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DIGMAN: A Computer Program to Illustrate the Complexities in Sampling Commercial Low-Level Waste Sites for Radionuclide Spills or Migration

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J. M. Thomas

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May 11, 1984

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DIGMAN: A COMPUTER PROGRAM TO ILLUSTRATE THE COMPLEXITIES IN SAMPLING COMMERCIAL LOW-LEVEL WASTE SITES FOR RADIONUCLIDE SPILLS OR MIGRATION

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DIGMAN: A Computer Program to Illustrate the Complexities in Sampling Commercial Low-Level Waste Sites for Radionuclide Spills or Migration

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ABSTRACT

DIGMAN is an interactive computer program which allows the user to sample a hypothetical waste site. Using sample results, the user is then required to determine the area contaminated by a waste spill or migration. The report contains instructions for running the program and a sample session to aid the novice user. DIGMAN is programmed for an Apple II computer with a minimum of 64K RAM and one disk drive. A disk containing a copy of the program is available from the authors.

SUMMARY

The DIGMAN program was developed to illustrate the complexities in sampling a commercial low-level radioactive waste site for spills or migration. Monitoring for both purposes is required by 10 CFR Part 61. The site-manager (player) is given prior knowledge that a spill has occurred and subsequently migrated through or over the soil surface. In addition, the location is given for one point where some contamination is known to exist. Such an array of information may or may not be available at actual sites. The DIGMAN waste site provides the player with 1600 possible sampling sites, clearly far fewer than would actually be available. Thus, the situations depicted by DIGMAN are perhaps the simplest of the myriad of possible scenarios that might be faced by a site-manager. We invite prospective site-managers (players) to attempt the game.

ACKNOWLEDGEMENTS

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CONTENTS

FIGURES

INTRODUCTION

Hazardous waste sites of all kinds pose a major problem for the 1980's. A major difficulty at a specific site is to locate the contaminated area and determine the areal extent of contamination. It is also important to determine whether the contamination has migrated off-site. One problem for the regulatory agencies is providing guidance on how to sample an area to determine the extent of contamination. Both the expense of collecting and analyzing samples makes efficiency mandatory.

DIGMAN was developed to illustrate the difficulties in sampling a commercial radioactive low-level waste site and ultimately to evaluate alternative sampling strategies. The extension to hazardous chemical sites is straightforward. DIGMAN was designed to test a site manager's ability to locate a contaminated area and to determine its areal extent.

In the DIGMAN scenario, it is assumed that historical records or a preliminary site survey indicate that contamination is present and that the highest possible concentration is ten units per area. By sampling the site, the extent of the contamination must be determined and a decision made as to whether the contaminant has migrated off-site. Because of high laboratory fees, only five samples (composites) can be analyzed. Each of the five permitted composite samples can be composed of from one to nine component samples (i.e., you may combine up to nine samples into one sample), but only the total sample may be analyzed.

Samples containing more than one component are termed composites. When laboratory costs and/or collection costs are high, compositing allows for a more extensive sampling of the waste site. Readers will find more information on compositing at commercial low-level waste sites in Eberhardt and Thomas (1983). Skalski and Thomas (1984) discuss some field sampling and compositing strategies that might aid in playing DIGMAN. Since site cleanup costs may be very high, a site manager will want to arrive at the smallest possible estimate for the contaminated area to avoid condemning a larger area than necessary. In the DIGMAN scenario, sampling is restricted to the waste site; however, the contaminated area may extend beyond site boundaries.

Several different scenarios relating to sampling and costs can be used in playing DIGMAN (Table 1). In scenario 1 (Table 1), costs of collecting and analyzing samples are high. For this scenario, the site manager would probably want to take the maximum number of components per composite and also take all five composite samples. In a second scenario (2), collection costs are low, but analysis is still expensive. In this situation, the site manager might wish to take fewer than five composite samples, analyze the results and then resample. A third scenario would be where collecting the samples is expensive while the analysis is relatively cheap, here a sampling strategy similar to that used in the first scenario might be employed. Another scenario (4) would be where the costs for collection and analysis are

TABLE 1. Possible Scenarios for Playing DIGMAN

	Costs	
	Cheap	Expensive
Collection	2,4	1,3
Analysis	3,4	1,2

inexpensive, compositing would probably not be advantageous in this situation.

