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Microcomputer-Based Spreadsheet and CAD System for Inventory and Analysis of Small Quantity Generators of Hazardous Wastes

by

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MICROCOMPUTER-BASED SPREADSHEET AND CAD SYSTEM FOR INVENTORY AND ANALYSIS OF SMALL QUANTITY GENERATORS OF HAZARDOUS WASTES

by

LEEL KNOWLES, JR.

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF ENGINEERING

UNIVERSITY OF FLORIDA

1988

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TABLE OF CONTENTS

CHAPTERS Page

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Engineering

MICROCOMPUTER-BASED SPREADSHEET AND
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April 1988

Chairman: James P. Heaney
Major Department: Environmental Engineering Sciences

An easy and effective method for monitoring and tracking a large array of hazardous waste data is through the use of inexpensive, PC software packages to create programs which facilitate data searching and analysis. This thesis describes a microcomputer database management system using Lotus 1-2-3 and AutoCAD for the inventory and analysis of small quantity generators of hazardous wastes in Alachua County, Florida.

Initially, the design of this project was to develop a microcomputer-based model, using the Geographic Information System (GIS) technology, to handle a large hazardous waste database by interfacing the AutoCAD graphics software with the Lotus 1-2-3 spreadsheet. As a result of AutoCAD's limitations, the project efforts were diverted to handle the database information exclusively within the Lotus 1-2-3 spreadsheet. AutoCAD was used to construct a highly detailed study area map with the generator sites containing the hazardous waste information. This map

contains spatial information on the following topographical features: major highways, lakes and surface water bodies, soils, political boundaries, and small quantity hazardous waste generator sites. A discussion on the extraction of the hazardous waste information contained within the map to spreadsheets is also presented.

The second part of this thesis discusses how the Lotus 1-2-3 spreadsheet has been used to develop a database model to process and produce an action letter by using an expert system approach. The methodology of setting up a knowledge base, a rule base for user interaction, an extraction table, and the development of macro statements to run the extraction process for creating an action letter are also included in this discussion. A map for viewing generator sites, using the same expert system approach, is also developed and examined.

The results of the model show that the spreadsheet environment provides an easy, inexpensive, and effective way to store, manipulate, analyze, and process knowledge-based information. The spreadsheet environment also offers the graphics capabilities to produce maps which require much less training and knowledge than the expensive CAD systems in the mainframe and PC GISs. This model provides a quick, easy-to-use paperwork processor for notification purposes. Although this technology has been applied to the hazardous waste management field, a similar procedure can be developed in a wide area of engineering analyses and/or design activities requiring the preparation of paperwork.

CHAPTER 1
INTRODUCTION

Proper management of hazardous wastes is a major concern to both environmental professionals and the public. This problem is complicated by the diversity of these wastes and how they can be effectively and inexpensively monitored and managed. One approach to solve this problem would be to analyze a geographic area (e.g., county) by obtaining hazardous waste information from all of the generation sites within that area. As a result of this effort's length and complexity, it has become much too costly to perform tedious analytical solutions manually. Computer-aided engineering systems (CAE) allow engineers to perform various interactive modeling analyses that help in the study of environmental management problems. Availability of these models increases productivity, enhances the quality of analyses and designs, and improves the overall management and planning process.

Advances in the design of the models subsystem has resulted in the proliferation of desktop microcomputers which use spreadsheets, graphics, database management, and word-processing packages. Using microcomputers to store and analyze hazardous waste inventories has become quite popular as a result of its attractiveness in both the low cost and user-friendliness of software packages. The development of computer-aided design (CAD) programs has revolutionized the fields of management in which a large database is required. The result has been the provision of graphical and pictorial displays which substantially improve both the communication of spatial information and user-computer interaction.

The objectives of this project were to develop a stand-alone, PC CAD system for county-level professionals to use in the inventory and analysis of generator hazardous waste information. This model would be "user-friendly", with built-in menus, so the need for an expert computer programmer would be eliminated. The progress in the project's objectives involved two major applications. The first was the development of a Geographic Information-type System using AutoCAD. The second part of the project entailed building a knowledge-based model using the Lotus 1-2-3 software, exclusively.

The project's methodology consisted of the following:

1. collecting inventory information from potential hazardous waste producers;

2. constructing (digitizing) a study area map using AutoCAD. Layered information includes topographical features, street network, soils, and location sites of typical small quantity generators;

3. storage of hazardous waste inventory information onto spreadsheet files and into the AutoCAD drawing file;

4. system interfacing between Lotus 1-2-3 and AutoCAD;

5. knowledge-based model development using Lotus 1-2-3;

6. data analysis and production of action letters through selection model programming; and

7. demonstration of the system in a workshop to other professionals.

The following chapter discusses the development of a GIS-related model using AutoCAD. The methods of creating, editing, and extracting layered spatial inforamtion is also presented. Chapters 3 and 4 present the concepts of expert system technology, and how they were used to develop a spreadsheet model which can produce an action letter from selections made from its self-contained knowledge base.

CHAPTER 2
MAPPING USING AUTOCAD

Introduction

The GIS Approach

Geographic Information System (GIS) technology has been developed from specialized applications in spatial analyses of map processing. The main advantage of developing and using these systems is that they provide advanced analytical capabilities allowing users to address complex problems in a completely new way. The data structure consists of relational map layers which allow the user to view and access stacks of desired layers. The analytical processing consists of having a completely automated and internal referencing system designed for mapping, management, and data analysis.

Marx (1986) describes how the Bureau of Census is currently developing the TIGER system to support numerous departmental operations. The first implementation of this automated geographic system is planned to begin with the 1990 Decennial Census. Closer to the hazardous waste management issue, Dr. Joseph Berry of Yale University describes the fundamental operations in developing computer-assisted map analysis in the "Geographic Information Analysis Workbook" (1985) and how they can be used in hazardous waste site evaluations. The workbook outlines the workshop used to teach and demonstrate GIS fundamentals using the aMAP microcomputer software. Berry (1986) describes GIS technology as "difficult to teach," "yet very few classrooms can provide extensive hands-on experience," and "require expensive and specialized hardware." AutoCAD software was initially used in an attempt to develop and test such a system. For supplemental readings in water resource modeling consult Basta (1986), Fedra and Loucks (1985), Loucks, Kindler, and Fedra (1985), and Loucks, Taylor, and French (1985).

The first effort in this study was the construction of a Geographic Information System which could be used to analyze large arrays of data from small quantity generators of hazardous wastes. Initially, this phase of the study was spent becoming familiar with the mainframe CADAM system at the University of Florida. The intent in using this system was to evaluate the friendliness and possible applications to developing the map area. The training program took two weeks to complete and did not include design techniques for map construction. It was concluded that CADAM could be used for map design, but it was geared more towards architectural and mechanical aspects of design. The PC systems, on the other hand, seemed to offer a much more flexible and user-friendly environment. Lerner (1986) describes how the features of these PC CAD programs vary considerably and are usually highly correlated to the price. Some offer state-of-the-art graphic capabilities (e.g., 3-D images); others offer easy-to-use information shuffling capabilities; while still others offer systems with faster, more powerful, and larger memory capacities. The user must decide which features are the most advantageous for the system that is needed in a desired price range.

Microcomputer CAD Systems

Advances in hardware technology, subsequent compatible software availability, and price reductions have made scientific programs, once restricted to the mainframes, now available on PCs. The most popular software program utilizing the PC for engineering CAD is AutoCAD. We used the 2.18 version of AutoCAD for mapping (Autodesk, Inc., 1985). This powerful drawing aid allows easy, quick, and precise diagram replications. "Digitizing" is performed by the use of a pointing device (mouse) in which crosshairs track its movement on the screen. As the mouse tracks across a digitizing tablet, its movement is stored and displayed continuously on the monitor. To aid in construction, entities (e.g., lines, circles, arcs, text) can be added by commands which can either be typed on the keyboard, chosen from a screen menu, or entered by a button on the digitizing tablet or pointing device. Other commands easily modify, zoom in or out, or pan across the drawing. The "zoom ratio" of AutoCAD is approximately ten trillion to one! AutoCAD uses a cartesian coordinate system for ease and precision in positioning and locating specialized points (e.g., entities). Zoom levels change the apparent distance between points but the unit itself remains fixed. The graphics monitor has relatively high resolution, but the accuracy of the "hard copy" is limited by the printer/plotter's resolution. Other features include drawing insertion, layering, coloring, the use of prototype drawings, and Advanced Drafting Extension packages.

AutoCAD was used in attempt to create polygon-structured information layers. Information was to be placed within each polygon and then later accessed for analysis. This logic differs from the database created by Miller et al. (1986) where their database information was accessed from parcels within sections. Each parcel was identified as a point, instead of a polygon, and contained attributed information corresponding to that parcel. In AutoCAD, however, attributed information was to be "tagged" to each polygon.

Hardware/Software Needs

The PC system hardware workstation consisted of many components. The majority of the components were contained within the Zenith Z-200 PC Series which includes an INTEL 80286, 16-bit, AT microprocessor and a 800x560 pixel, color monitor. Additional components included the HIPAD digitizing tablet and pointer, a keyboard, and an EPSON dot matrix printer for hard copies. The microprocessor contained a 70MB hard disk drive and a 1.2MB floppy disk drive. An additional 80287 Math Coprocessor had been added to the PC AT to expedite calculations and runtimes. The digitizer was used for graphical design in conjunction with AutoCAD software.

The software packages, AutoCAD and Lotus 1-2-3 (Version 2), were stored in the AT's hard disk for easy access. Drawings and information can be stored in the hard disk and/or floppy disks. High density disks are recommended for larger storage capabilities; however, they require a high density (1.2MB) floppy disk drive on the microprocessor.

Map Construction

The Base Map

In this geographic information system portion, a digitized map area of Alachua County was constructed using an original map as shown in

Figure 2-1. The map was scaled and designed on the digitizing tablet using the TABLET mode. This was done by picking any two points from the original map on the digitizing tablet. The entire map was drawn with the tablet mode "ON", so that when zooming in, the tablet and screen would be exactly synchronized and map shifting would be eliminated. Individual views can be stored for quick reference and assimilation by using VIEW.

The "base map" was set up so that the designated origin of the diagram was placed at 29.0^{o} N, 83.0^{o} W. The full scale map included the polygon bounded by the latitude and longitude coordinates of 29.0/30.0^{o} N (69.15 mi.) and 82.0/83.0^{o} W (61.05 mi.), respectively, and included Alachua County and the surrounding eleven counties (United States Geological Survey, 1980). Generation of county lines can be "sketched" by tracing along map lines. An assignment of 10 points/mile for sketching was used since increased point frequency did not significantly increase accuracy. Use of the GRID (on) function key helps with visual interpretation on the screen monitor. County lines which are defined by a river are redesignated (joined) as a polyline and then altered to a best-fit line through sketch points which were formed in sketch generation. This curve fitting does not represent an exact duplication of the boundary, but allows it to appear more like a river. The user decides how many points should be specified along an entity. More points may mean better accuracy, but the time and byte-space used to generate entities with large numbers of points were very large for the insignificant increase in accuracy. This layer contained 400 generated data points.

Lines were not drawn to curve-fit, so that rivers were drawn with sharp points and square bends and when enlarged did not represent true

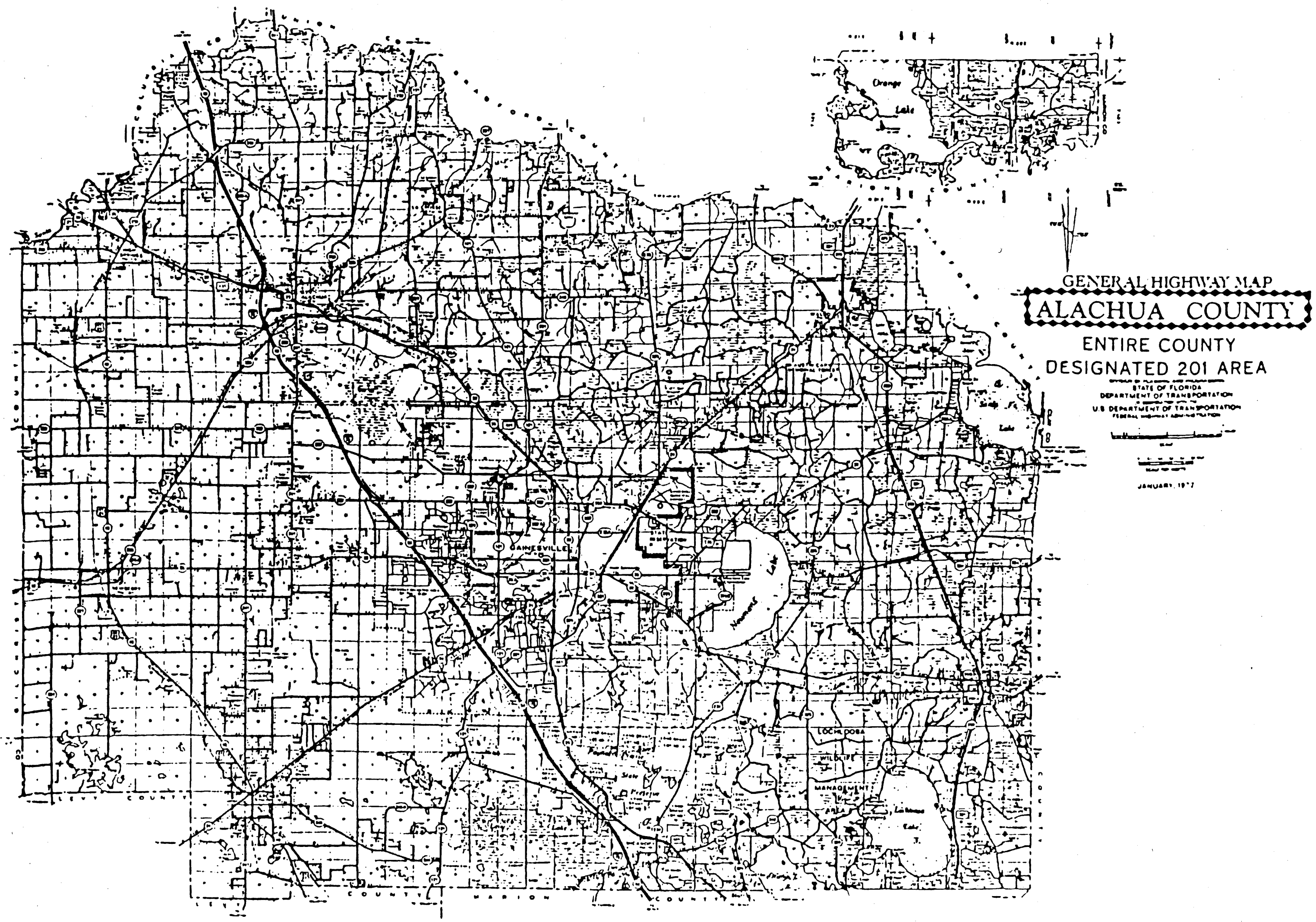


Figure 2-1. Original Alachua County Map for Subsequent Digitized Maps. (Florida Dept. of Pollution Control, 1972)

river geometry. Straight-line county line generation was easily performed by "grabbing" a point along an entity to begin a new intersecting line entity and then by designating points at vertices while in the POLYLINE function. "Grabbing" is used to define how one wants to pick a starting point for line generation. By presetting the OSNAP function key to the desired reference, AutoCAD will pick the point by the appropriate method. "Nearest to" and "Endpoint of" were most commonly used; however, "Center of" and "Midpoint of" were also used. When one of the methods listed above was set, but another was needed, typing an abbreviated version of the command prompted AutoCAD to temporarily change its grabbing technique (e.g., "Near", "End", "Cen", and "Mid"). This "base map" drawing, as shown in Figure 2-2, was stored on the "0" layer which AutoCAD always designates as the first layer.

Color

The LAYER function was used to define one color and the desired line-type. The color feature of AutoCAD's Enhanced Graphics Display (Extension Drafting Package 1) allowed a choice of up to 15 colors and resulted in a vivid delineation of features on the monitor. Of course, a color printer/plotter was required to achieve the same effect. Figure 2-3 shows the modal display of available colors represented by a corresponding number label. Figure 2-4 shows how the LAYER function can give the status of each layer upon typing "?".

Map Scaling

Design scaling can be accomplished by either of two methods. The preferred and easiest method is to scale AutoCAD's axes to fit the

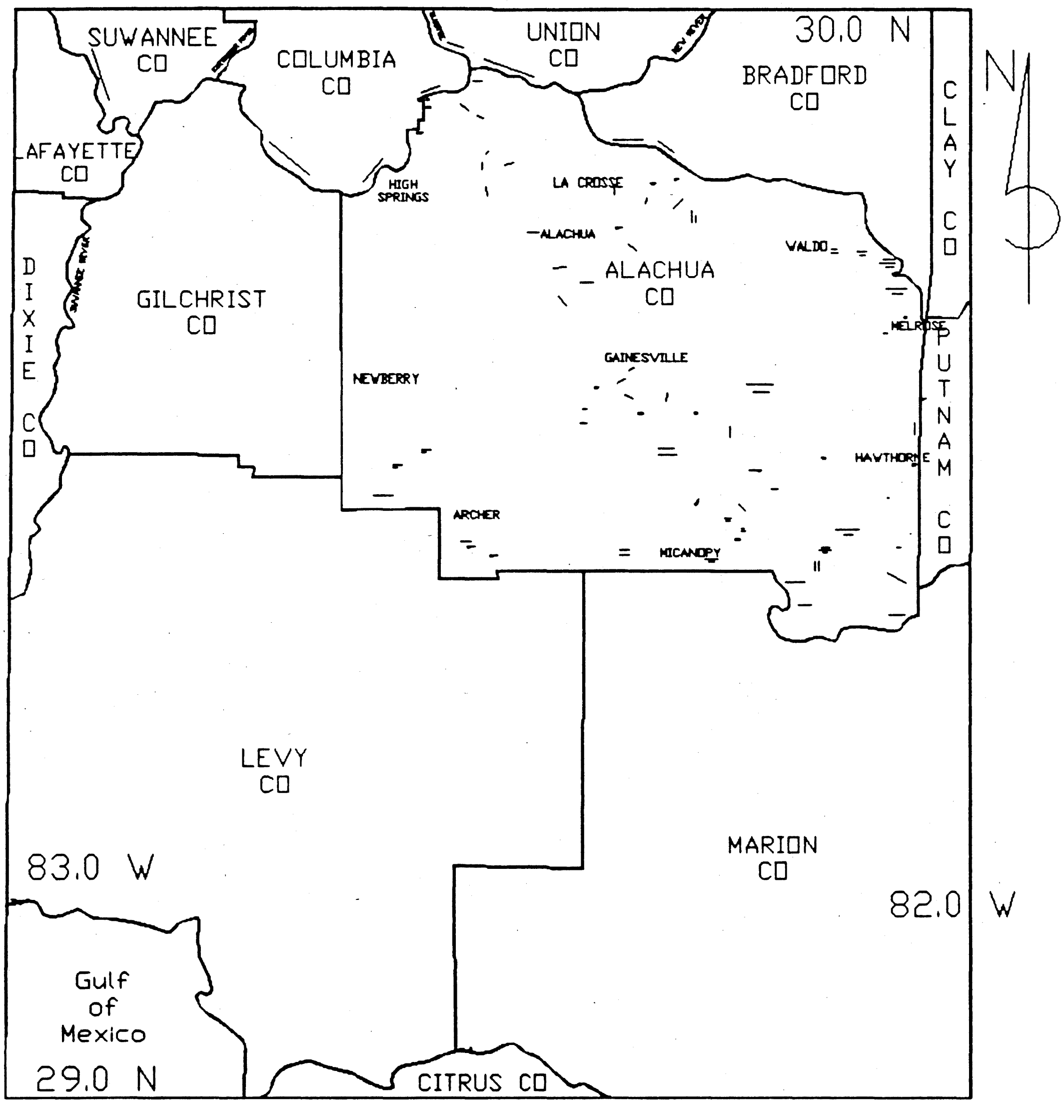


Figure 2-2. Base Map (with "LABELS" Layer on).

IBM Color Display

This mode displays 15 colors (plus black) with a resolution of 640 x 200 pixels. The colors assigned to the AutoCAD color are as follows:

1 - Red	8 - Dark grey
2 - Yellow	9 - Low intensity red
3 - Green	10 - Low intensity yellow
4 - Cyan	11 - Low intensity green
5 - Blue	12 - Low intensity cyan
6 - Magenta	13 - Low intensity blue
7 - White	14 - Low intensity magenta
	15 - Light grey

All other color numbers will display as white.

Figure 2-3. AutoCAD's Color Format. (Autodesk, Inc., 1985)

Layer name	State	Color	Linetype
0	On	10	CONTINUOUS
ROADS	On	8	CONTINUOUS
LAKES	Off	5 (blue)	CONTINUOUS
SQGS	Off	1 (red)	CONTINUOUS
LABELS	Off	7 (white)	CONTINUOUS
DIMENSION	Off	7 (white)	CONTINUOUS
LOCATE	Off	11	CONTINUOUS
SOILS	Off	4 (cyan)	CONTINUOUS

Current Layer: 0

?/Set/New/On/Off/Color/Ltype/Freeze/Thaw:

Figure 2-4. Example of LAYER Status.

user's units of choice before map digitizing. For example, if a user wants to digitize a map so that the units are in miles, then the ZOOM window magnification feature can be used to zoom out so that each unit on AutoCAD's axes will represent a mile in the drawing. The zoom factor is determined by establishing the map limits (inches/mile) by manual measurement from the original map. The TABLET function is then used to calibrate the tablet pointing device with the original map. The alternative method is by first digitizing the map without altering the preprogrammed axes (zoom ratio=1), "blocking" out different groups (layers), and inserting them into the appropriate drawing layer at the newly calculated zoom factor previously discussed. Detailed instructions on blocking are discussed later in the Road Network section. A word of caution using the latter method: The new drawing formed by blocks cannot be directly revised; therefore, the original must be saved! Any changes to the block must be made on the original drawing. The new block drawing is not automatically revised but can be by "reblocking" the edited original. The results are identical and the choice is up to the user.

Labeling

Labels on a layer can be turned off/on to the user's liking depending on the need. This allowed the removal of interfering text or confused images at will. Labeling was simply done with the TEXT function key. The prompt asks for the insertion point, size, rotation angle, and the text itself. The insertion point is a choice of several picks. By default, the text starts at the insertion point, or it can be changed so that the text is centered, right-aligned, or squeezed between two points. Rotation angles are measured counterclockwise from 3 o'clock. This is a very useful function key. All labels were placed on this layer, except for "ROADS" and "SOILS", where labels were placed for convenience.

Sectioning of Alachua County

Digitized territorial divisions of townships, ranges, and one square mile sections were placed and labeled within Alachua County. The sectioning structure of the county is quite complex as a result of the alteration effect of land grants and reservations having been placed inconsistent with the township/range sections. In addition, many sections are not divisions of exactly one square mile, but are distorted (or adjusted) to "take up slack" and conform to existing grant lines. Therefore, sections were digitized (as polylines) across the entire county, special land grant divisions were placed in their actual locations, and section lines were later edited to their respective locations. Each section line had to be drawn individually as many of them were not consistently straight. Figure 2-5 shows the complex nature of sectioning for Alachua County.

