lines, 6 Inch Diameter Main Only, Separate
123. Water Transmission Lines, 8 Inch Diameter Main Only, Separate
124. Water Transmission Lines, 12 Inch Diameter Main Only, Separate
125. Water Transmission Lines, 16 Inch Diameter Main Only, Separate
126. Water Transmission Lines, 20 Inch Diameter Main Only, Separate (See Following Example)
127. Water Transmission Lines, 24 Inch Diameter Main Only, Separate
128. Water Transmission Lines, 30 Inch Diameter Main Only, Separate
129. Water Transmission Lines, 36 Inch Diameter Main Only, Separate
130. Water Transmission Lines, 42 Inch Diameter Main Only, Separate
131. Water Transmission Lines, 48 Inch Diameter Main Only, Separate
132. Water Transmission Lines, 54 Inch Diameter Main Only, Separate
133. Water Transmission Lines, 60 Inch Diameter Main Only, Separate
134. Water Transmission Lines, Hydrant Leads, Branches, Earth Backfill
135. Water Transmission Lines, Hydrant Leads
136. Water Transmission Lines, Hydrant Leads, Branches, Earth Backfill
137. Water Transmission Lines, Manholes Blowoff, 8 Inch Drain Pipe
138. Water Transmission Lines, Manholes, Inspection Used With 24 Inch Or Larger Mains
139. Water Transmission Lines, Manholes, Blowoff, 6 Inch Drain Pipe
140. Water Treatment Plant
141. Water Well

Table G-1

LAND USE DESIGN MODEL
CONSTRUCTION COSTS

FOUNDATIONS - RESIDENCES

MULTIPLY ALL FIGURES BY 10**2
$ PER ACRE[c]

	SLOPE[d]	LESS THAN 1 FT TO WATER TABLE			1 TO 5 FT TO WATER TABLE			MORE THAN 5 FT TO WATER TABLE		
		LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK
	A	78.54	362.40	659.40	63.40	171.40	302.90	48.47	107.40	166.20
FINE	B	227.80	584.80	952.80	146.85	225.65	434.65	67.77	116.00	166.20
	C1	392.40	826.40	1258.40	239.40	284.90	570.90	90.35	126.40	166.20
GRAINED	C2	426.60	853.40	1278.20	273.60	308.90	585.30	124.55	149.40	178.80
	D1	460.80	880.40	1298.00	307.80	332.90	599.70	158.75	173.10	191.40
SOILS[a]	D2	506.40	916.40	1324.40	353.40	365.90	618.90	204.35	204.40	208.20
	E	592.40	984.40	1373.90	439.40	426.90	654.90	290.35	266.40	239.70
	F	740.40	1101.40	1458.40	587.40	524.90	717.30	438.35	364.40	294.20
	A	78.54	682.40	1296.40	63.40	415.40	793.90	48.47	107.40	166.20
COARSE	B	227.80	984.80	1784.80	146.85	549.65	1079.65	67.77	116.00	166.20
	C1	392.40	306.40	2286.40	239.40	679.90	1364.90	90.35	126.40	166.20
GRAINED	C2	426.60	333.40	2306.20	273.60	703.90	1379.30	124.55	149.40	178.80
	D1	460.80	360.40	2326.00	307.80	727.90	1393.70	158.75	173.10	191.40
SOILS[b]	D2	506.40	396.40	2352.40	353.40	760.90	1412.90	204.35	204.40	208.20
	E	592.40	464.40	2401.90	439.40	821.90	1448.90	290.35	266.40	239.70
	F	740.40	581.40	2486.40	587.40	919.90	1511.30	438.35	364.40	294.20
	A	78.54	132.00	1410.90	63.40	565.00	1094.90	48.47	305.00	559.90
	B	227.80	244.40	1903.30	146.85	724.25	1433.15	67.77	364.60	661.90
ORGANIC	C1	392.40	366.00	2404.90	239.40	889.50	1783.40	90.35	425.00	762.90
	C2	426.60	406.00	2450.30	273.60	923.15	1816.50	124.55	456.50	791.70
SOILS	D1	460.80	446.00	2495.60	307.80	956.80	1849.60	158.75	488.00	820.60
	D2	506.40	498.50	2556.00	353.40	1001.50	1893.40	204.35	530.00	858.90
	E	592.40	598.50	2669.90	439.40	1086.00	1976.40	290.35	609.00	930.90
	F	740.40	771.00	2866.40	587.40	1232.00	2120.40	438.35	745.00	1055.90
	A							48.47		
	B							67.77		
	C1							90.35		
BEDROCK	C2							124.55		
	D1							158.75		
	D2							204.35		
	E							290.35		
	F							438.35		