An additional feature of DIGMAN allows the site manager to resample after the first sampling sequence is completed and the analytical results are available. This two or more stage sampling emulates the circumstances where laboratory turnaround is fast (and perhaps cheaper than assumed in DIGMAN) so that a much better definition of the spill area can be obtained.

The waste site is simulated as a 40 x 40 grid (Figure 1). The player is given information that contamination exists at least at one point on the waste site; this appears on the screen as a darkened square, and is called a PRIOR. However, the concentration at this point is not known since in real circumstances a site manager will usually only have sketchy information.

The contaminated area is represented by an ellipse, because point spills are generally moved by physical forces (e.g., wind or surface water). The ellipse is generated using a bivariate normal distribution, and parameters affecting placement, orientation, and shape are randomly determined. Thus, the ellipse can be very small or large, and of varying length and widths (e.g., very "skinny" or "fat"). In addition, it is possible for part of the ellipse to be outside the defined waste site, an indication that radioactivity has moved off-site.

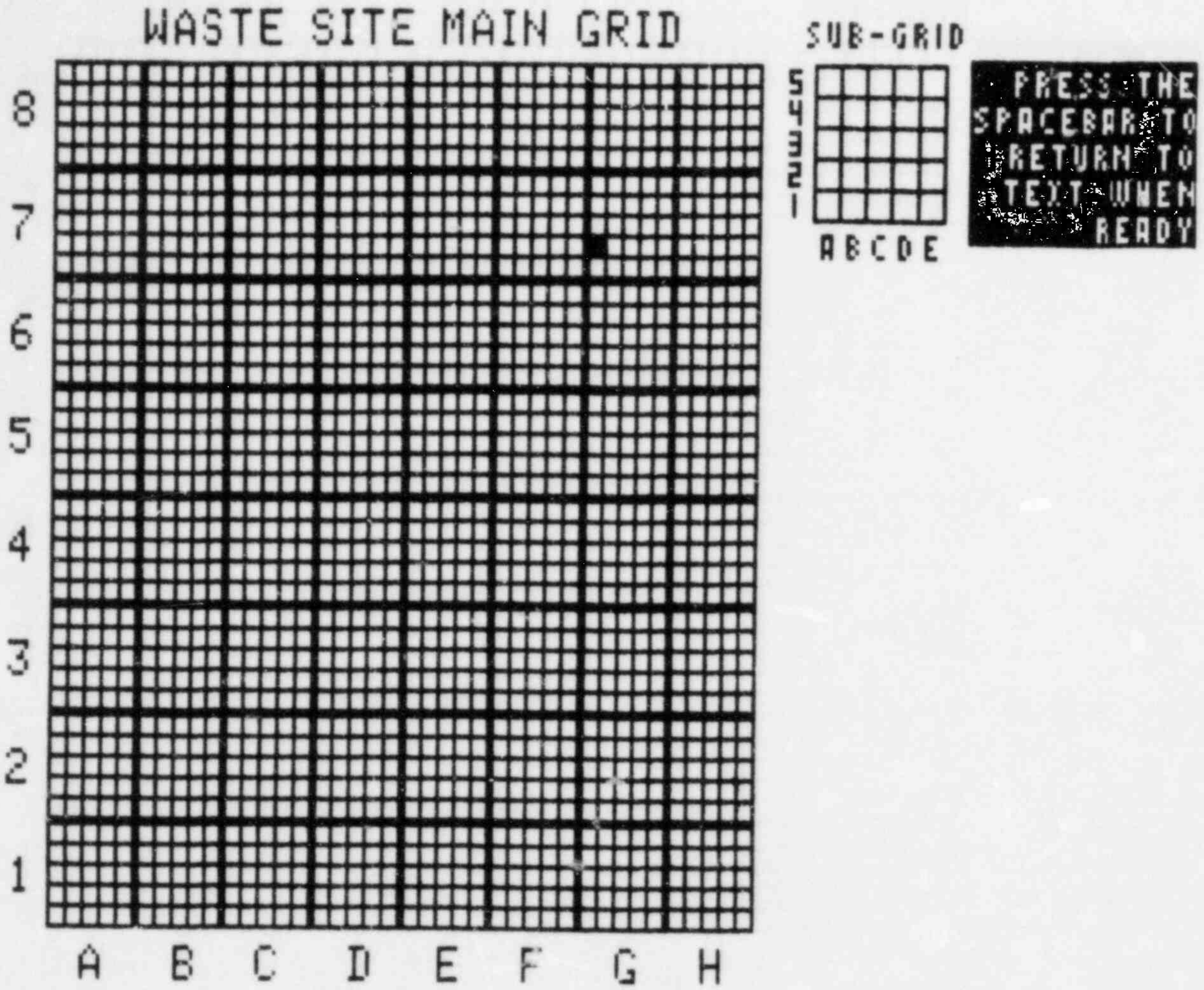

FIGURE 1. Simulated Waste Site Used in DIGMAN. Location of PRIOR is indicated by the darkened square at 7G/2A.

SYSTEM REQUIREMENTS

DIGMAN is programmed for an APPLE II computer with a minimum of 64K RAM (Random Access Memory) and 1 disk drive.

GENERAL DESCRIPTION

DIGMAN is menu driven (Figure 2). After each step is completed, the menu is again shown to allow the next option to be selected.

The main segments of DIGMAN given in the menu are:

1. Introduction to DIGMAN
2. Generate Random Contaminated Area
3. Choose Sample Points on the Graph
4. Edit or Fix Incorrect Graph Points
5. Get Final Answer and Computations
6. Exit This Set of Programs

Each segment of DIGMAN is a self-contained and accessible program. A brief description of each segment is given below.

1. Introduction to DIGMAN.

   This section outlines the purpose of DIGMAN and gives detailed operating instructions. This option should always be selected when DIGMAN is run for the first time. In subsequent runs, OPTION 1 can be skipped and OPTION 2 selected to generate the random contaminated area.

