INTERN EXPERIENCE AT

DALLAS POWER AND LIGHT COMPANY

AN INTERNSHIP REPORT

by

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in partial fulfillment of the requirement for the degree of

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Abstract

A survey of the author's internship experience with the Dallas Power & Light Company during the period January, 1979 through January, 1980 is presented. During this one year internship, the author worked as an Engineer in the Executive Department. The intent of this report is to demonstrate that this experience fulfills the requirements for the Doctor of Engineering internship.

The author's activities during this period can be categorized into two major areas. First, technically oriented, in which he developed a model to project future electrical demands based on land usage, and a computer program that implements this model. Secondly, a selection of non-technical business oriented areas were investigated. The tasks in these areas offered him the opportunity to be exposed to the organization and operation of an investor owned public utility company and to gain experience in a non-academic business environment.

Internship Objectives

1. To become familiar with the organization and operation of an investor-owned electrical utility company.

2. To make an identifiable contribution to the organization in which the internship is served.

3. To gain experience in a non-academic business environment especially in the areas of planning, cost analysis and economics.

Introduction

This report describes my Doctor of Engineering internship experience with the Dallas Power & Light Company, an investor-owned electric utility company. The internship was performed over the period January 11, 1979, through January 10, 1980. My internship supervisor was Mr. Don M. Deffebach, executive assistant to the vice president responsible for the Engineering, Distribution and Plant Departments. During this year, I was exposed to both technical and non-technical aspects of operating an electric utility company.

My technical assignment was initially described in general terms: project the Dallas Power & Light electrical system configuration for a time when the electrical demand is double its present value. Working toward this goal, a small area load projection and substation location model was developed and a computer program implementing this model was written. This program allows the user to investigate many possible growth scenarios, projecting the service area electrical demand distribution for each growth pattern selected. The detailed technical report prepared at the conclusion of this project is provided as an enclosure to this internship report.

Non-technical areas of experience during the internship varied from corporate philosophies to communications. Working at the vice presidential level within the organization provided me with a broad outlook that would not have been possible had I been assigned to a position deeper within the organizational structure. The partial organizational chart on the next page (Figure 1) shows the location of my internship position with respect to the company's top managers.

The intent of this report is to show that my internship experience with DP&L fulfilled the requirements for the Doctor of Engineering internship. The fact that these requirements have been satisfied will be demonstrated through a discussion describing how each of the three objectives of the internship were met. This report is divided into three main sections, one for each of the objectives.

The page numbering is continuous through the report including the enclosure. Since the enclosure has separately numbered pages, the page numbers corresponding to this report are given in parenthesis before the original page numbers. For example, a page in the enclosure numbered "(48) 20" would be page 48 of the internship report and page 20 of the enclosed technical report.

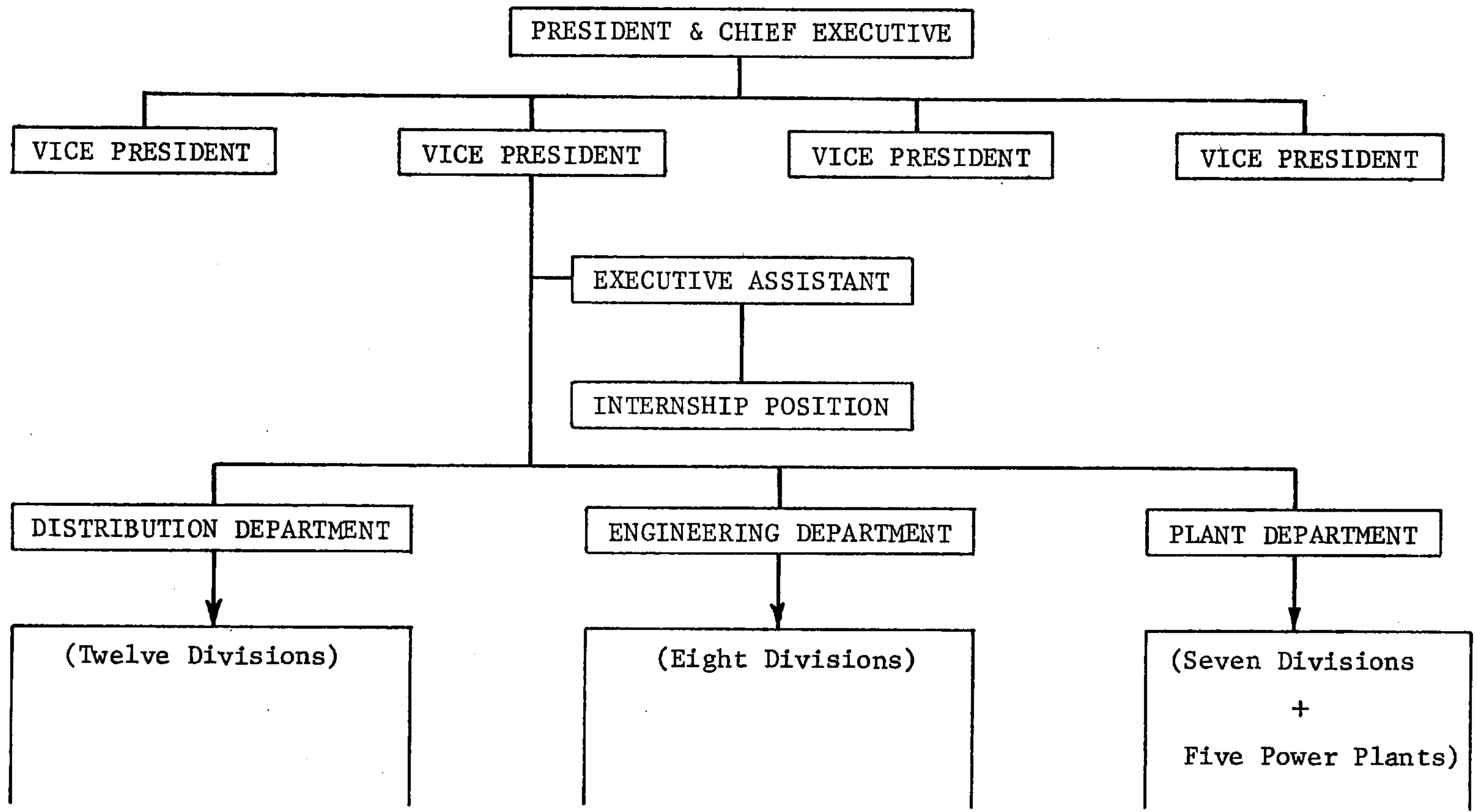
PRESIDENT & CHIEF EXECUTIVE
VICE PRESIDENT
VICE PRESIDENT
VICE PRESIDENT
VICE PRESIDENT
EXECUTIVE ASSISTANT
INTERNSHIP POSITION
DISTRIBUTION DEPARTMENT
ENGINEERING DEPARTMENT
PLANT DEPARTMENT
(Twelve Divisions)
(Eight Divisions)
(Seven Divisions
+
Five Power Plants)

FIGURE 1

The Internship Company

The Dallas Power & Light Company (DP&L) is an investor-owned public electric utility. DP&L is one of three operating companies within the Texas Utilities Company System. The Texas Utilities Company System is an investor owned electric utility holding company that includes three electric utility companies (Dallas Power & Light Company, Texas Power & Light Company, and Texas Electric Service Company), two resource development companies (Chaco Energy Company and Basic Resources Inc.), a fuel company (Texas Utilities Fuel Company), a generating company (Texas Utilities Generating Company), and a services company (Texas Utilities Services Incorporated). The three operating electric utility companies supply electrical energy to over four million people.

Dallas Power & Light Company supplies electrical energy to the Greater Dallas area, including the cities of Dallas, Highland Park, University Park, and Cockrell Hill. DP&L also serves some of the adjacent unincorporated area. The service area extends into five Texas counties (Dallas, Denton, Collin, Rockwall, and Kaufman). The Company's system of transmission lines is interconnected with the systems of

Texas Power & Light and Texas Electric Service. Five generating stations within Dallas County are totally owned by DP&L (Dallas, Lake Hubbard, Mountain Creek, North Lake, and Parkdale Steam Electric Stations) and the Company also maintains a partial ownership in three lignite plants (Big Brown, Martin Lake, and Monticello) and one nuclear plant. The nuclear plant, Comamche Peak, is scheduled to begin commercial operation in 1981.

Section One

OBJECTIVE: To become familiar with the organization and operation of an investor-owned electrical utility company.

This first internship objective was met through the accomplishment of several technical and non-technical activities. In order to obtain an overview of the Company's organization, I reviewed the Organization and Procedure Manual. This document contains a set of organization charts for DP&L as well as many operational and personnel procedures. After reviewing this document and discussing information contained therin that was not clear to me with my internship supervisor, I was given an opportunity to spend three weeks on an orientation tour of the Company.

My orientation took me through seven of the Company's thirteen departments. These were the Energy Services, Engineering, Distribution, Plant, Accounting, Rate & Economic Research, and Data Processing Departments. This tour provided me with my first exposure to the actual operation of an investor-owned electrical utility company.

The Energy Services Department is subdivided into seven main sections, three of which are geographically oriented, that is, they perform basically the same functions but for different parts of the DP&L service area. The four remaining divisions are company wide in scope. Each of the three geographically oriented divisions provide assistance to customers by classes, such as large commercial or residential, and they all have a consumer services subsection which deals primarily with efficient uses of electricity in the home. The Power Accounts Division assists three main classes of customers including apartment developers, government agencies (city, state, and federal), and food services (restaurants). The assistance provided usually deals with the supply of electrical energy with sufficient reliability to meet the needs of the customer at the most reasonable cost. The Industrial Accounts Division performs a similar service for the DP&L industrial customers. Customer consultation, consumer services, technical services, and program coordination are all responsibilities of the Consumer and Technical Services Division. This division provides customer assistance in the areas of lighting, heating, air conditioning, solar applications, energy efficiency of appliances, and public displays and programs. The last division of Energy Services Department is the Service Coordination and Statistics Division. As their name implies, this division coordinates service requests and accumulates department related statistics such as market research, load use, appliance saturation, and customer buying patterns.

Eight divisions make up the Engineering Department. As would be expected, this department provides the engineering expertise for the Company. Four of the divisions are primarily design oriented, these being the Substation & Transmission, Power Plant, Overhead, and the Underground Divisions. The Planning Division studies system reliability and long range requirements. During my internship I worked very closely with the personnel of this division. Acquisition of real estate and rights of way is the responsibility of the Real Estate & Right of Way Division. This division also maintains all real estate records and performs surveying services for the Company. Preparation and maintenance of the system maps comes under the Drafting Division as does the Department tracing and micro-film files. This Division also performs many special projects, one of which was part of the data collection for the small area load projection model developed as a part of this internship.

The Estimating & Statistical Division rounds out the Engineering Department. These people prepare estimates and work authorizations for overhead and underground work, and for changes in the Company's transportation, communication, laboratory and office equipment. They also prepare the Department's budget and perform an analysis of construction costs.

The Distribution Department is responsible for construction, operation and maintenance of the electrical distribution system, street lighting system, and customer metering and services. They are also responsible for construction and maintenance of the transmission system and for operation and maintenance of the Company's vehicle fleet. In order to carry out these functions, the Department is divided into twelve divisions. To assist the Department Manager, an intermediate management level has been established and staffed with four managers: the Manager of Distribution - Construction and Maintenance, the Manager of the Northeast Service Center, the Manager of the Southwest Service Center, and the Manager of Distribution - Operations and Services. The Accounting Division and the Safety and Employee Welfare Division both report directly to the Department Head while all of the remaining divisions report to one of the intermediate managers. This Department is probably the most visable to the public since the large majority of customers will never meet Company employees from the other departments except for the meter readers. The employees that connect and disconnect electrical service, replace wires downed by a storm, and construct new electrical distribution and transmission lines all work in the Distribution Department. An organizational chart for the Distribution Department is shown on the next page (Figure 2).

Operation of the Company's generating stations, transmission system, and distribution substations is the responsibility of the Plant Department. As in the Distribution Department, the Plant Department contains an intermediate management level, three group managers in this case. Again, Safety and Accounting report directly to the Department Manager. The Generation Group Manager coordinates the activities of the five generating stations (Dallas, Mountain Creek, Parkdale, North Lake, and Lake Hubbard Steam Electric Stations) and the Plant Betterment Division. This division seeks to improve production efficiency through technical studies of operation and maintenance procedures and other engineering aspects of generating station equipment. The Maintenance & Construction Group is composed of four divisions: Mechanical Maintenance and Construction, Electrical

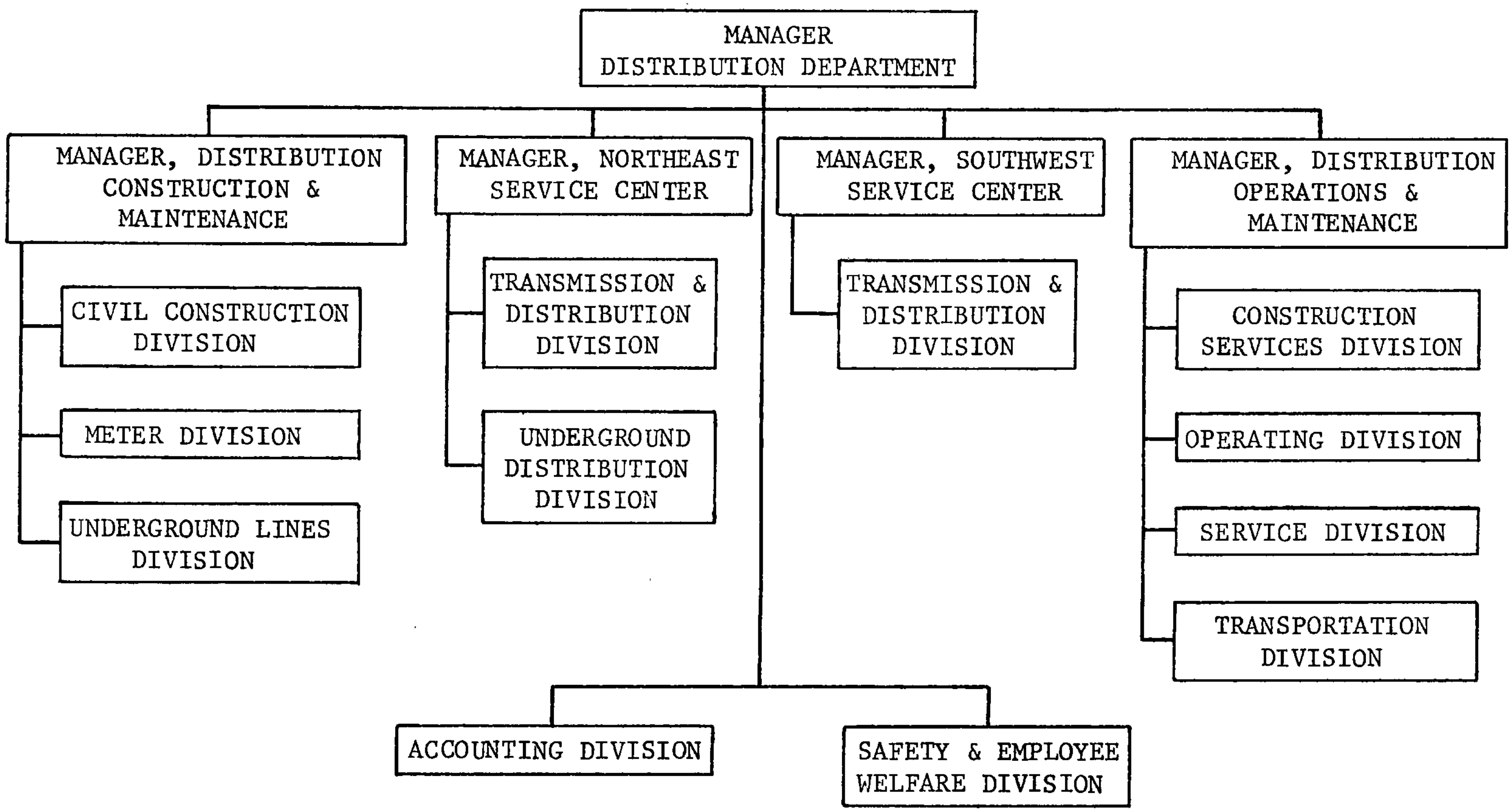
MANAGER
DISTRIBUTION DEPARTMENT
MANAGER, DISTRIBUTION CONSTRUCTION & MAINTENANCE
CIVIL CONSTRUCTION DIVISION
METER DIVISION
UNDERGROUND LINES DIVISION
MANAGER, NORTHEAST SERVICE CENTER
TRANSMISSION & DISTRIBUTION DIVISION
UNDERGROUND DISTRIBUTION DIVISION
MANAGER, SOUTHWEST SERVICE CENTER
TRANSMISSION & DISTRIBUTION DIVISION
MANAGER, DISTRIBUTION OPERATIONS & MAINTENANCE
CONSTRUCTION SERVICES DIVISION
OPERATING DIVISION
SERVICE DIVISION
TRANSPORTATION DIVISION
ACCOUNTING DIVISION
SAFETY & EMPLOYEE WELFARE DIVISION

FIGURE 2

Maintenance and Construction, Civil Maintenance and Construction, and Grounds Maintenance and Construction. In addition to coordinating maintenance among DP&L plants, the Group Manager also coordinates maintenance activities with the associate electric companies (Texas Power & Light, and Texas Electric Service Company) and assures that an adequate supply of spare parts is maintained. The third group within the Plant Department is the Substation and Transmission Operation Group which is responsible for the operation of the System Control Center, and system protection. The System Control Center is the nerve center for the entire electrical system, being tasked with the continuous and safe operation of the transmission system and substations, allocating load among generating stations, and regulating power interchange with interconnected companies.

Three divisions make up the Accounting Department which is responsible for corporate treasurer functions, general accounting, property accounting and customer accounting activities of the Company. The General Accounting Division performs all of the services normally associated with an accounting section of a company: general accounting records, taxes, payroll, financial reports, audits and reconciliations, cash budgeting, and external reports. Since a utility has so many customers, a separate division exists to maintain customer accounts. The Customer Accounting Division performs all accounting services required for customer accounts such as: customer accounts receivable, customer's deposit records, auditing bills, receiving and accounting for customer mail remittances, calculating KW demands for billing purposes, receiving payments from customers who call in person, and other services as required. Responsibilities of the Property Accounting Division include maintaining property records; maintaining property vintage, location, and tax code records: keeping records of plant investment; and preparation of yearly ad valorem tax reports.

Developing and administering sound rates and rate policies is one of the responsibilities of the Rate & Economic Research Department. In addition to rate analysis and design, they also supervise rate application, perform rate and economic research studies, review large contracts for service prior to execution, analyze actual and estimated energy sales and system demands, operate the Company library, prepare the official load projections, and gather statistics pertaining to system demands, energy sales, revenues, rates, power plant operation, and weather. This is the Department with which I worked most closely during my research on marginal costs and marginal cost pricing of electricity.

My official orientation ended at the Data Processing Department. Since the Company was in the process of implementing a computerized customer information system at the time of my orientation, I only had a brief visit at that time. However, my exposure to this Department increased as my work on the computer implementation of the small area load projection model progressed. This Department operates the company's keypunch, tabulating, and computer equipment. They also maintain the Company's Organization and Procedure Manual, including format design and issuance of approved revisions and additions.

The following departments were not included on my orientation schedule: Personnel; Purchasing & Stores; Research and Environmental Services (I visited with this Department at a later date); Taxes, Insurance & Property; Treasury; Customer Information (since my office was on their floor, I learned quite a bit about this Department during the internship); and Communications Services.

My courses at Texas A&M University proved useful during the orientation since they allowed me to communicate with members of these departments in their own jargon resulting in greater information flow and better questions concerning their areas of responsibility.

While the orientation provided me with an overview of the Company, much more was learned over the period of the internship through discussions with my intern supervisor. Fortunately for me, he was willing to spend many hours explaining various management philosophies, corporate policies, and business practices. From time to time throughout the internship period we talked about management styles and methods of improving communications. Many times our discussions continued after completion of the normal work day. He often routed technical trade periodicals to me so that I had the opportunity to become familiar with the hardware used by an electrical utility in addition to the theory behind the hardware. During my internship one of the Company's generators was undergoing a major overhaul and I was fortunate to be able to visit the manufacturer's overhaul facility and observe part of the generator field rewinding operation.

I was asked to review and comment on a number of technical documents. These ranged from documents dealing with system reliability and the marginal cost reporting requirements under Section 133 of the Public Utility Regulatory Policies Act of 1978 to detailed testimony presented during the rate cases then in progress.

In November, the Company started one of its evening in-house courses for employees. This 24 week course was the

Steam Power Plant Course which covers such topics as basic laws and properties, generation of steam, work from steam, fluid flow, electricity, and a number of other miscellaneous topics. I decided to take advantage of this opportunity and enrolled in the course. While the theory contained in this course is a worthwhile review, associating with plant operators and maintenance personnel presents an opportunity to learn their jargon and some of their behavioral patterns. Through an agreement with the instructor, I have been able to continue the course by correspondence during this semester.

Section Two

OBJECTIVE: To make an identifiable contribution to the organization in which the internship is served.

This internship objective was met through the accomplishment of the primary assignment of my internship which was to project the Dallas Power & Light system configuration after a one hundred percent growth in system demand has occurred. Based on the official company projections, this level would be reached within the next twenty years. My initial approach to this task was to obtain and read as much material on the subject of load forecasting as was available within a reasonable time frame. After two months I had a collection of over twenty relevant documents. Reviewing these, it became obvious to me that the classical methods of load forecasting were inadequate for my purposes. Most of these classical methods depended on time series analysis to project future energy or demand on a system-wide basis so that even if they produced valid results, they did not provide the spacial distribution of these projections. That is, they would purport to be capable of predicting system-wide demands but not the demands in any particular small geographical location. Since the system configuration includes substation locations, a method to determine the geographical location of any projected demands was required. After some thought, the small area load projection and substation location model concept began to take form. A few weeks after working on this concept, I learned that another utility was also working on a geographically orientated load forecasting procedure. I contacted these personnel and obtained some technical papers from them which described the work they were doing. After reviewing this work, I decided that their methods were not directly applicable to the Dallas area but that some of their ideas corresponded with the ones I had been developing. This fact gave me confidence in my continuing development of the small area model that was applicable to the Dallas Power & Light service area. The final report covering this Small Area Load Projection and Substation Location Model and the computer implementation is included as pages 16 through 133 of this internship report.

Once the model concept was formulated, the question of data requirements was addressed. The model requires data for numerous small segments of area, called cells, throughout the service area. Basically, the data required for each cell includes the present use to which the land is being put, the city zoning for that land (in Dallas this is an estimate of the future use for the land), the electrical feeders that serve the cell, and the percent of the feeder area covered by the cell. The number of cells is dependent on the cell size which in turn is determined by the required resolution the model user desires in the results. This represents a trade off between resolution and data collection time and cost. A meeting was held with the planning engineers and other representatives of the Engineering Department and it was decided that the cell size should be one quarter of a district. The DP&L service area is divided into one square mile segments called districts. The electrical system maps are based on this district "grid" and it is a common reference frame used throughout the Company. Cell size was therefore set at one quarter of a square mile in area, four cells to a district. The task of data collection for the more than 1500 cells still lay ahead.

A representative group of cells was selected and data collected for these so that a time estimate for the total data collection process could be made. The estimate came to approximately six man-months. Two persons from the Drafting Division were recruited for the data collection task primarily because they were most familiar with the system maps and aerial photographs of the DP&L service area. While this data collection effort progressed, the computer implementation of the small area load forecasting model was developed and debugged. After the data collection and computer encoding efforts were completed, several runs of the model were made. The results of these test runs are presented in the enclosed report.

This model and computer implementation will allow the system planners to study many possible growth scenarios to determine the sensitivity of resulting configurations to changes in the growth estimates. In addition to determining substation locations to satisfy future demands, the model can be used to study system distribution line losses versus feeder length, substation loading, or number of substations. These studies are useful for making economic comparisons among possible alternatives.

Section Two-A

SMALL AREA LOAD PROJECTION

AND

SUBSTATION LOCATION MODEL

Dallas Power & Light Company

Roger L. Fischer

January 1980

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Foreword

The traditional methods of load forecasting for electrical utilities do not provide information concerning the locations of projected demands since they are area-wide techniques. In order to plan and construct facilities for short-range requirements which will mesh with the long-range growth patterns, some projections of load locations over the longer term must be available. This report describes a small area load projection model and its computer implementation developed during the author's Doctor of Engineering internship with Dallas Power & Light Company.

Abstract

A small area load projection model based on land use has been developed which allows the user to determine future demands by geographical location. The model also collects all demands scattered throughout the service area into substation locations. A computer implementation of this model has been successfully developed. This implementation allows the user to specify up to twenty separate growth areas within the total service area, each of which can have independently selected growth rates. Demands are projected on the basis of how the land will be used during the target period. Future use is assumed to follow the City Zoning Ordinances. Demands for various land uses are calculated for present use patterns and technology but may be varied for projection purposes. These demands are of the form kilowatts per square mile, for each of fourteen identified land use types. Locations for future substations are automatically selected and can then be specified for further investigations concerning losses, feeder loading and feeder length.

Introduction

In order to have present construction meet not only the requirements of today but also those of the future, some knowledge of the future demand patterns by location should be known. Unfortunately, the most commonly used projection methods only attempt to determine an area-wide demand for some future point in time. This projection may suffice for bulk power requirements but is inadequate for long-range planning of distribution substation requirements. The relatively short lead times for substations and distribution feeders as compared to generation capacity has, in the past, allowed the system planners to provide adequate capacity for customer needs. Today, however, with the rapid development of the remaining real estate within the City of Dallas, locations for future substations are becoming not only harder to find, but also much more expensive. To limit the cost to our customers, substation sites and transmission right-of-way must be obtained as early as possible. Ideally, these locations can be selected and procured prior to the development of the surrounding areas.

The selection of these locations depends on the availability of a geographically oriented demand projection technique. The small area load projection method developed provides the required geographically distributed demands. This model determines the projected demands for each one quarter square mile "cell" within the service area. After these projections are made, the individual demands are collected or "gathered" to existing substation locations. If the capacity of the existing substation is insufficient, additional substations are located as required. In addition to projecting possible substation locations, the computer implementation of the small area load forecasting model keeps track of all substation - cell "transactions" so that a record is maintained of which substations (up to six) feed each cell. This information is useful for feeder design and routing studies. A measure of system losses, by substation, is maintained in the form of demand times distance (megawatt-miles) so that comparisons among several possible sets of substation locations can be made. A detailed description of the small area model is presented in Appendix A while Appendix B contains a user's guide for the LANDUSE computer program that implements this model. Appendix C contains a listing of the computer program.

Background

The small area load projection model is based on the theory that total system demand is composed of small parts. These small increments of demand are caused by electrical usage within given environments. One of these usage environments is land use. It is reasonable to assume that the electrical demand in any given area depends to a large extent on the use to which that area is put. For example, one would expect the electrical demand density to be lower in a rural area than in an urban area. Similarly, various land uses within an urban area, such as Dallas, result in different electrical demand densities. Since the DP&L service area maps are based on a one square mile district system, this "grid" was adopted as frame of reference during data collection. Each district was subdivided into four parts, called cells, identified by their compass direction from the district's center. That is, the four cells of a district identified as 11N01W would be 11N01WNW, 11N01WNE, 11N01WSW, and 11N01WSE. These cells, each one-fourth of a square mile, are the basic unit of area used in the small area model. There are over 1500 of these cells in the service area each of which required a separate set of data. Fourteen land use types were identified for use within the Dallas Power & Light service area. These land use types are listed in Table 1. Zoning maps covering all areas of Dallas were obtained from the City of Dallas. Aerial photographs of the DP&L service area were on hand at the start of this project and were used extensively throughout the data collection process.

The raw data was initially recorded on Data Sheets and later entered into a computer disk file. A sample sheet is shown in Figure 1. The actual use and average age of facilities in the cell were coded from aerial photographs while the zoning was taken from the city zoning maps. Transportation and age information is being reserved for possible future use. Electrical distribution feeder data was taken from the Company's 13KV one line feeder maps. This data includes the feeder's nomenclature or name, the percentage of area fed by the feeder that is also in the cell, and the percentage of the cell's area that is covered by the feeder. Approximately eight man-months were expended during the data collection/coding portion of this project. While the data coding was in progress, computer programs implementing the small area model were being developed.

TABLE 1: LAND USE CODES

Code	Description
R1	Large single family
R2	Single family
R3	Small single family
M1	Multi-family (1-3 stories)
M2	Multi-family (more than 3 stories)
C1	Small commercial
C2	Medium commercial (2-3 stories)
C3	Heavy commercial (over 3 stories)
C4	Large shopping centers
I1	Light Industrial
I2	Medium industrial
S1	Vacant and usable
S2	Undevelopable (park, cemetery, etc.)
S3	Flood plain

DATA SHEET

Coder ______________ Date ______________

District ______________ NW NE SW SE

East __________ North __________

Land Use:

	Actual Use		Present Zone	
	%	Code	%	Zoning
1.	______	______	______	______
2.	______	______	______	______
3.	______	______	______	______

Age: __________

Transportation:

	Now	Proposed
Highway lanes	______	______
Rail tracks	______	______
Bus routes	______	______
Through streets	______	______

Feeders:

	Name	% Feeder	% Cell
1.	______	______	______
2.	______	______	______
3.	______	______	______

Comments: ______________________________________

____

Figure 1

The Model

Since the projections of future demands are based on land usage, the demand density for each of the fourteen land use types had to be determined. Three of the fourteen uses represent vacant land with a zero electrical demand. The eleven remaining demand densities were determined using an iterative process that matches cell and feeder areas with land use types. Appendix A contains a detailed description of this process in the "Theory of the Model" section. Once the demand densities are known, the present demands within each cell can be easily calculated since the percentage of each land use type within the cell is known (this is part of the data).

The growth portion of the model takes us from the existing cell demands to the cell demands at some future point in time. Two possible ways land use within a cell can change are modeled, referred to as the two growth modes. The first of these, vacant development, is a process whereby all land area that is presently being used remains unchanged with respect to use and all vacant developable land is developed in accordance with the city zoning for that area. All city zone types are matched with one of the fourteen land use types used by the model. The second growth mode is complete redevelopment of the area. In this mode, all area that is presently used as well as vacant area is transformed to its zoned usage. Since, in the City of Dallas, the zones reflect a land use plan rather than actual use, the city zoning is an indication of ultimate land use for an area. Of course zoning changes, but it is today's best guess at the future use.

Up to twenty separate areas can be identified for growth. Each of these areas may have a separate growth amount which equates to a percentage of vacant land developed in the vacant development mode or a percentage of "zonal compliance" in the redevelopment mode. Figure 2 illustrates this growth area concept by indicating four possible growth areas with an estimated growth amount for each. The growth areas are chosen based on experience as well as the outputs of other population trend models such as the Urban Growth Simulation Model used by the Department of Transportation, North Central Texas Council of Governments. The growth areas and growth amounts are influenced most by the target year for which the projection is being made. That is, larger areas are expected to have higher growth amounts as one looks further into the future.