Unlabeled areas of sections were left for future location sites of lakes in a "LAKES" layer and its construction will be discussed in the following section. Sections can be edited to lake shorelines as sections are not normally drawn across lakes on maps.

Lakes and Surface Water Features

As shown in Figure 2-6, major Alachua County surface water features including lakes, rivers, streams, and creeks were all placed in the

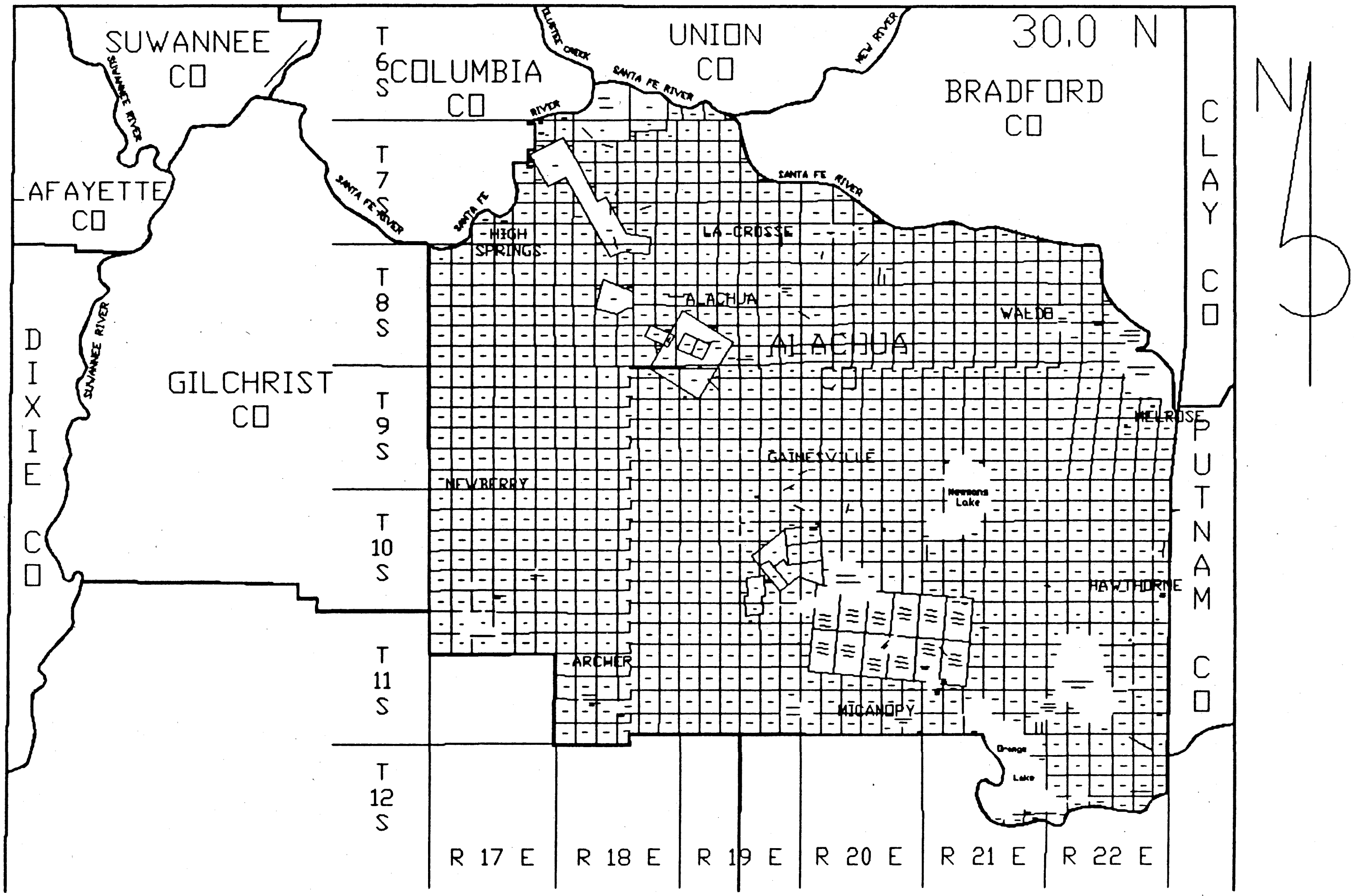


Figure 2-5. Alachua County Sectioning.

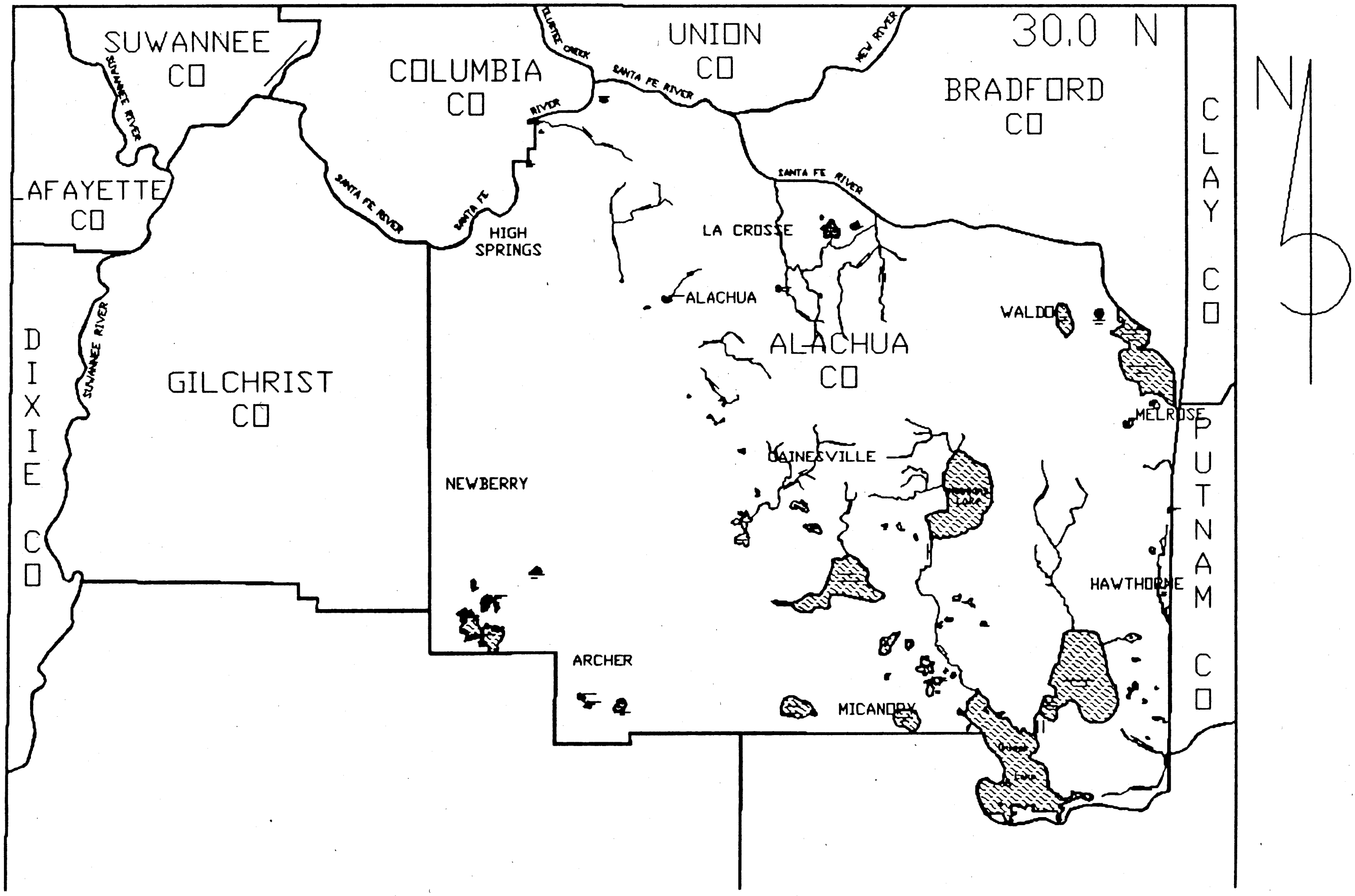


Figure 2-6. Surface Water Features in LAKES Layer.

LAKES layer. Each water feature was defined as a polyline using the section lines as a guide for better accuracy and then crossing section lines were edited to intercept the shorelines of lakes. Areas of the county which did not consistently have surface water, typically marshes, were digitized as soils in the SOILS layer and is explained in the Soils section. Labeling of all water features was included in the LABELS layer to give the user the option to turn the text off when needed.

Road Network

The "ROADS" layer consisted of all major highways and most of the paved roadways within Alachua County (City Atlas Systems, Inc., 1978). As shown in Figure 2-7, each road was digitized as a polyline so that winding ones could be curve-fitted, and editing, where necessary, was performed. Digitizing the roads required intuitive judgment on the exact placement of each point (e.g., road bends) because of the error associated with the pointing device and the tablet. The sections that had been previously digitized were very helpful, if not crucial, to accomplishing this task. Many roads follow or parallel section lines, so that the slight error associated with the tablet was corrected for by using the layer containing the sections as a guide. Only major highways were labeled. All road symbols on this layer were formed by using a preconstructed drawing and inserting the corresponding number centered. Then the newly constructed symbol was reblocked and placed (centered) on the highway polyline at "eye-pleasing" locations. This function is very useful when a user wants to pull a design from the drawing library. To use the "library", the user creates a drawing of any dimension, stores

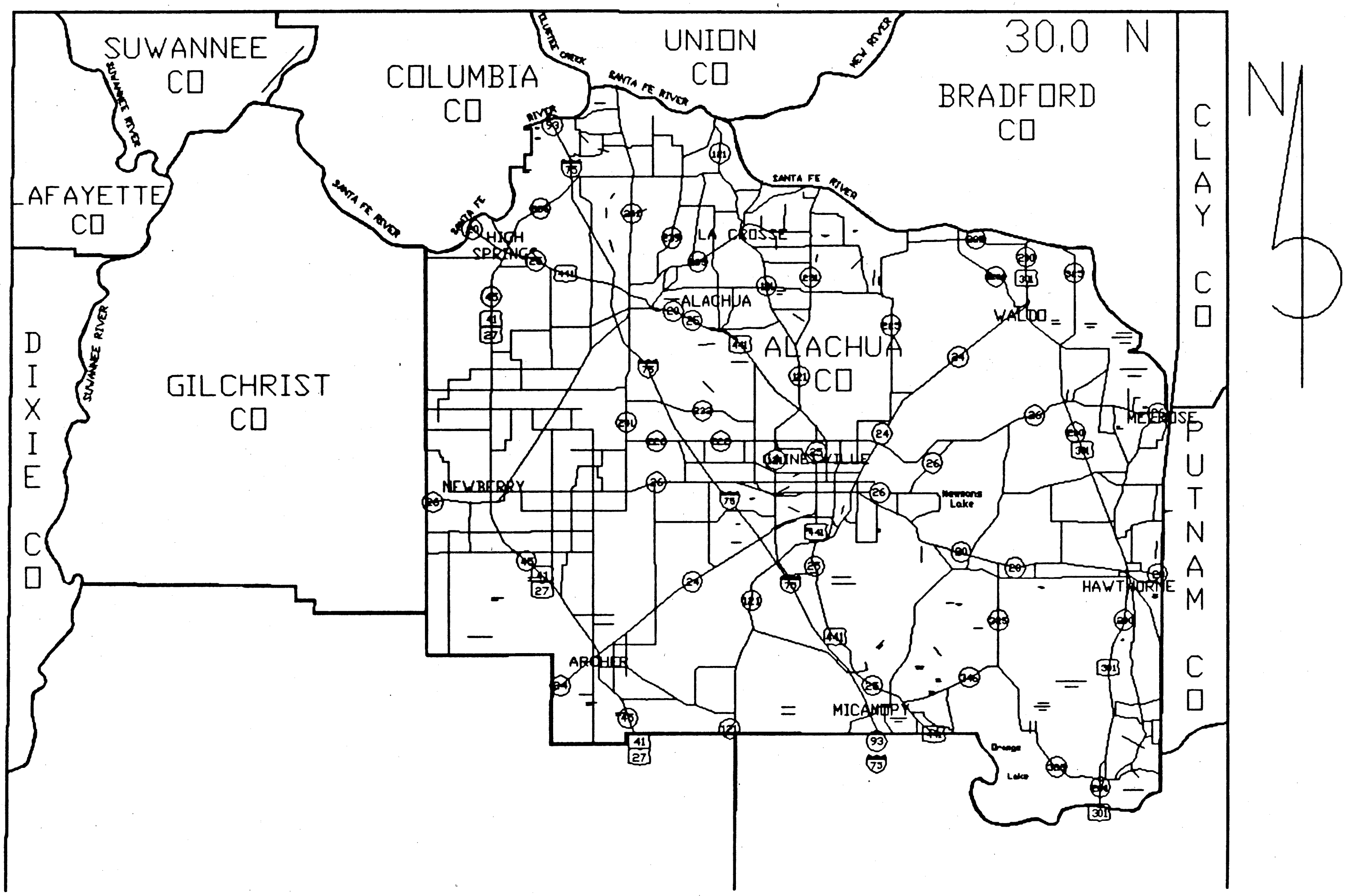


Figure 2-7. Road Network.

it in the library using the BLOCK command, names it, locates the point of insertion, inserts the named design using the INSERT command, and has the option to redimension the design. Here, the options include X, Y, and/or Z scale factors and rotation angles. The INSERT command can be used to change the original design and answer the prompt by typing in *(blockname). The user can then edit the design and reBLOCK it under the same, or a different name. This technique can also be done by using the LOAD and SHAPE menu functions.

Figure 2-8 shows the completed map with the sectioning, water features, and labeling layers turned on.

Soils

A SOILS layer containing soil associations within Alachua County was digitized using a soil survey map provided by the US Department of Agriculture (Thomas et al., 1985) as shown in Figure 2-9. The soils map consists of fourteen soil types based on composition and characteristics of depth, slope, and drainage.

Soil boundaries were digitized using the SKETCH command as previously discussed in the Base Map Construction section. Again, ten points/mile were assigned for each sketched entity. Labels for soils were placed onto the SOILS layer and numbered for referencing to the soil legend. The soil legend, which was also placed onto the SOILS layer, gives the name and a brief description of the numbered soil association. The soil legend was placed to the right of the map study area because of the lack of space within the mapping area for such a large array of information. When a description of a soil type in Alachua County is needed, a previously saved "view" of the soil legend can be

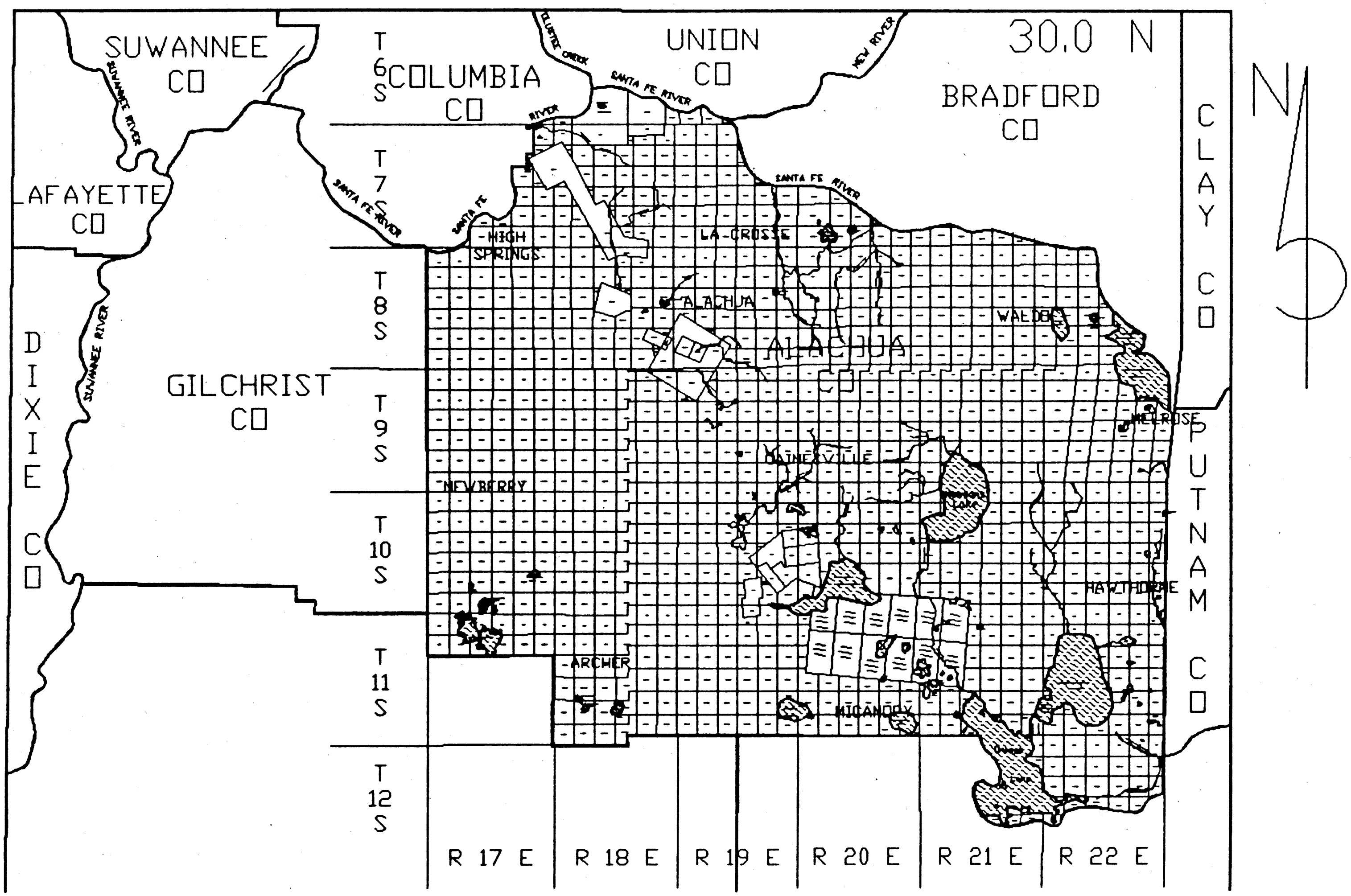


Figure 2-8. Completed Map ("ROADS" Layer Off).

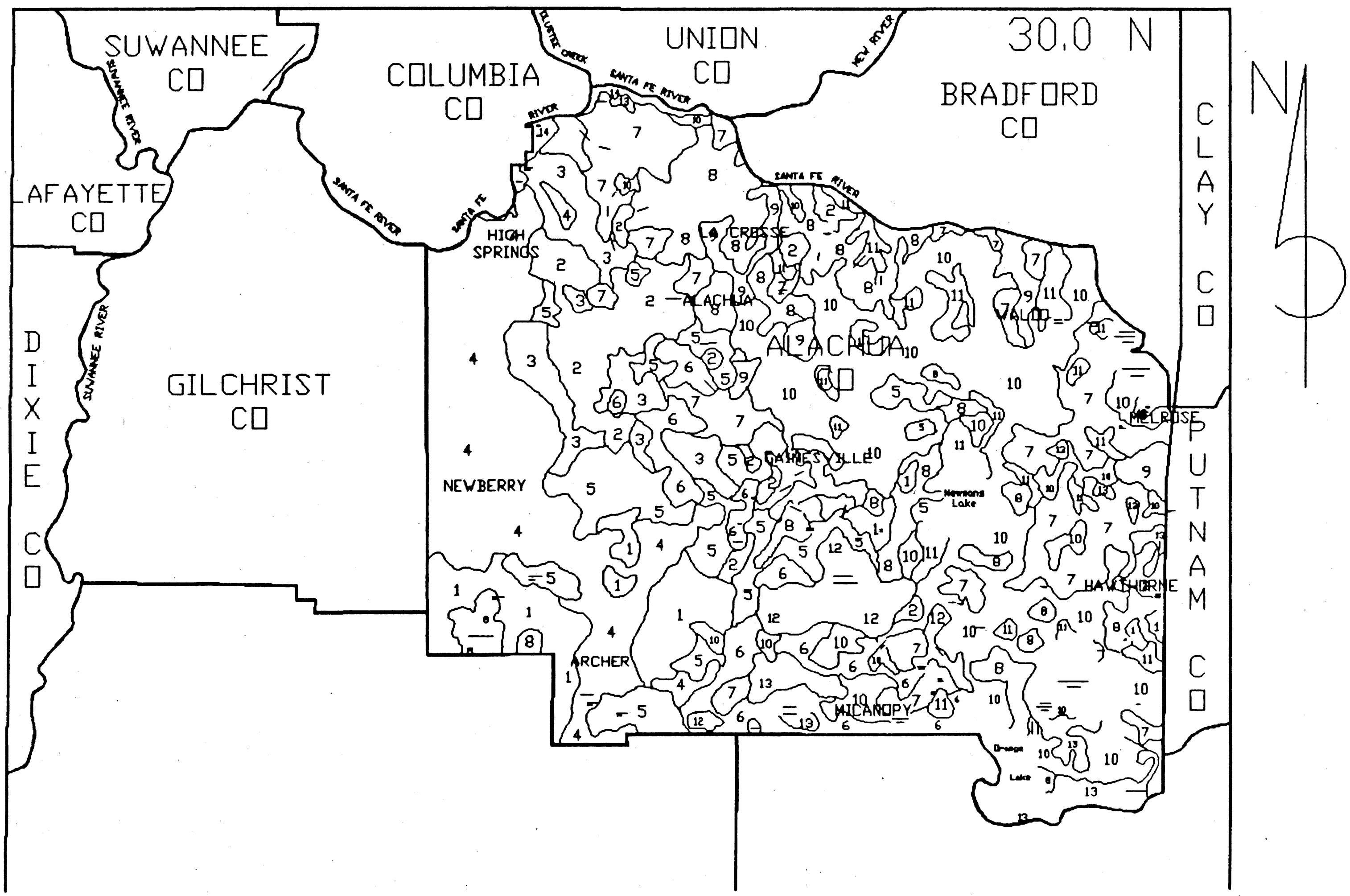


Figure 2-9. SOILS Map.

called up by typing the commands: VIEW, RESTORE, SOILS. Once viewed, the previous map can be recalled by typing the commands: VIEW, RESTORE, ALACHUA. As a result of the extensive amount of data associated with the map, it may take some time (ca. 2 minutes) to go back and forth between views. An alternative method to save time and avoid confusion is to print a hard copy of the legend the first time the view is recalled using the PRINT SCREEN key. The Soil Legend is shown in Figure 2-10.

The descriptive information of soil types in the soil legend has been abbreviated; for example, PD, MD, and WD were used to describe poorly, moderately, and well-drained soils, respectively. A key to abbreviated terms was also included for easy access within the soil legend.

The surface area of the soil types can be determined by exactly the same method as described in the Dimensioning Section, using the AREA command.

Dimensioning

An additional layer, called DIMENSION, includes stored geometrical analysis information of any feature(s). This information is any linear distance between points along an entity or between features. This layer was used to calculate, locate, and label designated distances of individual or group entities.