BATTELLE DIGMAN OPTION SELECTION

[1] INTRODUCTION TO DIGMAN

[2] GENERATE RANDOM CONTAMINATED AREA

[3] CHOOSE SAMPLE POINTS ON THE GRAPH

[4] EDIT OR FIX INCORRECT GRAPH POINTS

[5] GET FINAL ANSWER AND COMPUTATIONS

[6] EXIT THIS SET OF PROGRAMS

THE HIGHLIGHTED OPTION IS THE NEXT STEP
THAT YOU SHOULD LOGICALLY CHOOSE
YOU CAN DO THIS BY PRESSING <RETURN>
OTHERWISE PRESS A NUMBER FROM 1 TO 1
TO END AT ANY TIME AFTER 2 - PRESS 6

FIGURE 2. Individual Program Segments Comprising the DIGMAN Menu. Each segment is selected in turn to run DIGMAN.

2. Generate Random Contaminated Area.

This program segment generates an elliptical representation of a contaminated area and randomly chooses a point to serve as the PRIOR. The PRIOR may be at the edge or well inside the ellipse. While no input is required at this point, OPTION 2 must be selected to run the program. To terminate the session anytime after selecting this option, simply select OPTION 6 (Exit) in the menu.

3. Choose Sample Points on the Graph.

In this program segment, the user samples the waste grid in an effort to define the contaminated area. A maximum of five composite samples may be taken; each sample may contain up to nine component samples. Location of the PRIOR can be used to restrict the area sampled. Mistakes in the choice of grid coordinates can be corrected by using menu OPTION 4 after sampling is completed.

4. Edit or Fix Incorrect Graph Points.

This program segment allows correction of any input errors introduced when sample points are selected. In addition, samples (i.e., components) may be added or deleted.

5. Get Final Answer and Computations.

Once sampling has been completed, users should choose OPTION 5 to allow the program to compute the average concentration for each composite sample. With these data, the player is asked to define the smallest circle that contains the contaminated area. The program then draws the circle, computes the percentage of the contaminated area enclosed by the circle, indicates how close the radius chosen by the player was to the smallest one which could have enclosed the entire contaminated area, indicates whether an accurate prediction of off-site migration was made; and shows the actual location of the contaminated area.