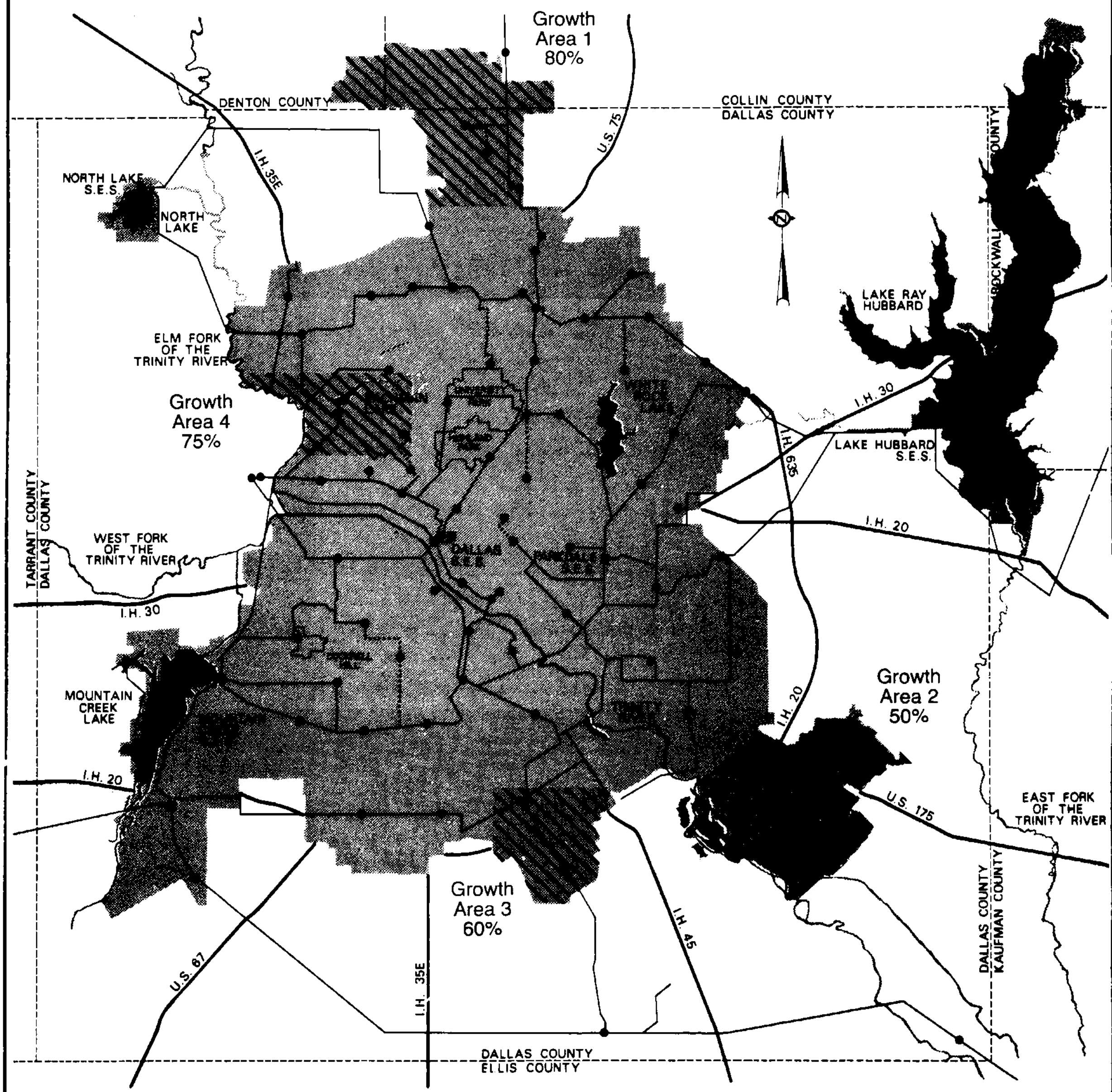

Growth
Area 1
80%
DENTON COUNTY
COLLIN COUNTY
DALLAS COUNTY
U.S. 75
I.H. 35E
NORTH LAKE
S.E.S.
NORTH
LAKE
LAKE RAY
HUBBARD
ELM FORK
OF THE
TRINITY RIVER
Growth
Area 4
75%
I.H. 30
LAKE HUBBARD
S.E.S.
I.H. 635
I.H. 20
TARRANT COUNTY
DALLAS COUNTY
WEST FORK
OF THE
TRINITY RIVER
DALLAS
S.E.S.
I.H. 30
MOUNTAIN
CREEK
LAKE
Growth
Area 2
50%
I.H. 20
I.H. 20
U.S. 175
EAST FORK
OF THE
TRINITY RIVER
Growth
Area 3
60%
I.H. 45
DALLAS COUNTY
KAUFMAN COUNTY
U.S. 67
I.H. 35E
DALLAS COUNTY
ELLIS COUNTY

Figure 2

Since technological and psychological changes can affect energy use patterns, the model allows external adjustment to the land use demand densities if the user has information that indicates energy use patterns will change for any or all of the land use types by the study year. After the future cell demands are obtained, they are fed from distribution substations.

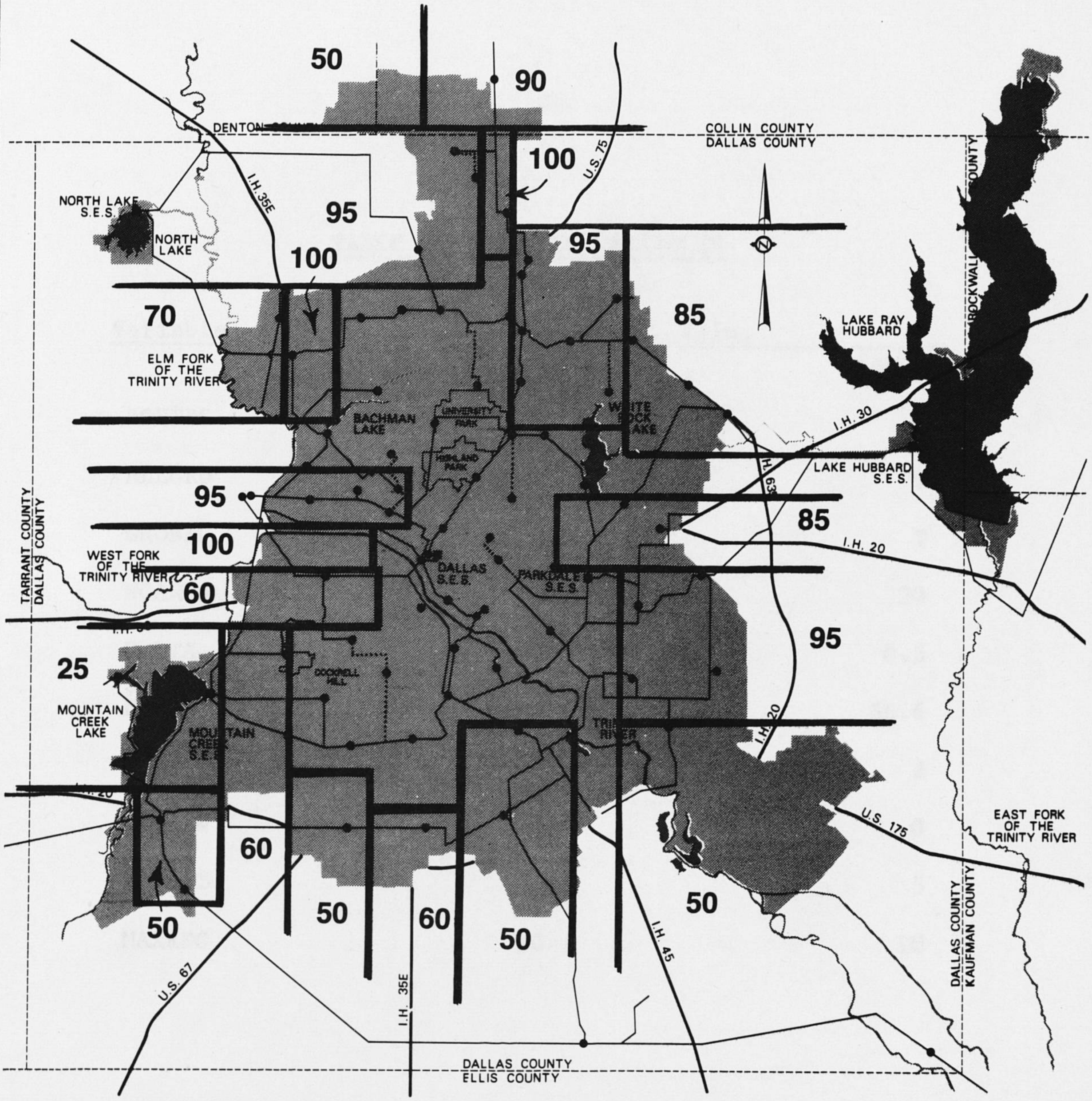
The process by which substations are assigned demands from the cells is called gathering since the substations go from cell to cell collecting increments of demand. Initially, a substation feeds all of the demand within its own cell. Then it reaches out to all cells adjacent to its own. If capacity is still available, it then reaches out to the next layer of cells and the process continues until either all the capacity is used, all the cells are satisfied, or the maximum distance a substation is allowed to reach is exceeded. After this process is completed, there may still be some cells with unsatisfied demands. In these cases the model will select locations for additional substations in those cells with the greatest unsatisfied demands. The number of substations that will be created at any one time is a user specified variable. During the gathering process, the relationship between each substation and each cell, if one exists, is recorded so that we know which substations feed which cells and the demand satisfied by each substation. A measure of the distribution line loss is also maintained for each substation as a sum of all demands satisfied times the distance from the substation to that demand.

Results

The small area model was used to project the demands that would exist in a period twenty years from now. The growth areas selected and the amount of growth in each are shown in Figure 3. It should be noted that although some amount of effort was put into this selection, the primary purpose of this growth case was to exercise the model. Table 2 lists the significant control variables used during the model runs. For a description of the variables and their function see Appendix B, Table B-2. One run was made with growth taking place in the vacant development mode (case 1) and another with the redevelopment mode (case 2).

In the vacant development mode case, the run resulted in nine additional substations. These are indicated by triangles or stars in Figure 4. The run using redevelopment growth identified thirty-five additional substation locations. The circles or stars indicate their locations in Figure 4. In Figure 4 the stars indicate locations selected by both runs of this test case.

Six of the nine substation locations created in the first case have identical positions to those of the second case. The other three are in the same general area as three substa-



Dallas Power & Light Company
Service Area and Major Facilities

0 SCALE IN MILES 5

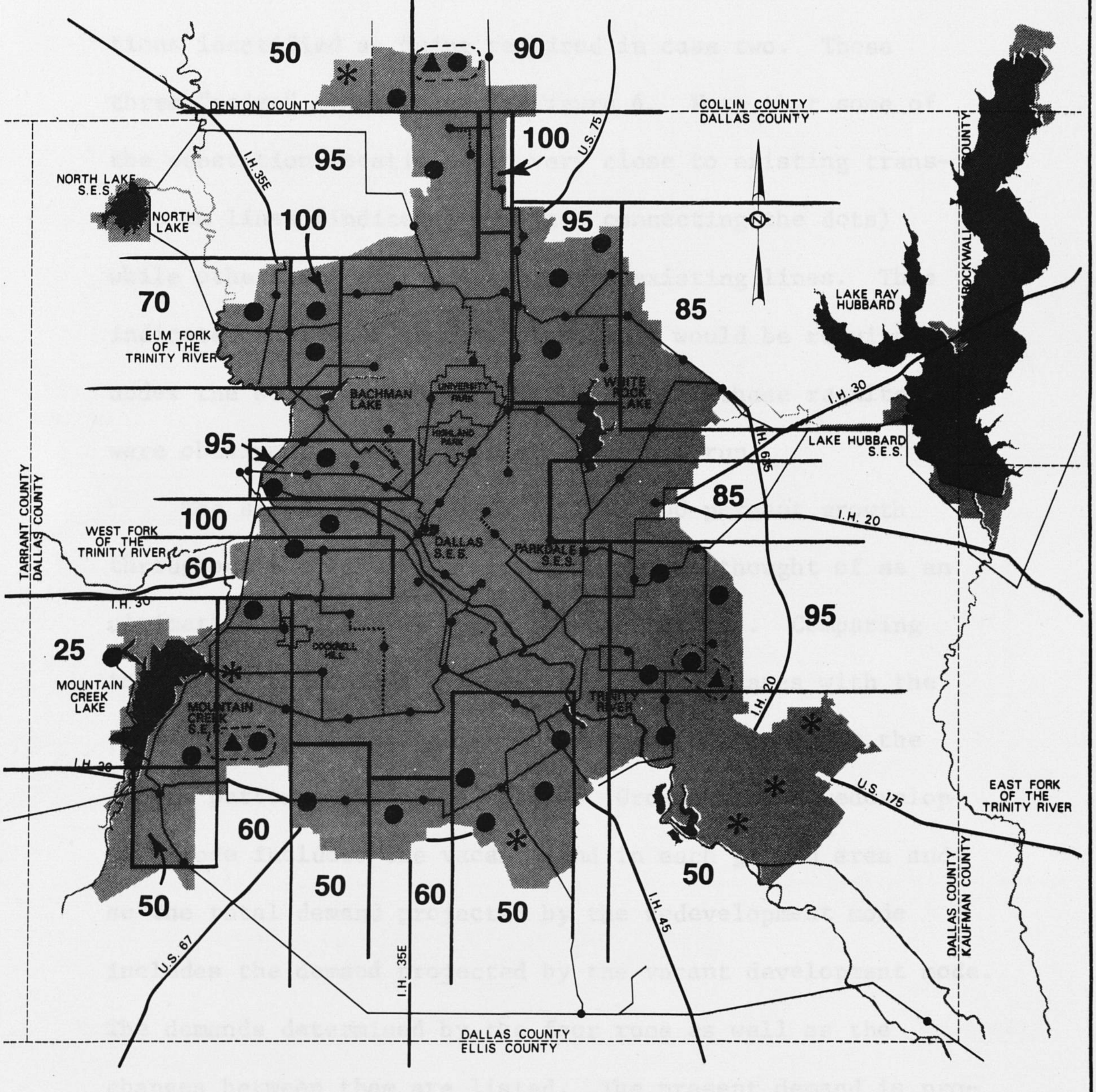
LEGEND

- ■ GENERATING STATION
- —— TRANSMISSION LINE - OVERHEAD
- ------ TRANSMISSION LINE - UNDERGROUND
- • SUBSTATION OR SWITCHING STATION

Figure 3

TABLE 2: EXAMPLE VARIABLES

Variable	Value	
	Case 1	Case 2
BOUNDS	F	F
ALLGRO	F	T
GROBND	T	T
NGAREA	20	20
DELTA	0.5	0.5
NEWLMT	66.6	66.6
NNEW	2	2
DELNEW	0	0
MDBSUB	5	5
MAXRNG	10	10



Dallas Power & Light Company

Service Area and Major Facilities

0 SCALE IN MILES 5

▲ VACANT DEVELOPMENT
● REDEVELOPMENT
* COMMON CELL
(●▲) COMMON PAIR

LEGEND

■ GENERATING STATION
—— TRANSMISSION LINE - OVERHEAD
------ TRANSMISSION LINE - UNDERGROUND
● SUBSTATION OR SWITCHING STATION

Figure 4

tions identified as being required in case two. These three "pairs" are circled in Figure 4. Note that some of the substation locations are very close to existing transmission lines (indicated by lines connecting the dots) while others are quite distant from existing lines. This indicates where new transmission lines would be required under the selected growth pattern. After these results were obtained, another pair of cases was run.

The second set of cases assumed 100 percent growth throughout the service area. This may be thought of as an ultimate saturation or upper bound condition. Comparing the projected demands of these two sets of cases with the presently experienced actual demands brings to light the growth patterns shown in Table 3. Growth in the redevelopment mode includes the vacant land in each growth area and so the total demand projected by the redevelopment mode includes the demand projected by the vacant development mode. The demands determined by the four runs as well as the changes between them are listed. The present demand is provided as a reference point.

Subtracting the growth in demand due to vacant development from the total growth leaves that portion of the growth due to land use changes. This basis for growth and the

TABLE 3: GROWTH PATTERNS

	MODE					
	Vacant			Redevelopment		
Time Period	MW		%	MW		%
Present	2343	-	-	2343	-	-
20 Years	3243	900	58	4742	2399	39
100%	3887	644	42	8468	3726	61
Total Growth to 100%		1544	100		6125	100

TABLE 4: GROWTH BASIS

Period	Total Growth	-	Vacant Growth	=	Use Change Growth	% Vacant	% Use Change
Present to 20 Years	2399		900		1499	38	62
20 Years to 100%	3726		644		3082	17	83

TABLE 5: DISTRIBUTION LINE LOSSES AND SUBSTATION LOADING

Mode	Size (MW)	Number	"Loss"	% Loading
	80.0	86	2.11	87
Redevelopment	66.6	88	2.11	89
	66.6	93	1.82	84
	80.0	71	2.28	77
Vacant	66.6	73	2.21	79
	66.6	75	2.07	76
Present	Varies	68	1.66	65

percentages of growth due to both bases are shown in Table 4. Note that 38 percent of the growth over the next twenty years is due to development of presently vacant land while only 17 percent of the growth beyond twenty years is attributable to the same basis. This is due primarily to the "using up" of vacant land.

The model can also be used to investigate the effects that substation size and the number of substations have on voltage drop (megawatt-miles), losses (megawatts squared-miles) and percent average substation loading. A comparison among several runs is given in Table 5. Again, the present is included for comparison purposes. In general, as the number of substations is increased, losses due to distribution lines decreases along with the average loading. In all cases the substations are more heavily loaded than they are at present.

Conclusions and Recommendations

To date, application of the model has been limited to a relatively small number of cases. In every case the model has performed as expected. Based on this limited experience, it appears that the LANDUSE program will be a useful tool for system planners, especially those involved in distribution planning. Some of the program features have not been used other than for programing checks. For example, if the BOUNDS feature were used, portions of the system that required further analysis could be investigated without calculating results for the entire system.

One limiting factor was discovered during the selection of the twenty growth areas and their growth amounts. The present program requires that all growth areas be grown by the same mode. In reality, growth takes place by both modes not only in different areas but even within a given area. To overcome this inflexibility, the growth subroutine will be reprogramed to allow both modes of growth in each growth area. Each mode within an area will be able to have its growth amount specified independently.

Appendix A - Small Area Model

General

While traditional load forecasting methods and models are frequently used to determine future peak demands and energy requirements, they do so on a system wide basis which does not allow the user to gain insight into the geographical location of future load centers. This missing information is required if one is to provide long range predictions for the purpose of substation siting. To overcome this shortfall, a small area load forecasting model was developed that uses incremental areas called cells as the basic building blocks of the service area. The size of this cell is not a model dependent absolute but rather a variable which is determined by the resolution required by the user for a particular application. There is almost always a trade off between desired resolution and data collection costs. In general, the farther into the future one looks, the larger the cell may be. Assumptions associated with the development and implementation of this small area model are based on the prime assumption that the cell size has been selected so that the required resolution can be obtained. That is, the uses of the land contained within any given cell can be represented as a homogeneous "mixture" spread throughout the cell. For example, if a given cell contains the following land usage: 50% small residential, 30% small commercial, and 20% light industrial, the areas within the cell that are used for these purposes could not be distinguished. They would, in effect, be blurred together. We would know, for example, that 20 percent of the cell was used for light industrial purposes, but we would be unable to tell where within the cell this activity takes place.

The same thought process carries over to the electrical feeders within the cell. We know which feeders supply energy to the cell but the information concerning which parts of the cell are fed by each is lost. Having determined that whatever size has been selected will be adequate for the purpose at hand, we can now proceed into the theory of the small area projection model.

Theory of the Model

This model projects future electrical demands based on land usage. The model is actually a land use projection tool rather than an electrical model although part of the model does determine the electrical load densities for various types of land usage. Initially, present electrical demands for eleven land use types are determined by overlapping areas of feeders and cells. Figure A-1 illustrates this overlapping process. The common area of cell "I" and feeder "F-1" is shown shaded. Assume the peak demand for feeder "F-1" is D_{F-1} and that cell "I" is composed of 20% land use 1, 30% land use 2, and 50% land use type 3. Further assume that 40% of the feeder area is overlapped by the area of cell "I". The demand for land use 2, let us call it D_{LU-2} is given by:

$$D_{LU-2} = 0.30 \text{ X } 0.40 \text{ X } D_{F-1}$$

Since all land uses do not have the same electrical demand density, this initial estimate always contains some error if the cell encompasses more than one land use type. Even with only one land use type within the cell, error would be present if any of the feeder area contained other land use types. To overcome this difficulty, relative demand densities for all the land uses

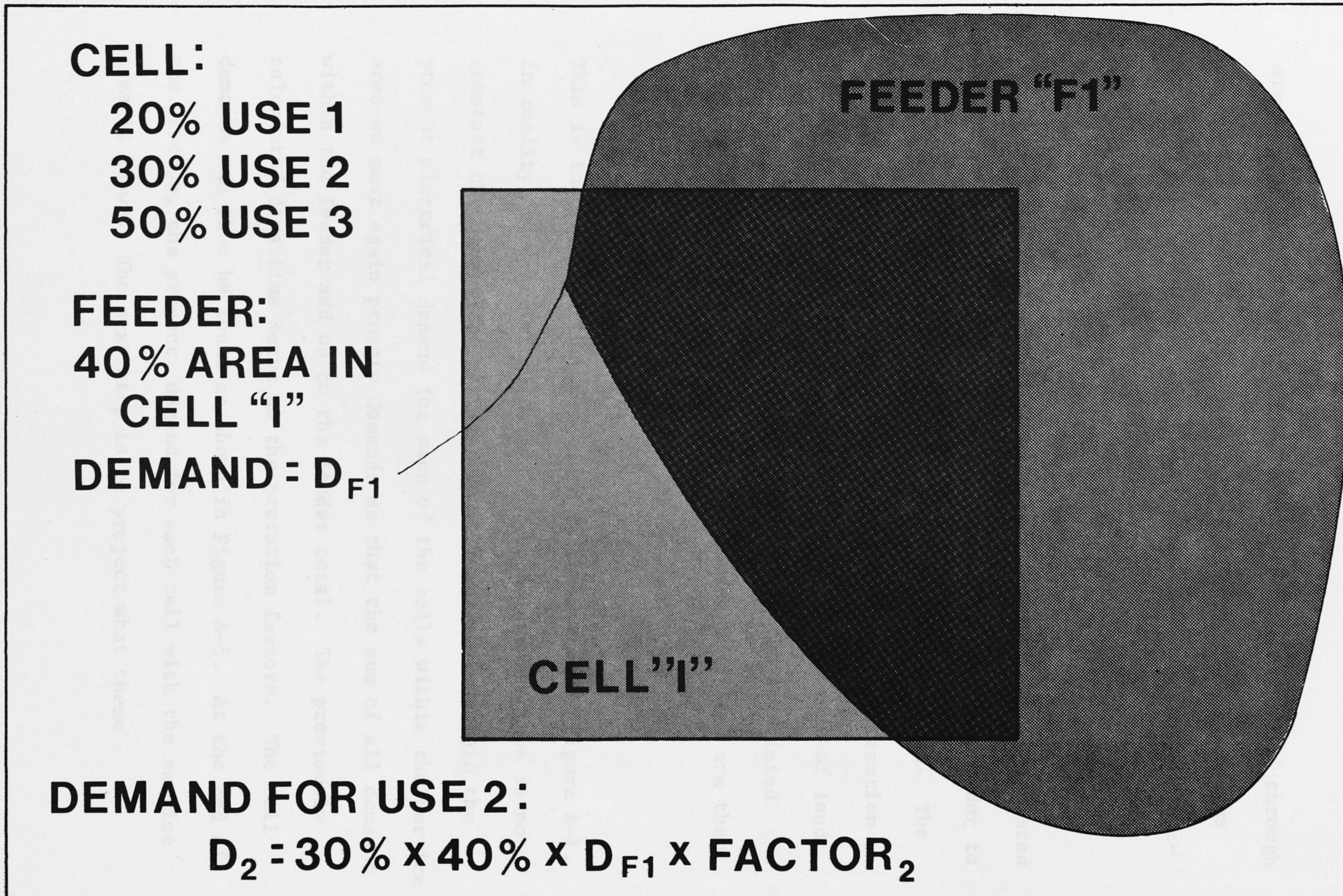
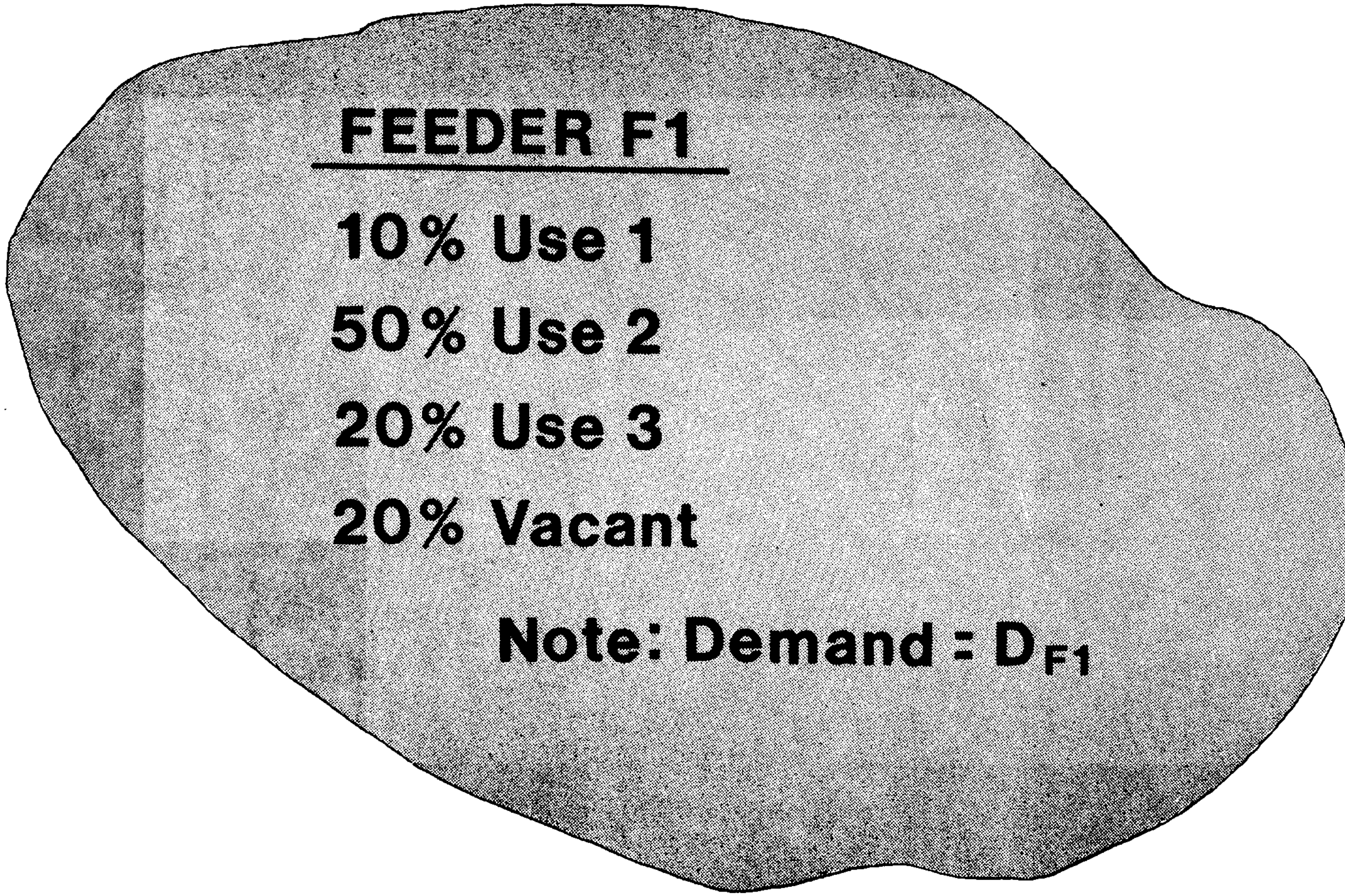

CELL:
20% USE 1
30% USE 2
50% USE 3
FEEDER:
40% AREA IN
CELL "I"
DEMAND = D_{F1}
FEEDER "F1"
CELL "I"
DEMAND FOR USE 2:
$D_2 = 30\% \times 40\% \times D_{F1} \times FACTOR_2$

Figure A-1

are determined. These relative demand factors are found through an iterative process. Initially, all the nonvacant land uses are assigned factors of 1.0 while vacant uses are assigned factors of 0.0. The total feeder demands are preserved through a proration of the total feeder demand among the land uses as shown in Figure A-2. After an initial iteration, the calculated demand densities for each land use type are compared in order to find the relative density factors for the next iteration. The process continues until there is no change from one iteration to the next. Figure A-3 shows a typical convergence case of land use demand densities and Figure A-4 presents the associated relative demand density factors. New demand densities are then calculated as follows:

$$D_{LU-2} = 0.30 \text{ X } 0.40 \text{ X } D_{F-1} \text{ X (factor for use 2)}$$

This is the equation that was given at the bottom of Figure A-1. In reality, the electrical demand for each land use type is not constant throughout the service area. In order to obtain the present electrical demand for each of the cells within the service area we must again prorate demands so that the sum of all demands within the feeder add up to the feeder total. The previously calculated densities serve as the proration factors. The cell demands can then be found as shown in Figure A-5. At the end of the process, the present demand for each cell with the service area is known. The next step is to project what these



New Demand For Use 2:

$$D'_2 = \frac{D_2}{D_1 + D_2 + D_3} \times (D_{F1})$$

Figure A-2

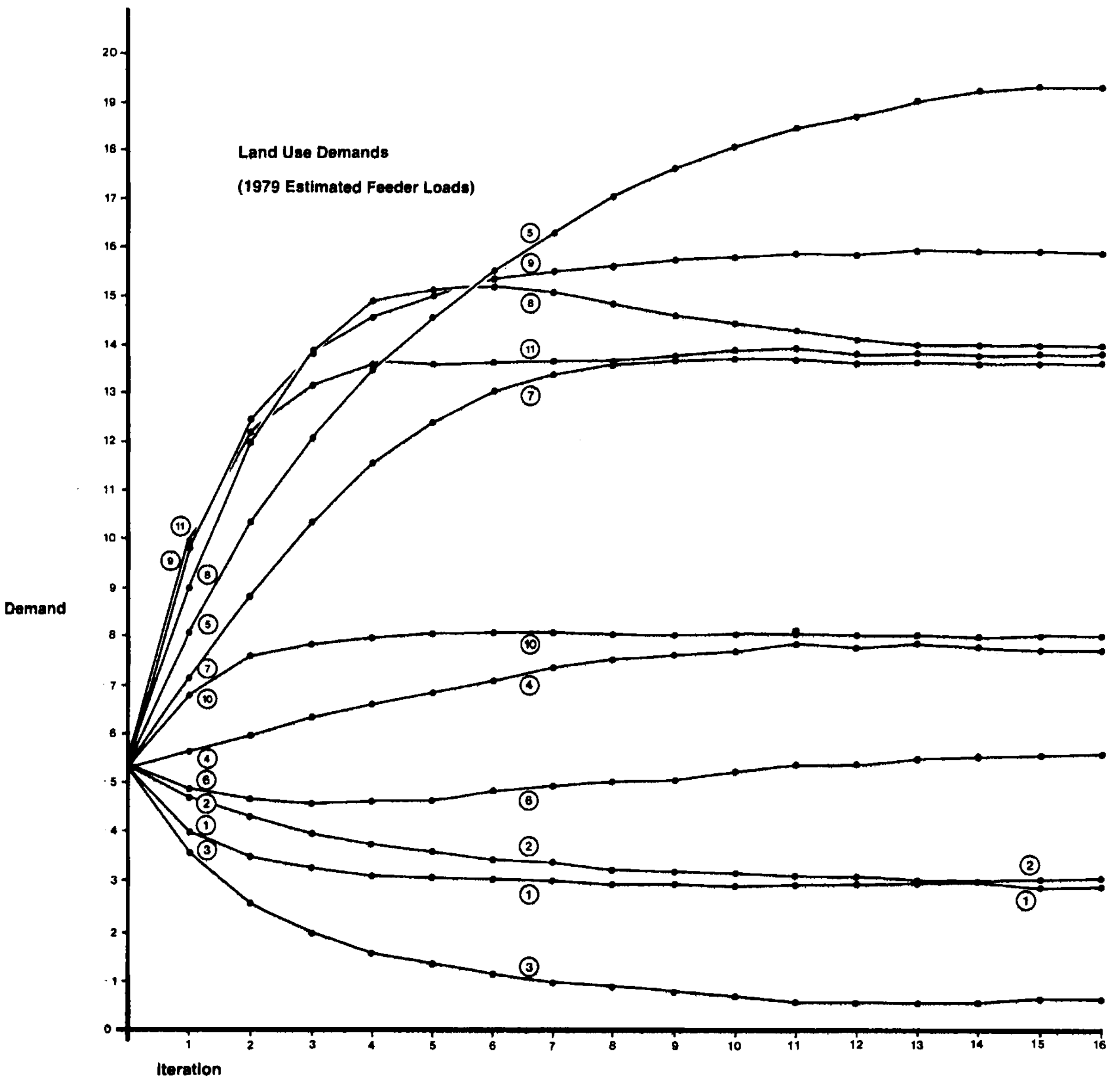

Land Use Demands
(1979 Estimated Feeder Loads)
Demand
Iteration
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Figure A-3