For example, as shown in Figures 2-11 and 2-12, exact lengths of line segments along an entity (polyline) can be shown. The individual lengths were calculated with AutoCAD by designating endpoints of each

SOIL LEGEND

UPLAND SOILS

2 Arredondo-Gainesville-Millhopper:
L/S; WD; Sandy >40 in. deep, loamy below

3 Kendrick-Arredondo-Bonneau:
L/S; WD; Sandy >20-40 in. deep, loamy below

4 Arredondo-Jonesville-Lake:
L/GS; WD & ED; Sandy >20-40 in. deep, limestone/loamy below some

5 Millhopper-Bonneau-Arredondo:
L/S; WD; Sandy 20-80 in. deep, loamy below

6 Blichton-Lochloosa-Bivans:
L/SS; PD; Sandy 20-40 in. deep, loamy below,
<20 in. deep, clayey below

FLATWOOD, SLIGHT KNOLL, & UPLAND/FLATWOOD TRANSITION SOILS

7 Millhopper-Lochloosa-Sparr:
L/GS; WD & PD; Sandy 20-80 in. deep, loamy below

8 Chipley-Tavares-Sparr:
L; PD & WD; Sandy, some 40-80 in. deep, loamy below

9 Pelham-Mulat:
L; PD; Sandy 20-80 in. deep, loamy below

10 Pomona-Wauchula-Newnan:
L; PD; Sandy organic <30 in. deep, & loamy
28-80 in. deep subsoils

SAND RIDGE SOILS

1 Candler-Apopka: L/S; ED & WD; Sandy, some
w/ thin loamy lamellae >50 in. deep, some loamy below > 40in. deep

WETLAND & FLOODPLAIN SOILS

11 Monteocha-Surrency:
L; PD; Sandy <40 in. deep, or 40-80 in. deep have
organic coated layer <30 in. deep, all loamy below

12 Ledwith-Wauberg:
L; PD; Sandy 20-40 in. deep, loamy below or thin organic &
loamy layers <20 in. thick, clayey below

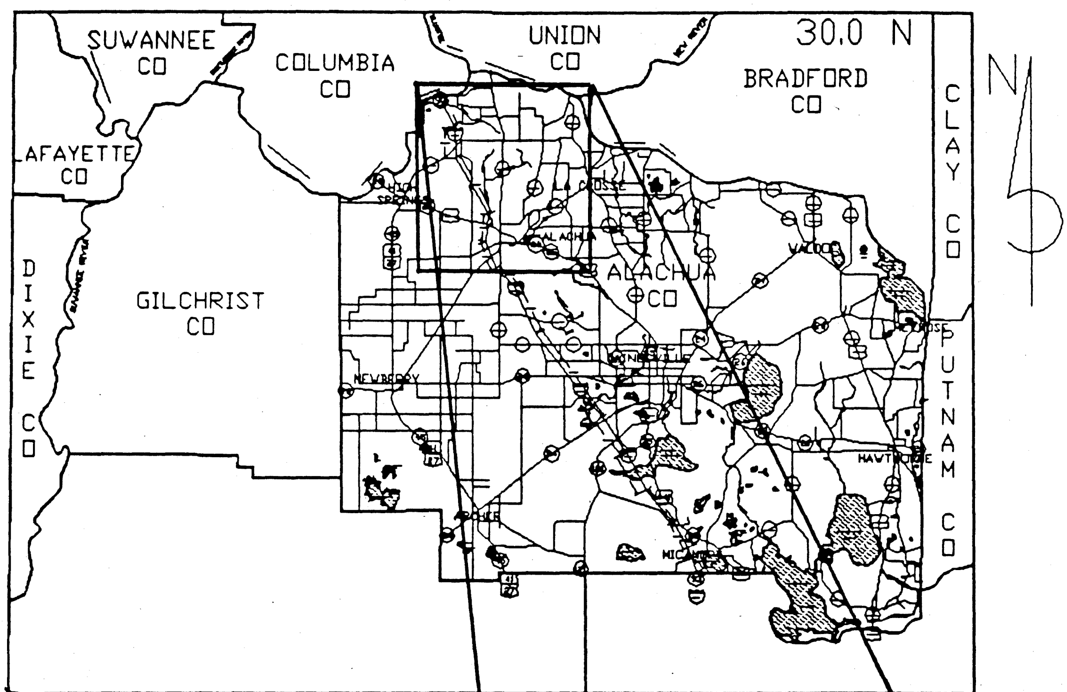
13 Shenks-Terra Ceia-Okeechobee:
L; PD; Organic 16-50 in. deep, clayey below, or organic >51 in. thick

14 Oleno-Pompano:
L; PD & FL; Sandy or clayey fluvial 26-47 in. deep to sandy,
loamy, or clayey material

KEY

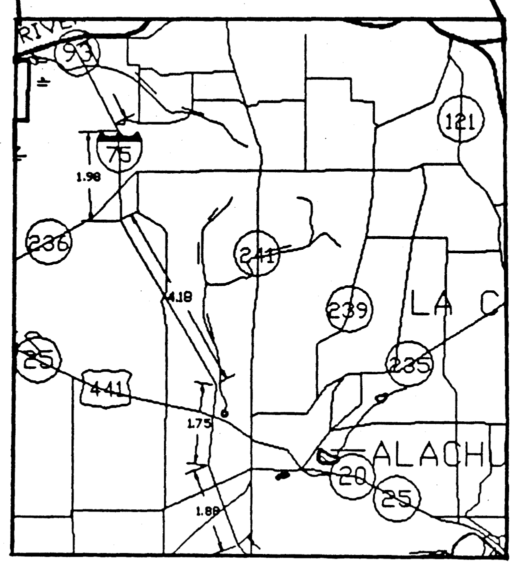
L = Level
S = Sloping
GS = Gently Sloping
SS = Strongly Sloping
PD = Poorly Drained
WD = Well Drained
ED = Excessively Drained
FL = Subject to Flooding

Figure 2-10. Soil Legend.



Above:

Figure 2-11.
I-75 Dimensioning.



Right:

Figure 2-12.
Zoom Window.

line segment and positioning of the dimensioning text was done with user judgment. Unfortunately, AutoCAD treats a polyline as line segments and does not directly calculate the distance of the entire entity, making dimensioning more time consuming. When a specific distance is desired without text showing in the layer, the DIST menu function is used instead of the DIM function. Figure 2-12 represents a "zoom window" of Figure 2-11 showing that dimensioning text can be read when magnified.

The AREA function is used to determine the enclosed area and perimeter of a polygonal entity; however, the computer-calculated dimensions are not represented as layer-text, but are presented, like DIST, in the screen text. Again, polylines are not directly computed and points need to be identified along them. This is done by picking the "Endpoint of" line segments along the polyline. Straight lines are easy to define, but county lines formed by river geometry must be defined by closely spaced points (e.g., "grabbing" the "Endpoint of" polyline segments) in order to maintain reasonable accuracy.

The digitized map of Alachua County has a calculated area of 988.54 sq. mi. and a perimeter of 139.52 miles. The summation of points along I-75 has a computed (digitized map) value of 35.20 miles. This correlates extremely well with the calculated estimate of 35.00 miles from the original map (Rand McNally, 1985). Using this result, the Alachua County dimensioning values should also be in good agreement. Values shown in Figure 2-12 are rounded to two decimal places, but can be adjusted to the desired decimal place by using the UNITS function. Point data on any entity is accessible through the ID function.

Inventory Data Handling

Hazardous Waste Disclosure Forms were sent by the Alachua County Department of Environmental Services to approximately 1200 prospective generator sites in 1985 (Appendix A). The selection of the sites to which the forms were sent is based on the US Department of Commerce's Standard Industrial Classification (SIC) Codes: Those businesses which were potential producers were selected. Of the twelve hundred that were mailed out, four hundred and sixty were completed and returned (Alachua County Department of Environmental Services (Vol I), 1987). Two Lotus spreadsheet files were created to store all site information. The first file contained all of the initial 1200 potential producers ordered by the SIC codes. Sites within each number were arranged alphabetically, and contained information on identification number (Site ID), the SIC code (Class Index), business name, mailing/location address, phone number, and supervisor's name. In addition, each site was labeled numerically beginning with the first site listed. The second file listed those reporting sites in order by the same method described above. Each site had coded information of quantity generated, waste types, and storage/disposal methods. The storage/disposal methods were segregated according to frequency. For example, the most frequent occurrences were placed in the "Primary" column, the next most frequent in the "Secondary" column, and the third in the "Tertiary" column. Both files were merged into a single file for easier manipulation and referencing. A 'Code Index' was also included for defining coded labels. Examples of inventory files are shown in Figures 2-13 and 2-14, and the 'Code Index' in Appendix B. All listed values are randomly generated.

Site ID	Class Index	--------Site Name--------	-----Mailing Address-----	----------Mailing------- City	State	Zip
100001	161	D.W. CARTWRIGHT		NEWBERRY	FL	32669
100002	161	W.D. ELOPE, CROPS	RT. 1, BOX 84	ALACHUA	FL	32615
100003	171	LOCAL BLUEBERRIES	2801 S.W. ARCHER ROAD	GAINESVILLE	FL	32608
100004	181	BEST ROSES NURSERY		MICANOPY	FL	32667
100005	181	PECAN HILL NURSERY	ROUTE 3	ALACHUA	FL	32615
100006	181	WEST COAST FLORIST	3600 S.W. ARCHER RD. #C	GAINESVILLE	FL	32608
100007	181	GREENS AND STUFF PLANT SHO	2222 N.W. 6 STREET	GAINESVILLE	FL	32609
100008	181	WEST COAST GREENHOUSE	RT. 4, BOX 325A	GAINESVILLE	FL	32608
100009	181	WALNUT WHOLESALE		ARCHER	FL	32618
100010	181	MOTHERS NURSERY	HWY 235	NEWBERRY	FL	32669
100011	181	KINGS PRODUCE	SR 26	NEWBERRY	FL	32669
100012	181	SPRINGS NURSERY	1012 N. W. 2ND AVENUE	HIGH SPRINGS	FL	32643
100013	191	HILLS PLANTATION		ALACHUA	FL	32615
100014	191	E A SPIKE CROPS	RT. 1, BOX 14	ALACHUA	FL	32615
100015	191	GOLDEN CORRAL FARM	RT. 2, BOX 26, ARCHER	ARCHER	FL	32618
100016	212	MOODY BROS., INC.	P.O. DRAWER 42	EVINSTON	FL	32633
100017	291	ARABIAN KNIGHTS	RT. 2, BOX 115	MICANOPY	FL	32667
100018	721	NORTH AG. SERVICE	P.O. BOX 659	NEWBERRY	FL	32669
100019	751	HARRY'S GROOMING & PET	506 N.W. 75 STREET	GAINESVILLE	FL	32607
100020	751	CANINE CARE CORP	1107 N. MAIN STREET	GAINESVILLE	FL	32601
100021	751	HOPESVILLE LIVESTOCK	P.O. BOX 1175	GAINESVILLE	FL	32602
100022	751	QUEENS DEN		HIGH SPRINGS	FL	32643
100023	751	HORSE RIDING SCHOOL	HWY 441 SOUTH	MICANOPY	FL	32667
100024	751	ROCKY RANCH & KENNELS	RT. 1, BOX 565	NEWBERRY	FL	32669
100025	782	LAND DEVELOPERS	RT. 2, BOX 337-B5	GAINESVILLE	FL	32601
100026	782	MOORE'S LAWN SERV	2838 NW 42ND PL	GAINESVILLE	FL	32605
100027	782	EXCELLENT LAWN CARE	2639 NW 45TH PL	GAINESVILLE	FL	32605
100028	783	ARMY TREE SERVICE	2121 N.W. 2 STREET	GAINESVILLE	FL	32608
100029	783	TOM'S TREE SURGERY	3621 N.W. 52 AVENUE	GAINESVILLE	FL	32606
100030	783	BEAUTIFUL LANDSCAPERS	6802 N. W. 18TH DRIVE	GAINESVILLE	FL	32606
100031	783	GORDON'S TREE SERVICE	RT.3 BOX 114-C	GAINESVILLE	FL	32606
100032	783	CLIPPERS QUALITY TREE	RT. 10 BOX 147	GAINESVILLE	FL	32605
100033	783	NORTH BEND TREE SERVICE		HIGH SPRINGS	FL	32643
100034	783	ELM TREE MALL	6419 NEWBERRY ROAD	GAINESVILLE	FL	32605
100035	783	HOPESVILLE LANDSCAPE	2406 N.W. 43 STREET	GAINESVILLE	FL	32606
100036	783	CUTTERS TREE SERVICE	RT. 10, BOX 147	GAINESVILLE	FL	32605

Figure 2-13. Excerpt from Site Information File.

Site ID	Waste Code (Type)	Quantity Generated [LB/YR]	-----Storage Methods------ Primary	Secondary	Tertiary	Disposal Site	-----Disposal Methods----- Primary	Secondary	Tertiary
100003	C	30	7	0	0	F	1	0	0
100005	Y	22	4	7	0	F	1	0	0
100006	C	3	4	0	0	F	1	0	0
100007	C	6	9	0	0	F	1	0	0
100008	A	71	0	0	0	O	3	0	0
100008	C	3	7	0	0	F	1	0	0
100015	W	76	9	0	0	F	1	0	0
100015	Y	190	1	0	0	F	8	0	0
100018	B	83	5	0	0	O	4	0	0
100018	C	500	4	0	0	F	2	0	0
100018	W	190	6	0	0	F	8	0	0
100018	Y	419	3	0	0	F	8	0	0
100019	C	24	4	0	0	F	1	0	0
100019	E	12510	0	0	0	F	6	0	0
100020	B	12009	4	0	0	F	6	0	0
100020	C	24	7	0	0	F	1	0	0
100034	C	18	7	0	0	F	1	0	0
100035	C	50	7	0	0	F	1	0	0
100036	W	114	6	0	0	F	8	0	0
100036	Y	76	4	0	0	F	8	0	0
100038	C	2	4	0	0	F	2	0	0
100039	Y	76	9	0	0	F	8	0	0
100040	C	12	0	0	0	F	1	0	0
100041	C	75	4	0	0	F	2	0	0
100041	K	41	0	0	0	F	1	0	0
100041	Y	609	3	0	0	F	8	0	0
100042	C	250	0	0	0	F	2	0	0
100042	Y	274	3	0	0	F	8	0	0
100043	Y	1828	3	0	0	O	8	0	0
100049	W	456	6	0	0	F	8	0	0
100049	Y	9144	3	0	0	F	8	0	0
100050	W	2280	0	0	0	F	8	0	0
100050	Y	13716	1	0	0	F	8	0	0
100051	W	1596	6	0	0	F	8	0	0
100051	Y	26670	1	0	0	F	8	0	0
100052	L	2688	3	0	0	F	5	0	0

Figure 2-14. Excerpt from Site Inventory File.

Location Site Placement

Nearly one-quarter of the reporting, small quantity generator sites were placed onto the digitized map by location address. These sites, represent the largest producers of non-recyclable hazardous waste in the county (=>700 lb/yr or the converted equivalent). The term, non-recyclable, is used to describe those wastes which do not fall under the "Recycled" category as defined by the Florida Department of Environmental Regulation (FDER). A list of these waste management/disposal practices can be found in Appendix A. Appendix B shows the conversion tables used for waste amounts. Each generator site was denoted by an attribute (numerical label) which corresponded to the number listed for the site in the inventory spreadsheet. An AutoCAD program was used to extract each attribute with its X,Y position in the map. This program enables a user to obtain a complete listing of all the current sites placed within the map. A more detailed look at creating template files for data extraction is described in the following section.

Attribute Entry/Retrieval

Waste data were placed onto the AutoCAD map directly at the location of the generating site. This was accomplished by creating a block symbol with AutoCAD's command function, BLOCK. This block entity was also given a list of tagging attributes to contain the site's address and waste information. This process is performed by using the ATTDEF command function which allows the user to name (or tag) attributes for input. For example, the typical site would have a named SITENAME tag for containing the sites names, an ADDRESS tag for containing address information, and multiple STORAGE and DISPOSAL tags for the information concerning the waste handling practices. In such a case, STORAGE1, STORAGE2, and so forth would be used as attribute tags. All inventory data was placed with each block symbol and can be viewed by simply zooming in on a site.

Data can be extracted from the drawing file by the use of template files which are easily created by the user. Autodesk, Inc. (1985) outlines how to set up a file that extracts selective attributes. For example, the block, SITE, has many attributes designated to it. However, the user only requires a portion of the attribute information like the x and y-coordinates of the site, the ID number, and the site address. Figure 2-15 shows a template file which performs this extraction. The first line in every template file has the statement, C:QUOTE ". This command places quotes around each character string or attribute. The second line specifies which block to search, which in this case is SITE. The third and fourth lines are for extraction of the x and y-coordinates. The "BL:" preceding those statements is for identifying non-attribute values of the block. No prefix is needed on the attribute identifiers, SITE-ID and SITENAME. The comment field to the right of the command field is used to format the character or numeric fields, C or N, respectively. For example, N007003, translates into a numeric field search and places the output with seven characters (including the decimal) to three decimal places. Similarly, the remaining comment fields can be adjusted to the field width of choice. Figure 2-16 shows how a template file was constructed to extract all the information for every site in the drawing. Once a template file is written using AutoCAD, MS-DOS, or any file editor, the file name needs to have

```
C:QUOTE "
BL:SITE    C015000
BL:X       N007003
BL:Y       N007003
SITE-ID    C005000
SITENAME   C050000
```

Figure 2-15. Template 1.

```
C:QUOTE "
BL:SITE                    C015000
BL:X                       N007003
BL:Y                       N007003
SITE-ID                    C005000
SITENAME                   C050000
ADDRESS                    C050000
TYPE                       C001000
AMOUNT                     N006000
STORAGE1                   N002000
STORAGE2                   N002000
STORAGE3                   N002000
DISPOSAL1                  N002000
DISPOSAL2                  N002000
DISPOSAL3                  N002000
ON/OFF<SITE-DISPOSAL>      C004000
```

Figure 2-16. Template 2.

the ".TXT" extension added. The file must also be placed in the same directory as the drawing file. To run a template file while in the AutoCAD drawing editor, the ATTEXT command function is used. AutoCAD will give the last template used as a default; however, any template file can be typed in. The resulting extract file will have the same file name as the drawing; however, it will have the ".TXT" extension. Extraction files are written in ASCII which Lotus 1-2-3 can easily access. The following chapter presents how these ASCII files can be imported, parsed, and manipulated within the spreadsheet environment.

Unfortunately, the attribute extraction process with template files was found to be quite limiting. The user simply retrieved exactly the same information that was put into the map. Template files cannot do any sorting, selecting based on criteria, or numerical analysis. Auto-LISP programs, which require an extensive background, serve as the data manager with AutoCAD. It is difficult for novice users to quickly learn such an extensive computer language. However, it is an extremely powerful language for using AutoCAD in GIS-related work. It was at this point, that our efforts were concentrated into using the Lotus 1-2-3 spreadsheet, exclusively, as a database management system.

CHAPTER 3
EXPERT SYSTEM TECHNOLOGY

Introduction

Another approach to analyzing and managing hazardous waste information is by using PC expert system technology. These systems are integrated computer hardware and software packages which incorporate expert knowledge or judgement into the analysis process to solve unstructured or underspecified problems and are depicted by If-Then rules (Johnson, 1986). Applications of expert system technology to problems in environmental engineering are rapidly becoming a popular method for controlling sources of pollution and managing their impact on the environment (Kim et al., 1986). Much of the attention has been focused on the area of hazardous waste management. Issues which have motivated the use of expert system technology on hazardous waste problems include emergency response actions of chemical spills, cleanup and securing of abandoned waste sites, design of waste facilities, and impacts of waste release on human health (Rossman and Siller, 1987). Rossman and Siller (1987) also discuss seven expert system developments and their methodologies. The development of these systems frees the expert from analyzing every piece of information from a huge knowledge base needed to reach decisions, thus saving considerable time and money. Ortolano and Steinemann (1987) and Scoville (1988) can be consulted for additional information in PC expert system technology.

Expert systems are identifiable by their reasoning process. This judgment can be applied in a number of ways. The most popular method, the heuristic approach, is to make an inference about a certain parameter which cannot be easily ascertained so that the process can continue to reach a conclusion.

Much of the time involved in performing a task is spent gathering, sifting through, and extracting pertinent information from a large database. In order to expedite this process so that more emphasis can be applied to using the database as a decision aid, an operational expert system prototype has been developed using the Lotus software to query a hazardous waste inventory knowledge base. The result of the query is a written response to the generator regarding the acceptability of his practices.

Applications of expert systems to civil engineering are summarized in a recent book edited by Maher (1987). Maher and Allen (1987) outline the characteristics of conventional programs and expert systems as shown in Table 3-1. By "conventional" programs, the authors are referring to Fortran and Basic programs for doing numerical calculations. By contrast, expert systems deal with problems which are oriented toward analyzing symbolic or textual relationships. An engineer wishing to use an expert system faces the task of learning a new language such as Lisp or Pascal, or using one of numerous available expert systems shells. Typically, the user wishes to do both numerical and symbolic processing. The dilemma is that he or she must choose a programming language or software that only performs one of these functions well. An alternative is to interface the numerical processing with the expert system.

Table 3-1. Characteristics of Conventional Programs and Expert Systems.

Conventional Programs	**Expert Systems**
Representation and use of data	Representation and use of knowledge
Knowledge and control integrated	Knowledge and control separated
Algorithmic (repetitive) process	Heuristic (inferential) process
Effective manipulation of large databases	Effective manipulation of large knowledge bases
Programmer must ensure uniqueness and completeness	Knowledge engineer inevitably relaxes uniqueness and completeness restraint
Midrun explanation impossible	Midrun explanation desirable and achievable
Oriented toward numerical processing	Oriented toward symbolic processing

Source: Maher and Allen, 1987.

Table 3-2. Characteristics of the Spreadsheet Expert System.

Attributes of This Expert System
Knowledge base contains numerical and textual information
Knowledge and control separated
Algorithmic process
Effective manipulation of a large knowledge base
Relaxed uniqueness and completeness conditions
Midrun explanation included
Symbolic and numerical processing

However, this can be an arduous task. In comparison, Table 3-2 shows the characteristics of the expert system hybrid developed using Lotus 1-2-3.

Maher and Allen (1987) contrast conventional programs and expert systems based on whether data or knowledge are being analyzed. If data are defined as numbers and knowledge is defined by text in the form of words, clauses, sentences or other symbolic representation, then it is easy to recommend a programming environment if either numerical or symbolic representation is used exclusively. However, the systems of interest are typically hybrids so a programming environment that can handle both situations is needed. Engineers have traditionally converted the symbolic part of their analysis into numerical equivalents. For example, a truth table can be constructed to enumerate the possible relationships between two statements, X and Y. A numerical equivalent of zero (statement is false) or one (statement is true) is assigned for each possibility, i.e., X and Y, X or Y, If X, then Y, X, and not X covering the cases where X and Y are both false, both true, or one is true and the other is false. Given this numerical equivalent, then a variety of techniques can be used to find efficient solutions to such logic problems.

Another area of comparison is in how conventional systems handle large databases as compared to how expert systems handle large knowledge bases. However, this difference does not appear to be significant if the knowledge base can be converted to a numerical equivalent or the database can be converted to a symbolic equivalent. In fact, a good programming environment should be able to handle both systems simultaneously.