6. Exit this Set of Programs.

This program segment ends DIGMAN by "zeroing out" all the data files generated during the current run. Errors will occur in subsequent runs when this option is not selected.

SAMPLE SESSION

This section of the report illustrates a typical DIGMAN run, step by step. Before beginning, make several copies of the "waste grid" worksheets found at the end of this manual to help you plan your sampling strategy and keep a record of your performance. Note that < > around a word indicates a key on the APPLE keyboard that must be pressed. For example, <RETURN> means press the RETURN key.

1. Turn on APPLE, insert DIGMAN disk.

2. Following the introduction, a menu listing six options is shown (Figure 2). Each option must be selected in turn to play DIGMAN. If the needed option is highlighted you may select it by pressing <RETURN>. Any option may be selected by pressing the appropriate number, e.g., <1>.

3. OPTION 1 - Introduction to DIGMAN

   Select this option if you have never played DIGMAN. Read through the Introduction, pressing <SPACEBAR> at the end of each page. You may look at some sample ellipses (spills) by pressing <S>; to return to the text, press <SPACEBAR>. At the end of OPTION 1 you will automatically be returned to the menu.

4. OPTION 2 - Generate Random Contaminated Area.

   When OPTION 2 is selected, the program generates an ellipse that represents the contaminated area at the waste site. This takes a few minutes; during this time, you should hear a ticking sound, a built-in indicator that the program is working. No input is required by this option. Upon completion of the option, press <SPACEBAR>.

5. OPTION 3 - Choose Sample Points on the Graph.

   After the ellipse representing the contaminated area (its size, shape, and orientation are still unknown to you), has been generated, you are ready to start sampling. Use the worksheet to map your strategy. You will first be shown the PRIOR, the point on the waste grid which is known to be contaminated. To see this point plotted on the waste grid, press <S>; the square will be filled in. After looking at the PRIOR, press <SPACEBAR> to continue.

   The waste site in DIGMAN is represented by a 40 x 40 grid with the major vertical axis labeled from 1-8 and the horizontal axis labeled from A-H (Figure 1). Thus, the grid is an 8 x 8 array of 5 x 5 small squares. You will select the smaller squares. The position of the squares are defined first by the location within the 8 x 8 array and then by the position within the 5 x 5 array. For example, the point 7G/2A (Figure

1) is found at the convergence of row 7 and column G, in the 8 x 8 array, and in row 2, column A of the 5 x 5 array.

You must now decide how many composite samples you wish to take. The maximum is five (remember--each composite may contain up to nine components). You will be asked to confirm the number of composites selected by pressing <Y> if the answer is correct, <N> if it is not. After selecting the number of composites, you must select the number of components for the first composite (maximum of nine). Again you will be asked to confirm your answer.

To input the grid coordinates, first select the vertical (Y-axis) coordinate for the larger square, then the horizontal (X-axis) coordinate, followed by the coordinates that define the point within the larger square. Consequently each set of coordinates will consist of a sequence of four alternating numbers and letters. You may look at the waste grid at any time by pressing <S>, to return press <SPACEBAR>. After entering the coordinates of a component, you will be shown its position (by a unique symbol) on the waste grid, to return to the text, press <SPACEBAR>.

The screen displayed during sample selection (Figure 3) contains important sampling information. It indicates which composite sample you are currently forming (Figure 3, a), as well as the component (Figure 3, b) and the total number of components in the composite (Figure 3, c). In addition, all samples will be listed (Figure 3, d).

After entering [illegible] components for a particular composite, you will be asked for [illegible] of components for the next composite. This process will [illegible]til all composites have been entered. If you make a mis[illegible]ng a sample point, simply wait until all the points are ente[illegible]se OPTION 4 to make corrections. Once sampling is comp[illegible]u will be returned to the menu where you may select either OPTIO[illegible] you wish to make corrections, or OPTION 5 to compute the concentrations and to define the contaminated area.

6. OPTION 4 - Edit or Correct Graph Points.

   In option 4, all the component samples for each composite are listed at the top of the screen. You will be given four options. Then put in

   - EDIT - press <E>

     Indicate both the composite and the component number erroneously entered (selecting a component which does not exist returns you to the four options). Then put in new coordinates.