Land Use Factors (1979 Estimated Feeder Loads)

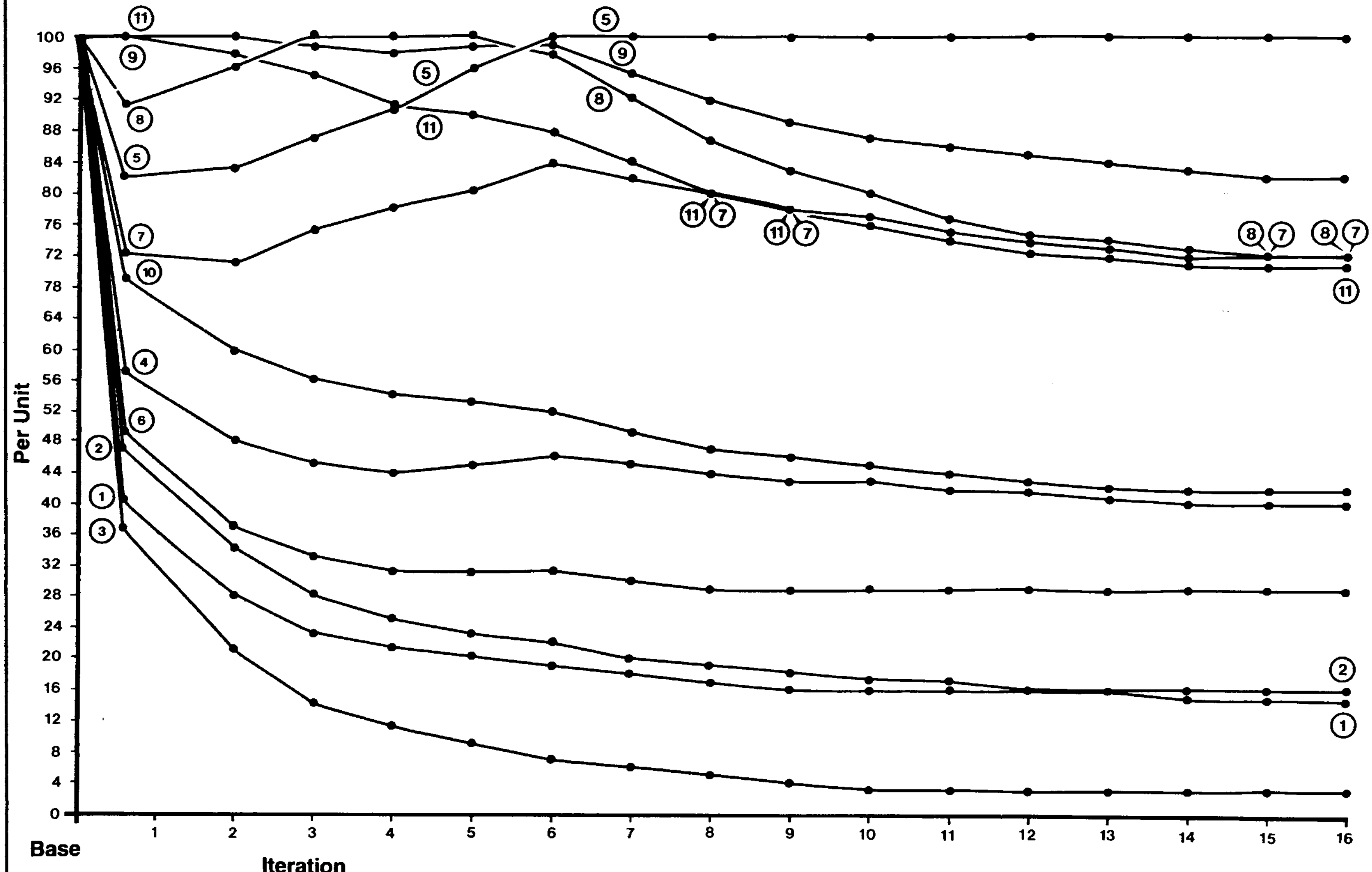
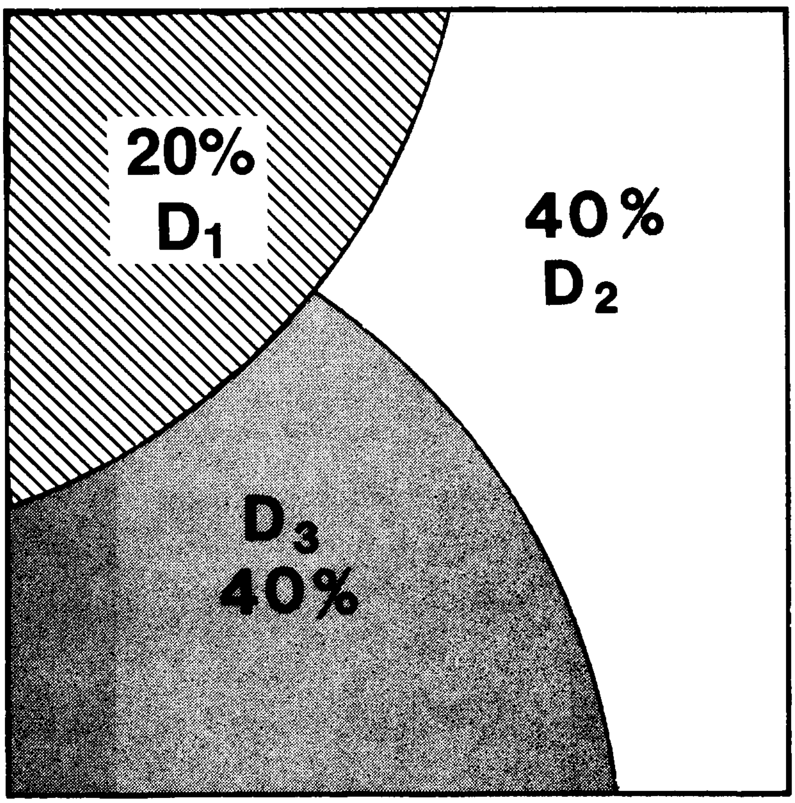


Figure A-4

CELL DEMANDS



$$\text{CELL KW} = 20\%\ D_1 + 40\%\ D_2 + 40\%\ D_3$$

Figure A-5

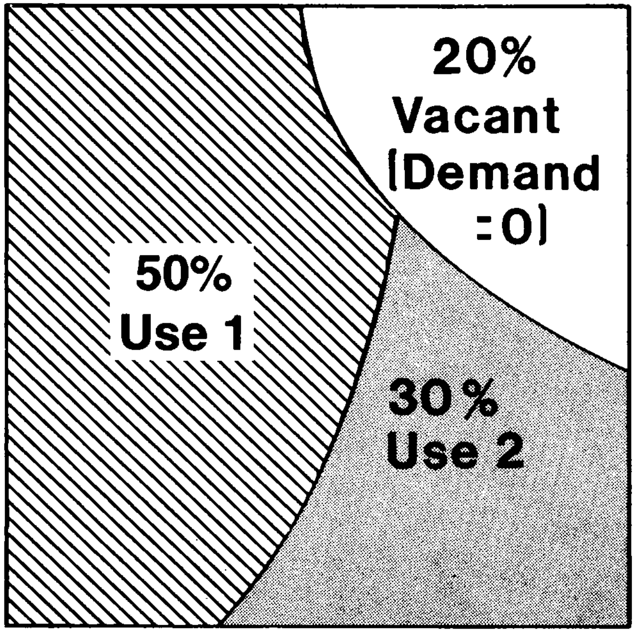
demands will be at some future point in time. In order to accomplish this task, a land use growth process is used.

Growth Process

The land use within a cell can and will change over time. Within the City of Dallas, zoning reflects a land development plan rather than an actual use. Because of this, the city zoning is used as the future use for all land. This model considers two possible methods of growth from the present land usage to that indicated by the zoning. These methods are referred to as the growth modes. The first mode will be called "vacant development" because in this mode only the land that is presently vacant is changed in use. That is, the previously vacant land is now developed. The second growth mode is called "redevelopment" since in this mode all of the land within a cell is changed from present use to that dictated by the city zoning for that area. It should be noted that in both modes the growth takes place as indicated in the city zoning ordinances for that area in question. If a cell has more than one zoning within its boundaries, the land is developed or redeveloped with a demand that is the weighted average of the demands associated with those uses. This process is shown in Figure A-6. The redevelopment mode is referred to as the alternate method in this figure. The GFACTOR is an area growth factor described below.

Ideally, one would specify the extent of development that takes place within each cell by the target year. This is not

GROWTH



ZONES:

$20\% \; Z_1 \rightarrow D_{Z1}$

$40\% \; Z_2 \rightarrow D_{Z2}$

$40\% \; Z_3 \rightarrow D_{Z3}$

"NEW" DEMAND:

$D_N = 20\% \; D_{Z1} + 40\% \; D_{Z2} + 40\% \; D_{Z3}$

$\text{CELL KW}' = \text{CELL KW} + (20\% \; D_N \times \text{G FACTOR})$

Alternate: $\text{CELL KW}' = (20\% \; D_{Z1} + 40 \; D_{Z2} + 40\% \; D_{Z3}) \times \text{G FACTOR}$

$= D_N \times \text{G FACTOR}$

Figure A-6

possible in practice so a number of growth areas are identified and all of the cells within these growth areas are developed by the same amount. This growth factor (GFACTOR) indicates the percent of development or redevelopment that takes place within the cells of that growth area. While the model does not limit the number of growth areas, the computer implementation presently limits the user to twenty areas. At present all areas must be grown by the same mode; however, this restriction is being relaxed by a programing modification that will allow each area to be grown by both modes with separately specified amounts. When the growth process has been completed, projected demands for each cell within the service area are calculated by applying the electrical demands for each land use type to the projected uses. The next task is to satisfy these scattered electrical demands.

Gathering Process

The projected cell demands are satisfied through a "gathering" process whereby the individual cell demands are gathered to distribution substations. Initially, existing substations are used until they are fully loaded or loaded to the desired level. If some demands remain after this is completed, additional substation locations are selected which will satisfy the remaining demand. The gathering process proceeds as follows.

Initially, an existing substation satisfies all of the demand within its own cell. If this demand is larger than the substation's capacity, the remaining demand will be satisfied by adjacent substations if they have available capacity. If the adjacent substations are also at maximum load, a new substation location will be selected that can satisfy the demand. If the substation has remaining capacity after satisfying the demand within its own cell, it reaches out to adjacent cells and satisfies the demands within these cells. The maximum distance (RANGE) a substation is allowed to reach out is called the MAXRNG and is equivalent to specifying a maximum feeder length. The RANGE is increased by one cell each iteration. An iteration being one pass through all substations at a given range setting. During each iteration the substations with remaining capacity reach out another cell in range until the maximum range is attained.

If a demand is within the range of two or more substations, they take turns satisfying portions of the demand. Figures A-7 through A-10 demonstrate this gathering procedure. If all of the cell demands have been satisfied, the gathering process stops. If all of the substations within MAXRNG of an unsatisfied demand are at full capacity, a new substation location will be selected to satisfy this demand. The capacity of this new substation is a user specified input variable (all new substations will have the same capacity). A cycle is defined as that period between substation creations; during any given cycle the number of substations remains constant. The selection of a new substation location coincides with the start of a new cycle. The maximum number of cycles as well as the maximum number of substations that can be created at any one time are user specified input variables.

GATHERING - STEP 1

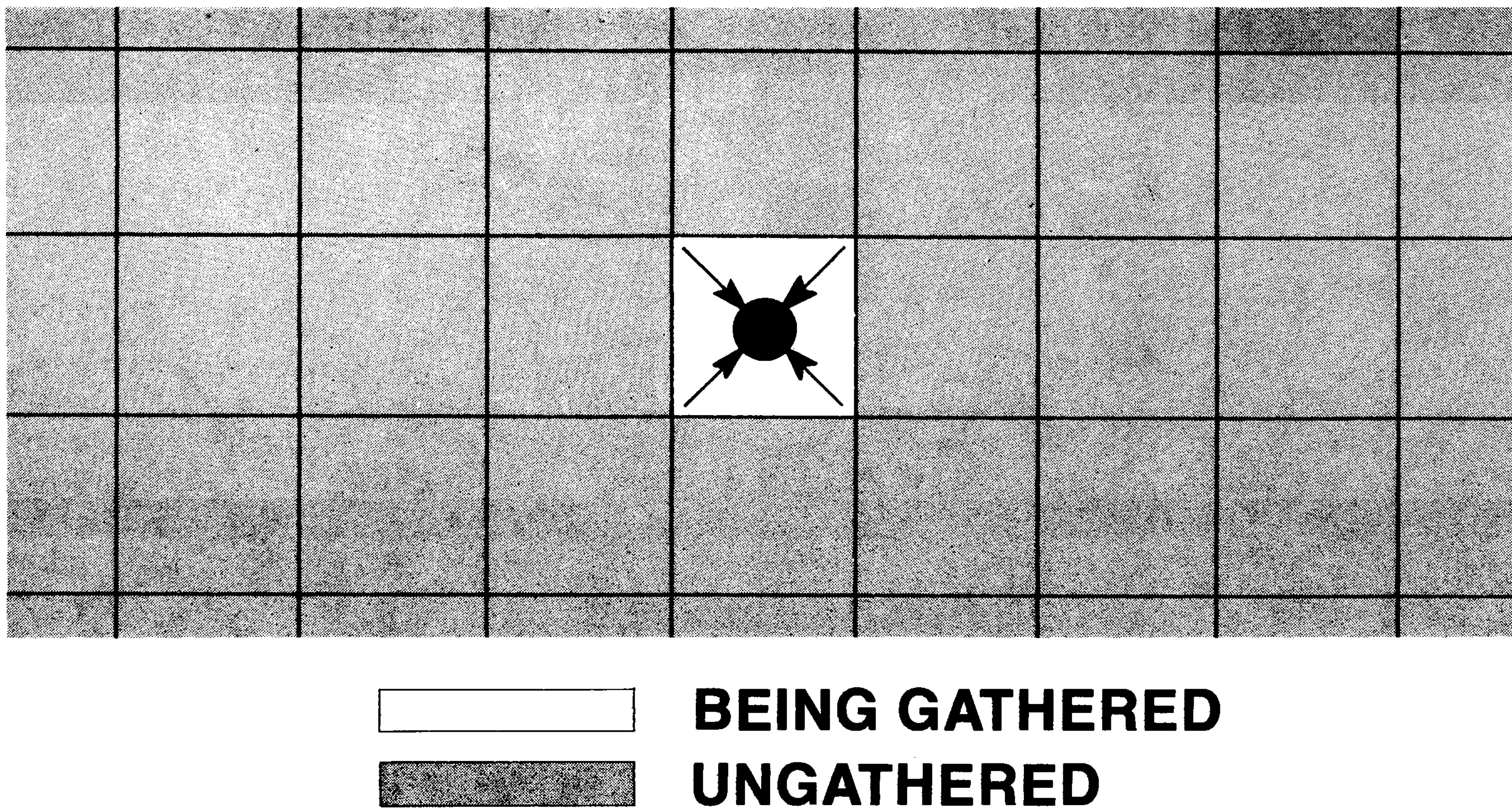


Figure A-7

GATHERING - STEP 2

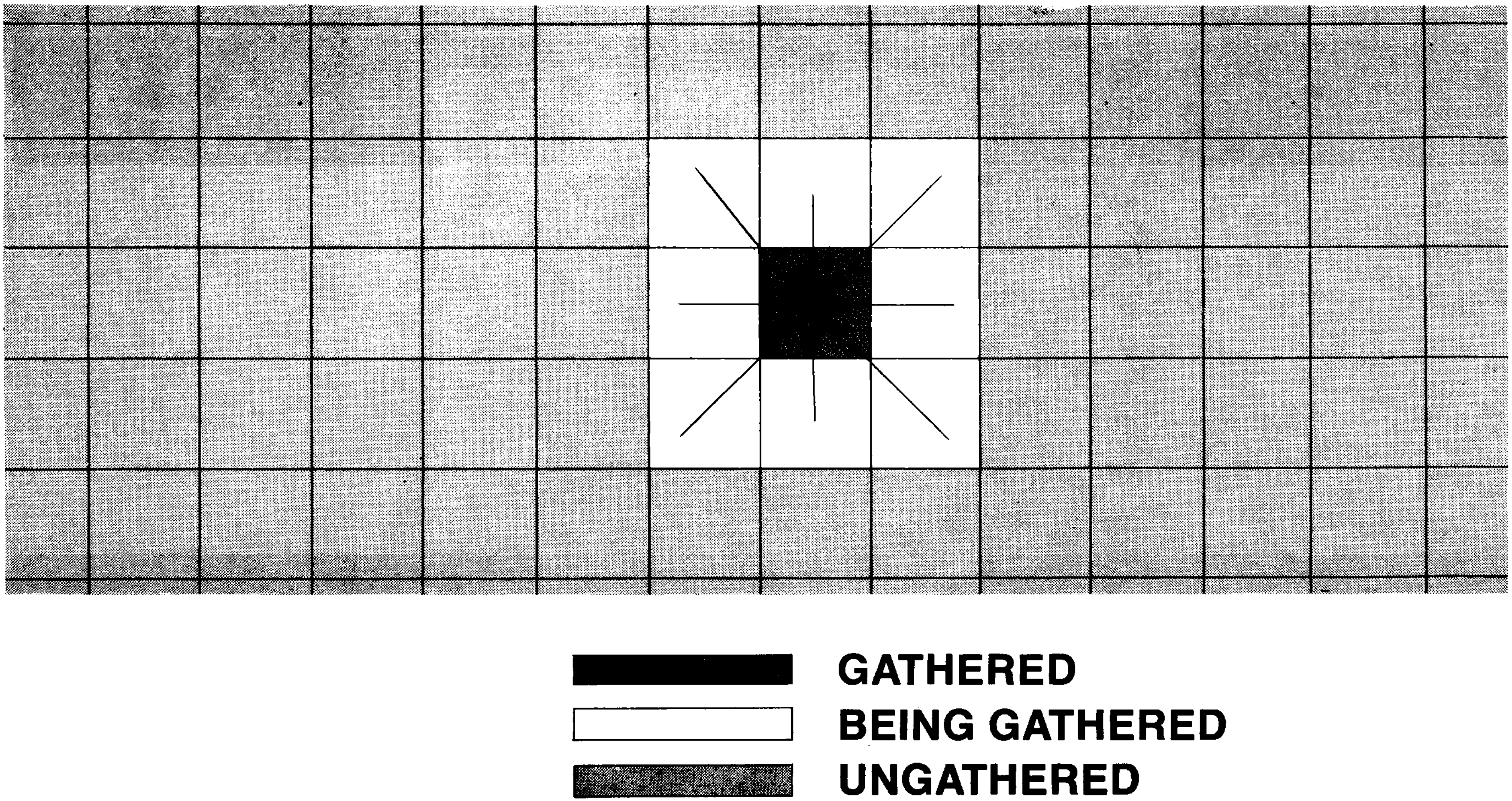


Figure A-8

GATHERING - STEP 3

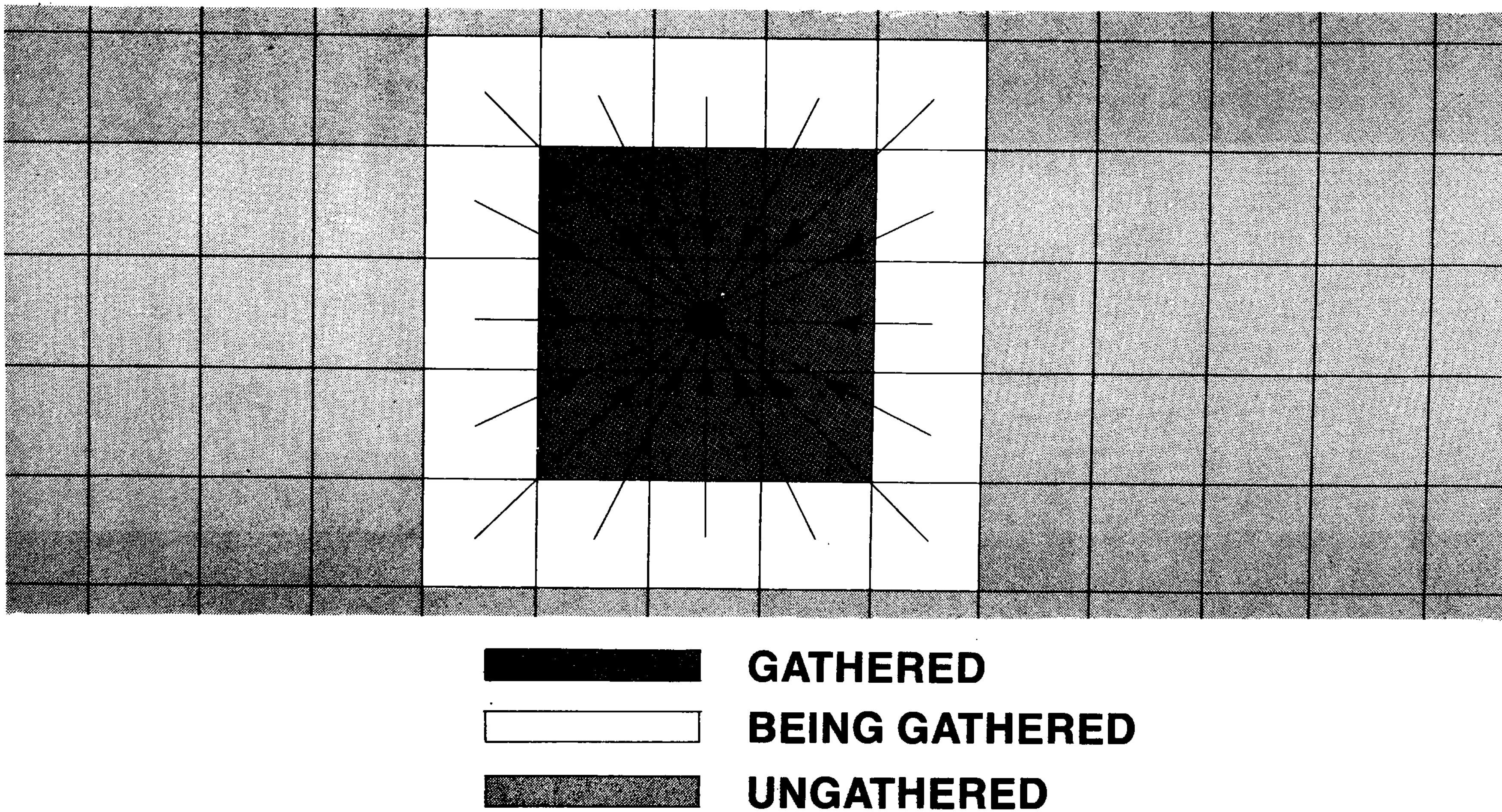


Figure A-9

GATHERING - BOUNDARIES

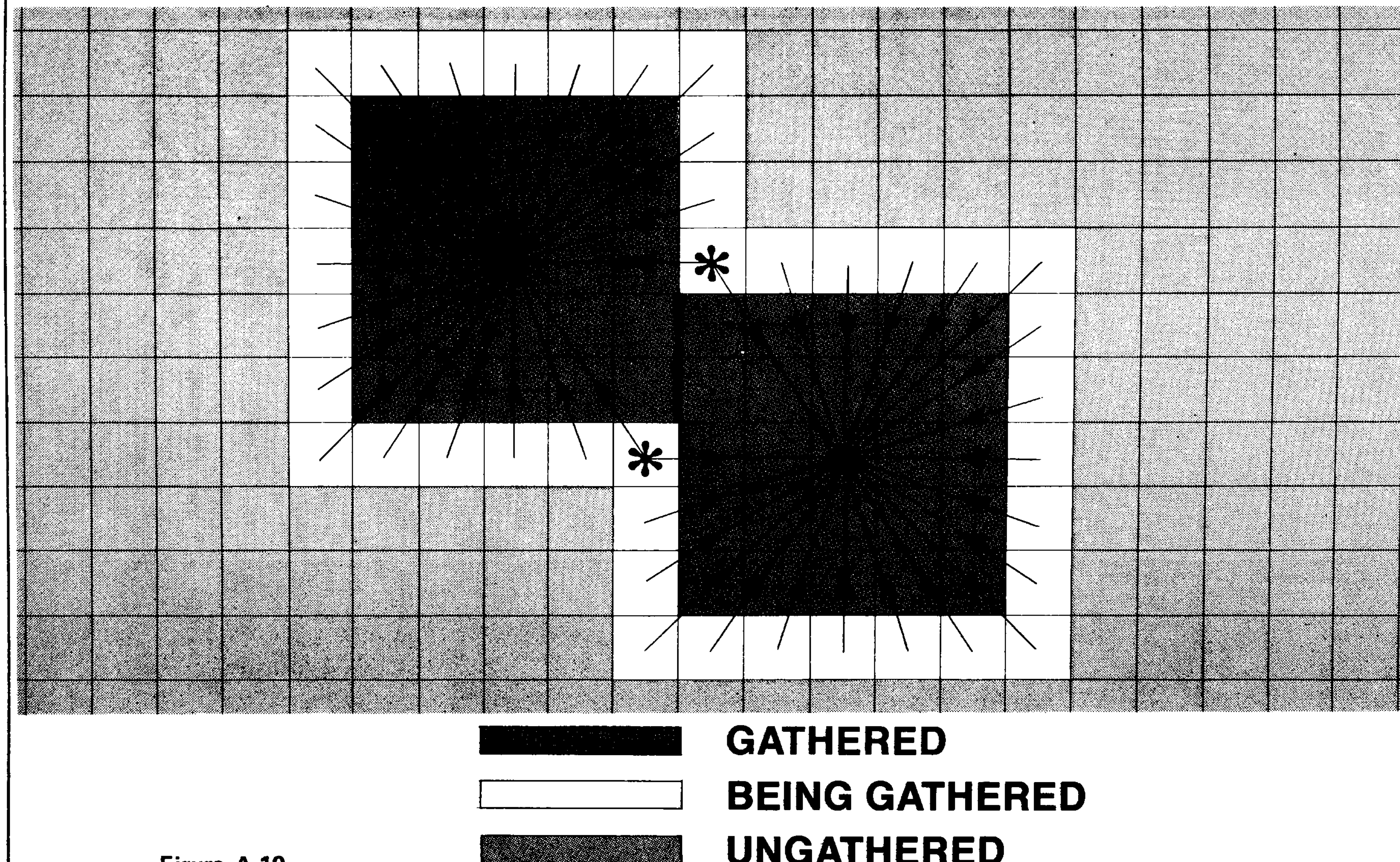


Figure A-10

Appendix B - LANDUSE User's Guide

General

The LANDUSE computer programs implement the small area growth model described in Appendix A. It is assumed that the user has read through Appendix A prior to this point and that he/she has a general overall understanding of the model being implemented. This model has the capability of determining load densities for various land uses throughout the DP&L service area. These land use related demand densities are later used to project the future demands based on the projected land uses within the service area. Control variables determine which functions are executed and which data sets are used.

Data to the programs falls into three main categories: cell and feeder data, substation data, and control data. Each of these will be covered in more detail later in this guide.

Table B-1 lists the LANDUSE computer routines by name and version/modification number for the DP&L UPIN computer file. Also included in this table is a brief comment concerning the routine's purpose. LUSE is the main control program which calls the subroutines needed to accomplish the tasks indicated in the control data. INPUT, CHECKF and NORMAL take the raw data and determine the relative demand densities for the fourteen land use types and the present kilowatt demand for each cell in the service area. After this is accomplished, the user has the option of storing these intermediate results or continuing on to the growth phase.

Subroutine GROW takes the existing cell demands and modifies them according to one of two possible growth procedures. The first procedure assumes that only the vacant developable land within a cell will be developed. This land is then developed according to the way the area has been zoned by the controlling city. The second growth procedure involves a complete redevelopment of the land within the cell. Again, this development takes place as the land is zoned. In both cases, the user can specify up to twenty growth areas within the service area and select an independent growth for each of these areas. At the present time the computer implementation requires that all areas be grown by the same method (vacant areas being developed or complete redevelopment). Future modifications to the program will allow the user to specify either or both methods for each growth area independently. Each area will then have the possibility of two separate growth rates: one for development of vacant land and another for redevelopment. After completion of the growth process and the determination of "new" cell demands in kilowatts, these scattered demands must be fed from existing substations or new ones if the existing substation capacity is insufficient.

TABLE B-1

LISTING OF LANDUSE COMPUTER PROGRAMS

Routine Name	LANDUSE VER-MOD	Comments
LUSE	01 01	Main Program, calls subroutines, reads some control data, provides some output.
VAR	01 02	A group of non-executable comments describing the global variables, fourteen land use types, and the age codes.
INPUT	02 01	Reads data, sets and performs some preliminary data processing.
CHECKF	03 01	Checks feeder data, finds first and last cell record number for each feeder, number of cells fed by each feeder, adjusts feeder percentages to sum to 100%(+/- 5%).
NORMAL	04 01	Applies land use relative demand factors, calculates a modified feeder percentage.
BLOCK DATA	05 01	Initializes variables in common blocks MAIN4, MAIN2, and GROWBK.
GRID	06 01	Calculates the grid coordinates from the district and quadrant designation.
Common Variables	06 02	Contains the common block information for blocks MAIN4, MAIN2, and the associated type and dimension specifications.

TABLE B-1 (CONTINUED)

Routine Name	LANDUSE VER-MOD	Comments
Common Variables	06 03	Contains the common block information for GROWBK and the associated type and dimension specifications.
ORDER	07 01	Places the feeder list in alphabetical order.
PLOT	08 01	Plots selected variables on a cell coordinate "map".
STAT	09 01	For any given data set, calculates: Maximum value, Minimum value, Mean, Variance, Standard deviation of the mean, Variance of the mean, Variance of the data, Standard deviation of the data, Upper and Lower bounds for the 95, 90, 80, 70 and 60 Percent Confidence Intervals.
ABORT	10 01	Prints three "ABORT" pages and reads any remaining data cards.
OUT	11 01	Provides output by cell, feeder, and land use type.
SCATTR	12 01	Determines the demand density for each of the land use types and calls STAT for the statistics.
PLTR	(PLTR 01 01)	Continuous plot routine that plots up to four variables on the same set of axes as they are calculated.
DUMPS	14 01	Stores intermediate results on disk.

TABLE B-1 (CONTINUED)

Routine Name	LANDUSE VER-MOD	Comments
GROW	15 01	Provides for growth in up to twenty separately identified areas, each with its own level of growth. Two methods of growth are possible: vacant land only, or complete redevelopment up to the level specified.
ZCHG	16 01	Converts the City Zone to the equivalent land use type.
SECOND	20 01	A secondary control routine that controls the gathering process.
(main)	20 02	The main program equivalent of subroutine SECOND. It also reads the intermediate results from disk (FETCH).
GATHER	21 01	Gathers cell demand to substation locations, creates additional substations as required, keeps track of all substation-cell relationships.
FETCH	22 01	Reads the intermediate results from disk file.