[a] *This texture subclass is based on the unified classifications of CL, Ch, and ML as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[b] *This texture subclass is based on the unified classifications of GP, SM, GW, GM, SP, and SC as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[c] *Costs are in Hundreds of Dollars per Acre of Building Coverage.*

[d] *Slope categories A, B, C1, C2, D1, D2, E, and F have average slopes of 1, 5, 8, 11, 15, 19, 26, and 30 percent respectively.*

Source: SEWRPC.

Table G-2

LAND USE DESIGN MODEL
CONSTRUCTION COSTS

SEWAGE SANITARY COLLECTION LINES 10 DIA MAIN ONLY EARTH BACKFILL

$ PER FOOT [c]

	SLOPE	LESS THAN 1 FT TO WATER TABLE			1 TO 5 FT TO WATER TABLE			MORE THAN 5 FT TO WATER TABLE		
		LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK
	A	21.10	17.82	14.55	16.74	13.87	11.00	16.74	13.53	10.33
FINE	B	21.10	17.82	14.55	16.74	13.87	11.00	16.74	13.53	10.33
	C1	21.10	17.82	14.55	16.74	13.87	11.00	16.74	13.53	10.33
GRAINED	C2	21.10	17.82	14.55	16.74	13.87	11.00	16.74	13.53	10.33
	D1	21.10	17.82	14.55	16.74	13.87	11.00	16.74	13.53	10.33
SOILS [a]	D2	21.10	17.82	14.55	16.74	13.87	11.00	16.74	13.53	10.33
	E	21.10	17.82	14.55	16.74	13.87	11.00	16.74	13.53	10.33
	F	21.10	17.82	14.55	16.74	13.87	11.00	16.74	13.53	10.33
	A	21.10	21.10	21.10	16.74	18.92	21.10	16.74	15.64	14.55
COARSE	B	21.10	21.10	21.10	16.74	18.92	21.10	16.74	15.64	14.55
	C1	21.10	21.10	21.10	16.74	18.92	21.10	16.74	15.64	14.55
GRAINED	C2	21.10	21.10	21.10	16.74	18.92	21.10	16.74	15.64	14.55
	D1	21.10	21.10	21.10	16.74	18.92	21.10	16.74	15.64	14.55
SOILS [b]	D2	21.10	21.10	21.10	16.74	18.92	21.10	16.74	15.64	14.55
	E	21.10	21.10	21.10	16.74	18.92	21.10	16.74	15.64	14.55
	F	21.10	21.10	21.10	16.74	18.92	21.10	16.74	15.64	14.55
	A	21.10	21.10	21.10	16.74	18.92	21.10	16.74	14.12	11.50
	B	21.10	21.10	21.10	16.74	18.92	21.10	16.74	14.12	11.50
ORGANIC	C1	21.10	21.10	21.10	16.74	18.92	21.10	16.74	14.12	11.50
	C2	21.10	21.10	21.10	16.74	18.92	21.10	16.74	14.12	11.50
SOILS	D1	21.10	21.10	21.10	16.74	18.92	21.10	16.74	14.12	11.50
	D2	21.10	21.10	21.10	16.74	18.92	21.10	16.74	14.12	11.50
	E	21.10	21.10	21.10	16.74	18.92	21.10	16.74	14.12	11.50
	F	21.10	21.10	21.10	16.74	18.92	21.10	16.74	14.12	11.50

[a] *This texture subclass is based on the unified classifications of CL, CH, and ML as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[b] *This texture subclass is based on the unified classifications of GP, SM, GW, GM, SP, and SC as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[c] *Costs are in Dollars Per Lineal Foot.*

[d] *Slope categories A, B, C1, C2, D1, D2, E, and F have average slopes of 1, 5, 8, 11, 15, 19, 26, and 30 percent respectively.*

Source: SEWRPC.