DIGMAN SAMPLE LOCATION SELECTION

ENTER GRID COORDINATES

MAIN GRID VERTICAL : [1-8] COMPOSITE: 1[a]

MAIN GRID HORIZONTAL : [A-H]

SUB GRID VERTICAL : (1-5) COMPONENT

SUB GRID HORIZONTAL : (A-E) 1[b] OF 7[c]

PRESS [S] TO SEE THE GRID

	1[d]	2	3	4	5
1					
2					
3					
4					
5					
6					
7					
8					
9					

FIGURE 3. Example of Screen Display During Sample Selection. Sample coordinates are entered in the spaces indicated. Information is provided on which composite is being formed (a), which component is being selected (b), and on the total number of components in the composite (c). In addition, all samples will be listed (d).

- ADD - press <A>

  When selecting additional samples, input the associated composite number, and the coordinates of the sample. Press <*> if you decide not to add a sample.

- DELETE - press <D>

  To delete a sample, input the appropriate composite and component number. You will be queried to ensure that you have selected the correct component, and asked to press Y (yes) or N (no).

- QUIT - press <Q>

  You will be queried to make sure you want to quit--press <Y> for yes, <N> for no. After several seconds the waste grid will be shown to illustrate the corrected samples. To continue the program from here, press <SPACEBAR>.