This process takes place in subroutine GATHER. Results are printed by subroutine OUT.

The LANDUSE control variables are presented in the control variable section. This section gives a detailed description of the action initiated by these variables. The specified action is only taken if a control variable has the indicated value. For example, if the list states "XYZ will happen if ABC is equal to 0" and no reference is made to any other value of ABC, action will only be taken if ABC is equal to "0" and any other value of ABC is ignored.

The program tracks all cell data on a grid coordinate basis. This grid is composed of a north-south ordinate and a east-west abscissa with the origin located at the southwest corner of Dallas County for the DP&L data. The origin is dependent only on the input data and subroutine GRID. If the user desires to make use of the BOUNDS feature, the bounds are also specified in grid coordinates. Since the program stores cell data in a compact form, pointers relate the storage locations to the grid coordinates. These pointers, called EAST and NORTH, provide the east and north coordinates for the cell data set sequence number. That is, EAST(I) contains the east coordinate of the I-th cell in the cell data set.

Substations specified in the data set will be used during the first cycle of the gathering routine. If no substation locations are specified, the program will create NNEW (number of new substations created per cycle) substations prior to starting the first cycle. These substations will be located in the NNEW cells with the greatest demands while maintaining a spacing of at least MDBSUB (minimum distance between created substations in one cycle). Whenever a run results in the creation of a number of substations, it is always a good idea to specify these locations and run the gathering routine again. This procedure assures that all the substations will be loaded as evenly as possible.

Control Variables

This section contains a listing of the LANDUSE computer program control variables and a description of the actions caused by each of them. A careful reading of this list together with the "LANDUSE Data Requirements" section of this guide will prove to be invaluable to the user of this program. This listing is ordered in the same sequence as the data set in which the variables will be specified. However, if a conflict of order should arise, the order presented in the data requirements section is to be used. Figure B-1 presents an overview of the options (selected through the control variables) for the main control program. The options available in subroutine GATHER are summarized in Figure B-2.

All bounds are parallel to the axes and areas must be specified with four bounds even if one of the bounds is outside the service area (which is frequently the case with the bounds that determine growth areas). The DEBUG controls should only be used if there is a problem or if data tracking through the program is necessary.

NOTE WELL: Be especially careful when specifying GDEBUG greater than one since this results in a number of pages of

OPTIONS

MAIN PROGRAM

(A) Out Put:
- IDEBUG
- CDEBUG
- NDEBUG
- INLIST

(B) Control:
- ISCAT
- IGTHR
- INSTOR
- BOUNDS
  - (1) N BOUND
  - (2) S BOUND
  - (3) E BOUND
  - (4) W BOUND

(C) Land Use Factors

Relative Demand Density For The Fourteen Land Use Types.

Figure B-1

OPTIONS
GATHER SUBPROGRAM

1. BOUNDS
2. DELTA
3. SKIP
4. IGRAF
5. NEWLMT
6. NNEW
7. DELNEW
8. MDBSUB
9. NCYCLE
10. MAXITR
11. MAXRNG

Figure B-2

printed output per <u>iteration</u> of the gathering procedure. A normal run with a full set of data (about 1500 cells) and no substation locations specified can easily exceed ten cycles with 100 iterations in each, for a total of 1000 iterations.

List of Control Variables

IDEBUG - Subroutine INPUT debug code. Not used.

CDEBUG - Subroutine CHECKF debug code.

If equal to 1:

A) Lists by feeder (if cell percentages don't normalize to 100 ± 5%)

1) feeder abbreviation
2) feeder demand
3) list of cells fed by the feeder including:

i) cell coordinates
ii) cell record number
iii) percent of feeder area covered by cell - after normalization attempt.

NDEBUG - Subroutine NORMAL debug code.

If equal to 1:

A) Prints: "ENTERED NORMAL"

B) Lists by feeder:

1) feeder sequence number
2) feeder name (i.e. ABØ4)
3) first and last cell number in the cell file that is fed by the feeder
4) indicates if the number of cells calculated in CHECKF is different than the number calculated in NORMAL

LDEBUG - Main program debug code.

If not equal to 0:

Creates three plots, one for each of the vacant land uses, based on original data (before growth).

List of Control Variables (Continued)

INLIST - If equal to 1: Subroutine OUT is called; Subroutine OUT entry points are given (OUT1, OUT2, or OUT3) in parentheses. This results in the following output;

A) By cell: (OUT1)

1) cell record number (data order)
2) district and quadrant location of the cell (i.e. 10N01WNE) (data)
3) coordinates of the cell (data/calculated)
4) feeders feeding the cell with the original percentage of feeder area (data) and the normalized percentage based on land use (data and calculated)
5) demand in KW (as calculated)
6) the cell's land uses with associated percentages (data)
7) the cell's zoning with associated percentages (data)

B) By feeder: (OUT2)

1) feeder number (alphabetical order)
2) feeder name (data)
3) demand in KW (data)
4) percentage of the feeder area devoted to each of the 14 land uses (calculated)
5) summation of the percentages (May not sum to 1.0 due to service area boundary conditions and the fact that only three land use types and three feeders per cell are coded)
6) number of different land use types in the feeder area
7) number of cells fed by the feeder
8) the first and last cell record number of cells fed by the feeder
9) the cell record numbers of all the cells fed by the feeder

C) By land use type: (OUT3)

1) use number
2) use abbreviation
3) relative demand density factor (data)
4) total area (before growth)
5) total demand (before growth)

List of Control Variables (Continued)

D) By cell (OUT3)

1) cell reference number
2) land use distribution factors (amount of the cell's total demand attributable to each of its land uses)
3) the number of feeders feeding the cell
4) the number of land use types within the cell

ISCAT - If equal to 1:

Subroutine SCATTR will be called. This subroutine calculates the demand density for each land use type and confidence intervals. It also lists by feeder the area and demand for each land use type. A graphical representation of this list is also provided.

IGTHR - If equal to 1:

Subroutine GATHER will be called. This is the subroutine that collects the cell demands into substations. It creates new substations if the specified ones are insufficient. A record is maintained relating substations with cells and the cell demand satisfied by the substation. An indication of distribution line loss is also calculated. This indicator has the dimensions of (MW-miles) x 2 for a 1/2 mile cell grid coordinate.

INSTOR - If equal to 1:

Subroutine DUMPS will be called. This routine stores the following information on disk file.

A) By cell:

1) zones
2) percentage of cell covered by each zone
3) land use distribution factors
4) district and quadrant
5) demand in KW
6) coordinates

List of Control Variables (Continued)

B) By feeder:

1) abbreviation
2) demand in KW

C) The number of cells

D) The number of feeders

E) Pointer from coordinates to cell record number

BOUNDS - Used two places:
(logical variable)

A) When used in Subroutine SCATTR, the four bounds limit the area used to calculate the land use demand densities.

B) When used in Subroutine GATHER, the four bounds limit the area within which the gathering process takes place.

NOTE: In all cases the bounds are in grid coordinate units.

NBOUND, SBOUND, EBOUND, WBOUND - The North, South, East and West Bounds.

They should be specified even if the BOUNDS feature is not being used (specify: 70, 1, 60, 1).

GROWTH - Logical variable

If equal to -TRUE-

Subroutine GROW will be called. The performance of this routine depends on the following variable.

ALLGRO - Logical variable

This variable controls the mode subroutine GROW uses to project future demands.

List of Control Variables (Continued)

If ALLGRO is equal to -TRUE-

The land will be redeveloped according to the zone in that area.

If ALLGRO is equal to -FALSE-

Only the vacant land will be developed according to zone. All presently developed land remains unchanged,

NOTE: A revision to the program is planned that will increase the flexibility of this growth process by allowing both modes of growth within a growth area.

GROBND - Logical variable

If equal to -TRUE-

Only portions of the service area will be grown, otherwise, the total area will be grown.

NGAREA - The number of areas to be grown (up to 20) when GROBND is -TRUE-

If GROBND is -FALSE-, NGAREA should be set to 1.

RGRFAC (1) - Real growth factor for growth area one. This is the growth for the whole system if GROBND is -FALSE-.

NGBND (I), SGBND (I), EGBND (I), WGBND (I), RGRFAC (I) - The North, South, East and West bounds and growth factor for the growth areas

NOTE: I = 1, NGAREA

GDEBUG - Subroutine GATHER debug code.

I) If greater or equal to 1: Lists -

A) Initial substation data for all specified substations

B) The KW demand for each cell

List of Control Variables (Continued)

C) Cell demands before new substations are created

D) Substation data after each cycle

E) List of non-zero cell demands for cells that do not contain a substation (only if there are 20 or more substations)

F) Final substation data

G) Total capacity, loss, and demand for all substations

II) If greater or equal to 2:

A through G, above, plus

H) Initial values for NSSS (number of serving substations) for each cell. This information is repeated at two points within the gathering process. It is repeated each time the RANGE is incremented.

I) For each time an increment of demand is gathered from a cell, the cycle, range, iteration, substation number, cell pointer, substation pointer, the KW demand of both the cell being gathered and the substation, and the number of serving substations will be printed.

BEWARE: This option should not be used unless there is a problem with the cell-substation assignments. It results in thousands of pages if used during a normal run with a full set of data.

MXNSUB - The maximum number of substations. This limit is governed by the dimension of substation arrays.

BOUNDS - Logical variable

If equal to -TRUE-

The Bounds option will be in effect during the gathering process.

List of Control Variables (Continued)

DELTA - The MW increment of demand gathered from a cell to a substation at any one time. DELTA is normally set to 0.50 MW.

SKIP - Normally set equal to 1.

This limits the plotting of intermediate cell demands during the gathering process.

IGRAF - The number of iterations between cell demand plots. IGRAF is usually set to 20 or 50.

NEWLMT - The capacity of substations created by the computer in subroutine GATHER. Normally set to the sum of the middle capacity rating of the projected substation transformers.

NNEW - The maximum number of substations that can be created during any one creation cycle.

DELNEW - The decrease in NNEW each cycle.

MDBSUB - The minimum distance between substations created during any one creation cycle. It is measured in cells (1/2 miles).

NCYCLE - The maximum number of creation cycles during any run.

MAXITR - The maximum number of iterations during any one cycle (usually 150 for DELTA = 0.50).

MAXRNG - The maximum range, in cells, a substation will reach out to gather demand from a cell. This is equivalent to setting the maximum feeder length.

LANDUSE Data Requirements

The following is a detailed list of the optional and required data for the LANDUSE computer program. These data requirements should be read in conjunction with the "Control Variables" section of this appendix in order to gain a better feel for the actions caused by each. The data requirements are broken into five sets for ease of preparation and modification of the data. In all cases the required format for the data and control variables is given.

LANDUSE Data Requirements

Set 1

This set includes the control cards for the main program LUSE.

Card	Column(s)	Data and Format
1	1-20	IDEBUG, CDEBUG, NDEBUG, LDEBUG (4I5)
2	1-20	INLIST, ISCAT, IGTHR, INSTOR (4I5)
3	1-25	BOUNDS, NBOUND, SBOUND, EBOUND, WBOUND (L1, 4X, 4I5)
4	1-30	GROWTH, ALLGRO, GROBND, NGAREA, RGRFAC (1) (3(4X, L1) I5, F10.5)
5	1-30	NGBND, SGBND, EGBND, WGBND, RGRFAC (4I5, F10.5)

NOTE: There is one Card 5 for each of the growth areas if GROBND is TRUE. The set only contains four cards if the total service area is grown as one area or if the GROWTH option is not being used.

Set II

This set includes the land use relative demands and the feeder data.

First card - Fourteen land use abbreviations and the relative demand in the following format: 14(A2, I3).

Subsequent cards - (One for each five feeders).
Data: Feeder, Feeder KW demand in hundreds of KW's (6.5 MW is entered as 65)
Card Format: 5(A4, 1X, I3, 2X).

NOTE: If the last feeder card contains data for five feeders, a blank card must follow the last feeder data card. If the last data card contains data for less than five (one thru four) feeders, a blank card must not be added.

LANDUSE Data Requirements (Continued)

Set III

This set contains the cell data. There is one card for each cell.

NOTE: The last data card must be followed by a blank card.

Column	Data and Format
1-8	District and quadrant, such as 10N02WSE (2A4)
9-12	East and North grid coordinates (2I2) NOTE: These can be omitted and the computer will generate them. They are entered as an additional location check.
13-24	The three land use percentages and the uses 3(I2, A2) NOTE: 99 is converted to 100
25-42	The three zone percentages and the zones 3(I2, A4)
45	Age Code (I1)
46	Number of highways (zero thru nine) (I1)
47	Number of proposed highways (I1)
48	Number of rail lines (I1)
49	Number of bus lines (I1)
50	Number of streets (zero thru nine) (I1)
51	Number of proposed streets (I1)

LANDUSE Data Requirements (Continued)

Column	Data and Format
52-76	The three feeders with percentage of feeder area covered by the cell and the percentage of cell area covered by the feeder 3(A4, 2I2) NOTE: 99 is converted to 100
77-80	Card sequence number (optional) no format

Set IV

This set includes a plot symbol card and 14 landuse titles.

First Card - Eleven plotting symbols, the first of which should be a blank 11(A1).

Card 2-15 - Titles for the output of subroutines STAT. If STAT is not called, the data cards will be neglected. They must be included for proper placement of the following data cards.

Set V

Data for subroutine GATHER (read by SECOND (or LANDUSE 2002) and GATHER).

Card	Data and Format
1	GDEBUG, MXNSUB, BOUNDS, DELTA (2I5, 4X, L1, F10.3)
2	SKIP, IGRAF, NEWLMT, NNEW, DELNEW (2I5, F10.3, 2I5)
3	MDSUB, NCYCLE, MAXITR, MAXRNG (F10.3, 3I5)
4-23	Five hundred numbers (1-500) (25A3)

LANDUSE Data Requirements
(Continued)

Card	Data and Format
24	Substation data: four substations per card. If the last card contains data for four substations, a blank card must follow the last data card. (If no substations are to be specified, a blank card must be provided.) Column 1-20, 21-40, 41-60, 61-80 Data: Substation abbreviation, location (district and quadrant) and capacity (MW). Format: 4(A2, 2X, 2A4, F6.2, 2X) Example: LM__05N04ESW__66.6__

Appendix C - Listing of the LANDUSE Computer Program

```
C...........................................................................LUSE0010
C.......................LANDUSE 0101........................................LUSE0020
C .........................LANDUSE 0102....................................... VAR 002
C .*************************************************************************. VAR 004
C .             ALPHA LIST OF GLOBAL VARIABLES                               . VAR 006
C ........................................................................... VAR 008
C .      SYMBOLS USED BELOW:  (DIMENSION)                                    . VAR 010
C .                 C         CELLS (1575)                                   . VAR 012
C .                 F         FEEDERS (450)                                  . VAR 014
C .                 N         NUMBER OF LANDUSE TYPES OR                     . VAR 016
C .                              FEEDERS PER CELL (3)                        . VAR 018
C .                 LU        LAND USES (14)                                 . VAR 020
C .                 **        NOT PRESENTLY USED                             . VAR 022
C ........................................................................... VAR 024
C .      AGE(C)             AGE CODE FOR FACILITIES IN A CELL                . VAR 026
C .      ALLGRO             LOGICAL - TRUE IF THE TOTAL CELL IS TO BE        . VAR 028
C .                            REPLACED BY ZONES (NOT JUST VACANT AREA)      . VAR 030
C .      AREA(LU)           TOTAL AREA FOR A GIVEN LANDUSE TYPE (IN CELLS)   . VAR 032
C .                            THIS IS A REAL VARIABLE (DECIMAL)             . VAR 034
C .      BLANK              FOUR BYTE BLANK                                  . VAR 036
C .      BLANK2             TWO BYTE BLANK                                   . VAR 038
C .      BOUNDS             LOGICAL - TRUE IF BOUNDS FEATURE IS USED         . VAR 040
C .                            (TOTAL PROGRAM WIDE)                          . VAR 042
C .      BUS(C)             NUMBER OF BUS ROUTES IN THE CELL                 . VAR 044
C .      CDEBUG             DEBUG CONTROL FOR SUBROUTINE CHECKF              . VAR 046
C .      CELLKW(C)          THE KW DEMAND PER CELL (CORRECTED FOR LANDUSE    . VAR 048
C .                            FACTORS) THIS IS A REAL VARIABLE (DECIMAL).   VAR 050
C .      CIF(F,110)         CELL RECORD NUMBER OF CELLS COVERED BY FEEDER    . VAR 052
C .                            F (MAXIMUM NUMBER IS 110)                     . VAR 054
C .      DEMAND(14)         TOTAL DEMAND BY LANDUSE TYPE                     . VAR 056
C .      DISTRT(C,2)        THE DISTRICT OF CELL 'C' WITH QUADRANT           . VAR 058
C .                            FOR EXAMPLE      10N03ENW                     . VAR 060
C .      DUMMY(C)           A GENERAL PURPOSE ARRAY TO PASS DATA BETWEEN     . VAR 062
C .                            SUBROUTINES  (PLOT AT ENTRY PLOT3)            . VAR 064
C .      EAST(C)            THE EAST COORDINATE OF CELL 'C'                  . VAR 066
C .      EBOUND             EAST BOUND                                       . VAR 068
C .      EGBND(I)           THE I-TH EAST BOUND FOR GROW                     . VAR 070
C .      FACTOR(LU)         THE RELATIVE DEMAND FOR LANDUSE TYPES            . VAR 072
C .      FDR(C,N)           THE FEEDER LIST SEQUENCE NUMBER OF FEEDER 'N'    . VAR 074
C .                            IN CELL 'C'                                   . VAR 076
C .                         NOTE: WHEN THE DATA IS READ, FDR IS THE          . VAR 078
C .                              ALPHA NAME OF THE FEEDER (A4) AND IS        . VAR 080
C .                              THEN CONVERTED TO THE SEQUENCE NUMBER       . VAR 082
C .      FEEDER(F)          THE ALPHA NAME OF FEEDER 'F'  (A4)               . VAR 084
C .      FI(110)    ()      LOCALLY USED VARIABLES TO TRACK CELL RECORD      . VAR 086
C .      FJ(110)    ()      NUMBERS DURING SEARCHES                          . VAR 088
C .      FKW(F)             FEEDER LOADS (DATA) STORED AS INTEGERS SCALLED   . VAR 090
C .                         DOWN BY 100 (8.2 MW IS STORED AS 82)             . VAR 092
C .      GROBND             LOGICAL - TRUE IF THE BOUNDS FEATURE IS TO       . VAR 094
C .                            BE USED IN THE GROWTH PROCESS                 . VAR 096
C .      GROWTH             LOGICAL - TRUE IF THE GROWTH ROUTINE IS TO       . VAR 098
C .                            BE IMPLEMENTED                                . VAR 100
C .      HIGHC(F)           THE FIRST CELL RECORD TO CONTAIN FEEDER 'F'      . VAR 102
C .      HWY(C)             THE NUMBER OF HIGHWAYS IN CELL 'C'               . VAR 104
C .      HWYP(C)            THE NUMBER OF PROPOSED HIGHWAYS IN 'C'           . VAR 106
C .      IDEBUG             DEBUG CONTROL FOR SUBROUTINE INPUT               . VAR 108
C .  **  IDISK              DEVICE NUMBER FOR SCRATCH DISK DRIVE             . VAR 110
```

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C .       IDISK2          DEVICE NUMBER FOR STORAGE DISK DRIVE           . VAR 112
C .  **   IDISK4          DEVICE NUMBER FOR STORAGE DISK DRIVE           . VAR 114
C .       ILIST           DEVICE NUMBER FOR THE LINE PRINTER             . VAR 116
C .       INLIST          IF = 1, THE INPUT DATA WILL BE PRINTED         . VAR 118
C .       INSTOR          IF = 1, COMMON BLOCK WILL BE STORED ON IDISK2  . VAR 120
C .  **   IPUNCH          DEVICE NUMBER FOR THE CARD PUNCH               . VAR 122
C .       IREAD           DEVICE NUMBER FOR THE CARD READER              . VAR 124
C .       LCWC(F)         THE LAST CELL RECORD THAT CONTAINS FEEDER 'F'  . VAR 126
C .       LUDFC(C,N)      LANDUSE DISTRIBUTION FACTOR WITHIN 'C'         . VAR 128
C .       LUSE(C,N)       THE LANDUSE TYPE NUMBER FOR THE N-TH USE       . VAR 130
C .                           IN CELL 'C'                                . VAR 132
C .                       NOTE: WHEN THE DATA IS READ, LUSE CONTAINS     . VAR 134
C .                             THE ALPHA DESIGNATION UNTIL IT IS        . VAR 136
C .                             CONVERTED TO THE SEQUENCE NUMBER FOR     . VAR 138
C .                             THAT TYPE                                . VAR 140
C .       NBOUND          NORTH BOUND                                    . VAR 142
C .       NCELL           THE NUMBER OF CELLS                            . VAR 144
C .       NCIF(F)         THE NUMBER OF CELLS COVERED BY FEEDER 'F'      . VAR 146
C .       NDEBUG          DEBUG CONTROL FOR SUBROUTINE NORMAL            . VAR 148
C .       NFDR            THE NUMBER OF FEEDERS                          . VAR 150
C .       NFIC(C)         THE NUMBER OF FEEDERS SERVING CELL 'C'         . VAR 152
C .       NGAREA          THE NUMBER OF GROWTH AREAS (MAX: 10)           . VAR 154
C .       NGBND(I)        THE I-TH NORTH BOUND FOR GROW                  . VAR 156
C .       NLUIC(C)        THE NUMBER OF LANDUSE TYPES IN CELL 'C'        . VAR 158
C .       NLUIF(F)        THE NUMBER OF LANDUSE TYPES IN FEEDER 'F'      . VAR 160
C .       NORTH(C)        THE NORTH COORDINATE OF CELL 'C'               . VAR 162
C .       NWZONE(C,N)     ALPHA ZONE REPLACED BY SEQUENCE NUMBER OF      . VAR 164
C .                           THE EQUIVALENT LAND USE TYPE               . VAR 166
C .       NZIC(C)         THE NUMBER OF ZONES IN CELL C                  . VAR 168
C .       PCELL(C,N)      PERCENTAGE OF CELL 'C' COVERED BY THE          . VAR 170
C .                           N-TH FEEDER IN THAT CELL                   . VAR 172
C .       PFDR(C,N)       PERCENTAGE OF THE N-TH FEEDER IN CELL 'C'      . VAR 174
C .                           THAT IS COVERED BY CELL 'C'                . VAR 176
C .       PFDRM(C,N)      PFDR MODIFIED TO REFLECT THE RELATIVE DEMAND   . VAR 178
C .                           ASSOCIATED WITH THE LANDUSE TYPES IN       . VAR 180
C .                           CELL 'C'. THIS IS A REAL VARIABLE          . VAR 182
C .                           WITH THE DATA STORED IN DECIMAL FORM       . VAR 184
C .       PLUIF(F,LU)     PERCENTAGE OF FEEDER 'F' COVERED BY LANDUSE    . VAR 186
C .                           TYPE 'LU'. THIS IS A REAL VARIABLE         . VAR 188
C .                           WITH THE DATA STORED IN DECIMAL FORM       . VAR 190
C .       PLUSE(C,N)      PERCENTAGE OF CELL 'C' COVERED BY THE N-TH     . VAR 192
C .                           LANDUSE TYPE OF THAT CELL                  . VAR 194
C .       POINT(60,70)    A POINTER THAT POINTS FROM THE CELL COORDINATES. VAR 196
C .                           (EAST,NORTH) TO THE CELL RECORD NUMBER     . VAR 198
C .       PZONE(C,N)      PERCENTAGE OF CELL 'C' COVERED BY THE N-TH     . VAR 200
C .                           ZONE IN THAT CELL                          . VAR 202
C .       RAIL(C)         THE NUMBER OF RAIL LINES IN CELL 'C'           . VAR 204
C .       RDEMND(J)       THE KW DEMAND PER CELL FOR THE NON-VACANT      . VAR 206
C .                           LAND USE TYPE J (REAL VARIABLE)            . VAR 208
C .       RGRFAC(I)       RELATIVE GROWTH FACTOR FOR GROWTH AREA I       . VAR 210
C .                           THE VALUE IS BETWEEN 0.0 AND 1.0           . VAR 212
C .       SBOUND          SOUTH BOUND                                    . VAR 214
C .       SGBND(I)        THE I-TH SOUTH BOUND FOR GROW                  . VAR 216
C .       STRT(C)         THE NUMBER OF THROUGH STREETS IN CELL 'C'      . VAR 218
C .       STRTP(C)        THE NUMBER OF PROPOSED STREETS IN CELL 'C'     . VAR 220
C .       TITLE(20)       THE ARRAY USED TO PASS THE TITLE FOR PLOTS     . VAR 222
C .       USE(LU)         THE ALPHA NAME OF LANDUSE 'LU' (A2 FORMAT)     . VAR 224
```

```
C .     WBOUND        WEST BOUND                                          .
C .     WGBND(I)      THE I-TH WEST BOUND FOR GROW                        .
C .     ZONE(C,N)     THE ZONE NUMBER OF THE N-TH ZONE IN CELL 'C'        .
C .                   NOTE: ZONE CONTAINS THE ALPHA (A4) ZONE DURING      .
C .                          DATA INPUT AND IS LATER CONVERTED TO         .
C .                          THE ZONE LIST SEQUENCE NUMBER                .
C .........................................................................
C .                                                                       .
C .************************************************************************.
C .                  LANDUSE TYPES BY SEQUENCE NUMBER                     .
C .........................................................................
C .     01    R1    LARGE SINGLE FAMILY RESIDENTIAL                        .
C .     02    R2    SINGLE FAMILY RESIDENTIAL                              .
C .     03    R3    SMALL SINGLE FAMILY RESIDENTIAL                        .
C .     04    M1    MULTI FAMILY (1-3 STORIES)                             .
C .     05    M2    MULTI FAMILY (OVER 3 STORIES)                          .
C .     06    C1    SMALL COMMERCIAL (STRIP AND NEIGHBORHOOD)              .
C .     07    C2    MEDIUM COMMERCIAL (2-3 STORIES)                        .
C .                 NOTE: C2 INCLUDES CHURCHES AND SCHOOLS                 .
C .     08    C3    HEAVY COMMERCIAL (OVER 3 STORIES)                      .
C .     09    C4    LARGE SHOPPING CENTERS                                 .
C .     10    I1    LIGHT INDUSTRIAL                                       .
C .     11    I2    MEDIUM INDUSTRIAL                                      .
C .     12    S1    VACANT AND USABLE                                      .
C .     13    S2    UNDEVELOPABLE (LAKE,PARK,CEMETERY,ETC)                 .
C .     14    S3    FLOOD PLAIN (POSSIBLE FUTURE DEVELOPMENT)              .
C .........................................................................
C .                                                                       .
C .************************************************************************.
C .                           AGE CODES                                   .
C .........................................................................
C .           1     NEW (LESS THAN 5 YEARS OLD)                           .
C .           2     MODERATE (5 - 30 YEARS OLD)                           .
C .           3     OLD (OVER 30 YEARS OLD)                               .
C .           4     DECAYING (ANY AGE)                                    .
C .           5     DECAYED (ANY AGE)                                     .
C .........................................................................
C .                                                                       .
C .************************************************************************.
C   COMMON VARIABLES
C............................LANDUSE 0602...................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1          STRTP,PFDR,PCELL,POINT,INLIST,USE,   INSTOR,NLUIF,
     2          NFIC,NLUIC,CIF,NCIF,      FI,FJ,LOWC,HIGHC,BLANK2,
     3          IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1          IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2          FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3          DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     A          TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
```

```
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5               PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6               RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7               PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8               INSTOR,NLUIF(450),NFIC(1575),
     9               NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A               LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B               IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
C...........................LANDUSE C603........................................
C
      INTEGER*2 NZIC,NWZONE
      LOGICAL*1 GROWTH,GROBND,ALLGRO
      REAL RGRFAC,RDEMND
C
C
      COMMON /GROWBK/ NGAREA,NGBND(20),SGBND(20),EGBND(20),WGBND(20),
     *                RGRFAC(20),NZIC(1575),NWZONE(1575,3),RDEMND(14),
     *                GROBND,GROWTH,ALLGRO
C
C...............................................................................
C
C...............................................................................
C                          DEBUG CONTROL CONSTANTS
C
C     IF A DEBUG CONSTANT IS EQUAL TO 1, CERTAIN TRACKING INFORMATION
C    WILL BE PRINTED ON "ILIST". MUCH OF THIS INFORMATION HELPS DETECT
C    ERRORS WITH THE INPUT DATA.
C
C         IDEBUG..........INPUT SUBROUTINE
C         CDEBUG..........CHECKF SUBROUTINE
C         NDEBUG..........NORMAL SUBROUTINE
C         LDEBUG..........MAIN PROGRAM
C
C...............................................................................
C    WHEN INDEX IS EQUAL TO 1, SUBROUTINE PLOT READS ELEVEN SYMBOLS
C    ICODE TELLS SUBROUTINE PLOT WHICH PLOT TO MAKE
C             ICODE                       PLOT
C
C               1           NUMBER OF LAND USE TYPES PER CELL
C                                         AND
C                           NUMBER OF FEEDERS IN EACH CELL
C
C               2           DEMAND DENSITY PER CELL
C
C...............................................................................
      DIMENSION TITLE1(20),TITLE2(20),TITLE3(20),TITLE4(20),TITLE5(20)
      LOGICAL*1 BOUNDS
      DATA TITLE1/ 5*'    ',
     1  'NUMB','ER O','F VA','CANT',' CEL','LS (','S1) ',
     A   8*'    '/,
     2     TITLE2/ 5*'    ',
     3  'NUMB','ER O','F VA','CANT',' CEL','LS (','S2) ',
     4   8*'    '/,
     5     TITLE3/ 5*'    ',
     3  'NUMB','ER O','F VA','CANT',' CEL','LS (','S3) ',
     4   8*'    '/
```

```
C
      READ(IREAD,1000) IDEBUG, CDEBUG, NDEBUG, LDEBUG
      READ(IREAD,1000) INLIST, ISCAT, IGTHR, INSTOR
C
 1000 FORMAT(10I5)
C
      READ(IREAD,1002)BOUNDS,NBOUND,SBOUND,EBOUND,WBOUND
C
 1002 FORMAT(L1,4X,10I5)
C
      READ(IREAD,1003)GROWTH,ALLGRO,GROBND,NGAREA,RGRFAC(1)
C
 1003 FORMAT(3(4X,L1),I5,F10.5)
C
      IF(GROWTH .AND. GROBND) READ(IREAD,1004)
     *    (NGBND(I),SGBND(I),EGBND(I),WGBND(I),RGRFAC(I),I=1,NGAREA)
C
 1004 FORMAT(4I5,F10.5)
C
      IF(GROWTH )  READ(IREAD,1005)   (RDEMND(J),J=1,14)
C
 1005 FORMAT(7F10.2)
      WRITE(ILIST,1030)IDEBUG,CDEBUG,NDEBUG,LDEBUG,INLIST,ISCAT,IGTHR,
     1               INSTOR,BOUNDS,NBOUND,SBOUND,EBOUND,WBOUND,
     2    GROWTH,ALLGRO,GROBND,NGAREA,
     3    (I,NGBND(I),SGBND(I),EGBND(I),WGBND(I),RGRFAC(I),I=1,NGAREA)
 1030 FORMAT(1H1,////,1X,57('X'),' CASE VARIABLES ',57('X'),/// ,
     * T55,  'IDEBUG    ',    I5    ,/,
     * T55,  'CDEBUG    ',    I5    ,/,
     * T55,  'NDEBUG    ',    I5    ,/,
     * T55,  'LDEBUG    ',    I5    ,/,
     * T55,  'INLIST    ',    I5    ,/,
     * T55,  'ISCAT     ',    I5    ,/,
     * T55,  'IGTHR     ',    I5    ,/,
     * T55,  'INSTOR    ',    I5    ,/,
     * T55,  'BOUNDS    ', 4X,L1    ,/,
     * T55,  'NBOUND    ',    I5    ,/,
     * T55,  'SBOUND    ',    I5    ,/,
     * T55,  'EBOUND    ',    I5    ,/,
     * T55,  'WBOUND    ',    I5    ,/,
     * T55,  'GROWTH    ', 4X,L1    ,/,
     * T55,  'ALLGRO    ', 4X,L1    ,/,
     * T55,  'GROBND    ', 4X,L1    ,/,
     * T55,  'NGAREA    ',    I5    ,/,
     * T30,'AREA',T40,'NGBND',T50,'SGBND',T60,'EGBND',T 70,'WGBND',
     *       T 80,'RELATIVE GROWTH',/,
     * (T31,I2,T42,I2,T52,I2,T62,I2,T 72,I2,T 85,F8.6) )
      WRITE(ILIST,1006)
 1006 FORMAT(    ///,1X,130('X') )
      INDEX=1
      ICODE=1
C.........................................................................
      CALL INPUT
C.........................................................................
      WRITE(ILIST,1040) (J,USE(J),FACTOR(J),RDEMND(J),J=1,14)
C.........................................................................
 1040 FORMAT( 1H1////,1X,130('X'),///,
```