Table G-3

LAND USE DESIGN MODEL
CONSTRUCTION COSTS

THOROUGHFARES URBAN STANDARD ARTERIAL

$ PER FT. ROW[c]

	SLOPE[d]	LESS THAN 1 FT TO WATER TABLE			1 TO 5 FT TO WATER TABLE			MORE THAN 5 FT TO WATER TABLE		
		LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK
	A	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22
FINE	B	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22
	C1	52.27	52.26	52.25	52.27	52.25	52.24	52.27	52.25	52.24
GRAINED	C2	52.31	52.29	52.27	52.31	52.29	52.26	52.31	52.28	52.25
	D1	52.36	52.33	52.30	52.36	52.32	52.28	52.36	52.31	52.27
SOILS[a]	D2	52.42	52.37	52.33	52.42	52.36	52.30	52.42	52.35	52.29
	E	52.53	52.46	52.40	52.53	52.44	52.35	52.53	52.43	52.33
	F	52.72	52.62	52.51	52.72	52.58	52.43	52.72	52.56	52.40
	A	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22
COARSE	B	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22
	C1	52.27	52.26	52.25	52.27	52.25	52.24	52.27	52.25	52.24
GRAINED	C2	52.31	52.29	52.27	52.31	52.29	52.26	52.31	52.28	52.25
	D1	52.36	52.33	52.30	52.36	52.32	52.28	52.36	52.31	52.27
SOILS[b]	D2	52.42	52.37	52.33	52.42	52.36	52.30	52.42	52.35	52.29
	E	52.53	52.46	52.40	52.53	52.44	52.35	52.53	52.43	52.33
	F	52.72	52.62	52.51	52.72	52.58	52.43	52.72	52.56	52.40
	A	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22
	B	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22	52.22
ORGANIC	C1	52.27	52.27	52.28	52.27	52.26	52.26	52.27	52.26	52.26
	C2	52.31	52.32	52.34	52.31	52.31	52.31	52.31	52.30	52.30
SOILS	D1	52.36	52.38	52.40	52.36	52.35	52.35	52.36	52.34	52.33
	D2	52.42	52.45	52.48	52.42	52.41	52.41	52.42	52.40	52.38
	E	52.53	52.58	52.63	52.53	52.52	52.52	52.53	52.50	52.48
	F	52.72	52.80	52.89	52.72	52.71	52.71	52.72	52.68	52.64
	A							52.22		
	B							52.22		
	C1							52.27		
BEDROCK	C2							52.31		
	D1							52.36		
	D2							52.42		
	E							52.53		
	F							52.72		

[a] *This texture subclass is based on the unified classifications of CL, CH, and ML as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[b] *This texture subclass is based on the unified classifications of GP, SM, GW, GM, SP, and SC as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[c] *Costs are in Dollar Per Lineal Foot.*

[d] *Slope categories A, B, C1, C2, D1, D2, E, and F have average slopes of 1, 5, 8, 11, 15, 19, 26, and 30 percent respectively.*

Source: SEWRPC.

Table G-4

LAND USE DESIGN MODEL
CONSTRUCTION COSTS

WATER TRANS LINES 20 IN DIA MAIN ONLY -SEPARATE

$ PER FOOT [c]