With regard to whether a midrun status can be obtained, this status check can be of several varieties. An expert system run may be interrupted to ask why a certain question was posed. In a conventional program, subsets of the problem may be run to see that each is working correctly. While the midrun status check in an expert system is touted as an advantage, it is only a partial check. The overall search algorithm is usually not auditable by the user and this is a serious limitation. This spreadsheet model can be easily queried by the user. A more detailed description of this "midrun" inquiry can be found in the Control System section.

Another serious limitation is the "black box" effect which is inherent in almost every expert system developed today. The term black box refers to the case where the model's logical structure is not apparent. Thus, its validity cannot be readily checked. However, with the Lotus 1-2-3 spreadsheet, this task can be performed easily. Nothing is hidden from the user.

In summary, the distinctions between "conventional" programming and expert systems are rather blurred. The user typically seeks to deploy a hybrid system. An efficient programming environment should be able to perform the total task. If the majority of the work is numerical processing, then conventional programming tools are probably better. If most of the effort is in symbolic processing, then the expert system shells or languages are probably the preferred choice.

Expert systems are especially noted for handling subjective situations on a linguistic basis. This situation arises when "fuzzy" (vague or multiple meanings of) theoretical concepts are needed in an analytical operation. These subjective variables are represented with a word or string of words which are a qualitative representation of the quantitative value (Camara et al., 1987). Therefore, the operational process must make an inference in order to continue. Donahue, Hoctor, and Piskin (1987) describe how an index system is used to evaluate an underground storage tank knowledge base by assigning a linguistic value to each of the tanks. This index can assign any of the following qualitative values to a tank: VERYHIGH, HIGH, MEDIUM, LOW, VERYLOW, and NODATA. Each index value represents a range of quantitative values.

The major difference between the spreadsheet hybrid model and an "expert system" is the logic process. No inferences are made during the information processing in the Lotus model.

Spreadsheet as a Programming Environment

The preferred way to model problems which incorporate both conventional programming tools and the newer expert system ideas is to do all of the work in a single system. The Lotus 1-2-3 spreadsheet has been used to perform a variety of engineering problems ranging from normal calculations to doing graphics and database management (Hancock and Heaney, 1987). However, attempts to use expert system shells and to develop Lisp-based expert systems have been less successful due to their limited ability to perform numerical processing. They also require the user to be quite knowledgeable in high level computer languages. Fortunately, a recent publication and accompanying software provide an excellent introduction to the expert systems concepts and their incorporation into the spreadsheet environment (Benson, 1987). Several of the key ideas are described in the following chapter.

Building the Database Using Lotus 1-2-3

Creating a new spreadsheet file from other software program files is easy; however, they must be in an ASCII-formatted language. Before transferring an ASCII file into Lotus 1-2-3, the filename extension must first be changed to ".PRN". This is accomplished by using the DOS "Rename" command. For example, the original file, INVENTOR.SAS, is changed by typing RENAME INVENTOR.SAS INVENTOR.PRN, which now can be accepted by Lotus.

While in Lotus, the cell pointer is placed to the position in the top left corner of the new file. By using the /File Import <filename.PRN> command, a new spreadsheet file is created (or transferred). Additional files are transferred to the spreadsheet using the same command sequence. All site information was initially placed into a spreadsheet file by this method.

When files are created in this manner, all information is placed into the column below the cell pointer. Data stored in this fashion are usually not accessible for analysis; therefore, they will need to be parsed or sectioned into two or more columns. The reason for parsing information is to separate its components into simple distinct forms which will give a maximum advantage in analyses.

Data parsing is easiest when all the information within a column is separated by spaces. "Data parsing" a column is done by setting the cell pointer to the first row in the data, and then typing /Data Parse to activate the menu command. The first step, once in the parsing mode, is to set up the format line for the subsequent rows of data. Since the data will have a structured format, the first row of data should approximate the format of the entire body of data. Hence, after selecting the

Format-Line Create command, the blank row above the cell pointer changes to contain a letter or symbol for each character in the first data row. Usually it is necessary to edit this format line because of spaces used in the text. There is an option in the menu for this purpose. The Format-Line Edit command changes the format-line to a green (highlighted) color indicating the edit mode. Four characters in the format line indicate where a column parse (block) occurs when activated (Lotus Development Corp., 1986). The letter L, for label, indicates this column starts with a letter and can be parsed only when this character is recognized as a label (letter). The letter V, for value, is used when parsing a column beginning with a label or value (number). This can be very useful, especially when the initial character in a column begins with either type, e.g., addresses. The letter D is used for parsing date blocks and the T is used for time block parsing. The ">" characters succeeding each of the parsing characters indicate additional data characters available for placement into a column (continuation of the block). There is no character association with the ">" symbol. The original data were set up so that there were spaces between information parts, and the "*" symbol was used in the created format-line to indicate a break between blocks. The RETURN key moves the user back up a level in the menu.

Once the format-line is edited, the user specifies the data range, which is all in one column, to parse by using the Input-Column command in the menu. It is necessary to include the format-line when specifying the input range. The Output-Range command is used to specify the range of cells into which the parsed data are placed and is easily indicated by placing the cell pointer to the upper left most corner of the output range. Care must be taken that the parsed data (output) will not overwrite any existing data already on the spreadsheet.

Activation of the parsing process is accomplished by selecting the "Go" coomand from the menu. Lotus 1-2-3 produces a parsed list of data in the output range. Each block of data now occupies an individual cell. Cells, which were parsed incorrectly, can now be corrected.

An example of data parsing is presented in Appendix C, Section III and was used as an exercise during a hazardous waste workshop.

CHAPTER 4
BUILDING AN EXPERT SYSTEM HYBRID USING LOTUS 1-2-3

Architecture of the Action Letter Spreadsheet Model

The architecture of this model is very similar to that of a true expert system. This model, as shown in Figure 4-1, has six major components. The only difference between this model and an "expert system" is that an algorithmic control system is used instead of an inferential one. Each component represents a separate role-playing domain and is physically placed into different portions of the spreadsheet. The network flow of the operational process is also shown in Figure 4-1. The expert supplies, enters, and edits the knowledge base through the knowledge acquisition level. Information from the knowledge base is searched based on the user specifications in the rule base. The context component evaluates the knowledge and rule bases simultaneously. These results are used by the control system, which is operated through a spreadsheet macro program, to process the correct output responses in the action letter. A "macro" is a Lotus 1-2-3 programming code for a sequence of keystrokes that are invoked by striking the Alt key in conjunction with the alphabetic letter corresponding to the name of the macro. The purpose of the macro used in the Action Letter Spreadsheet Model is to extract those generators meeting criteria specified in the rule base, and then to create an action letter to send to each of these

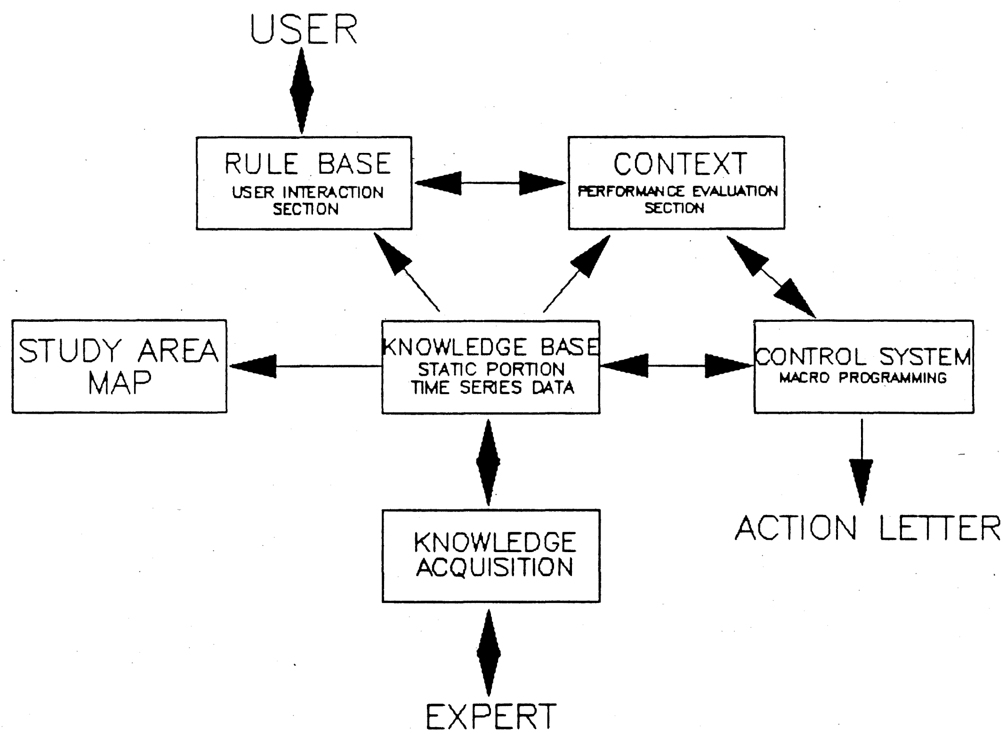


Figure 4-1. Architecture of the Action Letter Model.

generators. The following sections illustrate how each of these components have been developed and how they work together.

The Knowledge Base

Information Coding and Lookup Tables. Hazardous waste types were subdivided into 26 categories each of which was represented by a capital letter, A through Z. The reason for coding each waste type was to eliminate the errors associated with user misspellings. For instance, if users search for generators of a particular waste, they must know exactly how the waste type is specified and spelled. Since 1-2-3 matches cell contents with the use of an "=" sign, an incorrect search would result even if only one letter in the waste type was typed incorrectly. By using a letter, this error should be minimized.

Creating a lookup table in 1-2-3 is simple. In the example shown in Figure 4-2, a "Waste Code" column was created to form the letter waste codes, A through Z. The next column, called "ASCII Code", represents the ASCII numerical value associated with the code letter. This was easily performed in 1-2-3 by using the function, @CODE(string). For example, @CODE(B17) placed into cell A17 would yield a value of 65 in the same cell. It was found to be desirable to have these ASCII codes available when the searching rules were written because it reduced the amount of errors associated with spreadsheet editing.

The next step in creating this lookup table was the placing of the waste code descriptions in the "Hazardous Waste Type" column and Regulation Limit values in another column. The first column in the lookup table is referenced from another portion of the spreadsheet from which

	A	B		C D
10	RANGE TO CODE HAZARDOUS WASTE TYPES			
11	AND DETERMINE QUANTITY VIOLATIONS			
12				
13			Regulation	
14	ASCII	Waste	Limit	Hazardous
15	Code	Code	[#/mo]	Waste Type
16				
17	65	A	500	WASTE PESTICIDES
18	66	B	2000	PESTICIDE RINSES
19	67	C	5	EMPTY PESTICIDE CONTAINERS
20	68	D	500	TOXAPHENE ANIMAL DIP
21	69	E	2000	OTHER DIP SOLUTIONS
22	70	F	400	HEAVY METAL SCRAP
23	71	G	500	ELECTROPLATING RINSES
24	72	H	1000	ELECTROPLATING SLUDGES
25	73	I	400	WASTE INKS
26	74	J	500	IGNITABLE PAINT WASTES
27	75	K	400	OTHER PAINT WASTES
28	76	L	500	SPENT SOLVENTS
29	77	M	1000	DISTILLATION BOTTOMS
30	78	N	400	DRY CLEANING FILTERS
31	79	O	500	CYANIDE WASTES
32	80	P	2000	ACIDIC OR ALKALINE WASTES
33	81	Q	500	CORROSIVE PLATING WASTES
34	82	R	750	WASTE AMMONIA
35	83	S	900	PHOTOGRAPHIC WASTES
36	84	T	400	OTHER IGNITABLE WASTES
37	85	U	300	WOOD PRESERVING WASTES
38	86	V	250	WASTE FORMALDEHYDE
39	87	W	1000	LEAD_ACID BATTERIES
40	88	X	500	WASTE EXPLOSIVES
41	89	Y	2000	WASTE OILS AND GREASES
42	90	Z	0	AN UNSPECIFIED WASTE TYPE

Figure 4-2. Waste Coding and Labeling Table.

the adjacent column information is accessed. For example, the "ASCII Code" column, A, identifies the rows adjacent to the column and information can be extracted from these adjacent columns B, C, and D. However, when accessing the table using the VLOOKUP formula, the numbers 0, 1, 2, and 3 must be used to identify the columns A, B, C, and D, respectively as shown in Figure 4-2. Figure 4-2 is accessed during the information search and extraction process.

Object-Attribute-Value Representation. The knowledge base was set up so that all information was represented in an object-attribute-value (OAV) format. The main information category is called the "object" and it represents a fixed endpoint to which all data can be referenced. This information is classified into "attributes" which represent different but common aspects to all objects. Each attribute contains object-specific information, called a "value". An example of the OAV representation is presented in Table 4-1.

For this case, "Object1" will be replaced by a generator name, "Object2", by the same generator (or it could be replaced by the name of another), and so forth. "ATTRIBUTE1" represents the generated waste type, and "ATTRIBUTE2" the waste amount. Table 4-2 shows how the actual database might appear with the previously defined parameters.

The OAV format allows quick scanning through the database values meeting any prespecified criteria. A discussion on these criteria and how they are set up can be found in the Rule Base section. Once the criteria values are found, any attributes connecting to these values can be extracted and listed for user observation and further processing. The following section describes how the knowledge base for inventorying

Table 4-1. Example of an OAV Format.

	ATTRIBUTE1	ATTRIBUTE2
Object1	Value11	Value21
Object2	Value12	Value22
Object3	Value13	Value23
Object4	Value14	Value24

Table 4-2. Actual Database OAV Representation.

SITE_NAME	W_TYPE	W_AMT
Canine Care Corp	A	140
Canine Care Corp	B	12009
Crow Corp	Y	15240
Sunrise Painters	L	2688

hazardous wastes was constructed so that later analytical procedures could be developed around it.

The Fixed Data Section. Initially, the inventory data were downloaded from SAS files onto 1-2-3. Then, they were organized and parsed so that the object, SITE_NAME, made up the first column and subsequent columns contained the referencing attributes and their values, row-by-row. For example, the Fixed Site Data portion of the knowledge base is shown in Figure 4-3. This section contains the semipermanent basic information for each generator. All of the SITE_NAME objects have the common attributes of ST_# (address number), SEC (city quadrant), STREET, S_TYPE (street type), W_TYPE (waste type), W_AMT (waste amount), and so forth.

Each address is parsed into four attributes so that a site address can be scanned in as many ways as possible. It may be necessary to extract all sites in a particular quadrant of the city. For example, if the attribute, "SEC", was specified to have a searching value of "SW", then the data extraction list would contain information on three generators: CROW CORP, GAINESVILLE PRINTS, and BULLSEYE ARCHERY. If the entire address had been stored as one attribute, then the search would have been complicated by having to first identify the address number.

Time Series Data Section. The time series portion of the knowledge base contains the monthly waste generation quantities and is shown in Figure 4-4. Attributes in this section were identified by JAN, FEB, etc. and contain numerical values which summed to the value located in the W_AMT column of Figure 4-3. Data organized in this manner can

FIXED SITE DATA

SITE_NAME	ST_#	SEC	STREET	S_TYPE	X_COORD	Y_COORD	SUPERVISOR	W_TYPE	[#/YR] W_AMT	CODES FOR STORAGE	DISPOSAL
Harry's Grooming & Pet	506	NW	75	St	35.15	45.63	Mr. John Black	E	7671	1	7
Canine Care Corp	1107	N	Main	St	41.64	46.07	Mr. Greg Walters	B	12009	5	7
Crow Corp	6801	SW	Archer	Rd	36.18	41.87	Mr. Clay Blinkins	Y	15240	3	9
Sunrise Painters	1219	NW	43	Av	40.73	48.26	Mr. Tom Carter	L	2688	10	9
Gainesville Prints	2700	SW	13	St	40.60	43.53	Mr. Bob Bloom	S	5220	1	7
Starter Printing Co	1540	NE	Waldo	Rd	43.06	46.31	Mr. Jake Fields	S	2288	1	7
Beechnut's Printing	2161	NE	1	Blvd	41.61	47.01	Mr. Fred Beechnut	L	112	8	2
Graphic Press Ons	834	E	University	Av	42.13	45.31	Ms. Melinda West	S	1357	10	7
Suntan Paint Inc	1111	SE	22	Av	42.32	43.82	Mr. Paul H. Sanderson	L	1120	4	9
Hyde Laboratories Inc	2603	NW	74	Pl	39.03	50.37	Mr. Lee Smith	L	1100	4	6
Bullseye Archery	4600	SW	41	Blvd	38.12	42.53	Mr. William Hall	P	4081	1	6
Port-A-Let	1506	NW	55	Pl	40.56	49.17	Mr. Bill Spike	P	19080	10	5
Hot-Air Inc	3716	NE	49	Rd	44.44	48.79	Mr. Winfred R. Stockton	Y	4191	4	6
Interchange Video	2040	NW	67	Pl	43.40	47.53	Mr. Lee Lewis	L	1232	4	6
Volatile Industries	3700	NE	53	Av	44.26	48.91	Mr. Jack M. Newell, Jr.	L	672	4	6
Little Lake Marine Co	250	SE	10	Av	41.91	44.40	Mr. Walter Carson	M	1848	4	6
Refinish Manufacturing	3001	NE	20	Wy	43.23	47.45	Mr. Jon Tuckett	Z	100	10	2
Fast Craft	3530	SE	Hawthorne	Rd	44.19	44.58	Mr. Bill Reiner	L	1232	4	6

Figure 4-3. The Fixed Database Section.

AI54: @IF(AE54>@VLOOKUP(@CODE(G54),$QUAN_VIO,2)#AND#$K$11=1,G54,0)

AJ54: @IF(M54=@VLOOKUP(M54,$STOR_METH,1),M54,0)

AK54: @IF(N54=@VLOOKUP(N54,$DISP_METH,1),N54,0)

Q R S T U V W X Y Z AA AB AC AD AE AF AG AH AI AJ AK

51	******************TIME SERIES DATA***********************												SUMMARY STATISTICS			****PERFORMANCE EVALUATION*****		
52																		
53	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Max	Min	Mean	QUAN_VIOL	STOR_CRIT	DISP_CRIT
54	78	331	288	407	949	993	1362	1479	1486	1639	1705	1793	1705	1362	1534	0	0	0
55	747	859	1719	1528	195	1698	1703	925	939	1011	103	582	1719	103	1001	0	0	0
56	38	715	1627	1196	1392	2156	1496	1832	2072	356	1943	417	2156	38	1270	Y	3	9
57	139	374	174	43	328	253	53	268	263	255	305	233	374	43	224	0	10	9
58	758	130	684	629	124	200	123	291	507	787	213	774	787	123	435	0	0	0
59	28	37	112	220	189	151	398	427	313	65	26	322	427	26	191	0	0	0
60	9	11	4	5	9	15	11	2	15	6	15	10	15	2	9	0	0	0
61	164	122	100	65	39	57	196	151	197	112	33	121	197	33	113	0	10	0
62	70	4	34	39	152	104	172	198	103	76	90	78	198	4	93	0	0	9
63	20	27	133	143	32	146	113	27	101	137	58	163	163	20	92	0	0	0
64	318	520	164	466	493	387	157	401	382	166	456	171	520	157	340	0	0	0
65	2555	1620	416	2570	2469	445	2390	685	243	2525	2399	763	2570	243	1590	P	10	0
66	106	671	123	71	638	106	106	101	447	767	488	567	767	71	349	0	0	0
67	22	164	125	105	196	62	145	59	90	54	56	154	196	22	103	0	0	0
68	34	43	63	84	15	115	79	36	86	15	51	51	115	15	56	0	0	0
69	182	32	490	383	178	85	30	37	119	162	35	115	490	30	154	0	0	0
70	10	11	4	1	12	3	2	15	17	7	13	5	17	1	8	Z	10	0
71	88	97	118	21	123	8	96	57	151	149	173	151	173	8	103	0	0	0
72	**												*****************			******************************		

Figure 4-4. Time Series Data/Cell Contents of the Performance Evaluation Section.

facilitate creating graphs for observing apparent trends. Statistical operations on the time series data were performed in this section. For example, maximum, minimum, and average values were determined as well as checks for trends or other properties of the database. This section was easily set up by using the statistical @functions and regression analysis available in Lotus 1-2-3.

The Context: Performance Evaluation Section

This section evaluates any of the previous knowledge base information based on the selected criteria. As shown in Figure 4-4, the Performance Evaluation Section identified those sites which exceeded a maximum quantity of hazardous waste generated per month and/or used specific storage/disposal methods. The evaluation section is controlled by the rule base which will be discussed in greater detail in the section called The Rule Base.

This portion of the spreadsheet model was created by writing a formula in each cell to perform a database inquiry within that same row, to match the specified criteria identified in the Rule Base. For example, Figure 4-4 shows the cell formula for the first site in the column labeled, QUAN_VIO, which stands for quantity violator. The formula shown in cell AI54 displayed at the top of the page displays an @VLOOKUP argument that searches for the "Regulation Limit" identified with the waste code in the Fixed Site Data. The second portion of the "#AND#" clause determines if the governing rule has been specified. A detailed explanation of this rule will be presented in the following section. The entire cell formula reads as follows: If the maximum value of the

Time Series Data is greater than the Regulation Limit for the waste code value corresponding to the W_TYPE attribute, and the user specified that this criterion be searched, then put the waste code in this cell; otherwise, place a "0" which will indicate a FALSE response to the search. Each formula is copied down allowing only database information cell addresses to change. Figure 4-4 shows that three sites have exceeded the monthly allowable limit. This result can be verified by comparing Figures 4-2, 4-3, and 4-4.

The other two columns in the evaluation section were also set up as cell formulas for scanning the time series section of the knowledge base according to specifications in the Rule Base. Again, the successful search placed a non-zero digit into a cell. These columns take on the value that represents the code used for a storage/disposal method in the knowledge base. For example, Figure 4-4 again shows the cell formula used in each of the two columns. Cell formulas in both columns have a similar format and are read in the following manner. If the coded attribute (number) in the knowledge base matches the number in the Rule Base, then assign that value to the cell, otherwise make its value "0". The "...number in the Rule Base..." is a referencing factor indicating when the user has specified a search for the value of this attribute.

Examination of Figure 4-4 indicates that the storage codes, 3 and 10, and the disposal code, 9, are specified by the user in the Rule Base to be scanned and identified. The following section demonstrates the development of a rule base in an efficient tabular format to initiate a database search.

The Rule Base

This portion of the spreadsheet controls the data search parameters and lets the user choose the searching values. Additional searching rules can be easily inserted, integrated, and applied to meet future needs. Figure 4-5 shows how the rule base is set up. In this example, the rule base has been subdivided into three categories: Violation Rule, Disposal Methods, and Storage Methods. The first category contains only one option which is to identify sites exceeding a regulatory standard. If this option is selected, then all sites which have exceeded a monthly, maximum quantity will be extracted from the database and listed in the extraction table presented in the previous section. The Disposal Method category allows the option to scan the database for generators using any of fifteen possible disposal practices. Any desired number of practices may be searched at any one time. The Storage Method category format is identical to that of the Disposal Method category with up to ten options from which to choose.