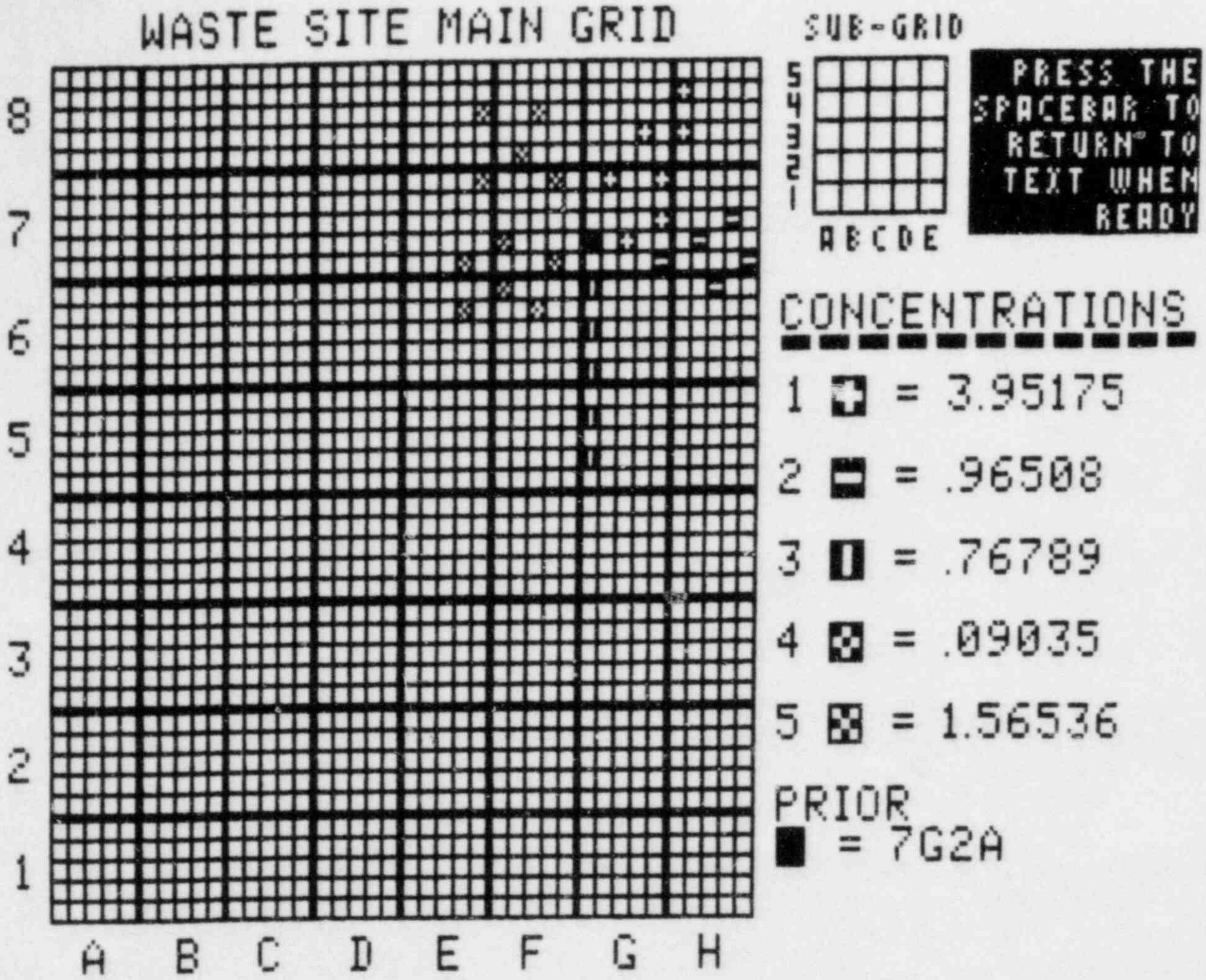

FIGURE 4. Results of an Example Session. Each composite is assigned a unique symbol. Average concentrations for each composite are given to the right of the waste grid.

7. OPTION 5 - Get Final Answer and Computations.

The size of this program requires that the data be loaded twice, so the concentrations (Figure 4) will momentarily disappear. After recording the concentrations on your worksheet, press <SPACEBAR>.

Now you must use your results to decide where the contaminated area is located. First, determine the point you believe has the maximum concentration, remembering that the maximum possible concentration is 10 units. This point should be the center of the circle you believe will encompass the spill. Input the coordinates for the center and confirm the answer.

Next, estimate the radius of the smallest circle that would enclose the entire spill. To estimate this radius, count the number of small squares either vertically or horizontally. If the perimeter of the circle extends beyond the waste site boundaries, this indicates you believe the contaminated area has also gone off-site. Input the radius and press <RETURN>. To look at the grid before entering the radius, press <S> followed by <RETURN>. Press <SPACEBAR> to return to the program.

Once your circle is drawn (Figure 5), press <SPACEBAR>. The percentage overlap of the circle and the contaminated area (i.e., the ellipse) will