```
     *    35X,'LANDUSE FACTORS (RELATIVE DEMAND DENSITY)',
     *    ' AND KW DEMAND PER CELL',
     1 ///,14(T45,I2,2X,A2,5X,I4,5X,F10.2,//),///,1X,130('X') )
C.......................................................................
      CALL CHECKF
C.......................................................................
      CALL NORMAL
C.......................................................................
      IF(INLIST .EQ. 1)  CALL OUT
C.......................................................................
      IF(GROWTH) CALL GROW
C.......................................................................
C................STORE INTERMEDIAT RESULTS...............................
      IF(INSTOR .EQ. 1) CALL DUMPS
C
C
C
CXXXXXXXX 1979 PROJECTED PEAKS USED FOR THIS DATA (FLAT START)XXXXXXXX
C...INITIAL DATA STORED IN 'LAND.USE1' (VOL157,TRACKS 8550 - 8557)......
C
CXXXXXXXX 1979 PROJECTED PEAKS USED FOR THIS DATA (FINAL FACTORS)XXXXXX
C...INITIAL DATA STORED IN 'LAND.USE2' (VOL157,TRACKS 8558 - 8565)......
C
CXXXXXXXX 1979 ACTUAL PEAKS USED FOR THIS DATA (FINAL FACTORS)XXXXXXXXX
C...INITIAL DATA STORED IN 'LAND.USE3' (VOL157,TRACKS 8566 - 8573)......
C
C
C
      IF(LDEBUG .EQ. 0) GO TO 25
      DO 24 KK = 1,3
      GO TO (10,12,14),KK
   10 DO 11 I=1,20
   11 TITLE(I) = TITLE1(I)
      GO TO 16
   12 DO 13 I=1,20
   13 TITLE(I) = TITLE2(I)
      GO TO 16
   14 DO 15 I =1,20
   15 TITLE(I) = TITLE3(I)
   16 DO 23 C=1,NCELL
      DUMMY(C) = 0.0
      LU = NLUIC(C)
      DO 22 L = 1,LU
      IF(LUSE(C,L) .NE. KK+11) GO TO 22
      FLT = PLUSE(C,L)
      DUMMY(C) = FLOAT(FLT) * 0.1 * 4.0
   22 CONTINUE
   23 CONTINUE
      CALL PLOT4(INDEX)
   24 CONTINUE
      GO TO 26
   25 READ(IREAD,1001) I
C     THIS DUMMY READ REMOVES THE SYMBOL DATA CARD
   26 IF(ISCAT .EQ. 0) GO TO 30
      IF(BOUNDS) WRITE(ILIST,1020)NBOUND,SBOUND,EBOUND,WBOUND
 1020 FORMAT(1H1,/////////,1X,130('X'),////,45X,'BOUNDS OPTION IN',
     1          ' EFFECT',////,50X,'NBOUND:',I3,//,
```

```
     2       50X,'SBOUND:',I3,//,50X,'EBOUND:',I3,//,50X,'WBOUND:',        LUSE1570
    .3       I3,////,1X,130('X'))                                          LUSE1580
      CALL SCATTR                                                          LUSE1590
      GO TO 35                                                             LUSE1600
   30 READ(IREAD,1001)(I,J=1,14)                                           LUSE1610
 1001 FORMAT(A5)                                                           LUSE1620
C     THIS DUMMY READ REMOVES THE 14 TITLE DATA CARDS                      LUSE1630
   35 IF(IGTHR .EQ. 1) CALL SECOND                                         LUSE1640
C READ ANY REMAING DATA CARDS NOT USED (FROM SECOND)                       LUSE1650
      READ (IREAD,1010,END=99)(I,J=1,999999)                               LUSE1660
 1010 FORMAT(A1)                                                           LUSE1670
   99 CONTINUE                                                             LUSE1680
      STOP                                                                 LUSE1690
      END                                                                  LUSE1700
```

```
      SUBROUTINE INPUT
C...........................LANDUSE 0201......................................
C   THIS ROUTINE CODED 9 JULY 1979
C              EXPANDED 24 JULY 1979
C              LAST REVISION: 20 AUG 1979
C** INCLUDE COMMON INFO
C   COMMON VARIABLES
C...............................LANDUSE 0602....................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1     STRTP,PFDR,PCELL,POINT,INLIST,USE,   INSTOR,NLUIF,
     2     NFIC,NLUIC,CIF,NCIF,             FI,FJ,LOWC,HIGHC,BLANK2,
     3     IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFORM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1     IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2     FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3     DISTRT(1575,2),BLANK,PFORM(1575,3),PLUIF(450,14),
     4     TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5     PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6     RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7     PFDR(1575,3),PCELL(1575,2),POINT(60,70),INLIST,
     8     INSTOR,NLUIF(450),NFIC(1575),
     9     NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A     LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B     IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
      INTEGER*2 LUSEN,NS,EW,A1,A2,A3,EA,NO
      DIMENSION LU(3)
C   READ LAND USE AND ASSOCIATED WEIGHTING FACTOR
      READ(IREAD,1020) (USE(I),FACTOR(I),I=1,14)
C   READ FEEDER DATA
      N = 0
   30 READ(IREAD,1010) (FEEDER(N+J),FKW(N+J),J=1,5)
      IF(FEEDER(N+5).EQ.BLANK) GO TO 40
      N = N+5
      GO TO 30
   40 NFDR = N+4
      DO 50 J=1,4
   50 IF(FEEDER(NFDR).EQ.BLANK) NFDR = NFDR - 1
C   PUT FEEDER LIST IN ALPHABETICAL ORDER
      CALL ORDER
        DNFDR=NFDR/8
         SCND1=FEEDER(DNFDR)
        FIRST2=FEEDER(2*DNFDR)
         SCND2=FEEDER(3*DNFDR)
        FIRST3=FEEDER(4*DNFDR)
         SCND3=FEEDER(5*DNFDR)
        FIRST4=FEEDER(6*DNFDR)
         SCND4=FEEDER(7*DNFDR)
C   READ CELL DATA
        FFLAG=0
```

```
C  FROM THIS POINT THROUGH STATEMENT 20, N IS THE CELL RECORD NUMBER
      N=1
   10 READ(IREAD,1000,END=20)(DISTRT(N,J),J=1,2),EAST(N),NORTH(N),
     1   (PLUSE(N,J),LUSE(N,J),J=1,3),(PZONE(N,J),ZONE(N,J),
     2   J=1,3),AGE(N),HWY(N),HWYP(N),RAIL(N),BUS(N),STRT(N),STRTP(N),
     3   (FDR(N,J),PFDR(N,J),PCELL(N,J),J=1,3),NS,A1,EW,A2,A3
      IF(DISTRT(N,1).EQ.BLANK   )  GO TO 20
C  CHECK GRID NUMBERS WITH RESPECT TO DISTRICT
      CALL GRID(NS,A1,EW,A2,A3,EA,NO)
      IF(EAST(N).EQ.EA.AND.NORTH(N).EQ.NO) GO TO 36
      WRITE(ILIST,1040)EAST(N),
     1    NORTH(N),EA,NO,(DISTRT(N,J),J=1,2)
 1040 FORMAT(//,130('*'),/,5X,'ERROR IN DISTRICT OR GRID NUMBER',
     1   5X,'DATA GRID=',2I3,5X,'CALCULATED GRID=',2I3,5X,'DISTRICT:',
     2   1X,2A4,3X,'CORRECTED',/,130('X'))
      EAST(N)=EA
      NORTH(N)=NO
   36 POINT(EAST(N),NORTH(N)) = N
      IF(PLUSE(N,1).EQ.99) PLUSE(N,1)=100
      IF(PZONE(N,1).EQ.99) PZONE(N,1)=100
      IF(PCELL(N,1).EQ.99)PCELL(N,1) = 100
C    DETERMINE THE NUMBER OF FEEDERS IN THE CELL
      NFICN=3
      IF(FDR(N,3).EQ.BLANK) NFICN = 2
      IF(FDR(N,2).EQ.BLANK) NFICN = 1
      NFIC(N)=NFICN
      DO 2 J=1,NFICN
    2 IF(PFDR(N,J).EQ.99) PFDR(N,J)=100
C    DETERMINE THE NUMBER OF LAND USE TYPES IN THE CELL
      NLUIN=3
      IF(LUSE(N,3).EQ.BLANK2) NLUIN=2
      IF(LUSE(N,2).EQ.BLANK2) NLUIN=1
      NLUIC(N)=NLUIN
      SUMLU = 0
      DO 13 JJ=1,NLUIN
      LU(JJ) = 0
      LUSEN=LUSE(N,JJ)
      DO 14 KK=1,14
      IF(LUSEN    .EQ.USE(KK)) GO TO 15
   14 CONTINUE
      WRITE(ILIST,1030) LUSE(N,JJ),N,EAST(N),NORTH(N),
     1    (DISTRT(N,J),J=1,2)
 1030 FORMAT(   /,1X,128('*'),//,5X,'LAND USE NOT FOUND IN LIST',//,
     1   5X,'USE: ',A2,' CELL:',I5,' EAST:',I3,'  NORTH:',I3,
     2   '    DISTRICT: ',2A4,//,1X,128('#'))
      FFLAG = 1
   15 LUSE(N,JJ) = KK
      LU(JJ) = FACTOR(KK) * PLUSE(N,JJ)
      SUMLU = SUMLU + LU(JJ)
   13 CONTINUE
C  ACCUMULATE THE AREAS FOR EACH LAND USE TYPE AND CALCULATE LUDFC
      DO 12 JJ=1,NLUIN
      IF(SUMLU .EQ. 0) GO TO 16
      LUJJ = LU(JJ)
      LUDFC(N,JJ) = FLOAT(LUJJ) / FLOAT(SUMLU)
      GO TO 17
   16 LUDFC(N,JJ) = 0.0
```

```
   17 IPLUSE=PLUSE(N,JJ)
   12 AREA(LUSE(N,JJ))=AREA(LUSE(N,JJ))+FLOAT( IPLUSE    )*0.01
C     DETERMINE THE FEEDER SEQUENTIAL NUMBER AND REPLACE THAT FEEDER'S
C     NAME WITH THE NUMBER.
C     THIS PROCEDURE ASSUMES THAT THE FEEDER LIST IS IN ALPHABETICAL ORDER
      DO 100 IFN = 1,NFICN
      IFDR = FDR(N,IFN)
      IF(IFDR.LT.FIRST2) GO TO 110
      IF(IFDR.LT.FIRST3) GO TO 120
      IF(IFDR.LT.FIRST4) GO TO 130
      START=6*DNFDR-1
      IF(IFDR.GT.SCND4) START =7*DNFDR-1
      STOP=NFDR
      DO 145 K1 = START,STOP
      IF(IFDR.EQ.FEEDER(K1)) GO TO 200
  145 CONTINUE
      GO TO 300
  130 START=4*DNFDR-1
      IF(IFDR.GT.SCND3) START=5*DNFDR-1
      STOP=NFDR-2*DNFDR+1
      DO 135 K1 =START,STOP
      IF(IFDR.EQ.FEEDER(K1)) GO TO 200
  135 CONTINUE
      GO TO 300
  120 START=2*DNFDR-1
      IF(IFDR.GT.SCND2) START=3*DNFDR-1
      STOP=NFDR-4*DNFDR+1
      DO 125 K1 =START,STOP
      IF(IFDR.EQ.FEEDER(K1)) GO TO 200
  125 CONTINUE
      GO TO 300
  110 START=1
      IF(IFDR.GT.SCND1) START=DNFDR-1
      STOP=NFDR-6*DNFDR+1
      DO 115 K1 =START,STOP
      IF(IFDR.EQ.FEEDER(K1)) GO TO 200
  115 CONTINUE
      GO TO 300
  200 FDR(N,IFN) = K1
      GO TO 100
  300 WRITE(ILIST,301)N,IFN,FDR(N,IFN),K1
      FFLAG=1
  301 FORMAT(///,1X,30('****'),//,5X,'FEEDER NOT FOUND IN LIST',/,
     1 10X,'CELL NUMBER',I5,' FEEDER',I2,' FEEDER NAME: ',
     2 A4,5X,'LIST SEQUENCE NUMBER: ',I4,//,1X,120('*'))
  100 CONTINUE
      N=N+1
      GOTO 10
   20 NCELL= N-1
      IF(FFLAG.EQ.1) GO TO 998
 1000 FORMAT(2A4,2I2,3(I2,A2),3(I2,A4),2X,7I1,3(A4,2I2),T1,2(I2,A1),A2)
 1010 FORMAT(5(A4,1X,I3,2X))
 1020 FORMAT(14(A2,I3))
      RETURN
  998 CALL ABORT
      END
```

```
      SUBROUTINE CHECKF
C...........................LANDUSE 0301.................................
C    THIS ROUTINE CODED 9 JULY 1979
C         LAST MODIFICATION     24 AUGUST 1979
C    THIS ROUTINE CHECKS FEEDER DATA FROM THE LANDUSE DATA FILE.
C    IT ALSO FINDS AND STORES THE FIRST AND LAST CELL RECORD NUMBER
C    FOR CELLS CONTAINING EACH FEEDER, RECORDS THE NUMBER OF CELLS
C    IN EACH FEEDER (NCIF) AND USES LINEAR INTERPOLATION TO
C    ADJUST THE PFDR'S IF THEIR SUM PER FEEDER DOES NOT DIFFER FROM
C    100% BY MORE THAN +20 OR -30 PERCENT. (TO 100% +/-5%)
C        IF THERE ARE LESS THAN FOUR CELLS IN THE FEEDER OR IF THE
C    SUM IS OUT OF THE ABOVE RANGE THE DETAILS OF THE SITUATION ARE
C    PRINTED OUT FOR MANUAL ADJUSTMENT IF REQUIRED.
C.........................................................................
C** INCLUDE COMMON INFO
C   COMMON VARIABLES
C...............................LANDUSE 0602..............................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1    STRTP,PFDR,PCELL,POINT,INLIST,USE,     INSTOR,NLUIF,
     2    NFIC,NLUIC,CIF,NCIF,        FI,FJ,LOWC,HIGHC,BLANK2,
     3    IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1               IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2               FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3               DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     A               TITLE(20),DUMMY(1575),LUDFC(1575.3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5               PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6               RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7               PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8               INSTOR,NLUIF(450),NFIC(1575),
     9               NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A               LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B               IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
      DIMENSION CELL(120)
      REAL RSUMF, RFIX, RPFDR
      IF(CDEBUG.EQ.1)  WRITE(ILIST,1000)
      LINES=1
 1000 FORMAT(1H1,'FEEDER  SUM',2X,4(6X,'EAST   NORTH   RECORD   %' ))
      DO 10 J=1,NFDR
      SUMF= 0
      I=0
      LFLAG=0
      LOWC(J)=0
      HIGHC(J)=0
      DO 20 K = 1,NCELL
      IF(FDR(K,1).NE.J.AND.FDR(K,2).NE.J.AND.FDR(K,3).NE.J) GO TO 20
      I = I+1
      IF(I.GT.110) WRITE(ILIST,1030)
 1030 FORMAT(//,1X,130('='),/2X,'MORE THAN 110 CELLS IN FEEDER')
```

```
      IF(LFLAG.EQ.0) LOWC(J)=K
      LFLAG=1
      CELL(I) = K
      KK=NFIC(K)
      DO 30 L= 1,KK
      IF(FDR(K,L).NE.J) GO TO 30
      SUMF = SUMF + PFDR(K,L)
      FI(I) = L
   30 CONTINUE
      HIGHC(J)=K
   20 CONTINUE
C.......................................................................
C               J     FEEDER NUMBER
C               I     NUMBER OF CELL 'CELL(I)' IN FEEDER J
C                     NOTE: THE LAST VALUE OF I IS NCIF(J)
C             CELL(I)    THE I-TH CELL IN FEEDER J
C             FI(I)      NUMBER OF FEEDER J IN CELL 'CELL(I)'
C.......................................................................
      NCIF(J) = I
      IF(   I .EQ.0) GO TO 40
      IF(SUMF.GT.94.AND.SUMF.LT.106) GO TO 10
C    AT THIS POINT WE KNOW THAT FEEDER J DOES NOT SUM TO 100 +/- 5  %
C    PRINT FEEDER NAME, APPROPRIATE CELLS AND ASSOCIATED PERCENTAGES
      IF( (I.LT.4) .OR. (SUMF.LT.70) .OR. (SUMF.GT.120) ) GO TO 50
      ITER = 0
   35 IF (ITER.GT.10) GO TO 50
      ITER = ITER + 1
C.........ADJUST THE FEEDER PERCENTAGES TO SUM TO ONE...................
      RSUMF = FLOAT(SUMF)
      RFIX = 100.-RSUMF
      SUMF=0
      DO 60 K=1,I
      CELLK=CELL(K)
      FIK=FI(K)
      RPFDR = PFDR(CELLK   ,FIK   )
      RPFDR = RPFDR +((RPFDR/RSUMF) * RFIX ) + 0.5
      PFDR(CELLK   ,FIK   ) = IFIX(RPFDR)
   60 SUMF=SUMF+PFDR(CELLK   ,FIK   )
      IF( SUMF.GT.92.AND.SUMF.LT.106) GO TO 10
      GO TO 35
C.......................................................................
   50 IF(CDEBUG.NE.1) GO TO 10
      LINES=LINES+((I+3)/4)+1
      IF(LINES.GT.59) WRITE(ILIST,1000)
      IF(LINES.GT.59) LINES = 1 + (I+3)/4
      WRITE(ILIST,1010) FEEDER(J),SUMF,
     1    (EAST(CELL(II)),NORTH(CELL(II)),CELL(II),
     2    PFDR(CELL(II),FI(II)),II = 1,I)
      GO TO 10
   40 IF(CDEBUG.NE.1) GO TO 10
      IF(LINES.GT.58) WRITE(ILIST,1000)
      IF(LINES.GT.58) LINES = 1
      WRITE(ILIST,1020) FEEDER(J)
      LINES=LINES+2
   10 CONTINUE
 1010 FORMAT(  /,  2X,A4,2X,I4,(T16,4(6X,I3,4X,I3,4X,2I4 )))
 1020 FORMAT(  /,2X,A4,5X,'THIS FEEDER HAS NO CELLS')
```

```
      RETURN                                                      CHECKF90
      END                                                         CHECKF91
```

```
      SUBROUTINE NORMAL
C...........................LANDUSE 0401.................................
C   THIS ROUTINE CODED 25 JULY 1979
C        LAST MODIFICATION:  6 AUG 1979
C*  INCLUDE COMMON INFO
C   COMMON VARIABLES
C...........................LANDUSE 0602................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1     STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,
     2     NFIC,NLUIC,CIF,NCIF,       FI,FJ,LOWC,HIGHC,BLANK2,
     3     IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1              IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2              FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3              DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     4              TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5              PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6              RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7              PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8              INSTOR,NLUIF(450),NFIC(1575),
     9              NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A              LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B              IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C   ADJUST PFDR(I) FOR LAND USE TYPE (APPLY FACTORS), THEN NORMALIZE
      DIMENSION TRACK(14)
      REAL  SUMP, SUML, FKWI, PFDRMJ
      IF(NDEBUG.EQ.1)                 WRITE(ILIST,1000)
 1000                                 FORMAT(1H1,5X,'ENTERED NORMAL')
      DO 1 I = 1, NCELL
    1 CELLKW(I) = 0
C   CYCLE THROUGH FEEDERS
      DO 100 I=1,NFDR
      IF(NDEBUG.EQ.1)                 WRITE(ILIST,1010) I,FEEDER(I)
 1010                                 FORMAT(10X,'FEEDER ',I3,2X,A4)
      N=0
      SUMP=0.
      NLUIF(I)=0
      DO 10 II=1,14
      PLUIF(I,II)=0.0
   10 TRACK(II)=0
      START=LOWC(I)
      STOP=HIGHC(I)
C   CYCLE THROUGH APPLICABLE CELL RECORD RANGE
      IF(NDEBUG.EQ.1)                 WRITE(ILIST,1020)START,STOP,FKW(I)
 1020                                 FORMAT('+',30X,'LOOK THROUGH CELLS',
     1                                I5,' TO',I5,5X,'FKW=',I5)
      IF(START.EQ.0.AND.STOP.EQ.0) GO TO 100
      IF(START.LT.1.OR.STOP.GT.NCELL) GO TO 70
      DO 50 J=START,STOP
```

```
      KK=NFIC(J)
      DO 40 K=1,KK
      IF(FDR(J,K).EQ.I) GO TO 45
   40 CONTINUE
      GO TO 50
   45 LL=NLUIC(J)
      SUML=0.
      PFDRJK= PFDR(J,K)
C  BELOW, L IS THE NUMBER OF LAND USE IN CELL J
C      LL IS THE NUMBER OF LAND USES IN CELL J
      DO 47 L=1,LL
      LUSEJL=LUSE(J,L)
      TRACK(LUSEJL)=1
      PLUIF(I,LUSEJL)=PLUIF(I,LUSEJL)+FLOAT( PLUSE(J,L)*PFDRJK )*0.0001
  147 SUML=SUML+FLOAT( PLUSE(J,L)*FACTOR(LUSEJL )  ) *0.0001
      PFDRM(J,K)=FLOAT(PFDRJK)  * 0.01 * SUML
      IF(PFDRM(J,K) .LT. 0.0) PFDRM(J,K) = 0.0
      SUMP=SUMP+PFDRM(J,K)
      N=N+1
      IF(N.GT.110)GO TO 48
C    J IS THE CELL RECORD NUMBER, K IS THE NUMBER OF FEEDER I IN
C    CELL J (0<K<4), N IS THE NUMBER OF CELL J IN FEEDER I
C    (FINAL VALUE OF N IN THE FEEDER LOOP IS THE NUMBER OF CELLS
C    COVERED BY FEEDER I)    (0<N<111)
      FI(N)=J
      FJ(N)=K
      CIF(I,N)=J
      GO TO 50
   48 WRITE(ILIST,1030) I, FEEDER(I), J,(DISTRT(J,Z),Z=1,2)
 1030 FORMAT(/,1X,130('*'),/,' THERE ARE MORE THAN 110 CELLS IN FEEDER',
     1      I5,2X,A4,5X,'CELL EXCLUDED: ', I5 ,5X,2A4,/,1X,130('*'),//)
   50 CONTINUE
C++++++++++++ NORMALIZE PFDRM ++++++++++++++++++++++++++++++++++++++++++
      IF(SUMP.EQ.0.0) GO TO 51
      SUMP=1.0/SUMP
   51 IF(N.GT.110)N=110
      DO 60 J=1,N
      FIJ = FI(J)
      PFDRMJ = PFDRM(FIJ,FJ(J))
      PFDRMJ = PFDRMJ * SUMP
      FKWI = FLOAT(FKW(I))
      FKWI = 100.0 * FKWI * PFDRMJ
      CELLKW(FIJ) = CELLKW(FIJ) + FKWI
   60 PFDRM(FIJ, FJ(J) ) = PFDRMJ
      IF(NCIF(I) .NE. N  .AND.  NDEBUG .GE. 1) WRITE(ILIST,1070)
     1   I,FEEDER(I),NCIF(I),N,N
 1070 FORMAT(///,40X,'THERE IS A DISCREPANCY IN THE NUMBER OF CELLS ',
     1   'FED BY A FEEDER',///,
     2   T50,  'FEEDER:        ' , I4   , 3X,A4,//,
     3   T50,  'CHECKF NCIF: ' , I5   , // ,
     4   T50,  'NORMAL NCIF: ' , I5   , // ,
     5   T50,  'VALUE USED:  ' , I5   , ////)
      NCIF(I)=N
C    COUNT UP THE NUMBER OF LAND USE TYPES
      DO 65  J=1,14
   65 IF(TRACK(J).EQ.1) NLUIF(I)=NLUIF(I)+1
      GO TO 100
```

```
   70 WRITE(ILIST,1040) START,STOP,I,FEEDER(1)
 1040 FORMAT(1H1,1X,130('E'),/,1X,130('E'),///,1X,'THERE IS AN ERROR '
     1 ,'IN THE CELL RANGE OF A FEEDER. THE STARTING AND ENDING CELLS',
     2 ' AS WELL AS THE FEEDER ARE GIVEN BELOW',//,T40,
     3'START=',I5,' STOP=',I5,5X,'FEEDER:',I4,3X,A4,//,2(/,1X,130('E')))
  100 CONTINUE
      WRITE(ILIST,1060)
 1060 FORMAT(1H1,T53,'CELL DEMANDS (KW)',/,10(2X,'CELL',4X,'KW',1X))
                                WRITE(ILIST,1050)(K,CELLKW(K),K=1,NCELL)
 1050                           FORMAT(10(2X,I4,1X,F6.0  ))
      DO 110 J = 1,14
  110 DEMAND(J) = 0
      DO 200 I = 1,NCELL
      NLU = NLUIC(I)
      DO 130 K =1,NLU
  130 DEMAND(LUSE(I,K))=DEMAND(LUSE(I,K))+
     1                    IFIX(CELLKW(I)*PLUSE(I,K)*0.01)
  200 CONTINUE
      RETURN
      END
```

```
      BLOCK DATA
C.................................LANDUSE 0501..............................
C   COMMON VARIABLES
C   COMMON VARIABLES
C.............................LANDUSE 0602...................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1     STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,
     2     NFIC,NLUIC,CIF,NCIF,         FI,FJ,LOWC,HIGHC,BLANK2,
     3     IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1               IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2               FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3               DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     A               TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5               PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6               RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7               PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8               INSTOR,NLUIF(450),NFIC(1575),
     9               NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A               LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B               IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C...........................LANDUSE 0603........................................
C
      INTEGER*2 NZIC,NWZONE
      LOGICAL*1 GROWTH,GROBND,ALLGRO
      REAL RGRFAC,RDEMND
C
C
      COMMON /GROWBK/ NGAREA,NGBND(20),SGBND(20),EGBND(20),WGBND(20),
     *               RGRFAC(20),NZIC(1575),NWZONE(1575,3),RDEMND(14),
     *               GROBND,GROWTH,ALLGRO
C
C.............................................................................
C
      DATA BLANK/'    '/, AREA/14*0.0/, IREAD/1/,IDISK/4/,IPUNCH/2/,
     1     ILIST/3/,BLANK2/'  '/,POINT/4200*0/,TITLE/20*'    '/ ,
     2     PFDRM/4725*0.0/,NBOUND/70/,SBOUND/1/,WBOUND/1/,EBOUND/60/,
     3     IDISK2/13/,NGBND/20*70/,SGBND/20*1/,WGBND/20*1/,EGBND/20*60/,
     4     RGRFAC/20*1.0/,RDEMND/14*0.0/,LUDFC/4725*0.0/
C
      END
```

```
      SUBROUTINE GRID (NS,A1,EW,A2,A3,EA,NO)
C.................................LANDUSE 0601..................................
C   THIS ROUTINE CALCULATES THE GRID COORDINATES FROM THE DISTRICT
C        THIS ROUTINE CODED 8 AUGUST 1979
      IMPLICIT INTEGER*2 (A-Z)
      DATA S/'S'/,W/'W'/,NW/'NW'/,NE/'NE'/,SW/'SW'/,SE/'SE'/
      ADDE=0
      ADDN=0
      EA=0
      NO=0
      IF(A3.EQ.NW) ADDN=1
      IF(A3.EQ.SE) ADDE=1
      IF(A3.EQ.NE) GO TO 5
      GO TO 10
    5 ADDN=1
      ADDE=1
   10 IF(A1.EQ.S) GO TO 20
      IF(A2.EQ.W) GO TO 15
C   NORTH EAST QUADRANT OF SERVICE AREA
      EA=25+2*EW+ADDE
      NO=31+2*NS+ADDN
      RETURN
C   NORTH WEST QUADRANT OF SERVICE AREA
   15 EA=27-2*EW+ADDE
      NO=31+2*NS+ADDN
      RETURN
   20 IF(A2.EQ.W) GO TO 25
C   SOUTH EAST QUADRANT OF SERVICE AREA
      EA=25+2*EW+ADDE
      NO=33-2*NS+ADDN
      RETURN
C   SOUTH WEST QUADRANT OF SERVICE AREA
   25 EA=27-2*EW+ADDE
      NO=33-2*NS+ADDN
      RETURN
      END
```

```
      SUBROUTINE ORDER
C...................................LANDUSE 0701..........................
C   THIS SUBPROGRAM CHECKS (AND ADJUSTS IF REQUIRED) THE ALPHABETICAL
C   ORDER OF THE FEEDER LIST
C      THIS ROUTINE CODED 8 AUGUST 1979
C*  INCLUDE COMMON INFO
C   COMMON VARIABLES
C.................................LANDUSE 0602..............................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1          STRTP,PFDR,PCELL,POINT,INLIST,USE,   INSTOR,NLUIF,
     2          NFIC,NLUIC,CIF,NCIF,       FI,FJ,LOWC,HIGHC,BLANK2,
     3          IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1               IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2               FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3               DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     4               TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5               PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6               RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7               PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8               INSTOR,NLUIF(450),NFIC(1575),
     9               NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A               LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B               IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
      FLAG=0
      J=NFDR
      DO 20 II=1,NFDR
      J=J-1
      DO 10 JJ= 1,J
      IF(FEEDER(JJ).LT.FEEDER(JJ+1)) GO TO 10
      HOLD=FEEDER(JJ+1)
      FEEDER(JJ+1)=FEEDER(JJ)
      FEEDER(JJ)=HOLD
      HOLD=FKW(JJ+1)
      FKW(JJ+1)=FKW(JJ)
      FKW(JJ)=HOLD
      FLAG=1
   10 CONTINUE
      IF(FLAG.EQ.0) RETURN
   20 FLAG=0
      RETURN
      END
```