	SLOPE [d]	LESS THAN 1 FT TO WATER TABLE			1 TO 5 FT TO WATER TABLE			MORE THAN 5 FT TO WATER TABLE		
		LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK
FINE GRAINED SOILS [a]	A	42.74	36.57	30.40	37.45	29.52	21.59	37.45	29.23	21.00
	B	42.74	36.57	30.40	37.45	29.52	21.59	37.45	29.23	21.00
	C1	42.74	36.57	30.40	37.45	29.52	21.59	37.45	29.23	21.00
	C2	42.74	36.57	30.40	37.45	29.52	21.59	37.45	29.23	21.00
	D1	42.74	36.57	30.40	37.45	29.52	21.59	37.45	29.23	21.00
	D2	42.74	36.57	30.40	37.45	29.52	21.59	37.45	29.23	21.00
	E	42.74	36.57	30.40	37.45	29.52	21.59	37.45	29.23	21.00
	F	42.74	36.57	30.40	37.45	29.52	21.59	37.45	29.23	21.00
COARSE GRAINED SOILS [b]	A	42.74	40.10	37.45	37.45	33.93	30.40	37.45	32.16	26.88
	B	42.74	40.10	37.45	37.45	33.93	30.40	37.45	32.16	26.88
	C1	42.74	40.10	37.45	37.45	33.93	30.40	37.45	32.16	26.88
	C2	42.74	40.10	37.45	37.45	33.93	30.40	37.45	32.16	26.88
	D1	42.74	40.10	37.45	37.45	33.93	30.40	37.45	32.16	26.88
	D2	42.74	40.10	37.45	37.45	33.93	30.40	37.45	32.16	26.88
	E	42.74	40.10	37.45	37.45	33.93	30.40	37.45	32.16	26.88
	F	42.74	40.10	37.45	37.45	33.93	30.40	37.45	32.16	26.88
ORGANIC SOILS	A	42.74	40.10	37.45	37.45	35.69	33.93	37.45	30.40	23.35
	B	42.74	40.10	37.45	37.45	35.69	33.93	37.45	30.40	23.35
	C1	42.74	40.10	37.45	37.45	35.69	33.93	37.45	30.40	23.35
	C2	42.74	40.10	37.45	37.45	35.69	33.93	37.45	30.40	23.35
	D1	42.74	40.10	37.45	37.45	35.69	33.93	37.45	30.40	23.35
	D2	42.74	40.10	37.45	37.45	35.69	33.93	37.45	30.40	23.35
	E	42.74	40.10	37.45	37.45	35.69	33.93	37.45	30.40	23.35
	F	42.74	40.10	37.45	37.45	35.69	33.93	37.45	30.40	23.35

[a] *This texture subclass is based on the unified classifications of CL, CH, and ML as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[b] *This texture subclass is based on the unified classifications of GP, SM, GW, GM, SP, and SC as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[c] *Costs are in Dollars Per Lineal Foot.*

[d] *Slope categories A, B, C1, C2, D1, D2, E, and F have average slopes of 1, 5, 8, 11, 15, 19, 26, and 30 percent respectively.*

Source: SEWRPC.

Table G-5

LAND USE DESIGN MODEL
CONSTRUCTION COSTS

SITE GRADING ALLOWABLE SLOPE 7PCT

MULTIPLY ALL FIGURES BY 10**1
$ PER ACRE[c]

		LESS THAN 1 FT TO WATER TABLE			1 TO 5 FT TO WATER TABLE			MORE THAN 5 FT TO WATER TABLE		
	SLOPE[d]	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK
	A									
FINE	B									
	C1									
GRAINED	C2	342.00	270.00	198.00	342.00	243.00	144.00	342.00	234.00	126.00
	D1	684.00	540.00	396.00	684.00	486.00	288.00	684.00	468.00	252.00
SOILS[a]	D2	1140.00	900.00	660.00	1140.00	810.00	480.00	1140.00	780.00	420.00
	E	1995.00	1575.00	1155.00	1995.00	1417.50	840.00	1995.00	1365.00	735.00
	F	3477.00	2745.00	2013.00	3477.00	2470.50	1464.00	3477.00	2379.00	1281.00
	A									
COARSE	B									
	C1									
GRAINED	C2	342.00	270.00	198.00	342.00	243.00	144.00	342.00	234.00	126.00
	D1	684.00	540.00	396.00	684.00	486.00	288.00	684.00	468.00	252.00
SOILS[b]	D2	1140.00	900.00	660.00	1140.00	810.00	480.00	1140.00	780.00	420.00
	E	1995.00	1575.00	1155.00	1995.00	1417.50	840.00	1995.00	1365.00	735.00
	F	3477.00	2745.00	2013.00	3477.00	2470.50	1464.00	3477.00	2379.00	1281.00
	A									
	B									
ORGANIC	C1									
	C2	342.00	397.80	453.60	342.00	336.60	331.20	342.00	315.00	288.00
SOILS	D1	684.00	795.60	907.20	684.00	673.20	662.40	684.00	630.00	576.00
	D2	1140.00	1326.00	1512.00	1140.00	1122.00	1104.00	1140.00	1050.00	960.00
	E	1995.00	2320.50	2646.00	1995.00	1963.50	1932.00	1995.00	1837.50	1680.00
	F	3477.00	4044.30	4611.60	3477.00	3422.10	3367.20	3477.00	3202.50	2928.00
	A									
	B									
	C1									
BEDROCK	C2							342.00		
	D1							684.00		
	D2							1140.00		
	E							1995.00		
	F							3477.00		

[a] *This texture subclass is based on the unified classifications of CL, CH, and ML as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*
[b] *This texture subclass is based on the unified classifications of GP, SM, GW, GM, SP, and SC as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*
[c] *Costs are in Tens of Dollars per Acre Graded.*
[d] *Slope categories A, B, C1, C2, D1, D2, E, and F have average slopes of 1, 5, 8, 11, 15, 19, 26, and 30 percent respectively.*

Source: SEWRPC.