To specify the search criteria within the model, type a "Y" (for yes) into the column, titled "Y"?, next to the rule description. Once all of the options have been selected, a macro sequence within the Control System is run to apply the rules to the database search, extraction, and listing process. Examination of the cell adjacent to the first specification cell shows a formula which analyzes the "Y"? column. It has been written so that if a label is placed into "Y"? column, then the associated rule number, (R#), is placed into the Determine column. If not, then the value in the Determine column is set to a high, currently non-usable number, like 100.

```
RULES TO BE APPLIED TO THE DATA BASE
Place a "Y" in the cell beside the number of each rule you
want to be applied, then write the message to be included in
the letter.
               |
               |
               |
               |      SEARCH RULES THAT CAN BE APPLIED
               V
          |"Y"?|R# VIOLATION RULE
        1 |Y   | 1 Quantity Regulation Violations
          |    |
          |    |   DISPOSAL METHODS
      100 |    | 1 Reporting No Disposal Method
      100 |    | 2 Waste Hauled To Landfill by Contractor
      100 |    | 3 Haul Own Waste To Landfill
      100 |    | 4 Bury Waste On Own Property
      100 |    | 5 Open Pit/Pond/Lagoon
      100 |    | 6 Hazardous Waste Facility
      100 |    | 7 Public Sewer
      100 |    | 8 Septic Tanks
        9 |Y   | 9 Recycle Waste
      100 |    |10 Blend/Burn Waste For Fuel Value
      100 |    |11 Incineration
      100 |    |12 Well Injection
      100 |    |13 Filtration
      100 |    |14 Neutralization
      100 |    |15 No Disposal Method Listed Above
          |    |
          |    |   STORAGE METHODS
      100 |    | 1 Reporting No Storage Method
      100 |    | 2 Above Ground Tanks
        3 |Y   | 3 Below Ground Tanks
      100 |    | 4 55-Gallon Drums
      100 |    | 5 Various-size Cans
      100 |    | 6 Open Pits/Ponds/Lagoons
      100 |    | 7 Pile Waste On Ground/Floor
      100 |    | 8 Dumpster/Bulk Waste Container
      100 |    | 9 Lab Packs
       10 |Y   |10 No Storage Method Listed Above
```

Figure 4-5. The Rule Base Setup.

The VLOOKUP mentioned in the Knowledge Base section references this portion of the spreadsheet. When the value of the Determine column is not 100, the Performance Evaluation Section is then activated to scan for the specified criterion (rule) in the knowledge base. The next section, called the Control System, describes a series of macro statements that have been developed to quickly examine the input and process the extracted information. It also presents how this same information can be used to process paper work to create an action letter.

Mapping Area Development

Direct linking of AutoCAD and Lotus 1-2-3 was investigated and rejected because of the tedious work required to transfer data from one system to the other. Instead, a much more efficient approach was developed to create a map. A Lotus 1-2-3 map of the study area was prepared so that the interfacing problem would be eliminated. This map was developed using 1-2-3's graphing menu commands. Initially, the coordinates of all map features must be determined by reading them off a gridded map or transferring them from a previously digitized map (Hancock, 1987). The section of the spreadsheet allocated for the mapping database can be created by either of two methods. The first method is to extend the original database by adding mapping coordinates of generator sites and other data points representing additional topographic features. The other method is to create an extracted table from the original database by using the /Data Query commands and add mapping coordinates of sites and features to it. The second method was preferred as it allowed easier insertion of new data and did not carry unnecessary knowledge base information along with it. This development is presented here.

The first step in building a data extraction table for the mapping database consisted of identifying the map database titles (column headings) to be used in extracting data from the same titles in the knowledge base. For a successful search, it was found to be easiest to copy titles over from the knowledge base so that they matched exactly. By invoking the /Data Query command, all needed information would be transferred. The only information needed in the mapping database was a site number and its x,y coordinates; however, the information on the site's name and address helped to identify the generators later on.

Next, the x,y coordinates of the generators and topographical features were placed within the table. Figure 4-6 shows how the table has been created for generator placement only. Mapping coordinates were placed in the knowledge base (see Figure 4-3) and extracted into the mapping database. The x-range was specified as the X_COORD column and all successive x coordinates of additional features were also specified within this x-range. To delineate each feature, a blank cell was inserted between the x-range values. Six different y-ranges can be plotted using 1-2-3, each representing a different feature. This map used only five of the y-range options. Each feature was also labeled using an adjacent column. Because of the table length, it should consist of an offset, two column set per feature which refers to a common x-range.

To locate sites which generated a specific waste type and/or were located within a certain sector of town, an extraction table was developed to "highlight" these sites which were already on the map. A

THE MAP DATABASE:

is created from the original static database or an extracted table. Extracted data from the HOT SPOTS table are added to the end of this table to highlight those sites meeting the waste type criterion.

* Data-labels are adjusted for correct map fit.

SITE_ID	EPA_#	SITE_NAME	ST_#	SEC	STREET	S_TYPE	X_COORD	Y_COORD	Labels
100019	751	Harry's Grooming & Pet	506	NW	75	St	35.15	45.63	19
100020	751	Canine Care Corp	1107	N	Main	St	41.64	46.07	20
100052	1620	Crow Corp	6801	SW	Archer	Rd	36.18	41.87	52
100093	1721	Sunrise Painters	1219	NW	43	Av	40.73	48.26	93
100200	2711	Gainesville Prints	2700	SW	13	St	40.60	43.53	200
100216	2752	Starter Printing Co	1540	NE	Waldo	Rd	43.06	46.31	216
100219	2752	Beechnut'S Printing	2161	NE	1	Blvd	41.61	47.01	219
100227	2791	Graphic Press Ons	834	E	University	Av	42.13	45.31	227
100234	2851	Suntan Paint Inc	1111	SE	22	Av	42.32	43.82	234
100235	2869	Hyde Laboratories Inc	2603	NW	74	Pl	39.03	50.37	235
100241	3079	Bullseye Archery	4600	SW	41	Blvd	38.12	42.53	241
100247	3448	Port-A-Let	1506	NW	55	Pl	40.56	49.17	247
100250	3449	Hot-Air Inc	3716	NE	49	Rd	44.44	48.79	250*
100262	3613	Interchange Video	2040	NW	67	Pl	43.40	47.53	262*
100264	3662	Volatile Industries	3700	NE	53	Av	44.26	48.91	264
100268	3732	Little Lake Marine Co	250	SE	10	Av	41.91	44.40	268
100269	3732	Refinish Manufacturing	3001	NE	20	Wy	43.23	47.45	269
100271	3732	Fast Craft	3530	SE	Hawthorne	Rd	44.19	44.58	271

Figure 4-6. A Portion of the Mapping Database.

database extension was built for this purpose. It included setting up the title headings below the existing mapping database. The X_COORD values were again placed in the same column; however, the Y_COORD values needed to be placed into a new column with a newly specified y-range from the graph menu. Then, the extracted sites were highlighted on the map. Again, the extracted information was data-labeled so that they were also highlighted. Extracted sites have an additional symbol representing them on the map which also helped in identification.

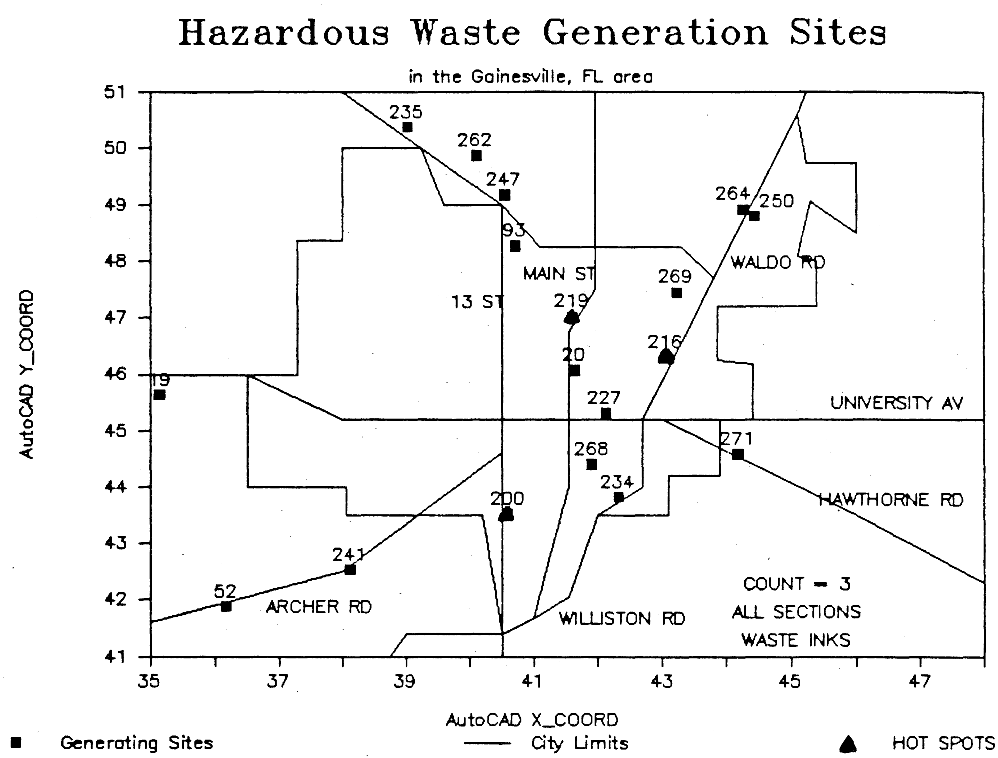
The graphing ranges were extended far enough down the spreadsheet to account for an extraction list of any size. All of the ranges were formatted for both the graphing and data query menu commands. The 1-2-3 function keys are then used to accelerate the extraction and graph viewing process. Once the criterion value to be searched is specified, then the F7, F9, and F10 keys are hit, respectively, giving an almost instantaneous view of the map with the newly selected sites. The selection process for mapping or any other extraction table can have as many criteria ranges as needed. For this map, two criteria ranges have been set up to extract sites, one for the title, W_TYPE, and one for SEC, the town quadrant.

The mapping database is easily adaptable to add sites; however, only six different features are allowable in 1-2-3 at any one time. To insert additional sites into the map, either shift underlying data rows downward on the spreadsheet, or insert rows using the 1-2-3 command menu. The graph ranges will not need readjustment. For a more in-depth discussion of how the criterion ranges are used, see the following section, titled Data Extraction and Listing. This section also discusses how the criterion range is used for selection within the expert system process.

The resulting map is shown in Figure 4-7. Generators of waste inks have been extracted and highlighted for viewing. The symbol for the sites labeled 200, 216, and 219 differs (triangular) from the remaining square symbols. The waste type value located on the bottom right portion of the map was created by allowing a cell within another specified, graphing y-range to read the criterion cell value.

Data Extraction and Listing

The process of data extraction to produce a listing of database derived information is an integral part of this system's design. The development of this process involved three steps: defining the input range, setting up and defining the criteria range(s), and setting up the extraction table. All three steps were defined while in the /Data Query command. The input range was defined as the entire knowledge base, including the column headings (attributes). The criteria range consisted of two or more cells. Figure 4-8 displays how the criteria range is commonly set up. The first cell contains the searching attribute and it must be in the exact form as the column heading in the input range. Therefore, these attributes were copied to other portions of the spreadsheet. The other cell underlies the first cell and contains the searching value specified by the user. This range of cells was also placed conveniently on the spreadsheet for convenient access. Additional, underlying cells were also allocated for searching more values, simultaneously, within the same attribute. More searching attributes were added to the criterion range using the same methodology.



Criterion Range

```
 ___________________________
|                           |
|  W_TYPE         SEC       |  <--Searching attributes
|                           |
|       I                   |  <--Searching values
|                           |
|                           |  <--Searching values (here
|___________________________|         and below are optional)
```

Figure 4-8. Data Query Criterion Setup.

The extraction table format is similar to that of the knowledge base. The top line of the output table contains the column headings of the desired database fields. Figure 4-9 shows how an extraction table format with its criteria range can be set up for the data query process. Examination of the criteria user-input cell shows that it contains a formula which scans and evaluates the Performance Evaluation Section. This formula analyzes each column for a non-zero cell value. If any one column has a value other than zero, then the data query process extracts information related to this cell row. This type of strategy allowed a more powerful and user-friendly approach in data searching. Instead of the user having to travel around the spreadsheet to find and edit all of the input variable cells, the Rule Base area of the spreadsheet was allocated for user input.

For example, a list of the generators and related information based on a few criteria may be required. By specifying these criteria in the Rule Base and recalculating the spreadsheet, the Performance Evaluation Section is re-evaluated through its cell formulas. Any data query performed after this revaluation will result in a new listing in the extraction table. This information can now be used in further processing. Figure 4-9 shows how the extraction table appears after the data query process.

The Control System

The Flow Logic Process

This portion of the spreadsheet is the operational mechanism that is based on a programming macro sequence. It controls the flow process

```
AP51: @ISSTRING(+AI54)=1#OR#AJ54<>0#OR#AK54<>0

|*********************************************************************************************************************|
|                                    |  CRIT2            |            EXTRACTION TABLE                                 |
|                 Criteria           |  -------          |                  FOR                                        |
|                   Setup--->        |  SITE_ID          |       SELECTED WASTE GENERATORS                             |
|                                    |  [ 0 ]            |                                                             |
|---------------------------------------------------------------------------------------------------------------------|
|SITE_ID        SITE_NAME         ST_# SEC   STREET   S_TYPE        SUPERVISOR         QUAN_VIOL STOR_CRIT DISP_CRIT W_TYPE|
|     52 Crow Corp                6801 SW  Archer     Rd      Mr. Clint Jenkins      Y                  3         9   Y  |
|     93 Sunrise Painters         1219 NW  43         Av      Mr. Ken Rosenlund              0         10         9   L  |
|    227 Graphic Press Ons         834 E   University Av      Ms. Donna Winchester           0         10         0   S  |
|    234 Suntan Paint Inc         1111 SE  22         Av      Mr. Joseph H. Anderson         0          0         9   L  |
|    247 Port-A-Let               1506 NW  55         Pl      Mr. Bill Spencer       P                 10         0   P  |
|    269 Refinish Manufacturing   3001 NE  20         Wy      Mr. Ken Fickett        Z                 10         0   Z  |
|*********************************************************************************************************************|
```

Figure 4-9. Extraction Table Example.

of the analysis in a forward chaining operation. Once the search criteria have been specified, the user activates the macro program to initiate the search, extraction, and letter processing operation. The entire flow process involved during the activated macro program is outlined in Figure 4-10.

The user can inquire about three major levels, simultaneously, within this model's database. These queries are on quantity violations, disposal, and storage methods. Let's examine each level independently.

When a user specifies a search for quantity violators, the knowledge base information is analyzed and compared to the LOOKUP table maximum level values. If these values are exceeded in the database, specific information is extracted into a table, from which a message is selected to be presented in a letter form. The message type is determined by the available knowledge on the appropriate action to take. For example, this level gives a message to the generator that itemizes necessary corrective action. However, other forms of solutions are also possible.

In the Disposal Method level, three different responses can result. If rule 4 is chosen, "Bury Waste On Own Property" (see Figure 4-5), and it is successfully found in the knowledge base, then pertinent information is extracted. However, with this rule, no corrective action can be relayed to the generator. A "no solution" situation arises from the lack of documented cases in this area. In such cases, the generator is still informed about the waste practice and is given a temporary plan of action. A "provisional solution" response to an inquiry would give the generator a temporary corrective alternative to implement. This type of message is given when there has been some past documented cases in this area; however, no permanent corrective method to solve the problem has

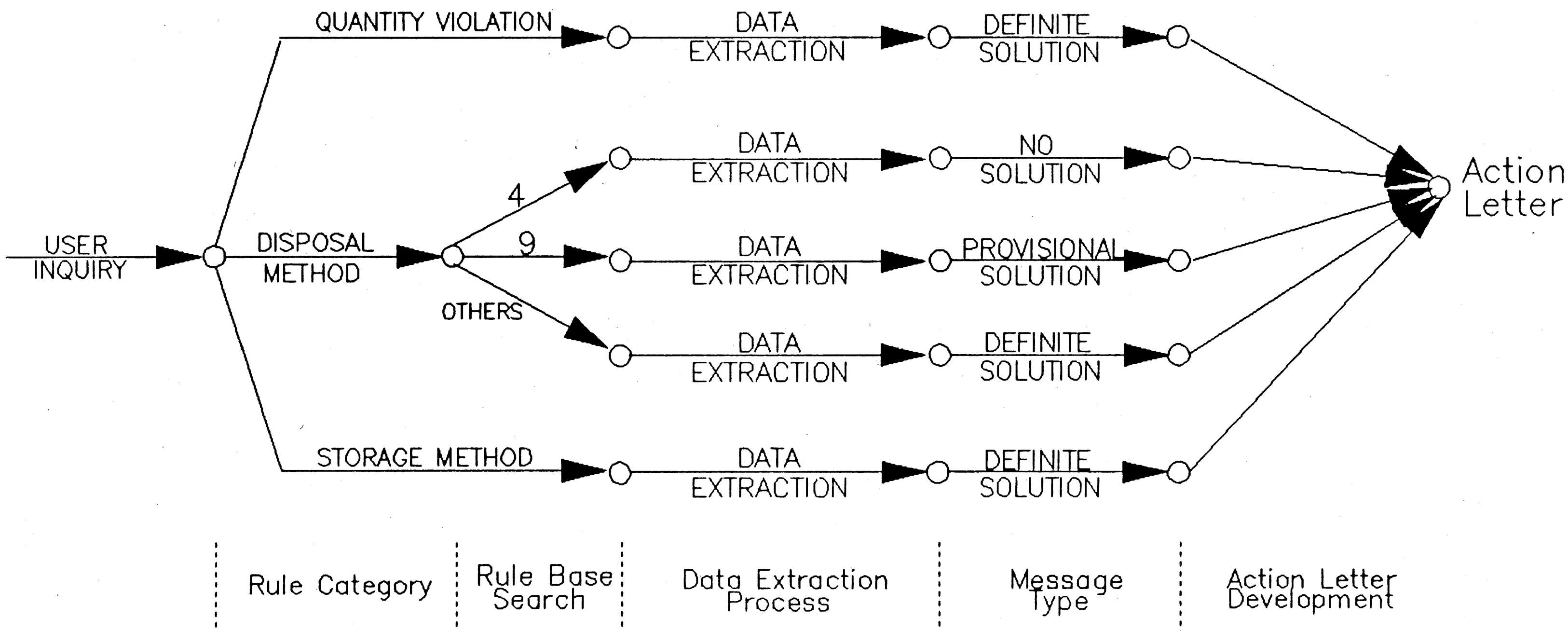


Figure 4-10. Flow Logic of the Control System.

been specified. Again, by examining Figure 4-10, the "definite solution" message types would be used in a successful search for any other rule, not mentioned above, in the disposal method level and also in the storage method level.

Earlier, it was observed that a midrun status could be obtained in this spreadsheet model. This inquiry can be handled by either of two methods using Lotus 1-2-3. First a user may want to inquire how the program flow operates. The user activates the macro step-mode sequence in Lotus 1-2-3 by striking the ALT-F2 keys, simultaneously. When the macro sequence is initiated to begin the control system selection, each process is viewed in sequence as the user strikes the space bar. In this method, the user can determine where the process of interest is located within the control system.

The other method simply relies on the user to stop the macro program prematurely by hitting the CONTROL-BREAK keys, simultaneously. Once the program has been halted, the user can activate the macro step-mode sequence as described above to view incremented processes. This midrun method in Lotus 1-2-3 is an excellent advantage to the users since it keeps them attuned to the model programming and prevents the black box effect.

Macro Programming Development

The macro program is initiated by striking the ALT key simultaneously with the "A" key. A custom menu appears at the top of the screen and some explanatory text appears in the spreadsheet window. The options in the custom menu MENU1 shown in Figure 4-11 are KNOWLEDGE

```
\A       /rfhREST_MESS~/wtc{beep}
\0       {goto}INITIAL~
         {menubranch MENU1}

\MENU1   KNOWLEDGE BASE     LETTER STATEMENTS           FORM LETTER        VIOLATION STANDARDS      RUN
         Edit the Knowledge Edit the Letter Statements Edit the Contents Edit the Waste Quantity Run the Program
         /rfrREST_MESS~     {goto}LETTER_STATMNTS~      {goto}FM_LETTER~  {goto}STANDARDS~         {branch \J}
         {goto}D_BASE~
         {up 10}{down 11}
         /wth{end}
         {down}{down}
```

Figure 4-11. Macro Program Controlling Custom Menu

BASE, RULE BASE, LETTER STATEMENTS, FORM LETTER, VIOLATION STANDARDS, and RUN. KNOWLEDGE BASE places the cursor at the cell just below the last data entry. The user may then edit existing data or input additional data. The RULE BASE option places the cursor at the top of the screen that contains the selection of rules that can be invoked. The user then chooses the rules that are applied to the knowledge base by placing the letter "Y" to the left of the cell corresponding to the desired rule. LETTER STATEMENTS allow the user to view and edit the statements that are assembled and inserted at the bottom of the letter. FORM LETTER allows the user to edit the main body of text in the letter. VIOLATION STANDARDS allows the user to change the quantity of waste that initiates selection of a generator as an action letter recipient. The RUN option is a macro subroutine that extracts the names of action letter recipients and assembles the letters using information on waste quantity and storage and disposal methods.

There are three separate parts of the RUN macro subroutine: data extraction, letter assembly, and printing. The first line of the macro subroutine, shown in Figure 4-12, represents the data query and extraction programming. It freezes the screen, queries the database using the criteria specified in the rule base, places the output in the extraction table, and resets the line counter to the row in the extraction table corresponding to the first generator.

Once the data extraction section of the macro has been performed, the macro branches to the letter assembly section which starts with the line of code directly to the right of "INCREMENT" in Figure 4-12. The letter assembly section of the macro assembles the action letter to be sent to each generator by taking a standard form letter and appending

```
\J          {windowsoff}{paneloff}{if L11=" "}{MIDRUN}
            /dqiD_BASE~cCRIT2~oOUT_2~eq~{let COUNTER,53}
            {let INDICATE,0}{branch INCREMENT}

INCREMENT   {if @Cell("Contents",@@(+"AN"&@String(COUNTER,0)))=""}{QUIT}
            {windowsoff}{paneloff}{let COUNTER,COUNTER+1}{calc}
            {goto}STATE1_LETTER~/re{down 15}~{goto}LETTER~
            {goto}NOTE_1~{down 5}/re{down 20}~
            {IF @Isstring(@VLookup(SITE_LETTER,OUT_2T,6))=1}
              {goto}NOTE_1~/rv~{down 5}~{down 5}/rj{right 6}
              {down 5}~/c{down 5}~STATE1_LETTER~
            {if @Vlookup(SITE_LETTER,OUT_2T,7)>0}
              {goto}NOTE_2~/rv~{down 10}~{down 10}/rj{right 6}
              {down 5}~/c{down 5}~STATE2_LETTER~
            {IF @Vlookup(SITE_LETTER,OUT_2T,8)>0}
              {goto}NOTE_3~/rv~{down 15}~{down 15}/rj{right 6}
              {down 5}~/c{down 5}~STATE3_LETTER~
            {if @Isstring(STATE1_LETTER)=1#AND#@Isstring(STATE2_LETTER)=1
              #AND#@Isstring(STATE3_LETTER)=1}
              {goto}NOTE_4~/rv~{down 20}~{down 20}/rj{right 6}
              {down 5}~/c{down5}~STATE4_LETTER~
            {if INDICATE=0}{calc}{windowson}{panelon}
              {menubranch PRINT_MENU}
```

Figure 4-12. Data Extraction and Letter Assembly Portion of the RUN Subroutine.

statements, containing the database information that initiated the action letter, onto the bottom of the letter. String arithmetic was used to add the pieces of text together that comprise the statements.