```
      SUBROUTINE PLOT (INDEX, ICODE)
C..............................LANDUSE 0801..........................................
C*  INCLUDE COMMON INFO
C  COMMON VARIABLES
C..............................LANDUSE 0602..........................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1       STRTP,PFDR,PCELL,POINT,INLIST,USE,     INSTOR,NLUIF,
     2       NFIC,NLUIC,CIF,NCIF,        FI,FJ,LOWC,HIGHC,BLANK2,
     3       IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1           IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2           FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3           DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     4           TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5           PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6           RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7           PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8           INSTOR,NLUIF(450),NFIC(1575),
     9           NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A           LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B           IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
      INTEGER*2 SYMBOL      ,LINE
      REAL RRA, RRB, RRC, RRD, RRE
      DIMENSION                        SYMBOL(11),LINE(131)
      DATA DOT /'.'/
 1010 FORMAT(11A1)
      IF(INDEX.EQ.1) READ(IREAD,1010) (SYMBOL(J),J=1,11)
      INDEX = 2
      IF(ICODE.NE.1) GO TO 100
C...................................................................................
C  PLOT THE NUMBER OF LAND USE TYPES AND FEEDERS IN EACH CELL
 1020 FORMAT(1H1)
 1030 FORMAT(T10,9('0 '),10('1 '),10('2 '),10('3 '),10('4 '),10('5 '),
     1 '6', /,T10,'1 2 3 4 5 6 7 8 9 ',5('0 1 2 3 4 5 6 7 8 9 '),
     2 '0 '              ,/,T10,60('. ')  )
      COUNT = 1
   10 WRITE(ILIST,1020)
      IF(COUNT.EQ.1) WRITE(ILIST,1070)
      IF(COUNT.EQ.2) WRITE(ILIST,1060)
      WRITE(ILIST,1030)
      DO 90 II = 1, 70
      J=71-II
      DO 80 I = 1, 60
      IF(POINT(I,J).NE.0) GO TO 20
      LINE(I)= BLANK2
C  I IS THE EAST COORDINATE, J IS THE NORTH COORDINATE
      GO TO 80
   20 L1=POINT(I,J)
      IF(COUNT.EQ.1) L2=NFIC(L1)+1
```

```
      IF(COUNT.EQ.2) L2=NLUIC(L1)+1
      LINE(I)=SYMBOL(L2)
   80 CONTINUE
      IF(LINE(1).EQ. BLANK2) LINE(1)=DOT
      IF(LINE(60).EQ. BLANK2) LINE(60) = DOT
      WRITE(ILIST,1040) J,(LINE(K),K=1,60),J
 1040 FORMAT( 2X,I5,T10,60(A1,1X),T129,I3)
   90 CONTINUE
      WRITE (ILIST,1050) (SYMBOL(K),K=1,11)
      WRITE(ILIST,1020)
      IF(COUNT.NE.1) GO TO 100
      COUNT=2
      GO TO 10
 1070 FORMAT(T30,'PLOT OF THE NUMBER OF FEEDERS IN EACH CELL',/)
 1060 FORMAT(T30,'PLOT OF THE NUMBER OF LAND USES IN EACH CELL',/)
 1050 FORMAT(T10,60('. '),//,
     *       T10,9('0 '),10('1 '),10('2 '),10('3 '),10('4 '),10('5 '),
     1 '6 ', /,T10,'1 2 3 4 5 6 7 8 9 ',5('0 1 2 3 4 5 6 7 8 9 '),
     3 '0 ',
     2      ///,T20,'SYMBOLS: ',11(A1,1X) )
  100 IF(ICODE.NE.2) GO TO 200
C.........PLOT DEMAND DENSITY PER CELL...................................
      WRITE(ILIST,1020)
      WRITE(ILIST,1080)
      WRITE(ILIST,1030)
 1080 FORMAT(T30,'PLOT OF THE KW LOAD IN EACH CELL',/)
      DO 120 II=1,70
      J=71-II
      DO 110 I=1,60
      IF(POINT(I,J).NE.0) GO TO 101
      LINE(I)= BLANK2
      GO TO 110
  101 L1=POINT(I,J)
      L2= IFIX( (CELLKW(L1)*0.001) + 0.5 ) + 1
      IF(L2.LT.1) L2=1
      IF(L2.GT.11) L2=11
      LINE(I)=SYMBOL(L2)
  110 CONTINUE
      IF(LINE(1).EQ.BLANK2 ) LINE(1)=DOT
      IF(LINE(60).EQ.BLANK2 ) LINE(60)=DOT
      WRITE(ILIST,1040)J,(LINE(K),K=1,60),J
  120 CONTINUE
      WRITE(ILIST,1050) (SYMBOL(K),K=1,11)
  200 IF(ICODE.NE.3) GO TO 300
C
C.......................................................................
      ENTRY PLOT3 (INDEX)
C.......................................................................
C
      IF(INDEX.EQ.1) READ (IREAD,1010)(SYMBOL(J),J=1,11)
      INDEX = 2
C.......................................................................
C     THIS IS A UNIVERSAL PLOT ROUTINE. THE VARIABLE TO BE PLOTTED
C     IS PASSED TO THE ROUTINE VIA THE DUMMY VARIABLE 'DUMMY'.
C     THE ROUTINE FINDS THE MAX AND MIN VALUES AND THE PLOTTING INCRAMENT
C     IF INDEX = 1, A NEW SET OF SYMBOLS WILL BE READ.
C     THE PLOT TITLE IS PASSED VIA THE VARIABLE 'TITLE'.
```

```
C.......................................................................
      MIN=9999999
      MAX=0
      DO 210 I=1,NCELL
      IF(DUMMY(I).LT.MIN) MIN = DUMMY(I)
  210 IF(DUMMY(I).GT.MAX) MAX = DUMMY(I)
      INCR =(MAX - MIN)/10
      IF(INCR.GE.1) GO TO 212
      INCR = 1
  212 WRITE(ILIST,1020)
      WRITE(ILIST,1090) (TITLE(J),J=1,20)
 1090 FORMAT(T30,20A4)
      WRITE(ILIST,1030)
      DO 220 JJ=1,70
      J=71-JJ
      DO 219 I=1,60
      L1 = POINT(I,J)
      IF( L1 .NE. 0 ) GO TO 202
      LINE(I) = BLANK2
      GO TO 219
  202 RRA = DUMMY(L1)
      RRB=MIN
      RRC=INCR
      L2 = IFIX((RRA - RRB)/RRC + 0.5 ) +1
      IF(L2.LT.1) L2 = 1
      IF(L2.GT.11) L2 = 11
      LINE(I) = SYMBOL(L2)
  219 CONTINUE
      IF(LINE( 1).EQ.BLANK2) LINE(1) = DOT
      IF(LINE(60).EQ.BLANK2) LINE(60) = DOT
      WRITE(ILIST,1040)J,(LINE(K),K=1,60),J
  220 CONTINUE
      WRITE(ILIST,1050) (SYMBOL(K),K=1,11)
  300 IF (ICODE.NE.4) GO TO 400
      RETURN
C
C.......................................................................
      ENTRY PLOT4 (INDEX)
C.......................................................................
C
      IF(INDEX.EQ.1) READ (IREAD,1010)(SYMBOL(J),J=1,11)
      INDEX = 2
C.......................................................................
C   THIS IS A UNIVERSAL PLOT ROUTINE SIMILIAR TO PLOT3 BUT DOES NOT
C   DETERMINE THE MAX AND MIN VALUES AND SCALE TO THESE LIMITS.
C   INSTEAD, THIS ROUTINE SCALES-DOWN 'DUMMY' BY A FACTOR OF FOUR AND
C   PLOTS THIS SCALLED VALUE IN ABSOLUTE TERMS.
C.........PLOT MODIFIED DEMAND DENSITY PER CELL.........................
      WRITE(ILIST,1020)
      WRITE(ILIST,1090)(TITLE(J),J=1,20)
      WRITE(ILIST,1030)
      DO 320 II=1,70
      J=71-II
      DO 310 I=1,60
      IF(POINT(I,J).NE.0) GO TO 301
      LINE(I)= BLANK2
      GO TO 310
```

```
  301 L1=POINT(I,J)
C       SCALE DOWN CELL DEMANDS BY A FACTOR OF FOUR
      L2= IFIX(DUMMY(L1)*0.25 + 0.5 ) + 1
      IF(L2.LT.1) L2=1
      IF(L2.GT.11) L2=11
      LINE(I)=SYMBOL(L2)
  310 CONTINUE
      IF(LINE(1).EQ.BLANK2 ) LINE(1)=DOT
      IF(LINE(60).EQ.BLANK2 ) LINE(60)=DOT
      WRITE(ILIST,1040)J,(LINE(K),K=1,60),J
  320 CONTINUE
      WRITE(ILIST,1050) (SYMBOL(K),K=1,11)
  400 CONTINUE
C 400 IF(ICODE.NE.5) GO TO 500
      RETURN
      END
```

```
      SUBROUTINE STAT(X,N,MEAN,SMEAN,S2,S,MAX,MIN,L,U,CI)
C.......................................................................
C......................LANDUSE 0901.....................................
C              X           ARRAY OF DATA (UP TO 1800 DATA POINTS)
C              N           NUMBER OF DATA VALUES IN X (0<N<1801)
C              MEAN        THE MEAN OF THE VALUES IN X
C              SMEAN       STANDARD DEVIATION OF THE MEAN
C              S2MEAN      VARIENCE OF THE MEAN
C              S2          VARIENCE OF THE DATA
C              S           STANDARD DEVIATION OF THE DATA
C              MAX         THE MAXIMUM VALUE IN THE DATA SET
C              MIN         THE MINIMUM VALUE IN THE DATA SET
C              L           LOWER BOUND ON THE 95% CONFIDENCE INTERVAL
C              U           UPPER BOUND ON THE 95% CONFIDENCE INTERVAL
C.......................................................................
      INTEGER  N, CI
      REAL MEAN, SMEAN, S2MEAN, S2, S, L, U ,T,X,MAX,MIN
      DIMENSION X(1800),T(46),T2(46),T3(46),T4(46),T5(46)
      DATA T/12.706,4.303,3.182,2.776,2.571,2.447,2.365,2.306,2.262,
     1       2.228,2.201,2.179,2.160,2.145,2.131,2.120,2.110,2.101,
     2       2.093,2.086.2.080,2.074,2.069,2.064,2.060,2.056,2.052,
     3       2.048,2.045,2.042,2.030,2.021,2.014,2.008,2.004,
     4       2.00,1.994,
     5       1.990,1.987,1.984,1.972,1.968,1.966,1.965,1.962,1.960/
      DATA T2/6.314,2.920,2.353,2.132,2.015,1.943,1.895,1.860,1.833,
     1       1.812,1.796,1.782,1.771,1.761,1.753,1.746,1.740,1.734,
     2       1.729,1.725,1.721,1.717,1.714,1.711,1.708,1.706,1.703,
     3       1.701,1.699,1.697,1.690,1.684,1.680,1.676,1.673,1.671,
     4       1.667,1.665,1.662,1.661,1.653,1.650,1.649,1.648,1.647,
     5       1.645/
      DATA T3/3.078,1.886,1.638,1.533,1.476,1.440,1.415,1.397,1.383,
     1       1.372,1.363,1.356,1.350,1.345,1.341,1.337,1.333,1.330,
     2       1.328,1.325,1.323,1.321,1.319,1.318,1.316,1.315,1.314,
     3       1.313,1.311,1.310,1.306,1.303,1.301,1.299,1.297,1.296,
     4       1.294,1.293,1.291,1.290,1.286,1.285,1.284,1.284,1.283,
     5       1.281/
      DATA T4/1.963,1.386,1.250,1.190,1.156,1.134,1.119,1.108,1.100,
     1       1.093,1.083,1.083,1.079,1.076,1.074,1.071,1.069,1.067,
     2       1.066,1.064,1.063,1.061,1.060,1.059,1.058,1.056,1.057,
     3       1.056,1.055,1.055,1.052,1.050,1.048,1.047,1.047,1.046,
     4       1.045,1.044,1.043,1.042,1.039,1.038,1.038,1.037,1.037,
     5       1.036/
      DATA T5/1.376,1.067,0.978,0.941,0.920,0.906,0.896,0.889,0.883,
     1       0.879,0.876,0.873,0.870,0.868,0.866,0.866,0.863,0.862,
     2       0.861,0.860,0.859,0.858,0.858,0.857,0.856,0.856,0.855,
     3       0.855,0.854,0.854,0.852,0.851,0.850,0.849,0.849,0.848,
     4       0.847,0.847,0.846,0.846,0.844,0.843,0.843,0.843,0.842,
     5       0.842/
C        T VALUES ARE FOR  CONFIDENCE INTERVALS
C        T(1) - T(30) ARE FOR 1 - 30 DEGREES OF FREEDOM
C        T(31) - T(35) ARE FOR 35 - 55 D.F. BY FIVES
C        T(36) - T(40) ARE FOR 60 - 100 D.F. BY TENS
C        T(41) - T(44) ARE FOR 200 - 500 D.F. BY HUNDREDS
C        T(45) IS FOR 1000 D.F.     AND   T(46) IS FOR INF.  D.F.
      MIN=1000000.
      MAX=0.
      SUM1=0.0
```

```
      SUM2=0.0
      IF(CI.NE.60.AND.CI.NE.70.AND.CI.NE.30.AND.CI.NE.90) CI=95
      N1=N-1
      DO 20 I=1,N
      XI=     X(I)
      SUM1=SUM1+XI
      SUM2=SUM2+(XI*XI)
      IF(MAX.LT.XI) MAX=XI
      IF(MIN.GT.XI) MIN=XI
   20 CONTINUE
      SUM3=SUM1*SUM1
      MEAN=SUM1/FLOAT(N)
      S2=(SUM2-(SUM3/FLOAT(N)))/FLOAT(N1)
      S=SQRT(S2)
      S2MEAN=S2/FLOAT(N)
      SMEAN=SQRT(S2MEAN)
C.......................................................................
      ENTRY STAT2(CI,L,U)
C.......................................................................
      J=1
      IF(N.GT.30)GO TO 30
      J=N
   25 IF(CI.EQ.95) GO TO 195
      IF(CI.EQ.90) GO TO 190
      IF(CI.EQ.80) GO TO 180
      IF(CI.EQ.70) GO TO 170
      IF(CI.EQ.60) GO TO 160
  195 L = MEAN - T(J) * SMEAN
      U = MEAN + T(J) * SMEAN
      RETURN
  190 L = MEAN - T2(J) * SMEAN
      U = MEAN + T2(J) * SMEAN
      RETURN
  180 L = MEAN - T3(J) * SMEAN
      U = MEAN + T3(J) * SMEAN
      RETURN
  170 L = MEAN - T4(J) * SMEAN
      U = MEAN + T4(J) * SMEAN
      RETURN
  160 L = MEAN - T5(J) * SMEAN
      U = MEAN + T5(J) * SMEAN
      RETURN
   30 IF(N.GT.59) GO TO 40
      J=((N-30)/5)+30
      GO TO 25
   40 IF (N.GT.109) GO TO 50
      J=((N-50)/10)+35
      GO TO 25
   50 IF(N.GT.599) GO TO 60
      J=((N-100)/100)+40
      GO TO 25
   60 J=45
      IF(N.GT.1200) J=46
      GO TO 25
      END
```

```
      SUBROUTINE ABORT
C..............................LANDUSE 1001.................................
C...........................................................................
C    THIS ROUTINE PRINTS THREE 'ABORT' PAGES, READS ANY REMAING DATA
C    CARDS INTO A DUMMY VARIABLE AND THEN STOPS THE PROGRAM.
C...........................................................................
      I=0
      IF(I.EQ.1) GO TO 30
C    THE ABOVE TWO STATEMENTS PROVIDE THE REQUIRED REFERENCE TO
C    STATEMENT 30, THE DUMMY RETURN
      WRITE(3,1000)
      WRITE(3,1000)
      WRITE(3,1000)
 1000 FORMAT(1H1,5(/,1X,131('A')),50(/,1X,'AAA',12(5X,'ABORT'),5X,'AAA')
     1      ,5(/,1X,131('A')))
 1010 FORMAT(A4)
   10 READ(1,1010,END=20) DATA
      GO TO 10
   20 STOP
C    DUMMY RETURN TO SATISFY THE COMPILER (SUBROUTINES NEED A RETURN)
   30 RETURN
      END
```

```
      SUBROUTINE OUT                                                    OUT 0010
C.............................LANDUSE 1101..............................OUT 0020
C.......................................................................OUT 0030
C   THIS ROUTINE OUTPUTS THE LANDUSE PROGRAM RESULTS AS WELL AS CERTAIN OUT 0040
C   INTERMEDIATE RESULTS AND INPUT DATA FOR DEBUGGING PURPOSES.         OUT 0050
C   A CALL TO OUT WILL PRODUCE THE MAXIMUM OUTPUT POSSIBLE. TO LIMIT    OUT 0060
C   THE AMOUNT OF OUTPUT, ENTER AT OUT#, WHERE # IS ONE OF THE          OUT 0070
C   ENTRY POINTS.                                                       OUT 0080
C.......................................................................OUT 0090
C   COMMON VARIABLES                                                        002
C.............................LANDUSE 0602..............................    004
C                                                                           006
      IMPLICIT INTEGER (A-Z)                                                008
C                                                                           010
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,     012
     1          STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,         014
     2          NFIC,NLUIC,CIF,NCIF,      FI,FJ,LOWC,HIGHC,BLANK2,          016
     3          IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND            018
C                                                                           020
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC                              022
C                                                                           024
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,     026
     1                IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,       028
     2                FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),          030
     3                DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),     032
     4                TITLE(20),DUMMY(1575),LUDFC(1575,3)                   034
C                                                                           036
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),     038
     5                PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),         040
     6                RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),          042
     7                PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,       044
     8                INSTOR,NLUIF(450),NFIC(1575),                         046
     9                NLUIC(1575),CIF(450,107),NCIF(450),USE(14),           048
     A                LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,          050
     B                IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND      052
      REAL TOT                                                          OUT 0110
      FINISH = 0                                                        OUT 0120
      GO TO 5                                                           OUT 0130
      ENTRY OUT1                                                        OUT 0140
      FINISH = 1                                                        OUT 0150
CXXXXXXXX OUTPUT BY CELL XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXOUT 0160
    5 WRITE( ILIST , 1000)                                              OUT 0170
 1000 FORMAT (1H1,1X,'CELL',' DISTRICT ','COORD',T25,'( FEEDERS   PFDRS OUT 0180
     1 PFDRMS )',T71,'CELLKW',    T80,'( LUSES    PLUSES    ZONES PZONES )'OUT 0190
     2  ,/)                                                             OUT 0200
      LINES = 2                                                         OUT 0210
      DO 50 I = 1,NCELL                                                 OUT 0220
      LINES = LINES + 1                                                 OUT 0230
      IF(LINES.LT.59) GO TO 10                                          OUT 0240
      WRITE(ILIST, 1000)                                                OUT 0250
      LINES = 2                                                         OUT 0260
   10 WRITE(ILIST,1010)I,(DISTRT(I,K),K=1,2),EAST(I),NORTH(I),          OUT 0270
     1(FEEDER(FDR(I,K)),PFDR(I,K),PFDRM(I,K).K=1,3 ),CELLKW(I),         OUT 0280
     2 (USE(LUSE(I,K)),PLUSE(I,K),K=1,3),                               OUT 0290
     3                          (ZONE(I,K),PZONE(I,K),K=1,3)            OUT 0300
 1010 FORMAT(1X,I4,1X,2A4,1X,I2,'-',I2,T22,3(1X,A4,I3,1X,F5.3),F10.1,   OUT 0310
     1   T80,3(A2,1X,I3,1X),3(A4,1X,I3,1X)  )                           OUT 0320
```

```
   50 CONTINUE
      IF (FINISH .EQ. 1) RETURN
      GO TO 60
C.......................................................................
      ENTRY OUT2
      FINISH = 2
C.......................................................................
C   DATA BY FEEDER
   60 WRITE(ILIST,1020)
      LINES = 3
 1020 FORMAT(1H1,T26,'............PERCENT LAND USE................',
     A   12('.'),'TOTAL',
     1 T111,'CELL LIMITS',
     2          /, 5X,'FEEDER',6X,'FKW',
     3T23,'  R1  R2  R3  M1  M2  C1  C2  C3  C4  I1  I2  S1  S2  S3',
     +          T90,'   NLUIF    NCIF      LOW    HIGH'   )
      DO 100 I=1,NFDR
      K1 = NCIF(I)
      TOT=0.0
      DO 63 K=1,14
   63 TOT=TOT+PLUIF(I,K)
      LINES = LINES + 3 + (K1+20)/20
      IF (LINES.LT.59) GO TO 65
      WRITE(ILIST,1020)
      LINES = 5
   65 WRITE(ILIST,1030) I, FEEDER(I), FKW(I), (PLUIF(I,J),J=1,14),TOT,
     1    NLUIF(I),NCIF(I),LOWC(I),HIGHC(I)
 1030 FORMAT(/,3X,I3,2X,A4,3X,I5,T25,14F4.2,T84,F4.2 ,T90,4I8   )
      WRITE(ILIST,1050) (CIF(I,J),J=1,K1)
 1050 FORMAT(T25, 29('.'),'CELLS IN THIS FEEDER',
     1  ' ARE',47('.'),/,(T25,20I5)   )
  100 CONTINUE
      IF ( FINISH .EQ. 2) RETURN
      GO TO 120
C.......................................................................
      ENTRY OUT3
      FINISH = 3
C.......................................................................
C   OUTPUT BY LANDUSE TYPE
  120 WRITE(ILIST,1060)(I,USE(I),FACTOR(I),AREA(I),DEMAND(I),I=1,14)
 1060 FORMAT(1H1,55X,'DATA BY LANDUSE TYPE',///,
     1    20X,'LANDUSE',T30,'FACTOR',T40,'AREA',T50,
     *    'DEMAND BEFORE GROWTH',/,
     2    20X,7('-'),T30,6('-'),T40,'----',T50,'-(KW)-',///,
     3    14(21X,I2,1X,A2,T30,I5,T38,F8.1,T50,I6,/))
C.......................................................................
C   ADDITIONAL OUTPUT BY CELL
C
      WRITE(ILIST,1070)
 1070 FORMAT(1H1,60X,'DATA BY CELL',/,2(1X,'CELL',5X,'LUDFC(1)',
     1    2X,'LUDFC(2)',2X,'LUDFC(3)',2X,'NFIC',2X,'NLUIC',10X),/,
     2    2(1X,'----',5X,3('--------',2X),'----',2X,5('-'),10X))
      LINES = 3
      DO 200 I = 1,NCELL,2
      II = I+1
      LINES = LINES + 1
      IF(LINES .LT. 59) GO TO 130
```

```
      LINES = 3
      WRITE(ILIST,1070)
  150 WRITE(ILIST,1080)I,(LUDFC(I,J),J=1,3),NFIC(I),NLUIC(I),
     1   II,(LUDFC(II,J),J=1,3),NFIC(II),NLUIC(II)
  200 CONTINUE
 1080 FORMAT(   2(1X,I4,5X,3(F8.4,2X),I4,2X,I4,11X))
      IF(FINISH .EQ. 3) RETURN
      GO TO 320
      ENTRY OUT4
      FINISH = 4
  320 RETURN
      END
```

```
      SUBROUTINE SCATTR                                                 SCAT 002
C.............................LANDUSE 1201..............................SCAT 004
C   COMMON VARIABLES                                                         002
C.............................LANDUSE 0602..................................  004
C                                                                            006
      IMPLICIT INTEGER (A-Z)                                                 008
C                                                                            010
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,      012
     1     STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,               014
     2     NFIC,NLUIC,CIF,NCIF,        FI,FJ,LOWC,HIGHC,BLANK2,              016
     3     IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND                  018
C                                                                            020
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC                               022
C                                                                            024
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,      026
     1                IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,        028
     2                FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),           030
     3                DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),      032
     A                TITLE(20),DUMMY(1575),LUDFC(1575,3)                    034
C                                                                            036
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),      038
     5                PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),          040
     6                RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),           042
     7                PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,        044
     8                INSTOR,NLUIF(450),NFIC(1575),                          046
     9                NLUIC(1575),CIF(450,107),NCIF(450),USE(14),            048
     A                LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,           050
     B                IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND       052
      REAL SUMA,SUMD,MAXA,MAXD,MINA,MIND,YMIN,YMAX,RX,XA,XD,Y,DEMCEL,   SCAT 008
     1   SUMLUA,SUMLUD,                                                 SCAT 010
     2   MEAN,SMEAN,VARIEN,STDDEV,MAX,MIN,LOWER,UPPER,RKW               SCAT 012
      DIMENSION TITLE8(14,20),XA(440),XD(440),Y(4),DEMCEL(440),IREF(440)SCAT 014
      LOGICAL*1 NOCELL                                                  SCAT 016
      READ(IREAD,1000)((TITLE8(I,J),J=1,20),I=1,14)                     SCAT 018
 1000 FORMAT(20A4)                                                      SCAT 020
C.......................................................................SCAT 022
C       TITLE8        THE 14 TITLES FOR THE AREA/DEMAND PLOTS           SCAT 024
C       MINA/MAXA     THE MIN/MAX AREA (IN CELLS) FOR LAND USE 'LU'     SCAT 026
C       MIND/MAXD     THE MIN/MAX DEMAND (IN KW) FOR LAND USE 'LU'      SCAT 028
C       NOCELL        LOGICAL - TRUE IF NO CELLS IN A FEEDER            SCAT 030
C                            HAVE LANDUSE TYPE LU (USED WITH BOUNDS)    SCAT 032
C       SUMA          BY FEEDER, THE SUM OF LAND USE 'LU' AREAS         SCAT 034
C       SUMD          BY FEEDER, THE SUM OF DEMAND OF 'LU'              SCAT 036
C       DEMCEL        BY FEEDER, SUMD/SUMA  ... (KW/CELL)               SCAT 038
C       IFDR          THE RELATIVE FEEDER NUMBER WITHIN 'LU'            SCAT 040
C       MEAN          THE MEAN OF DEMCEL (IFDR VALUES)                  SCAT 042
C       SMEAN         STANDARD DEVIATION OF THE MEAN                    SCAT 044
C       VARIEN        VARIENCE OF THE DATA (DEMCEL)                     SCAT 046
C       STDDEV        STANDARD DEVIATION OF THE DATA (DEMCEL)           SCAT 048
C       MAX           MAXIMUM VALUE OF THE DATA POINTS                  SCAT 050
C       MIN           MINIMUM VALUE OF THE DATA POINTS                  SCAT 052
C       LOWER         LOWER BOUND ON THE CONFIDENCE INTERVAL            SCAT 054
C       UPPER         UPPER BOUND ON THE CONFIDENCE INTERVAL            SCAT 056
C.......................................................................SCAT 058
      DO 100 LU=1,14                                                    SCAT 060
      SUMLUA= 0.0                                                       SCAT 062
      SUMLUD = 0.0                                                      SCAT 064
```

```
      INDEX=1
      MAXA=0.0
      MINA=99999.0
      MAXD=0.0
      MIND=99999.0
      IFDR=0
      DO 90 F=1,NFDR
      IF(PLUIF(F,LU) .LE. 0.0) GO TO 90
C   WE NOW KNOW THAT FEEDER 'F' CONTAINS LAND USE TYPE 'LU'.
      SUMA = 0.0
      SUMD = 0.0
      HIGH = NCIF(F)
      NOCELL = .TRUE.
      DO 80 CC=1,HIGH
      C = CIF(F,CC)
      IF(NORTH(C).GT.NBOUND) GO TO 80
      IF(NORTH(C).LT.SBOUND) GO TO 80
      IF( EAST(C).LT.WBOUND) GO TO 80
      IF( EAST(C).GT.EBOUND) GO TO 80
      TOP=NLUIC(C)
      DO 12 I=1,TOP
      IF(LUSE(C,I) .EQ. LU) GO TO 15
   12 CONTINUE
      GO TO 80
C   WE NOW KNOW THAT CELL 'C' HAS 'LU' AS ITS I-TH LAND USE TYPE.
   15 RR=PLUSE(C,I)
      NOCELL = .FALSE.
      SUMA=SUMA+(FLOAT(   RR      )*0.01)
      SUMD=SUMD+(LUDFC(C,I)*CELLKW(C))
C   WE NEED TO USE (LUDFC*CELLKW) RATHER THAN (PLUSE*FKW) BECAUSE
C   LUDFC AND CELLKW HAVE BEEN CORRECTED FOR THE LAND USE TYPES
   80 CONTINUE
      IF(NOCELL) GO TO 90
      IFDR = IFDR + 1
      IREF(IFDR) = F
      IF(MAXA .LT. SUMA) MAXA = SUMA
      IF(MINA .GT. SUMA) MINA = SUMA
      IF(MAXD .LT. SUMD) MAXD = SUMD
      IF(MIND .GT. SUMD) MIND = SUMD
      XA(IFDR)=SUMA
      XD(IFDR)=SUMD
      DEMCEL(IFDR) = SUMD/SUMA
      SUMLUA = SUMLUA + SUMA
      SUMLUD = SUMLUD + SUMD
   90 CONTINUE
C   PLOT RESULTS
      IF(IFDR .EQ. 0) GO TO 100
      YMIN=MINA
      YMAX=MAXA
      IMIND = IFIX(MIND)
      IMAXD = IFIX(MAXD + 100.)
      DO 92 J=1,20
   92 TITLE(J) = TITLES(LU,J)
      DO 99 KW=1,20001,100
      NUM = 0
      IF(KW.LT.IMIND.OR.KW.GT.IMAXD ) GO TO 99
      RKW= FLOAT(KW) - 1.0
```

```
      DO 95 K=1,IFDR
      IF(IFIX(XD(K)).LT.(KW+100).AND.IFIX(XD(K)).GE.(KW-1)) GO TO 93
      GO TO 95
   93 NUM = NUM + 1
      Y(NUM)=XA(K)
      IF(NUM .EQ. 4) GO TO 96
   95 CONTINUE
      IF(NUM .EQ. 0) GO TO 99
   96 CALL PLTR(RKW,YMIN,YMAX,Y,NUM,INDEX,TITLE)
   99 CONTINUE
C   PRINT RESULTS
      WRITE(ILIST,1010)(TITLE(J),J=1,20),(J,FEEDER(IREF(J)),XA(J),XD(J),
     1    DEMCEL(J)          ,J=1,IFDR)
 1010 FORMAT(1H1,T25,20A4,/,5X,'REF #',6X,'FEEDER',
     1       10X,'# CELLS', 7X,'KW DEMAND',
     1    T65,'DEMAND/CELL',/,
     1       (5X,I5,7X,A4,8X,F10.3,9X,F10.4,T65,F11.4))
C.............CALL SUBROUTINE STAT ...................................
      CI = 95
      CALL STAT (DEMCEL,IFDR,MEAN,SMEAN,VARIEN,STDDEV,MAX,MIN,
     1          LOWER,UPPER,CI)
      WRITE(ILIST,1020)(TITLE(J),J=1,20),MEAN,IFDR,VARIEN,STDDEV,
     1    MAX,MIN,UPPER,LOWER
 1020 FORMAT(1H1,20X,20A4,///, 55X,'DEMAND (KW) PER CELL',///,
     1       50X,'MEAN:', F15.5,//,50X,'NUMBER OF POINTS:',I8,
     2       //,50X,'VARIENCE:',F15.2,//,50X,'STANDARD DEVIATION:',
     3       F15.2,//,20X,'MAXIMUM VALUE:',F15.5,T80,'MINIMUM VALUE:',
     4       F15.5,///,40X,'95% CONFIDENCE INTERVAL:',/,50X,
     5       'UPPER BOUND:',F15.5,/,50X,'LOWER BOUND:',F15.5)
      DO 150 I=1,4
      CI = (10-I)*10
      CALL STAT2 (CI,LOWER,UPPER)
  150 WRITE(ILIST,1030)CI,UPPER,LOWER
 1030 FORMAT(//,40X,I2,'% CONFIDENCE INTERVAL:',/,50X,
     1       'UPPER BOUND:',F15.5,/,50X,'LOWER BOUND:',F15.5)
  100 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PLTR(X,YMIN,YMAX,Y,NUM,INIT,TITLE)
C.......................................................................
C...PLOTTER SUBPROGRAM....
C         X              'X-AXIS' VALUE
C         YMIN           SMALLEST VALUE ON Y-AXIS
C         YMAX           LARGEST Y-AXIS VALUE
C         Y              THE VALUE TO BE PLOTTED (MAX OF FOUR PER PLOT)
C         NUM            DIMENSION OF Y (NUMBER OF VARIABLES...LE. 4)
C         INIT           SET TO ONE. PLOT ROUTINE WILL PRINT AXIS AND
C                              RETURN INIT AS 10.
C         TITLE          TITLE TO BE PRINTED AT THE TOP OF THE PLOT
C.......................................................................
C      IT SHOULD BE NOTED THAT THIS IS A CONTINUOUS PLOT ROUTINE,
C     THAT IS, THE VALUES ARE PLOTTED AS THEY ARE CALCULATED.
C      IF AN ARRAY OF VALUES IS TO BE PLOTTED, THE CALL TO PLTR
C       MUST BE PLACED IN A 'DO' LOOP.
C.......................................................................
      INTEGER TITLE
      DIMENSION K(6),IA(101),Y(NUM),TITLE(20)
      DATA K/'A','B','C', 'D',' ','*'/
      IF(INIT.NE.1) GO TO 10
      DIFF=(YMAX-YMIN)/2.0
      YMID=YMIN+DIFF
      WRITE(3,5)(TITLE(JJ),JJ=1,20),YMIN,YMID,YMAX
    5 FORMAT('1',30X,20A4,
     $////17X,F15.7,36X,F15.7,35X,F15.7//24X,'*',49X,'*',49X,'*'/
     $24X,'*',10( 9X,'*')/24X,101('*'))
   10 CONTINUE
      DO 15 I=1,101
      IA(I)=K(5)
   15 CONTINUE
      R=YMAX-YMIN
      DO 30 N=1,NUM
      L=NUM+1-N
      IPT=IFIX(((Y(L)-YMIN)/R)*100.0+.51)+1
      IF(IPT.GT.101.OR.IPT.LT.1) GO TO 30
      IA(IPT)=K(L)
   30 CONTINUE
      IZERO=IFIX((-YMIN/R)*100.0+.51)+1
      IF(IZERO.GT.101.OR.IZERO.LT.1) GO TO 40
      IA(IZERO)=K(6)
   40 CONTINUE
      WRITE(3,260) X
  260 FORMAT(' ',6X,F15.7)
      WRITE(3,280) IA
  280 FORMAT('+',23X,101A1)
      INIT=10
      RETURN
      END
```