Table G-6

LAND USE DESIGN MODEL
CONSTRUCTION COSTS

STORM SEWER COLLECTION LINES 54 DIA MAIN ONLY GRAVEL BACKFILL

$ PER FOOT [c]

	SLOPE [d]	LESS THAN 1 FT TO WATER TABLE			1 TO 5 FT TO WATER TABLE			MORE THAN 5 FT TO WATER TABLE		
		LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK
	A	65.30	63.80	62.30	61.30	56.80	52.30	57.30	50.80	44.30
FINE	B	65.30	63.80	62.30	61.30	56.80	52.30	57.30	50.80	44.30
	C1	65.30	63.80	62.30	61.30	56.80	52.30	57.30	50.80	44.30
GRAINED	C2	65.30	63.80	62.30	61.30	56.80	52.30	57.30	50.80	44.30
	D1	65.30	63.80	62.30	61.30	56.80	52.30	57.30	50.80	44.30
SOILS [a]	D2	65.30	63.80	62.30	61.30	56.80	52.30	57.30	50.80	44.30
	E	65.30	63.80	62.30	61.30	56.80	52.30	57.30	50.80	44.30
	F	65.30	63.80	62.30	61.30	56.80	52.30	57.30	50.80	44.30
	A	65.30	65.80	66.30	61.30	58.80	56.30	57.30	51.30	45.30
COARSE	B	65.30	65.80	66.30	61.30	58.80	56.30	57.30	51.30	45.30
	C1	65.30	65.80	66.30	61.30	58.80	56.30	57.30	51.30	45.30
GRAINED	C2	65.30	65.80	66.30	61.30	58.80	56.30	57.30	51.30	45.30
	D1	65.30	65.80	66.30	61.30	58.80	56.30	57.30	51.30	45.30
SOILS [b]	D2	65.30	65.80	66.30	61.30	58.80	56.30	57.30	51.30	45.30
	E	65.30	65.80	66.30	61.30	58.80	56.30	57.30	51.30	45.30
	F	65.30	65.80	66.30	61.30	58.80	56.30	57.30	51.30	45.30
	A	65.30	71.80	78.30	61.30	61.80	62.30	57.30	52.80	48.30
	B	65.30	71.80	78.30	61.30	61.80	62.30	57.30	52.80	48.30
ORGANIC	C1	65.30	71.80	78.30	61.30	61.80	62.30	57.30	52.80	48.30
	C2	65.30	71.80	78.30	61.30	61.80	62.30	57.30	52.80	48.30
SOILS	D1	65.30	71.80	78.30	61.30	61.80	62.30	57.30	52.80	48.30
	D2	65.30	71.80	78.30	61.30	61.80	62.30	57.30	52.80	48.30
	E	65.30	71.80	78.30	61.30	61.80	62.30	57.30	52.80	48.30
	F	65.30	71.80	78.30	61.30	61.80	62.30	57.30	52.80	48.30

[a] *This texture subclass is based on the unified classifications of CL, CH, and ML as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[b] *This texture subclass is based on the unified classifications of GP, SM, GW, GM, SP, and SC as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[c] *Costs are in Dollars Per Lineal Foot.*

[d] *Slope categories A, B, C1, C2, D1, D2, E, and F have average slopes of 1, 5, 8, 11, 15, 19, 26, and 30 percent respectively.*

Source: SEWRPC.