String arithmetic in Lotus 1-2-3 is a means by which characters or words in different spreadsheet cells can be added together to create phrases or sentences. It is a powerful tool since text and numerical data can be combined into a single spreadsheet cell. The example in Figure 4-13 shows the phrase "The temperature is" in cell A1, the value 87 in cell A2, and the word "degrees." in cell A3. Cell A5 displays the phrase "The temperature is 87 degrees."; however, the contents of cell A6 as shown in cell A7 is a formula. The symbol "&" is used in string arithmetic to indicate addition of the text of one cell with the text of another cell. The @string function changes the value 87 into a string. The first line of the letter assembly section of the run subroutine, shown in Figure 4-12, determines if all of the generators in the extraction table have been sent letters. If unused data remains in the extraction table, then the second line of the letter assembly section increases the counter by one so that the next action letter can be assembled. The second line resets the counter to the row number corresponding to the first record listed in the extraction table.

The third and fourth lines of the letter assembly section, again shown in Figure 4-12, prepare the letter form for the assembly of the next action letter by erasing the statements that were assembled and appended to the previous letter. The fifth through eighth lines of this portion of the macro are IF statements used to determine the appropriate letter statements to include in the action letter being created. The

	A	B	C	D
1	The temperature is			
2	87			
3	degrees.			
4				
5	The temperature is 87 degrees.			
6	+A1&" "&@STRING(A2,0)&" "&A3			
7				

Figure 4-13. An Example of String Arithmetic.

last IF statement of the macro code in Figure 4-12 determines if the control passes to the menu that begins in the cell named PRINT_MENU. Once a printout of all the letters has been made, then the cell named INDICATE will have a nonzero value in it.

Figure 4-14 shows the second custom menu that contains the options VIEW LETTER, PRINT LETTER, NEXT LETTER, CONTINUOUS PRINT, AND QUIT. The first option allows the user to view the current letter, shown in Figure 4-15, before it is printed by using the cursor keys to move around the screen. Once the return key is pressed, the custom menu reappears. The second option in the custom menu is used to output a hardcopy of current letter. Once the letter has been printed out, the custom menu reappears. The third option has the macro branch to INCREMENT so that the next action letter is assembled. Once all of the selected sites have been used from the extraction table, the letter will show "NO INFO" responses at the appropriate locations. The fourth option continuously prints action letters for all of the generators found in the extraction table. The final option in the custom menu quits the RUN macro subroutine and returns the macro to the initial custom menu. Bold-faced characters in Figure 4-15 represent those portions of the letter which were constructed from the knowledge base using string arithmetic.

Hazardous Waste Workshop

After the completion of the action letter model, a workshop presentation was developed to demonstrate the applications of database management using Lotus 1-2-3 techniques. The workshop consisted of showing professionals how they could build, graph, and use macro programming on

PRINT_MENU	VIEW CURRENT LETTER	PRINT CURRENT LETTER	NEXT LETTER	CONTINUOUS PRINT	QUIT
	View the Current Letter	Print The Current Letter	Show Next Letter	Print All of the Letters	Stop Macro
	{goto}LETTER~	/pprLETTER~agq	{branch INCREMENT}	{let INDICATE,1}	Execution
	{?}	{menubranch PRINT_MENU}		{PRINT_ALL}	
	{menubranch PRINT_MENU}			{branch CONTINUOUS}	
				INDICATE	
Print_all	/pprLETTER~agq				0
	{recalc INDICATE}				
	{branch INCREMENT}				

Figure 4-14. The Second Custom Menu (Printing Portion of the Subroutine).

01/13/88

Department of Environmental Eng.
University of Florida
Black Hall
Gainesville, FL 32611

J Public Corp
4576 SW Frostproof Rd
Gainesville, FL 32601

Dear **Mr. Q. Public**:

Thank you for returning the hazardous waste inventory questionnaire. After compiling the data for all small quantity generators within our county, we are contacting the small quantity generators that are disposing of, or storing certain wastes in an undesirable manner.

Please contact our office within 30 days concerning the matters listed below.

1. Our records show that you have exceeded the monthly allowable limit of **2000** lb/month for **WASTE OILS AND GREASES** by generating **2156** lb/month.

2. You need to supply a detailed report on your disposal procedures for **WASTE OILS AND GREASES**.

3. You need to supply a detailed report on your storage procedures for **WASTE OILS AND GREASES**.

We will be contacting you in the near future concerning an inspection of your facilities.

Thank You.

Sincerely,

Mr. John Doe

Figure 4-15. Example of Assembled Action Letter.

a database in performing analysis. During the course of the workshop, participants worked on practice exercises at their own PC stations.

Attendance of the workshop was limited to 25 persons and consisted mainly of county and state environmental professionals. Many questioned how this model could be used in creating the courtesy letters which are sent out to selected hazardous waste generators before they are inspected. Others also expressed interest in the graphics capabilities of Lotus 1-2-3 to show selected attributes.

A packet, given to each attendee, contained a Lotus 1-2-3 tutorial, discussions and presentations of practice exercises, and two diskettes for their use during and after the workshop. A copy of this brochure is contained in Appendix C. The two diskettes that were used during the workshop can be obtained from the Department of Environmental Engineering. Some of the attending professionals also expressed an interest in acquiring the action letter model for possible use in their work.

CHAPTER 5
SUMMARY AND CONCLUSIONS

Using CAD Systems for Handling Hazardous Waste Information

Currently, there is a variety of CAD systems on the market. Most of them are developed for state-of-the-art architectural and mechanical drawing applications. Only a select few are capable of effectively manipulating and analyzing databases.

One major drawback in digitizing with CAD Systems is the time element involved in the learning and drawing process. It took nearly four weeks to learn the mechanics of the AutoCAD software and an additional five months to complete the digitization process. The map required extensive editing so data retrieval would be possible. This requirement meant that all lines had to intersect precisely, so that entities (e.g., polygons) could be correctly identified. It appears that even the GIS-related systems (e.g., pcARC/INFO) require a learning time-element which requires an extensive initial training period from a system expert and can dramatically decrease a project's cost-effectiveness (ESRI, 1987).

Initially, the intent of this project was to use AutoCAD as a geo-processing system which could acquire and analyze layered data and then present the results in additional layers. The system was found to be very useful in holding data in a layered format, but didn't allow the user easy access to relate the information between these layers. Extraction of data from individual layers was also quite limited.

AutoCAD still remains as an excellent tool to develop and plot drawings; however, it lacks the capacity to easily store and internally manipulate attributed information without the extensive knowledge of a computer programming language for mapping applications. Basically, AutoCAD serves as a tool to prepare visual, explanatory graphics that does not require extensive database information retrieval. The AutoCAD system requires the use of an AutoLISP expert to be of benefit. The South Florida Water Management District (SFWMD) is currently using AutoCAD for these types of analyses. They have spent the past several years developing maps and use their AutoLISP expertise to successfully manage their data within AutoCAD.

A copy of the completed AutoCAD drawing file, HAZARD.DWG, is available from the Department of Environmental Engineering. This map is ready for use, if needed, for data analysis requiring the AutoLISP language and comes with two template files for data extraction.

Hazardous Waste Database Management Within the Spreadsheet

The expert system hybrid model, described in Chapter 4, presents a stand-alone microcomputer-based expert system for evaluating information on small quantity generators of hazardous wastes, and then generating a draft of the response letter to them indicating what additional actions are required. This system can significantly reduce the total time required to perform the technical analysis and prepare the associated paperwork. The entire system was developed within a single software system, Lotus 1-2-3, thereby greatly simplifying the programming and interfacing complexity of the system. While the application of this system is to hazardous waste management, a similar procedure can be developed for the wide variety of engineering analysis and/or design activities where paperwork must be generated as an output from the technical analysis. This type of paperwork processing would greatly benefit those businesses which send courtesy letters, periodic notifications, and/or waste summary and trend reports.

Future Studies and Applications

The GIS Approach

Managing hazardous waste information through the use of GIS-related CAD systems is obviously another route. The costs involved with the purchasing of the software, training of the users, and digitization of data can be substantial; however, they can also be quite justifiable if future project needs using the same system are considered.

The geoprocessing microcomputer system, pcARC/INFO, appears to be the newest and most applicable database, CAD manager. Its growing influence during 1987 was substantial in Florida with at least four of the water management districts purchasing or desiring to purchase them. It may be worth the investment to use the ARC/INFO system in GIS-related work dealing with hazardous waste data management. Its ability to store, manage, and analyze segregated spatial information is immense, while its ability to produce grapically detailed results is even more spectacular. The starter kit currently costs about $5000 for the initial four modules; however, the entire nine module package runs about $11,000.

If the AutoCAD drawing file, HAZARD.DWG is needed for future development into a GIS, it can be translated to a pcARC/INFO drawing in a two step process. First, the original drawing which was digitized using the 2.18 version of AutoCAD, is converted to an updated (version 2.5 or higher) drawing. Then the updated version is translated into a pcARC/INFO drawing file by using the ERDAS Image Processing System as the interface. This interface is currently available for about $450.00 per AutoCAD station.

The Spreadsheet Approach

The Lotus spreadsheet provides an excellent environment for managing knowledge based models and is a considerably less expensive alternative. Smaller models can be fit entirely into one spreadsheet: however, it is limited. Therefore, Lotus users can handle this situation in either of two ways. First, it may be desirable to handle the knowledge base in a separate file from the rest of the model. Since the knowledge base size is almost always the limiting factor, add-in software, called @BASE, can be used as a tool to access data from one file to another. This "add-in" system allows the user to search for and extract only pertinent information from many data files. Individual files can be up to 32MB while each accessing data file actually uses only 8KB; a considerable reduction in memory usage. The newly marketed PC-version of the Oracle database-management system (DBMS) also looks quite promising. For this prototype, however, Lotus 1-2-3 still does quite well on its own, considering only about 10% of the RAM (640K) memory is taken up by the model itself.

Another approach, for the true expert system designer, would be to use the OPS-5 software. This package is much more powerful than Lotus and is also available for the PCs. It may be helpful to develop and refine a rule base first with the OPS-5 package and then try to translate these rules into the Lotus 1-2-3 language (Benson, 1987).

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APPENDIX A

HAZARDOUS WASTE DISCLOSURE FORM

(Alachua County Department of Environmental Services, 1987)

ALACHUA COUNTY
DEPARTMENT OF CODES ENFORCEMENT
COUNTY ADMINISTRATION BUILDING ANNEX
120 SOUTH MAIN STREET
GAINESVILLE, FLORIDA 32601

May 1, 1984

M E M O R A N D U M

TO: Businesses/Users and Handlers of Hazardous Wastes in Alachua County

FROM: Alachua County Department of Codes Enforcement

SUBJECT: Request for Disclosure Information about Your Hazardous Chemicals

In Florida, the water that we drink, cook with, wash in, and use in our businesses, comes from under the ground that we live and work on. Your health and the health of your family, friends, and employees depends on the water remaining pure and unpolluted by hazardous waste and chemicals. Once hazardous wastes enter the groundwater, it may not be possible to remove them, even with the latest water purification equipment.

According to Alachua County Ordinance 83-6, adopted by the Board of County Commissioners of Alachua County on December 6, 1983, any person who uses or handles a hazardous waste must annually submit a completed disclosure form to the Alachua County Department of Codes Enforcement, 120 South Main Street, Gainesville, Florida. It is the intent of the County Commission that the system of disclosure set forth in the ordinance shall provide information essential to public safety officers, including fire fighters, law enforcement, and emergency medical services providers; health officials; planners; elected officials; and residents, in meeting their responsibilities for the health and welfare of the County in such a way that trade secrets are not abridged.

ENCLOSED IS A HAZARDOUS WASTE DISCLOSURE FORM WHICH MUST BE COMPLETED AND RETURNED TO THE ALACHUA COUNTY DEPARTMENT OF CODES ENFORCEMENT OFFICE BY JUNE 1, 1984. THEREAFTER, THIS FORM MUST BE FILED ANNUALLY BY JANUARY 15 OF EACH YEAR.

Also note that a violation of the provisions of the ordinance shall be deemed a county ordinance violation punishable as provided by law.

If you have any questions with regard to completing the disclosure form or identifying hazardous wastes, please do not hesitate to call the Alachua County Department of Pollution Control, telephone number 373-8509, and ask for John Schert, Department Director, or Vince McLeod, Environmental Engineer.

Enclosures

ALACHUA COUNTY
HAZARDOUS WASTE DISCLOSURE FORM

Business Name: ________________ Telephone: ________ Business License No.(if any) ________

Address: ________________ Business License Renewal Date: ________ SIC No. ________

Facility Location: ________________________________

Person representing the business who would be available to assist emergency personnel during non-business hours:

Name: ________________; Title: ________; Telephone No. ________

PART I. Review the waste types below. For each type of waste generated at your facility, circle the appropriate waste code letter and fill in the estimated annual quantity generated. Indicate the appropriate units of measure for wastes generated by filling in pounds, tons, kilograms, cubic feet, 55-gallon drums, gallons, or specify other in the units column. (If you believe your firm does not generate any hazardous waste, check number 14 and complete the remainder of this form.)

Waste Types	Waste Code Letter	Maximum Monthly Quantity Handled	Average Annual Quantity Handled	Indicate Appropriate Units
1. **Pesticides—some examples are parathion, toxaphene, dieldrin, carbamates, and DDT**				
Waste pesticides..................................	A	________	________	________
Washing and rinsing solutions containing pesticides..	B	________	________	________
Empty pesticide containers.........................	C	________	________	________
Spent toxaphene solutions or sludges from dipping..	D	________	________	________
Spent pesticide solutions or sludges other than toxaphene from dipping............................	E	________	________	________
2. **Heavy metals—waste containing arsenic, barium cadmium, chromium, lead, mercury, selenium, or silver**				
Dust containing heavy metals.......................	F	________	________	________
Washing and rinsing solutions containing heavy metals..	G	________	________	________
Waste water treatment sludges containing heavy metals..	H	________	________	________

Waste Types	Waste Code Letter	Monthly Quantity Handled	Annual Quantity Handled	Indicate Appropriate Units
3. Waste ink containing flammable solvents and/or barium, cadmium, chromium, or lead	I	______	______	______
4. Waste paints				
Ignitable paint wastes containing flammable solvents (flash point less than 140°F)	J	______	______	______
Liquid paint wastes containing meavy metals (cadmium, chromium, mercury, or lead)	K	______	______	______
5. Solvents—some examples are benzene, chlorobenzenes, toluene, trichloroethylene, perchloroethylene, and methylene chloride, plus the still bottoms from the recovery of these solvents				
Spent solvents	L	______	______	______
Solvent still bottoms	M	______	______	______
Filtration residues from dry cleaning operations	N	______	______	______
6. Reactive wastes—some examples are cyanides (soluble cyanide salts), strong acids (hydrogen fluoride, sulfuric acid), or alkalies (sodium hydroxide), and spent plating wastes				
Cyanide wastes	O	______	______	______
Strongly acidic or alkaline wastes	P	______	______	______
Spent plating wastes	Q	______	______	______
Waste ammonia	R	______	______	______
Photographic wastes	S	______	______	______
7. Ignitable wastes (other than solvents and solvents still bottoms)—some examples are adhesives and epoxy resins (flash point less than 140°F)	T	______	______	______
8. Wood preservatives				
Waste water treatment sludges containing pentachlorophenol, creosote, or arsenic	U	______	______	______
9. Waste formaldehyde	V	______	______	______

Waste Types	Waste Code Letter	Monthly Quantity Handled	Annual Quantity Handled	Indicate Appropriate Units
10. **Lead-acid batteries**................................	W	____	____	____
11. **Waste explosives**..................................	X	____	____	____
12. **Waste oils, greases, or lubricants**..................	Y	____	____	____
13. **Other (specify on separate sheet, if necessary)**				
________________________________	Z	____	____	____
14. **No hazardous wastes generated (check if appropriate)**		____		

PART II. Storage Methods--For each waste type identified above, fill in the Waste Code Letter next to the types of storage used below. For example, if your firm has waste pesticides and stores them in 55-gallon drums, you would inse: the Waste Code Letter "A" in the space next to number 3 below for 55-gallon drums.

Storage Method	Waste Code Letter
1. Above ground tanks	____ ____ ____ ____ ____ ____ ____ ____
2. Below ground tanks	____ ____ ____ ____ ____ ____ ____ ____
3. 55-gallon drums	____ ____ ____ ____ ____ ____ ____ ____
4. Various-size cans	____ ____ ____ ____ ____ ____ ____ ____
5. Open pits, ponds, lagoons	____ ____ ____ ____ ____ ____ ____ ____
6. Piled on ground or floor	____ ____ ____ ____ ____ ____ ____ ____
7. Dumpster or bulk waste container	____ ____ ____ ____ ____ ____ ____ ____
8. Lab packs	____ ____ ____ ____ ____ ____ ____ ____
9. **Other (specify)** ____________	____ ____ ____ ____ ____ ____ ____ ____

PART III. Waste Management/Disposal Practices. For each waste type identified in Part II, fill in the Waste Code Letter next to the corresponding waste management/disposal practices listed below. Check the appropriate site where your wastes are disposed (on-site; off-site). For example, if your firm neutralizes waste acids at your facility, you would check "on-site" and fill in the Waste Code Letter "P" next to number 13 below, "neutralization treatment".

	On-Site	Off-Site	Waste Code Letter
1. City, county, or private hauler picks up waste and disposes in landfill		____	____ ____ ____ ____ ____ ____
2. Generator takes waste to landfill		____	____ ____ ____ ____ ____ ____

	On-Site	Off-Site	Waste Code Letter
3. Generator buries wastes on his property	____		____ ____ ____ ____ ____ ____
4. Disposed of in open pit, pond, or lagoon	____	____	____ ____ ____ ____ ____ ____
5. Sent to permitted hazardous waste facility		____	____ ____ ____ ____ ____ ____
6. Disposed of in public sewer		____	____ ____ ____ ____ ____ ____
7. Disposed of in septic tank	____	____	____ ____ ____ ____ ____ ____
8. Recycled	____	____	____ ____ ____ ____ ____ ____
9. Burned for fuel value or blended to produce fuel	____	____	____ ____ ____ ____ ____ ____
10. Destroyed by incinerator	____	____	____ ____ ____ ____ ____ ____
11. Injected into well	____	____	____ ____ ____ ____ ____ ____
12. Treated by filtering	____	____	____ ____ ____ ____ ____ ____
13. Treated by neutralization	____	____	____ ____ ____ ____ ____ ____
14. Other (specify)	____	____	____ ____ ____ ____ ____ ____

PART IV. Does your business or agency dispose of any waste products on-site other than the hazardous waste types identified in Part II? Yes ____ No ____

PART V. What was the largest number of full-time employees or equivalent part-time replacements employed at any on time during the past year. ____________

PART VI. Attach copies of all permits issued to your business by the Florida Department of Environmental Regulatio

PART VII. Thank you for completing the Alachua County Hazardous Waste Disclosure Form. If you would like to comme this form or on any waste storage, treatment, or disposal concerns, or future needs you may have, please use the sp below.

APPENDIX B
CODE INDEX/CONVERSION TABLES
(Alachua County Department of Environmental Services, 1987)

Taken From FDER

Hazardous Waste Work Session

May 31, 1984 Meeting Notes

Conversion Table

Short Tons x 2000 = Pounds
Kilograms x 2.2 = Pounds
Metric Tons x 2205 = Pounds
Gallons x 8.34 = Pounds
55-Gallon Drums x 458.8 = Pounds
Cubic Yards x 1685.6 = Pounds
Cubic Feet x 62.36 = Pounds

Code	Waste Type	Density (lb/gal)
A	Waste Pesticides	7.1
B	Pesticide Rinses	8.34
C	Empty Pesticide Containers	1.0 (lb/gal capacity
D	Toxaphene Animal Dip	8.34
E	Other Dip Solutions	8.34
F	Heavy Metal Scrap	21.0
G	Electroplating Rinse	8.34
H	Electroplating Sludges	20.0
I	Waste Ink	8.75
J	Ignitable Paint Waste	7.86
K	Other Paint Waste	8.2
L	Spend Solvent	11.2
M	Distillation Bottoms	11.2
N	Dry Cleaning Filters	13.6 (lb/unit)
O	Cyanide Waste	8.34
P	Acids or Caustic	10.6
Q	Corrosive Plating Waste	8.8
R	Waste Ammonia	8.25
S	Photographic Waste	8.7
T	Other Ignitable Waste	6.8
U	Wood Preserving Waste	8.8
V	Waste Formaldehyde	6.8
W	Lead-Acid Batteries	38.0 (lb/unit)
X	Waste Explosives	6.0
Y	Waste Oils and Greases	7.62

APPENDIX C
HAZARDOUS WASTE WORKSHOP BROCHURE

January 7, 1988

University of Florida
Florida Water Resources Research Center
Workshop for the Development and Usage of a Hazardous
Waste Microcomputer Inventory Database

I. INTRODUCTION

Hazardous waste management professionals are faced with the problem of how to easily and inexpensively create, access, and analyze database information associated with the small quantity generators. Computer systems, especially the mainframes, are still being used to store vast amounts of data. Retrieval of this data is not too difficult; however, analyzing this data with the mainframes may be quite arduous.

For example, a professional may need to find a weighted center for a specific waste type, select all sites generating a specific type, or list all generators within a certain area based on addresses. A database created with the microcomputer software, Lotus 1-2-3, can easily be developed to handle these examples and many more. It is also easy to change and update existing data as needed.

The development of microcomputers has resulted in the availability of easy to use software such as spreadsheets, graphics, database management, and wordprocessing packages. These packages yield a powerful, user-friendly way of rapidly performing analysis and design with little programming effort. The development of computer-aided design (CAD) programs has revolutionized the industry from an engineering standpoint.

The impact has been to provide graphical and pictorial displays which substantially improve communication of spatial information and user-computer interaction.

The most popular PC sreadsheet is Lotus 1-2-3. The spreadsheet eliminates the need for pencil, paper, calculator, graph paper, and mainframe hardware. Besides being easy to learn and use, Lotus can hold data equivalent to 12000 sheets of conventional paper, which is more than adequate for most problems. Figure C-1 shows an example of how a database model can be laid out using the spreadsheet environment. The ease in programming is greatly enhanced by partitioning the model into sections. Here, the model partitions contain user information text, database knowledge of text and numerical data, an analytical section which uses cell formulas in calculations, and a macro section which "runs" the model. Models, once successfully tested, can be used by executing the macro section which can access and implement any or all of the other partitions during its activation process. This programming language greatly expedites the routine functional process.

Objective

The purpose of this workshop is to teach and demonstrate how the microcomputer system, Lotus 1-2-3, can be used to analyze problems associated with hazardous waste management inventories. Users will be shown how they can use existing data to build, graph, and macro this database for analysis. During the course of the workshop, users will do practice exercises. The objective is to show that handling information in this manner will greatly improve efficiency.