```
      SUBROUTINE DUMPS
C..............................LANDUSE 1401.................................
C    INCLUDE COMMON INFO
C    COMMON VARIABLES
C..............................LANDUSE 0602...................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1          STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,
     2          NFIC,NLUIC,CIF,NCIF,          FI,FJ,LOWC,HIGHC,BLANK2,
     3          IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1                IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2                FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3                DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     4                TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5                PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6                RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7                PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8                INSTOR,NLUIF(450),NFIC(1575),
     9                NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A                LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B                IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
      WRITE(IDISK2)((ZONE(I,J),LUDFC(I,J),J=1,3),(DISTRT(I,J),J=1,2),
     1  CELLKW(I),I=1,1575),(FEEDER(I),FKW(I),I=1,450),NCELL,NFDR
C
      WRITE(IDISK2) ((PZONE(I,J),J=1,3),EAST(I),NORTH(I),I=1,1575),
     1   ((POINT(I,J),I=1,60),J=1,70)
      REWIND IDISK2
      RETURN
      END
```

```
      SUBROUTINE GROW
C.............................LANDUSE 1501..................................
C   COMMON VARIABLES
C.............................LANDUSE 0602...................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1      STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,
     2      NFIC,NLUIC,CIF,NCIF,         FI,FJ,LOWC,HIGHC,BLANK2,
     3      IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1           IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2           FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3           DISTRT(1575,2),BLANK,PFDRM(1575,3).PLUIF(450,14),
     A           TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5           PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6           RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7           PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8           INSTOR,NLUIF(450),NFIC(1575),
     9           NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A           LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B           IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C.............................LANDUSE 0603...................................
C
      INTEGER*2 NZIC,NWZONE
      LOGICAL*1 GROWTH,GROBND,ALLGRO
      REAL RGRFAC,RDEMND
C
C
      COMMON /GROWBK/ NGAREA,NGBND(20),SGBND(20),EGBND(20),WGBND(20),
     *                RGRFAC(20),NZIC(1575),NWZONE(1575,3),RDEMND(14),
     *                GROBND,GROWTH,ALLGRO
C
C
C...........................................................................
      LOGICAL*1 VACANT,SPOT
      DIMENSION MATCH(3),IMATCH(3)
      REAL RTOTAL,RSUM,RPZ
C
      CALL ZCHG
C
      VLUSE = 12
      AUTOLU = 0
      AUTOAG = 0
      AUTONW = 1
C
      DO 500 CELL = 1,NCELL
      IF( .NOT. GROBND) GO TO 19
C  CHECK GROWTH BOUNDS
      SPOT = .FALSE.
      EST = EAST(CELL)
      NTH = NORTH(CELL)
```

```
      DO 10 I =1,NGAREA
      IF(WGBND(I).LE.EST.AND.EGBND(I).GE.EST.AND.SGBND(I).LE.NTH
     *  .AND.NGBND(I).GE.NTH)    SPOT = .TRUE.
      GAREA = I
      IF( SPOT ) GO TO 20
   10 CONTINUE
      GO TO 500
   19 GAREA = 1
   20 NLU = NLUIC(CELL)
      VACANT = .FALSE.
      IF ( ALLGRO ) GO TO  70
      DO 30 I = 1,NLU
      LU = LUSE(CELL,I)
      IF(LU .NE. VLUSE) GO TO 28
      VACANT = .TRUE.
      KVCNT = I
   28 IF(LU .NE. AUTOLU .OR.  AGE(CELL) .LE. AUTOAG) GO TO 30
      LUSE(CELL,I) = AUTONW
      FLT = PLUSE(CELL,I)
      IF(RDEMND(AUTOLU) .LE. 0.0) GO TO 30
      CELLKW(CELL)=CELLKW(CELL)+( FLOAT( FLT )*0.01*
     *           RDEMND(AUTONW)/RDEMND(AUTOLU) )
   30 CONTINUE
      IF( .NOT. VACANT ) GO TO 500
      IF(NLU .EQ. 1) GO TO 70
      NZICC = NZIC(CELL)
      NMATCH = 0
      DO 40 I =1,NZICC
      DO 35 J =1,14
      IF(NWZONE(CELL,I) .EQ. J) GO TO 38
   35 CONTINUE
      GO TO 40
   38 NMATCH = NMATCH + 1
      IMATCH(NMATCH) = I
      MATCH(NMATCH) = J
   40 CONTINUE
C     WE NOW HAVE 'NMATCH' MATCHES BETWEEN 'MATCH(NMATCH)' LANDUSE TYPE
C     AND THE 'IMATCH(NMATCH)'-TH ZONE OF THE CELL.  THE 'KVCNT'-TH
C     LANDUSE TYPE OF THE CELL (VACANT) IS TO BE REPLACED.
C
      IF(NMATCH .LT. 0 .OR. NMATCH .GT. 3) GO TO 500
C     REPLACE THE VACANT AREA BY THE AVERAGED ZONED DEMAND
   50 RTOTAL = 0.0
      RSUM = 0.0
      DO 55 L = 1, NZICC
      FLT = PZONE(CELL,L)
      RPZ = FLOAT(FLT)
      RSUM = RSUM + RDEMND(NWZONE(CELL,L)) * RPZ * 0.01
   55 RTOTAL = RTOTAL + RPZ * 0.01
      IF(RTOTAL .LE. 0.0) GO TO 500
      FLT = PLUSE(CELL,KVCNT)
      CELLKW(CELL) = CELLKW(CELL) + RSUM * FLOAT(FLT) * RGRFAC(GAREA)
     *          * 0.01 / RTOTAL
      GO TO 500
C
C     IF THE TOTAL CELL IS VACANT: ( OR ALLGRO )
   70 NZICC = NZIC(CELL)
```

```
      DO 31 L =1,NZICC
      INDX = NWZONE(CELL,L)
      LUSE(CELL,L) = INDX
      FLT = PZONE(CELL,L)
      CELLKW(CELL) = CELLKW(CELL) + ( RDEMND(INDX) * 0.01 *
     *          FLOAT(FLT) * RGRFAC(GAREA) )
   31 CONTINUE
  500 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ZCHG
C.............................LANDUSE 1601.................................
C  INCLUDE COMMON INFO
C   COMMON VARIABLES
C.............................LANDUSE 0602..................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1          STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,
     2          NFIC,NLUIC,CIF,NCIF,        FI,FJ,LOWC,HIGHC,BLANK2,
     3          IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1                IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2                FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3                DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     4                TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5                PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6                RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7                PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8                INSTOR,NLUIF(450),NFIC(1575),
     9                NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A                LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B                IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C.............................LANDUSE 0603..................................
C
      INTEGER*2 NZIC,NWZONE
      LOGICAL*1 GROWTH.GROBND,ALLGRO
      REAL RGRFAC,RDEMND
C
C
      COMMON /GROWBK/ NGAREA,NGBND(20),SGBND(20),EGBND(20),WGBND(20),
     *                 RGRFAC(20),NZIC(1575),NWZONE(1575,3),RDEMND(14),
     *                 GROBND,GROWTH,ALLGRO
C
C..........................................................................
      DIMENSION OZONE(29),NZONE(29)
      DATA OZONE/'R7.5','FP'  ,'A'   ,'I2'  ,'SU'  ,'MF2' ,'PD'  ,'LC' ,
     *           'SC'  ,'R10' ,'GR'  ,'I1'  ,'HC'  ,'TH3' ,'R5'  ,'MF1',
     *           'R16' ,'O'   ,'R1'  ,'R.5' ,'I3'  ,'FPI' ,'TH2' ,'R13',
     *           'NS'  ,'MF3' ,'FPA' ,'TH1' ,'MF4'/
      DATA NZONE/ 2,14,12,10, 7, 4, 7, 6, 6, 1, 6,10, 8, 7, 2, 4, 1,
     *            8, 1, 2,11,14, 2, 1, 6, 5,14, 2, 5/
C
      DO 50 CELL = 1, NCELL
      NZICC = 3
      IF(ZONE(CELL,3) .EQ. BLANK) NZICC = 2
      IF(ZONE(CELL,2) .EQ. BLANK) NZICC = 1
      NZIC(CELL) = NZICC
      DO 50 I = 1,NZICC
      ZONECI = ZONE(CELL,I)
      DO 30 J =1,29
```

```
      IF(ZONECI .EQ. OZONE(J)) GO TO 35                                ZCHG 044
   30 CONTINUE                                                         ZCHG 050
      WRITE(ILIST,1000) ZONECI,CELL                                    ZCHG 051
 1000 FORMAT(5X,'ZONE ',A4,' NOT FOUND IN ZONE LIST. CELL:',I5)        ZCHG 051
      GO TO 50                                                         ZCHG 052
   35 NWZONE(CELL,I) = NZONE(J)                                        ZCHG 054
   50 CONTINUE                                                         ZCHG 056
      RETURN                                                           ZCHG 058
      END                                                              ZCHG 060
```

```
      SUBROUTINE SECOND
C..........................LANDUSE 2001...................................
C        THIS PROGRAM READS INTERMEDIAT RESULTS AND PERFORMS THE
C        LOAD GATHERING TASK.  IT CREATES NEW SUBSTATIONS IF NEEDED.
C=========================================================================
C        THIS PROGRAM REQUIRES THE FOLLOWING SUBROUTINES:
C             FETCH      (LANDUSE 2201)
C             GATHER     (LANDUSE 2101)
C             PLOT       (LANDUSE 0801)
C             GRID       (LANDUSE 0601)
C=========================================================================
C    COMMON VARIABLES
C...........................LANDUSE 0602......................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1          STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,
     2          NFIC,NLUIC,CIF,NCIF,       FI,FJ,LOWC,HIGHC,BLANK2,
     3          IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1                IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2                FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3                DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     4                TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5                PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6                RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7                PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8                INSTOR,NLUIF(450),NFIC(1575),
     9                NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A                LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B                IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
      REAL DELTA,MDBSUB,NEWLMT
      LOGICAL*1 BOUNDS
      COMMON /LAST/ DELTA,NCYCLE,MAXITR,MAXRNG,GDEBUG,NNEW,DELNEW,
     A                 NEWLMT,
     1                 MXNSUB,MDBSUB,IGRAF,SKIP,BOUNDS
C...MDBSUB: MINIMUM DISTANCE BETWEEN CREATED SUBSTATIONS IN A CYCLE.....
C
      READ(IREAD,1010) GDEBUG,MXNSUB,BOUNDS,DELTA,
     *                  SKIP,IGRAF,NEWLMT,NNEW,DELNEW,
     *                  MDBSUB,NCYCLE,MAXITR,MAXRNG
 1010 FORMAT(2I5,4X,L1,F10.3,/,2I5,F10.3,2I5,/,F10.3,3I5)
C
      WRITE(ILIST,1000)BOUNDS,DELTA,SKIP,IGRAF,NEWLMT,
     1   NNEW,DELNEW,MDBSUB,NCYCLE,MAXITR,MAXRNG,GDEBUG,MXNSUB
 1000 FORMAT(1H1,/////,1X,130('X'),//,T50,'CASE PARAMETERS',//,
     *    T40, 'BOUNDS          ', 5X,L1,//,
     *    T40, 'DELTA           ', F6.2 ,//,
     *    T40, 'SKIP            ', I6   ,//,
     *    T40, 'IGRAF           ', I6   ,//,
     *    T40, 'NEWLMT          ', F6.2 ,//,
```

```
     *   T40, 'NNEW         ', I6   ,//,
     *   T40, 'DELNEW       ', I6   ,//,
     *   T40, 'MOBSUB       ', F6.2 ,//,
     *   T40, 'NCYCLE       ', I6   ,//,
     *   T40, 'MAXITR       ', I6   ,//,
     *   T40, 'MAXRNG       ', I6   ,//,
     *   T40, 'GDEBUG       ', I6   ,//,
     *   T40, 'MXNSUB       ', I6   ,//,
     *   1X,130('X') ,///)
C
C.........GATHER LOADS.....................................................
      CALL GATHER
      RETURN
      END
```

```
C.............................LANDUSE 2002..................................
C       THIS PROGRAM READS INTERMEDIAT RESULTS AND PERFORMS THE
C       LOAD GATHERING TASK.  IT CREATES NEW SUBSTATIONS IF NEEDED.
C===========================================================================
C       THIS PROGRAM REQUIRES THE FOLLOWING SUBROUTINES:
C            FETCH     (LANDUSE 2201)
C            GATHER    (LANDUSE 2101)
C            PLOT      (LANDUSE 0801)
C            GRID      (LANDUSE 0601)
C===========================================================================
C   COMMON VARIABLES
C..............................LANDUSE 0602....................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1          STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,
     2          NFIC,NLUIC,CIF,NCIF,          FI,FJ,LOWC,HIGHC,BLANK2,
     3          IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1                IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2                FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3                DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     A                TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5                PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6                RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7                PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8                INSTOR,NLUIF(450),NFIC(1575),
     9                NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A                LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B                IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
      REAL DELTA,MDBSUB,NEWLMT
      LOGICAL*1 BOUNDS
      COMMON /LAST/ DELTA,NCYCLE,MAXITR,MAXRNG,GDEBUG,NNEW,DELNEW,
     A                NEWLMT,
     1                MXNSUB,MDBSUB,IGRAF,SKIP,BOUNDS
C
      IDISK2 = 13
C
C...MDBSUB: MINIMUM DISTANCE BETWEEN CREATED SUBSTATIONS IN A CYCLE.....
C
      READ(IREAD,1010) GDEBUG,MXNSUB,BOUNDS,DELTA,
     *                 SKIP,IGRAF,NEWLMT,NNEW,DELNEW,
     *                 MDBSUB,NCYCLE,MAXITR,MAXRNG
 1010 FORMAT(2I5,4X,L1,F10.3,/,2I5,F10.3,2I5,/,F10.3,3I5)
C
      WRITE(ILIST,1000)BOUNDS,DELTA,SKIP,IGRAF,NEWLMT,
     1   NNEW,DELNEW,MDBSUB,NCYCLE,MAXITR,MAXRNG,GDEBUG,MXNSUB,IDISK2
 1000 FORMAT(1H1,/////,1X,130('X'),//,T50,'CASE PARAMETERS',//,
     *    T40, 'BOUNDS        ', 5X,L1,/,
     *    T40, 'DELTA         ', F6.2 ,/,
     *    T40, 'SKIP          ', I6   ,/,
```

```
     *    T40, 'IGRAF          ', I6   ,/,
     *    T40, 'NEWLMT         ', F6.2 ,/,
     *    T40, 'NNEW           ', I6   ,/,
     *    T40, 'DELNEW         ', I6   ,/,
     *    T40, 'MDBSUB         ', F6.2 ,/,
     *    T40, 'NCYCLE         ', I6   ,/,
     *    T40, 'MAXITR         ', I6   ,/,
     *    T40, 'MAXRNG         ', I6   ,/,
     *    T40, 'GDEBUG         ', I6   ,/,
     *    T40, 'MXNSUB         ', I6   ,/,
     *    T40, 'IDISK2         ', I6   ,/,
     *    1X,130('X') ,///)
C
C.........READ INTERMEDIAT RESULTS.........................................
      CALL FETCH
C........GATHER LOADS......................................................
      CALL GATHER
      STOP
      END
```

```
      SUBROUTINE GATHER                                                 GTHR0002
C..............................LANDUSE 2101.............................GTHR0004
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXGTHR0006
C                                                                       GTHR0008
C        THIS ROUTINE REQUIRES SUBROUTINES  GRID AND PLOT               GTHR0010
C //////// NOTE: PLOT WILL NOT AUTOLINK SINCE WE ENTER AT PLOT4 ////////GTHR0012
C                                                                       GTHR0014
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXGTHR0016
C............................VARIABLE LIST..............................GTHR0018
C=======================================================================GTHR0020
C     ALLFUL        LOGICAL - TRUE IF ALL SUBSTATIONS HAVE REACHED      GTHR0022
C                             THEIR CAPACITY                            GTHR0024
C     ALLZRO        LOGICAL - TRUE IF ALL NON-SUBSTATION CELLS          GTHR0026
C                             HAVE ZERO DEMAND (FULLY 'GATHERED')       GTHR0028
C     BOUNDS        LOGICAL - TRUE IF THE BOUNDS OPTION IS              GTHR0030
C                             IN EFFECT                                 GTHR0032
C     CKWM(I)       CURRENT CELL DEMAND FOR CELL 'I' (IN MW)            GTHR0034
C     CYCLE         ONE COMPLETE RUN WITH A GIVEN NUMBER OF             GTHR0036
C                             SUBSTATIONS                               GTHR0038
C     DELNEW        DECREASE IN NNEW PER CYCLE                          GTHR0040
C     DELTA         MAX AMOUNT OF LOAD GATHERED FROM A GIVEN CELL       GTHR0042
C                             BY ANY SUBSTATION IN AN ITERATION (MW)    GTHR0044
C     DIST          DISTANCE FROM SUBSTATION TO CELL BEING GATHERED     GTHR0046
C     DNZROC(I)     DEMAND OF THE NON-ZERO CELL 'I'                     GTHR0048
C     EMPTY(I)      LOGICAL - TRUE IF THE CURRENT DEMAND FOR CELL       GTHR0050
C                             'I' IS ZERO                               GTHR0052
C     ESTS          EAST GRID COORDINATE OF SUBSTATION                  GTHR0054
C     FULL(S)       LOGICAL - TRUE IF SUBSTATION 'S' HAS REACHED        GTHR0056
C                             ITS CAPACITY                              GTHR0058
C     IGRAF         THE NUMBER OF ITERATIONS BETWEEN PLOTS AFTER        GTHR0060
C                             THE FIRST FIVE                            GTHR0062
C     ITER          THE ITERATION NUMBER. AN ITERATION IS ONE PASS      GTHR0064
C                             OF 'GATHERING' THROUGH ALL THE SUBSTATIONS GTHR0066
C     LIMIT(S)      MAX DEMAND FOR SUBSTATION 'S' (IN MW)               GTHR0068
C     LOSS(S)       SUBSTATION 'S' LOSS IN MW*CELL DISTANCE             GTHR0070
C     MAXITR        THE MAXIMUM NUMBER OF ITERATIONS PER CYCLE          GTHR0072
C     MAXRNG        THE MAXIMUM RANGE THE PROGRAM WILL REACH OUT        GTHR0074
C                             TO 'GATHER' LOAD TO A SUBSTATION          GTHR0076
C     MDBSUB        MINIMUM DISTANCE BETWEEN SUBSTATIONS                GTHR0078
C                             CREATED IN A GIVEN CYCLE                  GTHR0080
C     NCYCLE        THE MAXIMUM NUMBER OF CYCLES ALLOWED                GTHR0082
C     NEWLMT        CAPACITY OF CREATED SUBSTATIONS                     GTHR0084
C     NNEW          THE NUMBER OF SUBSTATIONS TO BE CREATED AFTER       GTHR0086
C                             THE FIRST CYCLE                           GTHR0088
C     NNZRO         THE NUMBER OF NON-ZERO CELLS                        GTHR0090
C     NSSS(I)       THE NUMBER OF SUBSTATIONS SUPPLYING CELL 'I'        GTHR0092
C     NSUB          THE NUMBER OF SUBSTATIONS                           GTHR0094
C     NSUBIN        THE NUMBER OF ORIGINALLY SPECIFIED SUBSTATIONS      GTHR0096
C     NTHS          NORTH GRID COORDINATE OF SUBSTATION                 GTHR0098
C     NZROC(J)      THE CELL REFRENCE NUMBER OF THE NON-ZERO            GTHR0100
C                             CELL 'J'                                  GTHR0102
C     ONSUB         THE 'OLD' NUMBER OF SUBSTATIONS, FROM THE LAST      GTHR0104
C                             CYCLE, PLUS ONE                           GTHR0106
C     OVRLD         EQUAL TO 1 IF SUBSTATION IS OVERLOADED              GTHR0108
C     POINT2        POINTER FROM (ESTS,NTHS) TO THE CELL RECORD         GTHR0110
C                             FOR THAT SUBSTATION                       GTHR0112
C     POINT3        POINTER FROM (E,N) TO THE CELL RECORD FOR           GTHR0114
```

```
C                            THE CELL BEING GATHERED
C       SKIP            IF EQUAL TO 1, ELIMINATES PLOT EACH ITERATION
C       SSS(I,J)        THE J-TH SUBSTATION SUPPLYING CELL I (0<J<4)
C       STOPRD          LOGICAL - TRUE IF ALL INITIAL SUBSTATION
C                            DATA HAS BEEN READ
C       SUBID           REFRENCE NUMBER OF OVERLOADED SUBSTATION
C       XSUB(J)         LOGICAL - TRUE IF CELL J IS A SUBSTATION
C=========================================================================
C   COMMON VARIABLES
C.............................LANDUSE 0602..............................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1         STRTP,PFDR,PCELL,POINT,INLIST,USE,   INSTOR,NLUIF,
     2         NFIC,NLUIC,CIF,NCIF,        FI,FJ,LOWC,HIGHC,BLANK2,
     3         IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1               IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2               FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3               DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     A               TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5               PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6               RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7               PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8               INSTOR,NLUIF(450),NFIC(1575),
     9               NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A               LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B               IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      COMMON /LAST/ DELTA,NCYCLE,MAXITR,MAXRNG,GDEBUG,NNEW,DELNEW,
     A               NEWLMT,
     1               MXNSUB,MDBSUB,IGRAF,SKIP,BOUNDS
C
      REAL DELTA,LOSS,DIST,DIF,CKWM,LIMIT,CKWMC,SQR2,CKWMP,
     1     DNZROC,DELS,MDBSUB,SUPPLY,NEWLMT,RCELLD,
     2     TOTAL1,TOTAL2,TOTAL3
C
      INTEGER*2 NS,A1,EW,A2,A3,EA,NO,SUBABR,NS1,A11,EW1,A21,A31,
     1          NSSS,NEWNAM,NZROC
C
      LOGICAL*1 FULL,ALLFUL,ALLZRO,XSUB,EMPTY,STOPRD,BOUNDS
C
      DIMENSION LOSS(200),CKWM(1575), SUBABR(200),SUBLOC(200,2),
     1          EST(200),NTH(200),FULL(200),NS1(4),A11(4),EW1(4),
     2          A21(4),A31(4),LIMIT(200),NSSS(1575),
     3          NZROC(1575),SSS(1575,6),DNZROC(1575),NEWNAM(200),
     4          TITLE2(20),NUMBER(500),XSUB(1575),SUPPLY(1575,6),
     5          EMPTY(1575)
C
      DATA NEWNAM/ 'A0','B0','C0','D0','E0','F0','G0','H0','I0','J0',
     B             'A1','B1','C1','D1','E1','F1','G1','H1','I1','J1',
```

```
     C                   'A2','B2','C2','D2','E2','F2','G2','H2','I2','J2',     GTHR0180
     D                   'A3','B3','C3','D3','E3','F3','G3','H3','I3','J3',     GTHR0182
     E                   'A4','B4','C4','D4','E4','F4','G4','H4','I4','J4',     GTHR0184
     F                   'A5','B5','C5','D5','E5','F5','G5','H5','I5','J5',     GTHR0186
     G                   'A6','B6','C6','D6','E6','F6','G6','H6','I6','J6',     GTHR0188
     H                   'A7','B7','C7','D7','E7','F7','G7','H7','I7','J7',     GTHR0190
     I                   'A8','B8','C8','D8','E8','F8','G8','H8','I8','J8',     GTHR0192
     J                   'A9','B9','C9','D9','E9','F9','G9','H9','I9','J9',     GTHR0194
     K                   '00','01','02','03','04','05','06','07','08','09',     GTHR0196
     L                   '10','11','12','13','14','15','16','17','18','19',     GTHR0198
     M                   '20','21','22','23','24','25','26','27','28','29',     GTHR0200
     N                   '30','31','32','33','34','35','36','37','38','39',     GTHR0202
     O                   '40','41','42','43','44','45','46','47','48','49',     GTHR0204
     P                   '50','51','52','53','54','55','56','57','58','59',     GTHR0206
     Q                   '60','61','62','63','64','65','66','67','68','69',     GTHR0208
     R                   '70','71','72','73','74','75','76','77','78','79',     GTHR0210
     S                   '80','81','82','83','84','85','86','87','88','89',     GTHR0212
     T                   '90','91','92','93','94','95','96','97','98','99'/     GTHR0214
C                                                                               GTHR0216
      DATA TITLE2/ 'CELL',' DEM','ANDS',' AFT','ER  ',                          GTHR0218
     1                   '    ',' ITE','RATI','ONS ','OF C','YCLE',             GTHR0220
     2                   '    ','. RA','NGE:',6*'    '/,                        GTHR0222
     3      SUBABR/100*'  '/,SUPPLY/9450*0.0/, STAR/'*'/                        GTHR0224
C                                                                               GTHR0226
      INDEX = 1                                                                 GTHR0228
      IF( IGRAF .LT. 1 )  IGRAF = 5                                             GTHR0230
C                                                                               GTHR0232
      READ (IREAD, 1060) (NUMBER (J) ,J=1,500)                                  GTHR0234
 1060 FORMAT(25A3)                                                              GTHR0236
      DO 5 I = 1,NCELL                                                          GTHR0238
      NSSS(I) = 0                                                               GTHR0240
      SSS(I,1) = 200                                                            GTHR0242
      EMPTY(I) = .FALSE.                                                        GTHR0244
      XSUB(I) = .FALSE.                                                         GTHR0246
C                                                                               GTHR0248
C                                                                               GTHR0250
C                                                                               GTHR0252
C    ADD 0.001    TO CELL DEMAND OF  CELLS WITH ZERO DEMAND                     GTHR0254
C    SO THAT THEY WILL HAVE AT LEAST ONE SUBSTATION ASSIGNED                    GTHR0256
      CKWM(I) = CELLKW(I) * 0.001                                               GTHR0258
      IF(CKWM(I) .LE. 0.0) CKWM(I) = 0.001                                      GTHR0260
    5 CONTINUE                                                                  GTHR0262
      IF(MXNSUB .GT. 200) MXNSUB = 200                                          GTHR0264
      DO 8 I = 1,MXNSUB                                                         GTHR0266
      DO 8 J = 1 , 2                                                            GTHR0268
    8 SUBLOC(I,J) = BLANK                                                       GTHR0270
C                                                                               GTHR0272
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXGTHR0274
      IF(GDEBUG .GE. 2) WRITE(ILIST,9900)(I,NSSS(I),I=1,NCELL)                  GTHR0276
 9900 FORMAT(1H1,50X,'CELL AND NSSS',/, 13(I6,I4) )                             GTHR0278
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXGTHR0280
C                                                                               GTHR0282
C                                                                               GTHR0284
C.........READ SUBSTATION LOCATIONS AND MAXIMUM DESIGN DEMANDS..........GTHR0286
      NSUB = 0                                                                  GTHR0288
      STOPRD = .FALSE.                                                          GTHR0290
   10 READ(IREAD,1000) (SUBABR(NSUB+J),(SUBLOC(NSUB+J,I),I=1,2),                GTHR0292
```

```
     1                  LIMIT (NSUB+J),J=1,4),(NS1(J),A11(J),
     2                  EW1(J),A21(J),A31(J),J=1,4)
 1000 FORMAT( 4(A2,2X,2A4,F6.2,2X),
     1        T05,I2,A1,I2,A1,A2,T25,I2,A1,I2,A1,A2,
     2        T45,I2,A1,I2,A1,A2,T65,I2,A1,I2,A1,A2)
      DO 15 K =1,4
      J = K
      IF(SUBABR(NSUB+K) .NE. BLANK2) GO TO 15
      J = K-1
      STOPRD = .TRUE.
      GO TO 16
   15 CONTINUE
   16 NSUB = NSUB + J
      IF(NSUB .GT. MXNSUB) GO TO 170
      IF(J .EQ. 0) GO TO 21
      DO 20 K=1,J
      NS = NS1(K)
      A1 = A11(K)
      EW = EW1(K)
      A2 = A21(K)
      A3 = A31(K)
      CALL GRID (NS,A1,EW,A2,A3,EA,NO)
      EST(NSUB-J+K) = EA
      NTH(NSUB-J+K) = NO
   20 CONTINUE
      IF( .NOT. STOPRD) GO TO 10
   21 NSUBIN = NSUB
      ALLZRO = .FALSE.
      OVRLD = 0
      ONSUB = 1
      ITER = 0
      CYCLE = 0
C     IF NO SUBSTATIONS ARE SPECIFIED, GO TO 120
      IF(NSUB .LE. 0) GO TO 120
      DO 33 J = 1 ,   NSUB
      FULL(J) = .FALSE.
      POINT2 = POINT( EST(J) , NTH(J) )
      NSSS(POINT2) = 1
      SSS(POINT2,1) = J
      XSUB( POINT2 ) = .TRUE.
      SUPPLY(POINT2,1) = CKWM(POINT2)
   33 LOSS( J ) = 0.25 * CKWM(POINT2)
C...............PRINT OUT INPUT...........................................
      IF(GDEBUG .GE. 1) WRITE(ILIST,1010)(I,SUBABR(I),EST(I),NTH(I),
     1  (SUBLOC(I,J),J=1,2),POINT(EST(I),NTH(I)), LIMIT(I),I,I=1,NSUB)
 1010 FORMAT(1H1,50X,'INITIAL SUBSTATION DATA',///,
     1        T10,'SUBSTATION',T30, 'COORDINATES',T50,'DISTRICT',
     2        T70,'CELL',T80,'MAX. DEMAND',/,
     3        T10,'----------',T30, '-----------',T50,'--------',
     4        T70,'----',T80,'-----------',///,
     5    (1X,I3,T14,A2,T33,I2,'-',I2,T50,2A4,T70,I4,T82,F8.2,5X,I3))
C=========================================================================
C.................START GATHERING PROCEDURE...............................
C=========================================================================
      IF(GDEBUG.GE.1)  WRITE(ILIST,1020) CYCLE,(J,CKWM(J),J=1,NCELL)
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      IF(GDEBUG .GE. 2) WRITE(ILIST,9000)(I,NSSS(I),I=1,NCELL)
```