Table G-7

LAND USE DESIGN MODEL
CONSTRUCTION COSTS

LATERALS - SANITARY SEWERS GRAVEL BACKFILL

$ PER FOOT [c]

	SLOPE [d]	LESS THAN 1 FT TO WATER TABLE			1 TO 5 FT TO WATER TABLE			MORE THAN 5 FT TO WATER TABLE		
		LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK
FINE GRAINED SOILS [a]	A	27.08	23.14	19.20	23.70	18.64	13.58	23.70	18.45	13.20
	B	27.08	23.14	19.20	23.70	18.64	13.58	23.70	18.45	13.20
	C1	27.08	23.14	19.20	23.70	18.64	13.58	23.70	18.45	13.20
	C2	27.08	23.14	19.20	23.70	18.64	13.58	23.70	18.45	13.20
	D1	27.08	23.14	19.20	23.70	18.64	13.58	23.70	18.45	13.20
	D2	27.08	23.14	19.20	23.70	18.64	13.58	23.70	18.45	13.20
	E	27.08	23.14	19.20	23.70	18.64	13.58	23.70	18.45	13.20
	F	27.08	23.14	19.20	23.70	18.64	13.58	23.70	18.45	13.20
COARSE GRAINED SOILS [b]	A	27.08	25.39	23.70	23.70	21.45	19.20	23.70	20.33	16.95
	B	27.08	25.39	23.70	23.70	21.45	19.20	23.70	20.33	16.95
	C1	27.08	25.39	23.70	23.70	21.45	19.20	23.70	20.33	16.95
	C2	27.08	25.39	23.70	23.70	21.45	19.20	23.70	20.33	16.95
	D1	27.08	25.39	23.70	23.70	21.45	19.20	23.70	20.33	16.95
	D2	27.08	25.39	23.70	23.70	21.45	19.20	23.70	20.33	16.95
	E	27.08	25.39	23.70	23.70	21.45	19.20	23.70	20.33	16.95
	F	27.08	25.39	23.70	23.70	21.45	19.20	23.70	20.33	16.95
ORGANIC SOILS	A	27.08	25.39	23.70	23.70	22.58	21.45	23.70	19.20	14.70
	B	27.08	25.39	23.70	23.70	22.58	21.45	23.70	19.20	14.70
	C1	27.08	25.39	23.70	23.70	22.58	21.45	23.70	19.20	14.70
	C2	27.08	25.39	23.70	23.70	22.58	21.45	23.70	19.20	14.70
	D1	27.08	25.39	23.70	23.70	22.58	21.45	23.70	19.20	14.70
	D2	27.08	25.39	23.70	23.70	22.58	21.45	23.70	19.20	14.70
	E	27.08	25.39	23.70	23.70	22.58	21.45	23.70	19.20	14.70
	F	27.08	25.39	23.70	23.70	22.58	21.45	23.70	19.20	14.70

[a] *This texture subclass is based on the unified classifications of CL, CH, and ML as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[b] *This texture subclass is based on the unified classifications of GP, SM, GW, GM, SP, and SC as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[c] *Costs are in Dollars Per Lineal Foot.*

[d] *Slope categories A, B, C1, C2, D1, D2, E, and F have average slopes of 1, 5, 8, 11, 15, 19, 26, and 30 percent respectively.*

Source: SEWRPC.

Table G-8

LAND USE DESIGN MODEL
CONSTRUCTION COSTS

RAILROAD MAIN LINE

$ PER FOOT [c]