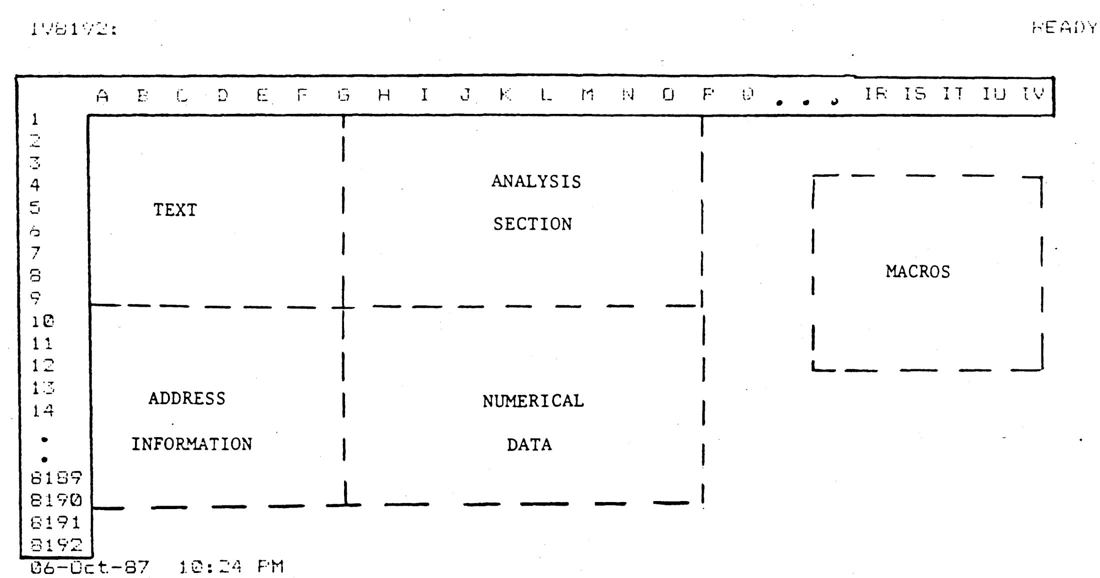


Figure C-1. The Lotus 1-2-3 Spreadsheet.

Problem Statement

The problem to be examined in this workshop is to sort, search, extract, and analyze hazardous waste generator inventory data from a created database based on existing file information. Data search and extraction will be based on the criteria of waste type, waste amount, site location, and business type.

Extracted information can then be listed into a table for any further information processing. For this workshop, we will use the information from this extraction table to quickly and easily create the paperwork (letters) for hazardous waste site notification and regulatory purposes.

II. REVIEWING LOTUS 1-2-3

To begin the workshop, the Lotus 1-2-3 software will be briefly reviewed. The following section should be used as a reference for 1-2-3 operational procedures. This section is not intended to be a substitute for the Lotus 1-2-3 Reference Manual which should also be used for more detailed explanations.

A. Applications

1. Simple mathematical calculations and creation of two dimensional graphics.

2. Financial and data management systems.

3. Database manager for Geographic Information Systems, e.g., hazardous waste assessment model as a decision-making tool.

B. Hardware/Software Needs

1. Lotus runs on most XT or AT PC Systems.

    a. AT microprocessor with a hard disk capacity >= 20MB,

    b. 1.2MB floppy disk drive,

    c. 640K RAM,

    d. EGA Board for higher resolution and multicolored graphics,

    e. a math coprocessor to expedite runtime, and

    f. an expansion memory board if files exceed 640K.

2. A color, high resolution (800x560 pixel) monitor.

3. A dot matrix printer and a keyboard.

4. DOS (version 2 or higher) and the Lotus 1-2-3 software package (also version 2) for about $400. Version 3 of Lotus is due out in the spring of 1988.

C. References

1. Lotus 1-2-3 Reference Manual which comes with the software package. A tutorial disk and manual is also included.

2. Le Blond, G. T. and D. F. Cobb. 1983. Using 1-2-3. Que Corporation, Indianapolis, Indiana.

3. Anderson, D. and D. F. Ford. 1984. 1-2-3: Tricks, Tips, and Traps. Que Corporation, Indianapolis, Indiana.

4. Trost, S. R. 1984. Advanced Business Models with 1-2-3. Sybex, Inc. Berkeley, California.

5. Lotus magazine published monthly by Lotus Development Corporation.

D. Getting Started with the PC

1. Loading Lotus 1-2-3 on an XT:

   a. Machine is off:

      COLD BOOT--Turn on machine with DOS or Lotus system disk (with DOS commands) in drive A.

   b. Machine is on:

      WARM BOOT--[CTRL] [ALT] [DEL] simultaneously and DOS or Lotus system disk in drive A.

   c. Insert file storage disk in drive B.

   d. Replace DOS with Lotus and type "123" or "Lotus" to activate the software. If using the Lotus system disk, type "1" or hit the "Return" key.

2. Loading up Lotus 1-2-3 on an AT:

   a. Perform a cold or warm boot using the hard disk (drive C).

   b. Type "123" or "Lotus" to activate program.

   c. Various ways to format usage set-up; however, using hard disk instead of floppies is common.

3. Useful DOS commands

   a. A new file storage disk must first be formatted using the DOS command, FORMAT <drivespec:>.

   b. DIR -- lists current drive disk files.

   c. DEL <filespec> -- removes current drive disk files.

   d. RENAME <oldfile newfile> -- changes current drive disk filename.

   e. COPY <filespec drivespec:> -- copies files from current drive to another.

E. Exploring the Spreadsheet

1. Introduction

   a. Worksheet is a rectangular grid of 254 columns and 8192 rows.

   b. Window -- screen view of worksheet portion.

   c. Cell -- basic unit of the worksheet at the intersection of a column and a row. See Figure D-2. Maximum of 240 characters/cell.

   d. Cell pointer -- highlights and identifies current usable cell.

   e. Entries as labels or values:

      Labels -- all directly inputted text and numbers.

      Values -- numbers or results of a calculation.

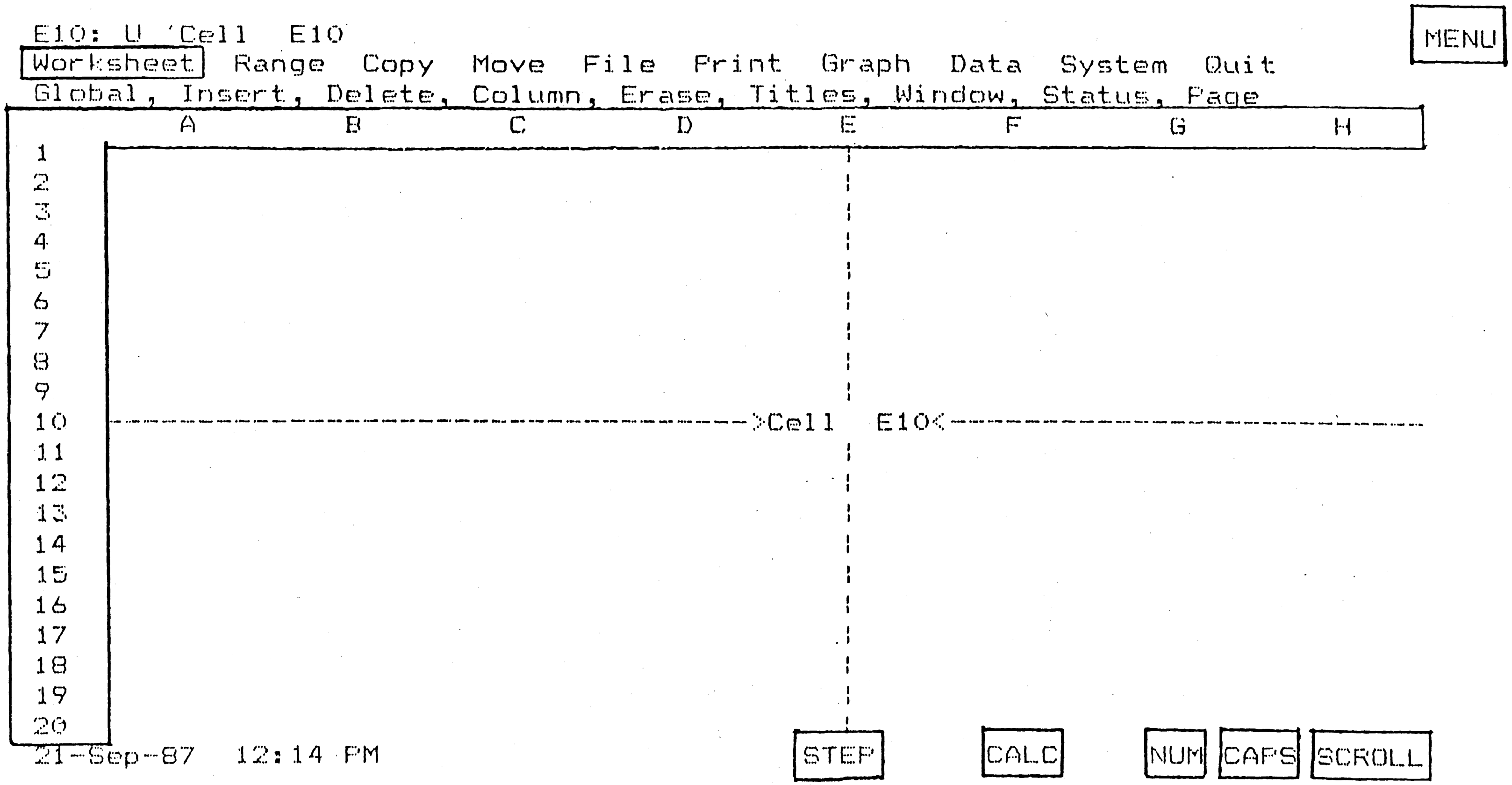


Figure C-2. Lotus 1-2-3 Worksheet Window.

f. Control Panel -- three lines displaying information above the column border:

i. Line 1 -- displays cell ID and contents,

ii. Line 2 -- displays command choices of the menu, and

iii. Line 3 -- displays prompts and command descriptions.

g. Mode Indicator -- highlighted top right box gives current operation mode.

h. Status Indicator -- bottom row displays key status and worksheet conditions.

2. Built-in Data Functions (@Functions)

a. For a complete listing, see Lotus 1-2-3 Reference Manual, e.g., Quick Reference.

b. Used for aid in data analysis.

c. Commonly Used

Commonly Used @Functions	Used For
@SQRT	Square root calculation
@IF(cond,x,y)	Returning x if cond is TRUE Returning y if cond is FALSE
@@(cell address)	Referencing cell contents
@CELLPOINTER(attribute)	Highlighting cell attribute information
@HLOOKUP(x,range,row #)	Returning table lookup with index row
@VLOOKUP(x,range,column #)	Returning table lookup with index column
@CODE(string)	Returning the ASCII/LICS code number
@NOW	Current date and time listing
@SUM(list)	Summing values in list
@MAX(list)	Listing the maximum value

c. Commonly Used @Functions	Used For
@MIN(list)	Listing the minimum value
@AVG(list)	Listing the average value
@STRING(x,n)	Converting value x to string with n decimal places
@VALUE(string)	Making a string appear as a value
@DBASE FUNCTIONS(input,offset, criterion)	Performing statistical analyses on databases by the identified offset column of the input range meeting the criterion in the specified criteria range
@DAVG	Mean of extracted data
@DCOUNT	Number of used cells
@DMAX	Maximum of extracted data
@DMIN	Minimum of extracted data
@DSTD	Population standard deviation
@DSUM	Sum of values
@DVAR	Population variance

3. Menu Function Commands

   a. Activated by typing "/" key and appear in Control Panel.

   b. Command Trees -- branched system of commands to aid in data handling, (Figures C-3, C-4, & C5).

   c. Commonly Used

Commands	Used For
/Worksheet	
Insert	Create rows/columns
Delete	Remove rows/columns
Titles	Fixes columns &/or rows
Window	Splits screen
Status	Displays current file information
/Range	
Format	Specifies cell(s) arrangement/style
Erase	Removes cell(s) content(s)
Name	Create/delete named cells
/Copy	Duplicates a cell(s)
/Move	Transfer a cell(s)
/File	
Retrieve	Revive an existing file
Save	Store current file
Combine	Merge an entire or named-range of an existing file into current spreadsheet
Erase	Eliminate disk files.

c. Commonly Used Commands	Used For
/File. . .Continued	
List	Index disk files
Import	Merge print files into current spreadsheet
/Data	
Fill	Enters a range of sequenced numbers
Sort	Data ranking
Parse	Sectioning cell information into other cells
Query	Extracts and lists database into a table (also F7 key)
/Graph	Creates/eliminates 2-D graphs using existing data
/Print	Printing to a printer or ASCII file
/System	Exits spreadsheet file for usage of DOS commands (file still stored in RAM)

4. Lotus 1-2-3 Function Keys (Lunsford, 1987)

   a. Access the command menu with one keystroke.

   b. A template with key names comes with the Lotus package.

   c. Function key names:

      i. F1-THE HELP KEY

         Accesses the HELP file which gives detailed information about Lotus. If you are using a hard disk system, just press the F1 key; however, if you are accessing the file from a floppy, you must replace the Lotus System disk with a floppy containing the Lotus 123.HLP file.

      ii. F2-THE EDIT KEY

         Allows cell information correcting and changing.

      iii. F3-THE NAME KEY

         Gives the user a list of the created range names and must be used in conjunction with the F5 key. By striking the F5 key and the F3 key once, the control panel will display a portion of the range name list. If the F3 key is struck twice after the F5 key, the screen will display the complete range name list.

      iv. F4-THE ABSOLUTE KEY

         Tags a cell address with the symbol $, which indicates that the row or column identifier is to remain constant. For example, C45 within a cell function, will continue to access the cell C45, even when the function is copied or moved.

      v. F5-THE GOTO KEY

         Allows the user to have access to any cell or range-named cell in the spreadsheet. Used alone, the user can type in the cell address or range name. Used in conjunction with the F3 key, the user can select a range name from a list.

vi. F6-THE WINDOW (-JUMP) KEY

It allows the user to jump across a window divide on the screen display to the cell where it was last placed in the window.

vii. F7-THE QUERY KEY

Repeats the last /Data Query command which searches, examines, and selects specified data.

viii. F8-THE TABLE KEY

Repeats the last /Data Table command which allow trials of different values in formulas in a tabled format.

ix. F9-THE CALC KEY

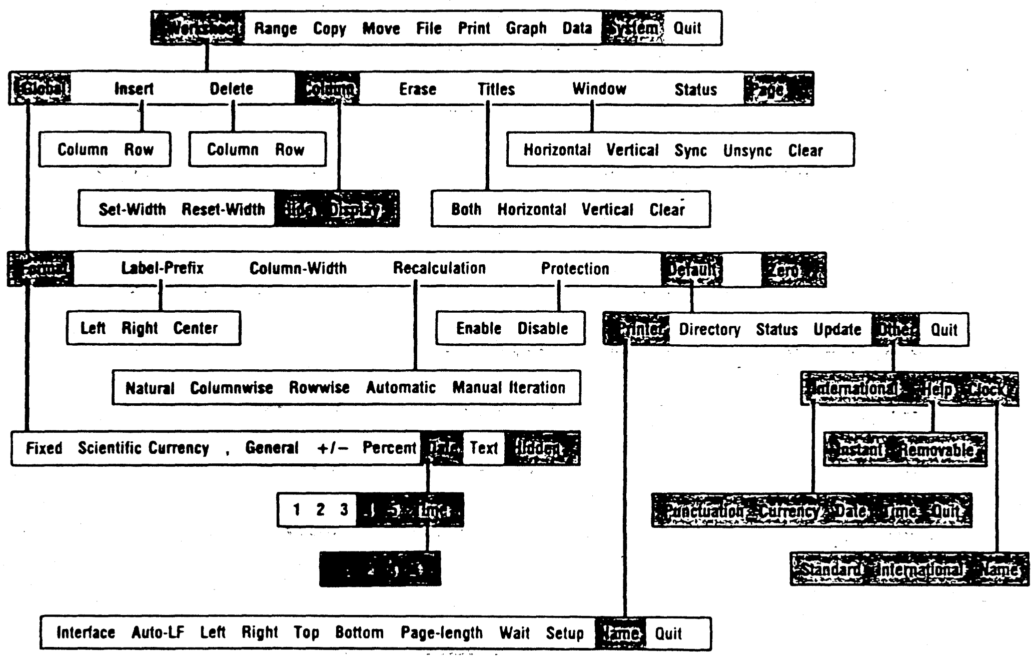
Induces recalculation or redrawing of the spreadsheet.

x. F10-THE GRAPH KEY

Allows the visual display of the current named graph.

Command Trees

Worksheet Commands



Range Commands

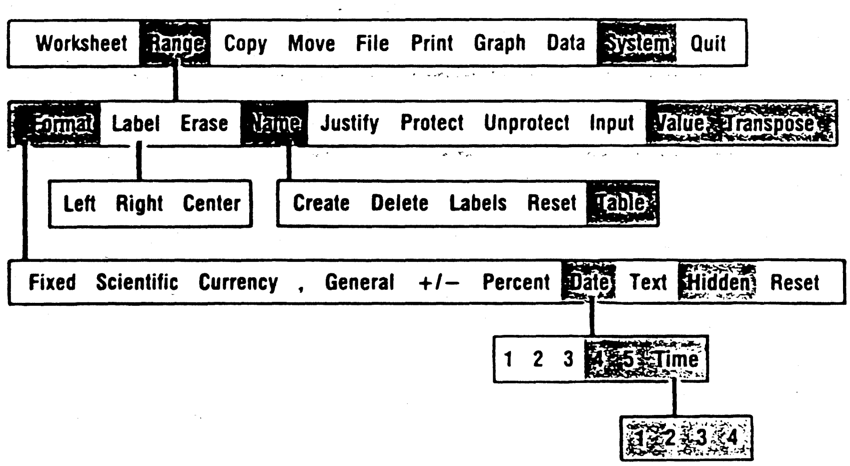
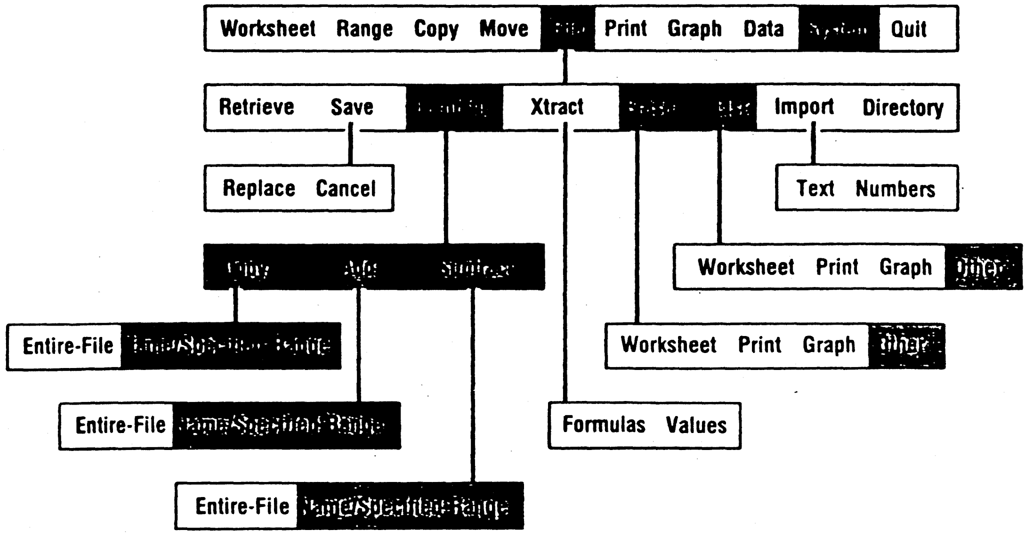


Figure C-3. Lotus 1-2-3 Menu Branches.

(Lotus Development Corp., 1986)

File Commands



Print Commands

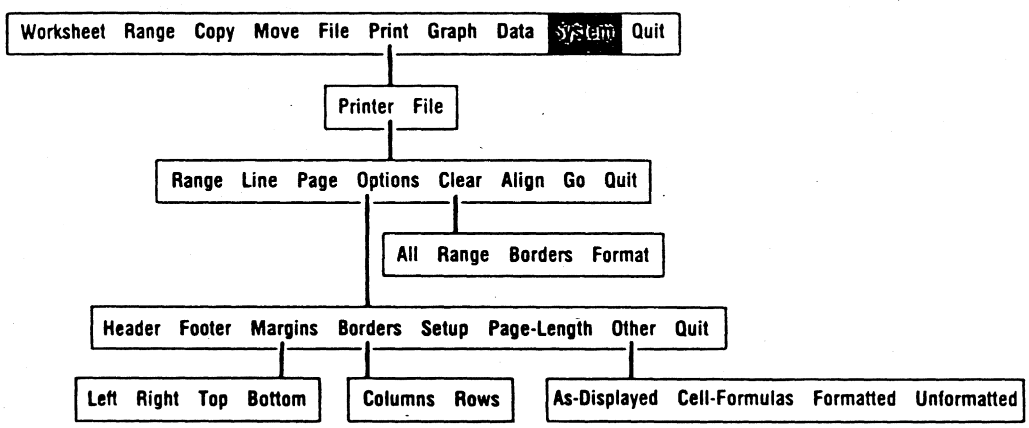
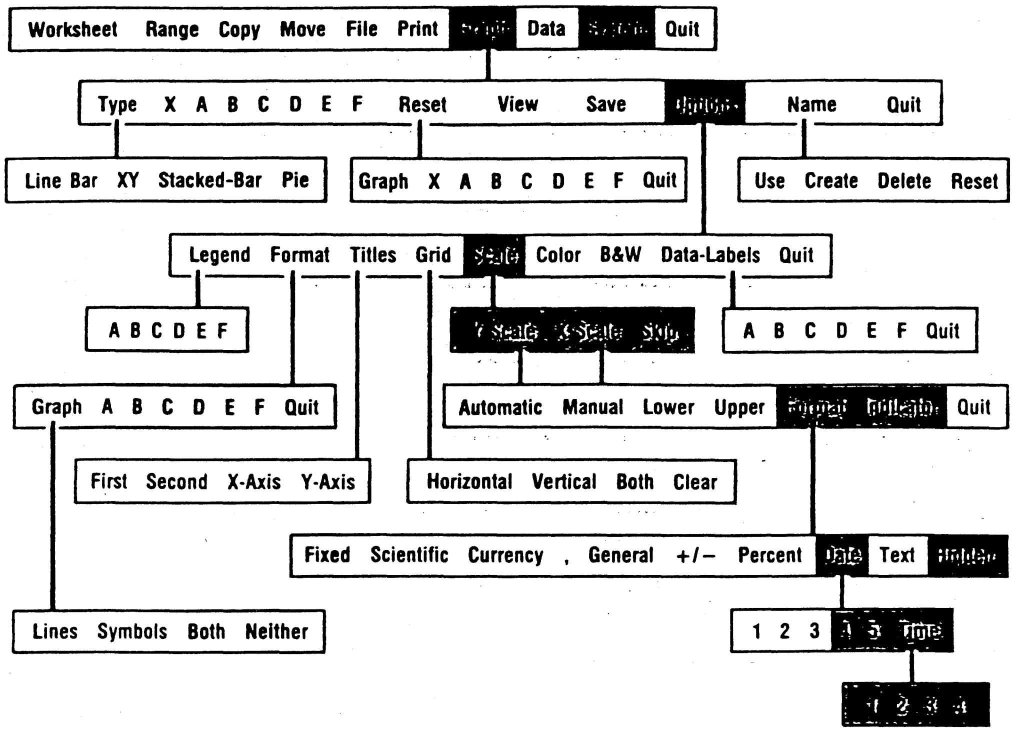


Figure C-4. Lotus 1-2-3 Menu Branches.