```
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
   34 CYCLE = CYCLE +1
      IF ( CYCLE .GT. NCYCLE ) GO TO 200
      IF(CYCLE .NE. 1)  NNEW = NNEW - DELNEW
      IF(NNEW .LT. 1) NNEW = 1
      RANGE = 0
   35 ALLFUL = .TRUE.
      RANGE = RANGE +1
      IF(RANGE .GT. MAXRNG) GO TO 110
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      IF(GDEBUG .GE. 2) WRITE(ILIST,9900)(I,NSSS(I),I=1,NCELL)
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      ALLZRO = .TRUE.
      DO 38 CELL = 1,NCELL
      IF(XSUB(CELL)) GO TO 38
C
C
      IF(CKWM(CELL) .GT. 0.00    ) GO TO 37
C
C
      EMPTY(CELL) = .TRUE.
      GO TO 38
   37 ALLZRO = .FALSE.
      EMPTY(CELL) = .FALSE.
   38 CONTINUE
      IF(ALLZRO) GO TO 200
   40 ITER = ITER +1
      IF(ITER .GT. MAXITR) GO TO 110
      IF(RANGE .GT. MAXRNG) GO TO 110
      FLAG = 0
   50 DO 100 SUB = ONSUB, NSUB
      IF(FULL(SUB)) GO TO 100
      NTHS = NTH(SUB)
      ESTS = EST(SUB)
      POINT2 = POINT(ESTS,NTHS)
      IF(CKWM(POINT2) .GE. LIMIT(SUB)) GO TO 99
            ESTART = ESTS - RANGE
            NSTART = NTHS - RANGE
            EEND = ESTS + RANGE
            NEND = NTHS + RANGE
C     THE FOUR BOUNDS ARE INITIALIZED IN BLOCK DATA (LANDUSE 2501)
            IF(ESTART.LT.WBOUND) ESTART = WBOUND
            IF(NSTART.LT.SBOUND) NSTART = SBOUND
            IF(EEND.GT.EBOUND) EEND = EBOUND
            IF(NEND.GT.NBOUND) NEND = NBOUND
C     IF THE BOUNDS FEATURE IS NOT IN EFFECT, GO TO 9060
            IF( .NOT. BOUNDS ) GO TO 9060
C     CHECK TO SEE IF SUB IS WITHIN BOUNDS; IF NOT, GO TO 100
            IF(NTHS .LT. NSTART .OR. NTHS .GT. NEND) GO TO 100
            IF(ESTS .LT. ESTART .OR. ESTS .GT. EEND) GO TO 100
 9060 DO 80 E = ESTART,EEND
      DO 65 N = NSTART,NEND
      POINT3 = POINT(E,N)
C     IF THIS CELL IS THE SAME AS SUB, GO TO 65
      IF(POINT3 .EQ. POINT2) GO TO 65
C     IF THIS CELL IS OUT OF THE SERVICE AREA, GO TO 65
      IF(POINT3 .EQ. 0) GO TO 65
```

```
      CKWMP = CKWM(POINT3)
      IF(XSUB(POINT3)) GO TO 51
      IF( EMPTY(POINT3)) GO TO 65
C
C
      IF(DEBUG .GE. 2) WRITE(ILIST,9999)
     1  CYCLE,RANGE,ITER,SUB,POINT2,POINT3,CKWMP,CKWM(POINT2),
     2  NSSS(POINT3)
 9999 FORMAT(1X,'CYCLE',I3,1X,'RANGE',I3,1X,'ITER',I4,1X,'SUB',I4,1X,
     1 'POINT2:',I5,1X,'POINT3:',I5,1X,'CKWMP:',F8.2,2X,'CKWM(SUB):',
     2    F8.2,2X,'NSSS(POINT3):',I6)
C
C
C
      GO TO 65
C     WE NOW KNOW THAT POINT3 POINTS TO A SUBSTATION OTHER THAN SUB
C     FIND OUT WHICH SUBSTATION IT IS
   51 DO 54 I = 1,NSUB
      IF(I .EQ. SUB) GO TO 54
      POINTS = POINT( EST(I), NTH(I) )
      IF(POINT3 .NE. POINTS) GO TO 54
C     WE NOW KNOW THAT POINT3 POINTS TO SUBSTATION 'I'
      IF(CKWMP .LE. LIMIT(I) ) GO TO 65
C     IT IS KNOW KNOWN THAT SUBSTATION 'I' IS OVERLOADED
      OVRLD = 1
      SUBID = I
      WRITE(ILIST,2000) POINT3,E,N,I,LIMIT(I),CKWMP
 2000 FORMAT(1H1,//////////,1X,130('X'),
     *  ///,50X,'OVERLOADED SUBSTATION',
     1  ///,60X,'CELL:',I5,
     2  //,60X,'EAST:',I4,
     3  //,60X,'NORTH:',I4,
     4  //,50X,'SUBSTATION#',I4,
     5  //,60X,'LIMIT:',F8.2,
     6  //,60X,'LOAD:',F8.2,///,1X,130('X'))
      GO TO 55
   54 CONTINUE
      WRITE(ILIST,1110)POINT2,POINT3,SUB,CKWMP,CKWM(SUB),ITER,
     1                 RANGE,CYCLE
 1110 FORMAT(1H1,20X,'XSUB = TRUE, BUT SUBSTATION NOT FOUND IN',
     1          ' CURRENT LIST',///,
     2         T40,  'POINT2     ',  I4, //,
     3         T40,  'POINT3     ',  I4, //,
     4         T40,  'SUB        ',  I4, //,
     5         T40,  'CKWMP      ',F8.2, //,
     6         T40,  'CKWM(SUB)',F8.2, //,
     7         T40,  'ITER       ', I4 , //,
     8         T40,  'RANGE      ', I4 , //,
     9         T40,  'CYCLE', I4 ,/////)
      GO TO 65
   55 CONTINUE
      DIF = DELTA
      IF(OVRLD .EQ. 1) GO TO 56
      IF(CKWMP .LT. DELTA) DIF = CKWMP
      IF(CKWM(POINT2)+DIF .GT. LIMIT(SUB) ) GO TO 99
      CKWM(POINT3) = CKWMP - DIF
      IF(CKWM(POINT3) .LT. 0.0001) EMPTY(POINT3) = .TRUE.
```

```
      CKWM(POINT2) = CKWM(POINT2) + DIF
      SQR2 = FLOAT( (ESTS-E)**2 + (NTHS-N)**2 )
      DIST = SQRT( SQR2 )
      LOSS(SUB) = LOSS(SUB) + DIST * DIF
      GO TO 57
   55 OVRLD = 0
      DELS = CKWMP - LIMIT(SUBID)
      IF(DELS  .LT. DELTA) DIF = DELS
      IF(CKWM(POINT2)+DIF .GT. LIMIT(SUB) ) GO TO 99
      CKWM(POINT3) = CKWMP - DIF
      CKWM(POINT2) = CKWM(POINT2) + DIF
      SQR2 = FLOAT( (ESTS-E)**2 + (NTHS-N)**2 )
      DIST = SQRT( SQR2 )
      LOSS(SUB) = LOSS(SUB) + DIST * DIF
      LOSS(SUBID) =  LOSS(SUBID) - DIST * DIF
      SUPPLY(POINT3,1) = SUPPLY(POINT3,1) - DIF
C........KEEP TRACK OF HOW MANY, AND WHICH, SUBSTATIONS FEED A CELL.....
   57 NSSSP = NSSS(POINT3)
      GO TO (60,60,60,60,60,63) , NSSSP
      IF(NSSSP .NE. 0) GO TO 66
      NSSS(POINT3) = 1
      SSS(POINT3,1) = SUB
      SUPPLY(POINT3,1) = DIF
      GO TO 66
   60 DO 61 J = 1,NSSSP
      IF(SSS(POINT3,J) .EQ. SUB) GO TO 64
   61 CONTINUE
      J = NSSSP + 1
      NSSS(POINT3) = J
      SSS(POINT3,J) = SUB
      SUPPLY(POINT3,J) = DIF
      GO TO 66
   63 J = 6
      IF(SSS(POINT3,J) .NE. SUB) GO TO 66
   64 SUPPLY(POINT3,J) = SUPPLY(POINT3,J) + DIF
   66 FLAG = 1
C
C
   65 CONTINUE
C
C
   30 CONTINUE
C
C
      ALLFUL = .FALSE.
      GO TO 100
   99 FULL(SUB) = .TRUE.
  100 CONTINUE
      IF(ITER .LE. 5) GO TO 101
      IF( MOD(ITER,IGRAF) .EQ. 0) GO TO 101
      IF( SKIP .EQ. 1) GO TO 106
C.........PLOT CKWM AFTER EACH ITERATION, TITLE GIVES ITERATION #.......
  101 TITLE2( 5) = NUMBER( ITER )
      TITLE2(12) = NUMBER (CYCLE)
      TITLE2(15) = NUMBER (RANGE)
      DO 103 J=1,20
  103 TITLE(J) = TITLE2(J)
```

```
      DO 105 J =1,NCELL                                                  GTHR0750
C    (RECALL THAT PLOT4 MULTIPLIES DUMMY BY 0.25)                        GTHR0752
  105 DUMMY(J) = CKWM(J) * 4.0 + 1.8                                     GTHR0754
      CALL PLOT4 (INDEX)                                                 GTHR0756
  106 IF(FLAG.EQ.1) GO TO 40                                             GTHR0758
      IF(ALLFUL) GO TO 110                                               GTHR0760
      GO TO 35                                                           GTHR0762
  110 CONTINUE                                                           GTHR0764
      IF(ITER .GT. MAXITR) ITER = MAXITR                                 GTHR0766
C.....................LIST CKWM..........................................GTHR0768
  120 IF(GDEBUG .GE.1) WRITE(ILIST,1020) CYCLE,(J,CKWM(J),J=1,NCELL)     GTHR0770
 1020 FORMAT(1H1,40X,'CELL DEMANDS BEFORE NEW SUBSTATIONS ARE CREATED',  GTHR0772
     A      /,50X,'CYCLE: ',I5,                                          GTHR0774
     1      //, 8(' CELL   CKWM    '),/, 8(1X,I4,F09.2,1X))              GTHR0776
C                                                                        GTHR0778
C.....LIST CURRENT SUBSTATION DEMAND AND LOSS............................GTHR0780
C                                                                        GTHR0782
      IF(NSUB .LE. 0) GO TO 130                                          GTHR0784
      IF(GDEBUG.GE.1)WRITE(ILIST,1070)CYCLE,(I,SUBABR(I),EST(I),NTH(I),  GTHR0786
     1  (SUBLOC(I,J),J=1,2),POINT(EST(I),NTH(I)), LIMIT(I),LOSS(I),      GTHR0788
     2   CKWM( POINT( EST(I),NTH(I) ) ),I,                               GTHR0790
     3   I=1,NSUB)                                                       GTHR0792
 1070 FORMAT(1H1,50X,'SUBSTATION DATA AFTER CYCLE',I3,///,               GTHR0794
     1      T10,'SUBSTATION',T30, 'COORDINATES',T50,'DISTRICT',          GTHR0796
     2      T70,'CELL',T80,'        LIMIT ',T100,'LOSS',T110,'DEMAND',/, GTHR0798
     3      T10,'----------',T30, '-----------',T50,'--------',          GTHR0800
     4      T70,'----',T80,'        ----- ',T100,'----',T110,'------',///, GTHR0802
     5      (1X,I3,T14,A2,T33,I2,'-',I2,T50,2A4,T70,I4,T82,F8.2,T98,    GTHR0804
     6      F7.2,T109,F7.2,10X,I3))                                      GTHR0806
C                                                                        GTHR0808
C.....CREATE NEW SUBSTATION SITES IF ALL NON-SUBSTATION CELLS            GTHR0810
C                 ARE NOT EQUAL TO ZERO..................................GTHR0812
      IF(CYCLE .EQ. NCYCLE) GO TO 200                                    GTHR0814
      IF(NSUB .EQ. MXNSUB) GO TO 200                                     GTHR0816
  130 NNZRO = 0                                                          GTHR0818
      ALLZRO = .TRUE.                                                    GTHR0820
      IF(NSUB .GE. 20 .AND. GDEBUG .GE. 1) WRITE(ILIST,1030)CYCLE, ITER  GTHR0822
 1030 FORMAT(1H1,10X,'LIST OF ALL NON-ZERO CELLS AND THEIR DEMANDS',/,   GTHR0824
     1        10X,'AFTER',I3,' CYCLES AND',I6,' ITERATIONS',///)         GTHR0826
      DO 150 CELL = 1,NCELL                                              GTHR0828
      IF( XSUB(CELL) .OR. EMPTY(CELL) )  GO TO 150                       GTHR0830
      CKWMC = CKWM(CELL)                                                 GTHR0832
      IF(NSUB .GE. 20 ) WRITE(ILIST,1040) CELL, CKWMC                    GTHR0834
      NNZRO = NNZRO + 1                                                  GTHR0836
      NZROC (NNZRO) = CELL                                               GTHR0838
      DNZROC(NNZRO) = CKWMC                                              GTHR0840
      ALLZRO = .FALSE.                                                   GTHR0842
  150 CONTINUE                                                           GTHR0844
 1040 FORMAT(' ', 6X,I6, F8.3)                                           GTHR0846
      IF(  ALLZRO   ) GO TO 200                                          GTHR0848
      ITER = 0                                                           GTHR0850
      DNSUB = NSUB+1                                                     GTHR0852
      DO 169 L =1,NNEW                                                   GTHR0854
      TRACKL = 0                                                         GTHR0856
  155 RMAX = 0.0                                                         GTHR0858
      TRACKL = TRACKL + 1                                                GTHR0860
      IMAX = 0                                                           GTHR0862
```

```
      DO 160 J = 1, NNZRO
      IF(RMAX.GT.DNZROC(J)) GO TO 160
      RMAX = DNZROC(J)
      IMAX = J
  160 CONTINUE
      IF (IMAX .EQ. 0) GO TO 200
C   IF THE LARGEST DEMAND UNGATHERED IS LESS THAN 0.25, AND
C            A)   NSUB .GE. ONSUB ... GO TO 34
C            B)   NSUB .LT. ONSUB (NO NEW SUBSTATIONS) GO TO 200
      IF( RMAX .LT. 0.25 .AND. NSUB .GE. ONSUB ) GO TO 34
      IF( RMAX .LT. 0.25 )  GO TO 200
      NSUB = NSUB + 1
      IF(NSUB.GT.MXNSUB) GO TO 170
      NZROCI = NZROC(IMAX)
      DNZROC(IMAX) = 0.0
      LOSS(NSUB) = 0.25 * CKWM(NZROCI)
      LIMIT(NSUB) = NEWLMT
      FULL(NSUB) = .FALSE.
C.......NOTE: WE START WITH "NSUBIN" SUBSTATIONS.........................
      KNSUB = NSUB - NSUBIN
      SUBABR(NSUB) = NEWNAM(KNSUB)
      DO 165 J =1,2
  165 SUBLOC(NSUB,J) = DISTRT(NZROCI,J)
      EST(NSUB) = EAST(NZROCI)
      NTH(NSUB) =NORTH(NZROCI)
      IF(L .EQ. 1) GO TO 168
      L2 = L - 1
      DO 166 IL = 1,L2
      SQR2=FLOAT((EST(NSUB-IL)-EST(NSUB))**2 +(NTH(NSUB-IL)-NTH(NSUB))
     1   **2 )
      DIST = SQRT(SQR2)
      IF(DIST .GT. MDBSUB) GO TO  166
      NSUB = NSUB - 1
      IF(TRACKL .GT. NNZRO  .AND. NSUB .GE. ONSUB  ) GO TO 34
      IF(TRACKL .GT. NNZRO ) GO TO 200
      GO TO 155
  166 CONTINUE
  168 POINTS  =   POINT( EST(NSUB) , NTH(NSUB) )
      WRITE(ILIST,1080) SUBABR(NSUB),POINTS,
     1  (SUBLOC(NSUB,J),J=1,2),EST(NSUB),
     2   NTH(NSUB),LIMIT(NSUB),CKWM(NZROCI),LOSS(NSUB)
 1080 FORMAT(1H1,////////////////////,1X,130('X'),///,40X,
     1  '************** NEW SUBSTATION CREATED **************' ,///,
     A   50X,'NAME: ',A2,//,50X,'CELL:',I5,//,
     2   50X,'LOCATION: ',2A4,//,50X,'COORDINATES:',I3,'-',I3,//,
     3   50X,'MAX DEMAND:',F8.2,'  MW',//,50X,'PRESENT DEMAND:',F8.2,
     4   '  MW',//,50X,'PRESENT LOSS:',F8.2,'  MW-CELLS',
     5 ///,1X,130('X'))
      XSUB( POINTS  ) = .TRUE.
      IF(NSSS(POINTS) .GE. 6) GO TO 169
      NSSS(POINTS) = NSSS(POINTS) + 1
      SSS(POINTS,NSSS(POINTS)) = NSUB
  169 CONTINUE
      GO TO 34
  170 WRITE(ILIST,1050) MXNSUB
 1050 FORMAT(1H1,/////,1X,125('X'),//,10X,'THE PROGRAM WANTS TO CREATE',
     1   'MORE THAN ',I3,' SUBSTATIONS',//,1X,125('X'))
```

```
      NSUB = MXNSUB
      GO TO 34
C     LIST BY CELL:  CELL NUMBER
C                    DISTRICT OF THE CELL
C                    SUBSTATIONS FEEDING THE CELL
C                    LOCATIONS OF SUBSTATIONS
C                    SUPPLY FROM SUBSTATIONS
  200 IF(NSUB .GT. MXNSUB) NSUB = MXNSUB
      WRITE(ILIST,1090)
      LINES = 5
      DO 210 I=1,NCELL
      NSSSI = NSSS(I)
      SUB = BLANK
      IF(XSUB(I)) SUB = STAR
      IF(NSSSI .LT. 1 .OR. NSSSI .GT. 6) GO TO 206
      LINES = LINES + 1
      IF( LINES .LT. 59) GO TO 205
      WRITE(ILIST,1090)
      LINES = 6
  205 RCELLD = CELLKW(I) * 0.001
      WRITE(ILIST,1100) I,(DISTRT(I,J),J=1,2),CELLKW(I),SUB,
     *      (SUBABR(SSS(I,J)),
     1   (SUBLOC(SSS(I,J),K),K=1,2),SUPPLY(I,J),J=1,NSSSI)
      GO TO 210
  206 WRITE(ILIST,1120) I,NSSSI,CKWM(I),CELLKW(I),SSS(I,1)
 1120 FORMAT(5X,'CELL:',I4,5X,'NSSSI:',I8,10X,'CKWM(I):',
     1         F12.6,10X,'CELLKW(I):',F12.0,10X,'SSS(I,1):',I8)
  210 CONTINUE
C        TOTAL1      CAPACITY (LIMIT)
C        TOTAL2      LOSS
C        TOTAL3      DEMAND
      TOTAL1 = 0.0
      TOTAL2 = 0.0
      TOTAL3 = 0.0
      DO 201 I = 1,NSUB
      TOTAL1 = TOTAL1 + LIMIT(I)
      TOTAL2 = TOTAL2 + LOSS (I)
      TOTAL3 = TOTAL3 + CKWM( POINT(EST(I),NTH(I)) )
  201 CONTINUE
C
 1090 FORMAT(1H1,50X,'FINAL CELL-SUBSTATION ASSIGNMENT',//,
     1 1X,'CELL',T07,'DISTRICT',3X,'DEMAND',T26,3( 5X,'SUBSTATION',
     A  3X,'DISTRICT', 3X,'SUPPLY')/
     2 1X,'----',T07,'--------',3X,'-(KW)-',T26,3( 5X,'----------',
     B  3X,'--------', 3X,'-(MW)-')//)
C
 1100 FORMAT(1X,I4,T07,2A4,2X,F7.0,5X,A1,
     1    (T27,3(08X,A2,7X,2A4,3X,F6.2,1X)))
C
      IF(JDEBUG.GE.1)WRITE(ILIST,1130) (I,SUBABR(I),EST(I),NTH(I),
C
     1  (SUBLOC(I,J),J=1,2),POINT(EST(I),NTH(I)), LIMIT(I),LOSS(I),
     2   CKWM( POINT( EST(I),NTH(I) ) ),I,
     3   I=1,NSUB)
C
 1130 FORMAT(1H1,50X,'  FINAL SUBSTATION DATA     ',   ///,
     1        T10,'SUBSTATION',T30, 'COORDINATES',T50,'DISTRICT',
```

```
     2        T70,'CELL',T80,'      LIMIT ',T100,'LOSS',T110,'DEMAND',/,
     3        T10,'----------',T30, '-----------',T50,'---------',
     4        T70,'-----',T80,'      ----- ',T100,'----',T110,'-------',///,
     5        (1X,I3,T14,A2,T33,I2,'-',I2,T50,2A4,T70,I4,T82,F8.2,T98,
     6        F7.2,T109,F7.2,10X,I3))
C
      IF(CDEBUG .GE. 1) WRITE(ILIST,1140)TOTAL1,TOTAL2,TOTAL3
C
 1140 FORMAT(//,T50,'--- TOTALS ---',T81,F9.2,T97,F8.2,T108,F8.2,/,1H1)
C
      RETURN
      END
      SUBROUTINE FETCH
C..................................LANDUSE 2201...................................
C    INCLUDE COMMON INFO
C    COMMON VARIABLES
C..................................LANDUSE 0602..................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1          STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,
     2          NFIC,NLUIC,CIF,NCIF,         FI,FJ,LOWC,HIGHC,BLANK2,
     3          IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFORM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1                IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2                FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3                DISTRT(1575,2),BLANK,PFORM(1575,3),PLUIF(450,14),
     4                TITLE(20),DUMMY(1575),LUDFC(1575,2)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5                PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6                RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7                PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8                INSTOR,NLUIF(450),NFIC(1575),
     9                NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A                LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B                IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
      READ (IDISK2)((ZONE(I,J),LUDFC(I,J),J=1,3),(DISTRT(I,J),J=1,2),
     1    CELLKW(I),I=1,1575),(FEEDER(I),FKW(I),I=1,450),NCELL,NFDR
C
      READ (IDISK2) ((PZONE(I,J),J=1,3),EAST(I),NORTH(I),I=1,1575),
     1    ((POINT(I,J),I=1,60),J=1,70)
      REWIND IDISK2
      RETURN
      END
```

```
      BLOCK DATA
C.................................LANDUSE 2501............................
C    COMMON VARIABLES
C    COMMON VARIABLES
C...........................LANDUSE 0602.................................
C
      IMPLICIT INTEGER (A-Z)
C
      INTEGER*2 EAST,NORTH,PLUSE,LUSE,PZONE,AGE,HWY,HWYP,RAIL,BUS,STRT,
     1        STRTP,PFDR,PCELL,POINT,INLIST,USE,    INSTOR,NLUIF,
     2        NFIC,NLUIC,CIF,NCIF,        FI,FJ,LOWC,HIGHC,BLANK2,
     3        IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
C
      REAL AREA,PFDRM,FLOAT,PLUIF,CELLKW,LUDFC
C
      COMMON /MAIN4/  ZONE(1575,3),FDR(1575,3),NCELL,IREAD,ILIST,IDISK,
     1             IPUNCH,IDISK2,FEEDER(450),NFDR,FKW(450),IDISK4,
     2             FACTOR(14),DEMAND(14),AREA(14),CELLKW(1575),
     3             DISTRT(1575,2),BLANK,PFDRM(1575,3),PLUIF(450,14),
     A             TITLE(20),DUMMY(1575),LUDFC(1575,3)
C
      COMMON /MAIN2/ EAST(1575),NORTH(1575),PLUSE(1575,3),LUSE(1575,3),
     5             PZONE(1575,3),AGE(1575),HWY(1575),HWYP(1575),
     6             RAIL(1575),BUS(1575),STRT(1575),STRTP(1575),
     7             PFDR(1575,3),PCELL(1575,3),POINT(60,70),INLIST,
     8             INSTOR,NLUIF(450),NFIC(1575),
     9             NLUIC(1575),CIF(450,107),NCIF(450),USE(14),
     A             LOWC(450),HIGHC(450),FI(110),FJ(110),BLANK2,
     B             IDEBUG,CDEBUG,NDEBUG,NBOUND,SBOUND,EBOUND,WBOUND
      DATA BLANK/'    '/, IREAD/1/,IDISK/4/,IPUNCH/2/,
     1   ILIST/3/,BLANK2/'  '/,
     2    NBOUND/70/,SBOUND/1/,WBOUND/1/,EBOUND/60/,
     3    IDISK2/13/
      END
```

Section Three

<u>OBJECTIVE:</u> To gain experience in a non-academic business environment especially in the areas of planning, cost analysis and economics.

One of the main benefits of an internship requirement within the Doctor of Engineering program is the exposure to non-technical and business aspects of industry. My internship has given me the opportunity to experience many of these areas. Some of these areas which will be described below are communications, long range planning, marginal costs, scheduling, and economics.

Prior to the start of this internship, all of my business experience had been military oriented. This military background together with three and a half years in an academic environment provided an inertial force that took a while to overcome. Gradually, I became acclimated to the civilian business environment through guidance by my intern supervisor. Some seemingly insignificant items that were not addressed in the academic communications courses became quite important. One of these is the fact that when one signs a letter on company stationary, that individual is speaking for the company and should therefore present the company's point of view, even if this point of view is different from his or her own. Another topic that was not covered in my course work is that of evaluating sources of information. There are many sources of information concerning electrical utility practices and procedures. As would be expected, some of these sources are more reliable than others depending to a large extent on the purpose of the information source and the technical expertise of the author. In some cases information is purposely distorted or left out to strengthen the author's position.

For a number of years the electrical utility industry has had a problem with communications between itself and the public, the industry's customers. The utility industry has become an information source that has low credibility in the eyes of the public. During the past few years the industry has been advertising ways in which the consumers of electricity can reduce their electric bills through energy conservation measures. Even though the information is factual, many citizens do not accept these conservation hints. Some of this lack of credibility originates from past industry actions but another portion of it has been caused by the media's misrepresentation of factual information.

Since the Company did not have a doctoral level engineer employed in the Engineering Department, and only one in the whole company, my presence was somewhat of a novelty to many of the engineers. This resulted in a defensive posture toward me which had to be relaxed before communication could take place. As time went on this defensive posture was slowly lowered by a number of the engineers. I feel that one of the contributing factors to the improved communications that resulted was my ability to ask them for assistance with my projects in such a way that anxieties were relieved. As I asked more questions, they started to return questions concerning some project that they were working on at the time. By the end of my internship period, an open communication channel between myself and most of the engineers in the Planning Division had been established.

Working at the vice presidential level within the organization gave me the opportunity to make a number of presentations to the Company's top management. These included both semi-formal discussions concerning the objectives and philosophies of my work as well as formal presentations in which I detailed the results of my efforts. These presentations were usually preceeded by a short description of the Doctor of Engineering program since its existance and objectives were not generally known by my audience. Interest in the Doctor of Engineering program was evident by the questions asked and the following discussions. My technical presentations were well received and several vice presidents made favorable comments concerning my technical and non-technical work. Slides for my presentations were prepared by the Company's graphic arts personnel. In addition to the above, I had informal discussions with vice presidents and department heads as the need arose.

My major assignment, the long range system configuration study, allowed me to become familiar with the area of long range planning. I had the opportunity to review many types of long range planning techniques. The long range load forecasting techniques mentioned in conjunction with my load projection work in section two were one area of planning to which I was exposed. In addition to these classical load projection techniques, a number of "system expansion" plans were made available for my review. These expansion plans dealt mostly with the bulk power generation capability of the Company, based on official electrical demand and energy forecasts for the Company. Most of these expansion plans considered some fuel cost escalation but few addressed the fuel availability problem. It makes little sense to plan for a very reliable generating unit that uses a non-available fuel. The expansion plans typically choose five or six possible combinations of future units and then analyze these configurations for reliability, construction cost, and fuel cost over the expected life of the units.

The electrical utilities that only serve customers within the State of Texas are interconnected through their transmission lines and form what is called the Texas Interconnected System (TIS). Each member of the TIS has certain operating responsibilities and limitations designed for the benefit of the system as a whole. For example, each company is required to have a minimum amount of generating capacity available "on line" at all times. This capacity is required so that the demands of the customers can be satisfied when some piece of equipment breaks down causing a decrease in the total instantaneous generation available. This margin is referred to as "spinning reserve" which is calculated by considering the capacity of the largest unit "on line" and some percentage of the load. The expansion plans must consider this spinning reserve requirement so that each company will be able to meet its reserve commitment in the future.

In addition to expansion plans and long range load forecasting, I was exposed to a small amount of corporate planning since the Company's goals and objectives were being reviewed during the latter part of my internship period. While not directly involved with the selection of these goals and objectives, I was offered the opportunity to review them and discuss them with my intern supervisor.

Initially, I was assigned two projects: the long range planning task described in section two and in the enclosed report, and an investigation into the calculation of electrical utility marginal costs. During the initial period of my internship, I conducted a literature search to identify published material on the subject of marginal costs of electrical utilities.

The concept of marginal cost is quite simple: determine the cost to produce one additional unit of production. The problem arises when one attempts to define in specific terms what the unit is and what the relevant costs for this unit are, for both the short and long time frames. Many times the total marginal cost is broken into components such as generation, transmission, and distribution marginal costs. The total cost for each of these components is divided by the number of customers served and this average cost used as a marginal cost. In other cases, these costs are neglected and a study based on estimated demand elasticity during different time periods is conducted to determine what the costs for electrical energy to the consumer should be during those periods.

It was planned that I would work closely with members of the Rate and Economic Research Department on this marginal cost project; however, a number of events prevented this from happening. First of all, the Company was in the midst of a rate case and as could be expected under such circumstances, all personnel of the Rate and Economic Research Department were extremely busy. In addition, the two other Texas Utilities operating companies (TESCO and TP&L) had decided to employ the services of a consulting engineering firm for the calculation of marginal costs. The decision was made that DP&L would join the two other companies in this contract. Since I had done the above mentioned literature search, I was invited to be present during the consultant's presentations and to comment on the methods they proposed to use. My literature search for this aborted project increased my knowledge of utility accounting and allowed me to interpret the Company's Financial and Operating Report in a more meaningful manner.

Throughout most of my internship, I was actively engaged in a number of simultaneous tasks. Some of these had quite short suspense times while others were to be completed at some undetermined future date. This variety of task durations and suspense dates, together with scheduled meetings and events, required me to work up a time schedule so that I could manage my time effectively. This schedule allowed me to avoid the "feast or famine" syndrome by allocating my time to the tasks in an efficient, organized manner.

Research for my primary assignment included the field of economics. The growth rate in electrical energy demanded by customers is influenced by the economic conditions within the service area and the adjacent areas. Local economic conditions and projections for the future were discussed with a number of organizations such as The City of Dallas, The North Central Texas Council of Governments, and the Company's own personnel familiar with local economic conditions. I attended a meeting of the Dallas Chamber of Commerce which brought to light many interesting facts concerning the economic future of the Dallas area. Business periodicals also provided information concerning the economic vitality of this area.

Summary

My one year internship with the Dallas Power & Light Company has satisfied the requirements for the Doctor of Engineering internship. The three internship objectives have been met.

From a personal point of view, this internship has been one of the best possible. The level within the organization and the willingness of company employees to cooperate was very condusive to a profitable internship experience. The positive attitude of my internship supervisor, Mr. Don M. Deffebach, and his ability to devote time to my many questions was a significant factor in the successful completion of this internship.

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