	SLOPE [d]	LESS THAN 1 FT TO WATER TABLE			1 TO 5 FT TO WATER TABLE			MORE THAN 5 FT TO WATER TABLE		
		LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK	LESS TN 2 TO BEDROCK	2-5 TO BEDROCK	MORE TN 5 TO BEDROCK
	A	20.38	20.30	20.22	20.38	20.27	20.16	20.38	20.26	20.14
FINE	B	22.28	21.80	21.32	22.28	21.62	20.96	22.28	21.56	20.84
	C1	24.56	23.60	22.64	24.56	23.24	21.92	24.56	23.12	21.68
GRAINED	C2	26.46	25.10	23.74	26.46	24.59	22.72	26.46	24.42	22.38
	D1	28.36	26.60	24.84	28.36	25.94	23.52	28.36	25.72	23.08
SOILS [a]	D2	31.02	28.70	26.38	31.02	27.83	24.64	31.02	27.54	24.06
	E	36.34	32.90	29.46	36.34	31.61	26.88	36.34	31.18	26.02
	F	45.84	40.40	34.96	45.84	38.36	30.88	45.84	37.68	29.52
	A	20.38	20.30	20.22	20.38	20.27	20.16	20.38	20.26	20.14
COARSE	B	22.28	21.80	21.32	22.28	21.62	20.96	22.28	21.56	20.84
	C1	24.56	23.60	22.64	24.56	23.24	21.92	24.56	23.12	21.68
GRAINED	C2	26.46	25.10	23.74	26.46	24.59	22.72	26.46	24.42	22.38
	D1	28.36	26.60	24.84	28.36	25.94	23.52	28.36	25.72	23.08
SOILS [b]	D2	31.02	28.70	26.38	31.02	27.83	24.64	31.02	27.54	24.06
	E	36.34	32.90	29.46	36.34	31.61	26.88	36.34	31.18	26.02
	F	45.84	40.40	34.96	45.84	38.36	30.88	45.84	37.68	29.52
	A	20.38	20.44	20.50	20.38	20.37	20.37	20.38	20.35	20.32
	B	22.28	22.65	23.02	22.28	22.24	22.21	22.28	22.10	21.92
ORGANIC	C1	24.56	25.30	26.05	24.56	24.49	24.42	24.56	24.20	23.84
	C2	26.46	27.51	28.57	26.46	26.36	26.26	26.46	25.95	25.44
SOILS	D1	28.36	29.72	31.09	28.36	28.23	28.10	28.36	27.70	27.04
	D2	31.02	32.82	34.62	31.02	30.85	30.67	31.02	30.15	29.28
	E	36.34	39.01	41.67	36.34	36.08	35.82	36.34	35.05	33.76
	F	45.84	50.06	54.27	45.84	45.43	45.02	45.84	43.80	41.76

[a] *This texture subclass is based on the unified classifications of CL, CH, and ML as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[b] *This texture subclass is based on the unified classifications of GP, SM, GW, GM, SP, and SC as described in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin.*

[c] *Costs are in Dollar Per Lineal Foot.*

[d] *Slope categories A, B, C1, C2, D1, D2, E, and F have average slopes of 1, 5, 8, 11, 15, 19, 26, and 30 percent respectively.*

Source: SEWRPC.

APPENDIX H
DATA REDUCTION INITIAL LINKAGE COST
CARD CODE 09

LINK NO.	COST PER FOOT
01	0.00
02	5.00
03	20.27
04	14.25
05	21.10
06	28.52
07	18.57
08	25.34
09	32.63
10	10.14
11	12.26
12	14.54
13	10.93
14	13.15
15	15.63
16	5.00
17	42.16
18	33.40
19	24.45
20	18.93
21	13.52
22	10.26
23	63.92
24	51.61
25	52.22
26	28.65
27	23.41
28	11.30
29	12.62
30	16.60

APPENDIX I
DATA REDUCTION DIVISION CONNECTIVITY PRICE
CARD CODE 05

DIVISION NO.	PRICE OF CONNECTION	DIVISION PARENT	PARENT DIVISION HALF	NO. CELLS IN THIS DIVISION	DISTANCE
1	1128.75	0	1	472	48500
2	1128.75	1	1	209	28500
3	1128.75	1	2	262	16250
4	1128.75	2	1	124	16000
5	1128.75	2	2	88	22000
6	1128.75	3	1	127	28000
7	1128.75	3	2	110	32000
8	1128.75	4	1	62	16000
9	1128.75	4	2	62	16000
10	1128.75	5	1	55	12000
11	1128.75	5	2	35	12000
12	1128.75	6	1	55	18000
13	1128.75	6	2	81	12000
14	1128.75	7	1	49	18000
15	1128.75	10	1	32	12000
16	1128.75	10	2	23	12000
17	1128.75	13	1	33	13500
18	1128.75	13	2	48	16000
19	1128.75	7	2	61	16000

APPENDIX J
DATA REDUCTION INITIAL CONDITIONS
CARD CODE 00

CELL	MODULE	QUANTITY
189	01	00001
132	01	00002
139	01	00001
145	01	00001
110	01	00001
144	01	00001
295	02	00001
111	02	00001
159	02	00002
152	02	00001
315	02	00001
110	02	00001
179	02	00001
132	02	00009
317	02	00002
138	02	00001
076	02	00001
114	02	00001
074	02	00001
228	02	00001
113	02	00001
122	02	00001
044	02	00001
279	02	00001
048	02	00001
280	02	00001
261	02	00001
246	02	00001
320	03	00001
269	03	00001
134	03	00002
253	03	00004
132	03	00055
272	03	00001
184	03	00001
246	03	00022