(Lotus Development Corp., 1986)

Graph Commands



Data Commands

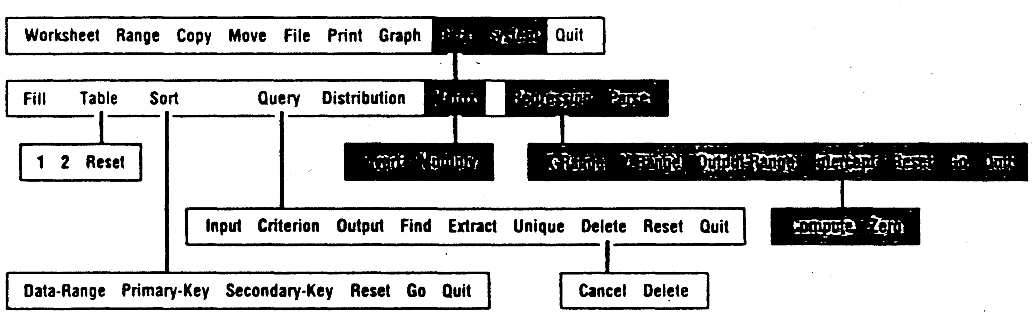


Figure C-5. Lotus 1-2-3 Menu Branches.

(Lotus Development Corp., 1986)

III. IMPORTING, PARSING, AND EDITING EXISTING WASTE INVENTORY FILE DATA INTO LOTUS SPREADSHEETS TO CREATE AN INVENTORY DATABASE

The following section involves the organization of transferred data within the spreadsheet. This organization involves the usage of the Object-Attribute-Value (OAV) representation. A knowledge base formatted with this setup can quickly and easily be scanned through by using specified searching criteria. The tables below show a simple example.

Table C-1. Example of an OAV Format.

	ATTRIBUTE1	ATTRIBUTE2
Object1	Value11	Value21
Object2	Value12	Value22
Object3	Value13	Value23
Object4	Value14	Value24

Table C-2. Actual Database OAV Representation.

SITE_NAME	W_TYPE	W_AMT
Canine Care Corp	A	140
Canine Care Corp	B	7671
Crow Corp	Y	12009
Sunrise Painters	L	15240

A. Getting Started

1. New spreadsheet each initial log-on, or

2. /Worksheet Erase command cleans off screen. Save first!

3. /File Retrieve command (.WK1 files)

4. /File Combine command (.WK1 files)

5. /File Import Text command (.PRN files)

   a. Can only be used on ASCII-formatted files.

   b. Rename file with extension .PRN.

   c. Place cell pointer to uppermost desired cell.

   d. All imported data will be contained within one column.

   e. Usually must then "Parse" data.

B. Parsing Imported Data

1. Create a "Format-Line" above data.

2. Edit Format-Line to the majority of the data.

   a. L = first of a label block

   b. V = first character of a value block

   c. D = first character of a date block

   d. T = first character of a time block

   e. S = skip the character below when parsing

   f. > = continuation of the block

   g. * = blank space immediately below, currently undefined, but can become part of a block of data in following cells.

3. Place a letter, L or V for example, to form a new block (column) and use as >'s or *'s as needed for additional characters or spaces within a block.

4. Specify the column range to parse from.

characters or spaces within a block.

4. Specify the column range to parse from.

5. Specify the output-range to parse to.

6. Select "Go" to parse the data.

7. Edit the parsed data as needed. Usually, some rows will have been parsed incorrectly.

C. Practice:

1. Place cursor onto cell D1. Create a new spreadsheet by calling up the address information from the "DATAFILE.PRN" file onto a clean screen (/File Import).

2. Place the cursor onto cell A5. Insert existing parsed data from the "WASTINFO.WKE" file into the first three columns.

3. Using Figures C-6 and C-7 as a guideline, parse the single column of data into multiple columns using the procedures outlined above. The output range begins with cell AA6.

4. Copy over the first three columns to X6.

5. Copy parsed rows into underlying blank rows.

6. Verify SITE IDs and delete one of the columns.

7. Title the column headings: WASTE_TYP, WASTE_AMT, SITE_ID, EPA#, SITE_NAME, ST_#, SEC, STREET, S_TYPE, SUPERVISOR, SUPER_POS, and PHONE#. Labels can be centered by using the "^" prefix.

8. Range-name the entire database, "D_BASE".

9. /File Save the worksheet as "FILE1.

```
     A         B         C         D                             E                       F      G            H
*V>*L>>>>*L>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>*L*L>>*L>>>*******V>*L>>******L>>***V>*L>>>*L>>>*L>>>>*********************
V>>>SV>>>>SL>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>SV>>>>SL>SV>>>>>>>>>>SL>>>>>>SLSV>>>>>SL>>>>>>>>>>>>>>>>>>>>>>SL>>>>>>>>>>
 19 . 751 .Harry's Grooming & Pet Supply . 506 .NW.         75 .St      .E.   24 .Mr. John Black           .
 20 . 751 .Canine Care Corp              .1107 .N .Main         .St      .B.12009 .Mr. Greg Walters         .OWNER
 52 .1620 .Crow Corp                     .6801 .SW.Archer       .Rd      .Y. 2688 .Mr. Clay Blinkins        .SHOP SUPT
 93 .1721 .Sunrise Painters              .1219 .NW.         43 .Av      .L.  943 .Mr. Tom Carter           .OWNER
200 .2711 .Gainesville Prints            .2700 .SW.         13 .St      .S. 1232 .Mr. Bob Bloom            .PROD DIR
216 .2752 .Starter Printing Co           .1540 .NE.Waldo        .Rd      .S. 2288 .Mr. Jake Fields          .PRESIDENT
219 .2752 .Beechnut's Printing           .2161 .NE.          1 .Blvd    .L.  112 .Mr. Fred Beechnut        .PRESIDENT
227 .2791 .Graphic Press Ons             . 834 .E .University .Av      .S. 1357 .Ms. Melinda West         .PRESIDENT
234 .2851 .Suntan Paint Inc              . 111 .SE.         22 .Av      .L. 1120 .Mr. Paul H. Sanderson   .PRESIDENT
235 .2869 .Hyde Laboratories Inc         . 603 .NW.         74 .Pl      .L.  440 .Mr. Lee Smith            .PRESIDENT
241 .3079 .Bullseye Archery              .4600 .SW.         41 .Blvd    .P. 4081 .Mr. William Hall         .DIR OF MFG
247 .3448 .Port-A-Let                    .1506 .NW.         55 .Pl      .P.  984 .Mr. Bill Spike           .VP MFG
250 .3449 .Hot-Air Inc                   .3716 .NE.         49 .Rd      .Y. 4191 .Mr. Winfred R. Stockton .SHOP MGR
262 .3613 .Interchange Video Systems     .2040 .NW.         67 .Pl      .L. 1232 .Mr. Lee Lewis            .MFG MGR
264 .3662 .Volatile Industries Inc       .3700 .NE.         53 .Av      .L. 1060 .Mr. Jack M. Newell, Jr. .MANAGER
268 .3732 .Little Lake Marine Co         . 250 .SE.         10 .Av      .M. 1848 .Mr. Walter Carson        .PRESIDENT
269 .3732 .Refinish Manufacturing Co     .3001 .NE.         20 .Wy      .Z.  100 .Mr. Jon Tuckett          .OWNER
271 .3732 .Fast Craft                    .3530 .SE.Hawthorne .Rd      .L. 1232 .Mr. Bill Reiner          .OWNER
```

Figure C-6. Format-Line Development.

N	O	P	Q	R	S	T	U	V	W	X
19	751	Harry's Grooming & Pet Supply	506	NW	75	St	E	24	Mr. John Black	
20	751	Canine Care Corp	1107	N	Main	St	B	12009	Mr. Greg Walters	OWNER
52	1620	Crow Corp	6801	SW	Archer	Rd	Y	2688	Mr. Clay Blinkins	SHOP SUPT
93	1721	Sunrise Painters	1219	NW	43	Av	L	943	Mr. Tom Carter	OWNER
200	2711	Gainesville Prints	2700	SW	13	St	S	1232	Mr. Bob Bloom	PROD DIR
216	2752	Starter Printing Co	1540	NE	Waldo	Rd	S	2288	Mr. Jake Fields	PRESIDENT
219	2752	Beechnut's Printing	2161	NE	1	Blvd	L	112	Mr. Fred Beechnut	PRESIDENT
227	2791	Graphic Press Ons	834	E	University	Av	S	1357	Ms. Melinda West	PRESIDENT
234	2851	Suntan Paint Inc	111	SE	22	Av	L	1120	Mr. Paul H. Sanderson	PRESIDENT
235	2869	Hyde Laboratories Inc	603	NW	74	Pl	L	440	Mr. Lee Smith	PRESIDENT
241	3079	Bullseye Archery	4600	SW	41	Blvd	P	4081	Mr. William Hall	DIR OF MFG
247	3448	Port-A-Let	1506	NW	55	Pl	P	984	Mr. Bill Spike	VP MFG
250	3449	Hot-Air Inc	3716	NE	49	Rd	Y	4191	Mr. Winfred R. Stockton	SHOP MGR
262	3613	Interchange Video Systems	2040	NW	67	Pl	L	1232	Mr. Lee Lewis	MFG MGR
264	3662	Volatile Industries Inc	3700	NE	53	Av	L	1060	Mr. Jack M. Newell, Jr.	MANAGER
268	3732	Little Lake Marine Co	250	SE	10	Av	M	1848	Mr. Walter Carson	PRESIDENT
269	3732	Refinish Manufacturing Co	3001	NE	20	Wy	Z	100	Mr. Jon Tuckett	OWNER
271	3732	Fast Craft	3530	SE	Hawthorne	Rd	L	1232	Mr. Bill Reiner	OWNER

Figure C-7. Parsed Data Into Individual Columns.

IV. LEVEL I STATISTICAL ANALYSIS ON A HAZARDOUS WASTE INVENTORY DATABASE. USE OF @FUNCTIONS AND MANUAL DATA SORTING TECHNIQUES TO EXTRACT ATTRIBUTED DATABASE INFORMATION.

In this exercise, it will be shown how information can be sorted, selected, extracted, and analyzed from the previously created database. Techniques will emphasize the use of menu operational commands for data manipulation and the database functions for statistical analysis.

A. Use the /Data Sort command to sort the database by:

1. SEC (location)
2. EPA#
3. Waste Type
4. Waste type (primary) and amount (secondary).

B. Use the @Functions on the WASTE_AMT column to determine the waste maximum, minimum, mean, and sum.

C. Save the worksheet.

V. CREATING A STUDY AREA MAP OF THE HAZARDOUS WASTE INVENTORY DATABASE FOR THE LOCATING AND SITE SELECTION OF GENERATORS WITH A COMMON WASTE TYPE.

This exercise will demonstrate how the Lotus graphics menu can be used to create a study area map. During this session, a pre-constructed spreadsheet will be examined and formatted step-by-step.

A. Reviewing the Lotus Graphics Menu

1. Plot 2-D graphs from data ranges using /Graph command.
2. Types:
    a. Bar
    b. XY
    c. Pie
3. Six abscissa types (colors) available.
4. Options for adjustment:
    a. Legend -- creates a graph legend to identify abscissa types,
    b. Format -- controls data plotting techniques,
    c. Titles -- creates axes and graph inscriptions,
    d. Grid -- creates a network of locating lines,
    e. Scale -- adjusts axes display, and
    f. Data Labels -- identifies data points.
5. View -- gives image of current graph (also F10 key).

6. Save -- creates a <filesspec>.PIC file for hardcopy plots, but cannot be edited.

7. Name -- saves a named graph in the worksheet file and can be edited, but not printed.

B. The Graphing Exercise

1. Call up the file "MAP_SITE.WK1".

2. Use the F10 key to view the completely formatted map.

3. Review the database set-up and the mapping database.

4. Erase the formatting graphing options by using the following command: /Graph Reset Graph.

5. Reformat the database to create a study map. This will allow the participant to become well acquainted with the graphic menu while also learning a few "tricks". Note: "Center" all of the data-labels.

   a. Specify the "X axis range" for all attributes. (AU12..AU200)

   b. Specify the "A axis range" for all of the generators. (AV12..AV29)

      i. Specify the corresponding data-label range for A.

      ii. Format the line-type to "symbols" only. (/Graph Options Format A Symbols)

   c. Specify the "B axis range" for the town boundary limits. (AX12..AX66)

      i. Specify the corresponding data-label range for B.

      ii. Format the line-type to "lines" only. (/Graph Options Format B Lines)

   d. Specify the "C axis range" for the major roads. (AZ12..AZ105)

      i. Specify the corresponding data-label range for C.

      ii. Format the line-type to "lines" only. (/Graph Options Format C Lines)

e. Specify the "D axis range" for the "HOT SPOTS". (BB12..BB200)

   i. Specify the corresponding data-label range for D.

   ii. Format the line-type to "symbols" only. (/Graph Options Format D Symbols)

f. Specify the "F axis range" for the statistics legend. (BD12..BD85)

   i. Specify the corresponding data-label range for F.

   ii. Format the line-type to be invisible. (/Graph Options Format F Neither)

6. Run the mapping sequence by choosing a waste code and/or the town section. Press the F7, F9, and F10 keys, respectively, to see the results. Refer to the "Code Index" in Figure C-8 on the following page for a reference to the waste types.

```
|**************************************************|
|              A    WASTE PESTICIDES               |
|              B    PESTICIDE RINSES               |
|              C    EMPTY PESTICIDE CONTAINERS     |
|              D    TOXAPHENE ANIMAL DIP           |
|              E    OTHER DIP SOLUTIONS            |
|              F    HEAVY METAL SCRAP              |
|              G    ELECTROPLATING RINSES          |
|              H    ELECTROPLATING SLUDGES         |
|              I    WASTE INKS                     |
|              J    IGNITABLE PAINT WASTES         |
|              K    OTHER PAINT WASTES             |
|              L    SPENT SOLVENTS                 |
|              M    DISTILLATION BOTTOMS           |
|              N    DRY CLEANING FILTERS           |
|              O    CYANIDE WASTES                 |
|              P    ACIDIC OR ALKALINE WASTES      |
|              Q    CORROSIVE PLATING WASTES       |
|              R    WASTE AMMONIA                  |
|              S    PHOTOGRAPHIC WASTES            |
|              T    OTHER IGNITABLE WASTES         |
|              U    WOOD PRESERVING WASTES         |
|              V    WASTE FORMALDEHYDE             |
|              W    LEAD_ACID BATTERIES            |
|              X    WASTE EXPLOSIVES               |
|              Y    WASTE OILS AND GREASES         |
|              Z    AN UNSPECIFIED WASTE TYPE      |
|**************************************************|
```

Figure C-8. The Waste Code Index.

VI. Level II Statistical Analysis on a Hazardous Waste Inventory Database. Use of Lotus Database Functions to Extract and Analyze Selected Hazardous Waste Generator Information.

Lotus has built-in database @Functions which perform statistical analyses on database information. The list is in Section II E 2 c. These functions provide a quick look at selected attributes. This exercise will allow the user to build a table, select, and observe the statistical results.

A. Call up the worksheet file saved in IV. Level I. We will apply database @Functions to this worksheet.

B. The database statistical functions have the form: @Dtype(input,offset,criterion), where the

   Dtype = the functional form

   input = the entire database, including column headings

   offset = the column number of searching column
   BEWARE The first column has the number, 0.

   criterion = range which contains the column heading with the underlying attribute identifier.

C. Create a database statistical function table as shown in Table C-3. Hint: Copy column heads to the table.

D. Insert the dbase formulas into the appropriate cells of the table. Use the F9 key to recalculate.

E. Save the worksheet.

	SEC	WASTE_TYP	WASTE_AMT	EPA#
INPUT =				
# OF =		COUNT	SUM	COUNT
TOTAL =				

Table C-3. @Function Table Setup.

VII. Level III Statistical Analysis on a Hazardous Waste Inventory Database. Hazardous Waste Data Extraction and Listing Using the Lotus Data Query command.

This exercise will demonstrate how database information can be easily scanned, extracted, and listed using the data extraction command. The participant will build an extraction table for a spreadsheet which has been developed for processing paperwork.

A. The query process involves three stages.

1. Accessing the database which is set up with identifier column headings (attributes).

2. Database searching is contolled by the users input in the criterion range which is shown in Figure C-8. The setup is exactly the same as used in the database statistical functions.

3. Selected information is extracted from the database which has met the specification in the criterion range. The selected information is listed under functional column headings. These functional column headings must be identical to those in the database.

4. The table will be built to extract and list the information shown in Figure C-9. This information will be extracted on the basis of a formula which scans a particular section of the database.

5. Again, copy column headings to ensure exactness. Use the diagrams in Figures C-4 and C-9 for help.

6. (A few of the) Data Query menu command descriptions

Input -- the range of input, usually the entire database (including the column headings).

Criterion -- the range of cells containing the criterion setup (see Figure C-8).

Output -- the range over which the listing is to be placed. It is easiest to only specify the functional column headings.

Extract -- performs the query process, similar to a "Go".

Criterion Range

```
 ___________________________
|                           |
|    W_TYPE        SEC      |  <--Searching attributes
|       I                   |  <--Primary searching values
|                           |  <--Additional searching values
|___________________________|       are optional
```

Figure C-8. Data Query Criterion Setup.

CRITERION:

WASTE_TYP SEC
I

OUTPUT:

WASTE_TYP	WASTE_AMT	SITE_NAME	ST_#	SEC	STREET	S_TYPE
I	2887	Gainesville Prints	2700	SW	13	St
I	481	Starter Printing Co	1540	NE	Waldo	Rd
I	60	Beechnut's Printing	2161	NE	1	Blvd

Figure C-9. Data Query Extraction Table.

VIII. Using Lotus Macros for Spreadsheet Programming.

The following two sections provide valuable information which can greatly enhance the use of the Lotus spreadsheet. During the demonstration of the statistical models which we have developed, the development and use of macros will be discussed. Section VIII should be used as a guide to writing macros.

A. Macro Commands

1. Macros are used to perform various routine functions which can greatly expedite calculation time and are actually the 1-2-3 programming language.

2. They are written as a series of cell entries typed in one or more cells in a single column. A macro cell entry must be entered as a label and has the form, {commandspec}, if it is to reference special keys or the macro command library. Macros can also access the Lotus 1-2-3 menu commands by typing the "/" followed by the first letter(s) in the branched command titles.

3. Macros best reference range-named cell addresses. Cell addresses are named by using the \Range Name Create command.

4. Commonly Used

Macro Commands	Used For
Note: The <arguments> are optional.	
{BEEP <number>}	Sounding the computer bell; <number> is 1 to 4.
{BLANK location}	Erasing a cell or range of cells' contents.
{BRANCH location}	Extending (continuing) a macro to a new location.

4. Commonly Used Macro Commands	Used For
{CONTENTS destination-location, source-location,<width#>, <format#>}	Moving the contents of one cell to another as a label. <width#>=1 to 240 <format#>-see Lotus Manual.
{FOR counter-location,start#, stop#,step#,starting-location}	Repeatedly executing a macro subroutine that begins at a starting location for a specfied number of steps.
{FORBREAK}	Canceling a {FOR} loop.
{GETLABEL prompt-string,location}	Halting a macro for storing a label into a cell with a prompt statement.
{GETNUMBER prompt-string, location}	Halting a macro for storing a value into a cell with a prompt statement.
{IF condition}{if true do this} {if false do this}	Conditionally executing the command following the {IF} command.
{INDICATE string}	Changing the mode indicator display.
{LET location,number} {LET location,string}	Replacing a named cell contents by a value or string.
{MENUBRANCH location}	Setting up a customized menu with user options.
{PANELOFF} {PANELON}	Suppressing and restoring control panel redrawing during macro execution.
{PUT location,column#,row#, number or string}	Placing a value or label of a range into a named cell.
{QUIT}	Terminating macro execution and returning keyboard control to the user.
{RECALC location,<condition>, <iteration>}	Recalculating the formulas of a range until the condition is TRUE, or until the iteration count is FALSE.

4. Commonly Used Macro Commands / Used For

Commonly Used Macro Commands	Used For
{WAIT <time serial-number>}	Suspending macro execution for <time..>=(hrs,mins,secs).
{WINDOWSOFF} {WINDOWSON}	Suppressing and restoring the display screen redrawing during macro execution.

5. Using Macros to Manipulate Data

   a. Macro commands are best written row-by-row with as few commands per row as possible.

   b. A macro is range-named for initialization by a "\" followed by a single letter.

   c. A macro is initiated by typing the ALT-<range name letter> keys simultaneously.

   d. Before running a macro, use the ALT-F2 keys to observe the step-by-step sequence of the macro for a check.

   e. A good way to develop a working macro is to actually perform the sequence of steps manually and then record the sequences for macro writing.

IX. LOTUS 1-2-3 ADD-IN PACKAGES.

A. The Screen Manager, SeeMORE.

1. SeeMORE is a powerful screen manager for Lotus 1-2-3 which allows the user to compress the screen display as well as to make compressed hardcopies.

2. Even though SeeMORE is not necessary to run Lotus 1-2-3 for this purpose, it greatly helps in developing a working model by allowing the user to view up to four times as much of the spreadsheet at a time.

3. SeeMORE is an "Add-In" accessory file obtainable through the Intel Corporation for about $50.

4. To attach SeeMORE, press the ALT-F10 keys, "A" or "RETURN", specify type (CGA or EGA), and then specify the function key that will be used to invoke the add-in thereafter.

5. SeeMORE comes with many additional features which operate the screen layout, color, and display options. Once a favorable set-up has been established, it can be saved for future use.

B. 3D-Graphics

1. This add-in allows users to transform data into various types of three-dimensional multicolored surface plots and barcharts from a vast array of display options.

2. 3D-Graphics is available through the Intex Solutions, Inc. for about $85.

3. This package can also be easily invoked and used with Lotus macros.

X. Demonstration of Waste Inventory Data Extraction from the CAD System, AutoCAD, using Template Files.

XI. Demonstration of ACTION, the Lotus Statistical Packages Developed for Hazardous Waste Inventory and Database Management in the Processing of Paperwork.

The preceding two sections demonstrate how the procedures outlined in the workshop have been used to develop a statistical package to analyze hazardous waste inventory data on a larger scale. It also demonstrates how the CAD system, AutoCAD, can be used to store hazardous waste information with a much more detailed mapping representation.

BIOGRAPHICAL SKETCH

Leel Knowles, Jr., is a native of Florida and was raised in the northeast area along the St. Johns River. During the years of 1978-1983, he attended the New Mexico Institute of Mining and Technology in Socorro from which he received Bachelor of Science degrees in geology and geological engineering. During his five year stay at New Mexico Tech, Leel studied and designed mine and oil well structures. Some work also included water flow studies.

During the following two years, he worked as a manager in the Jacksonville area. In 1986, Leel entered the Department of Environmental Engineering at the University of Florida. During the next two-and-a-half years, he studied and developed PC models of water-related systems. Leel's work in knowledge-based management systems led to the development of a notification software package for producing correspondence from a hazardous waste database. He expects to receive a Master of Engineering degree in environmental engineering sciences in April, 1988.