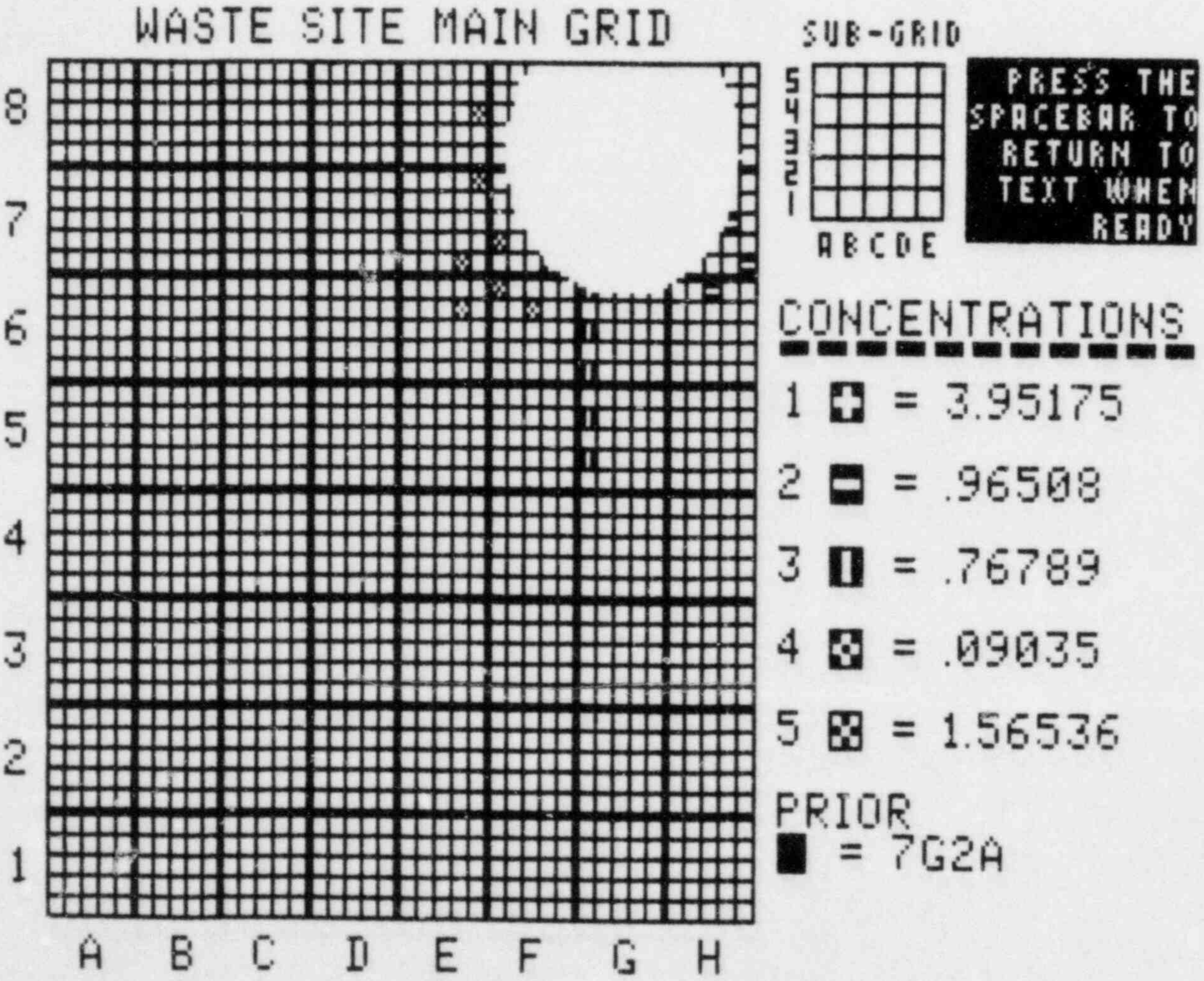

FIGURE 5. Circle, Drawn on Waste Grid, Represents the Area the User Believes Encloses the Contaminated Area. A circle which goes off-site indicates that the waste has also gone off-site.

now be computed. Since these calculations take several minutes, the proportion of the circle checked for overlap with the ellipse representing the contaminated area is given so that you can keep track of the program's progress.

The success of your sampling can be evaluated based on the following three criteria (Figure 6):

1. The proportion of the contaminated area (ellipse) within the circle (because of the algorithm used the answer may slightly exceed 100%).

2. The fraction of your chosen radius compared to the longest radius of the ellipse (this will indicate how conservative you were in your estimate of the size of the contaminated area).

3. Whether you accurately predicted that the contamination had gone off-site.

DIGMAN FINAL ANSWER & COMPUTATIONS

CENTER OF CIRCLE IS : 8G1C

RADIUS OF CIRCLE IS : 6

46% OF THE ELLIPSE IS IN THE CIRCLE[1]

YOUR RADIUS IS 43% OF THE MINIMUM
RADIUS REQUIRED TO ENCOMPASS THE ELLIPSE[2]

CIRCLE PREDICTS THAT CONTAMINATED AREA
HAS GONE OUTSIDE SITE

THIS IS CORRECT[3]

CONTINUE WITH ELLIPSE PLOT / RESAMPLE
PRESS THE [C] KEY OR THE [R] KEY

FIGURE 6. Results of a DIGMAN Session. Three criteria are used to evaluate a run: 1) the percent of the contaminant ellipse within the circle; 2) fraction of the circle radius compared to the longest radius of the ellipse (indicates how conservative the estimate was of the contaminated area); and 3) whether an accurate prediction was made concerning offsite migration of the waste.

If you press <C> at this point, the ellipse representing the contaminated area will be drawn (Figure 7). If you press <R>, you will be returned to the menu where you may select OPTION 3 to resample for the contaminant spill. Press <SPACEBAR> to return to menu.

8. OPTION 6 - Exit This Set of Programs.

   This option ends DIGMAN. The only input required is to enter the date (e.g. 10/30/84). If you make a mistake, use arrow <←> then press <RETURN>. You may select OPTION 6 anytime after OPTION 2. To play DIGMAN again, type RUN DIGMAN <RETURN>.

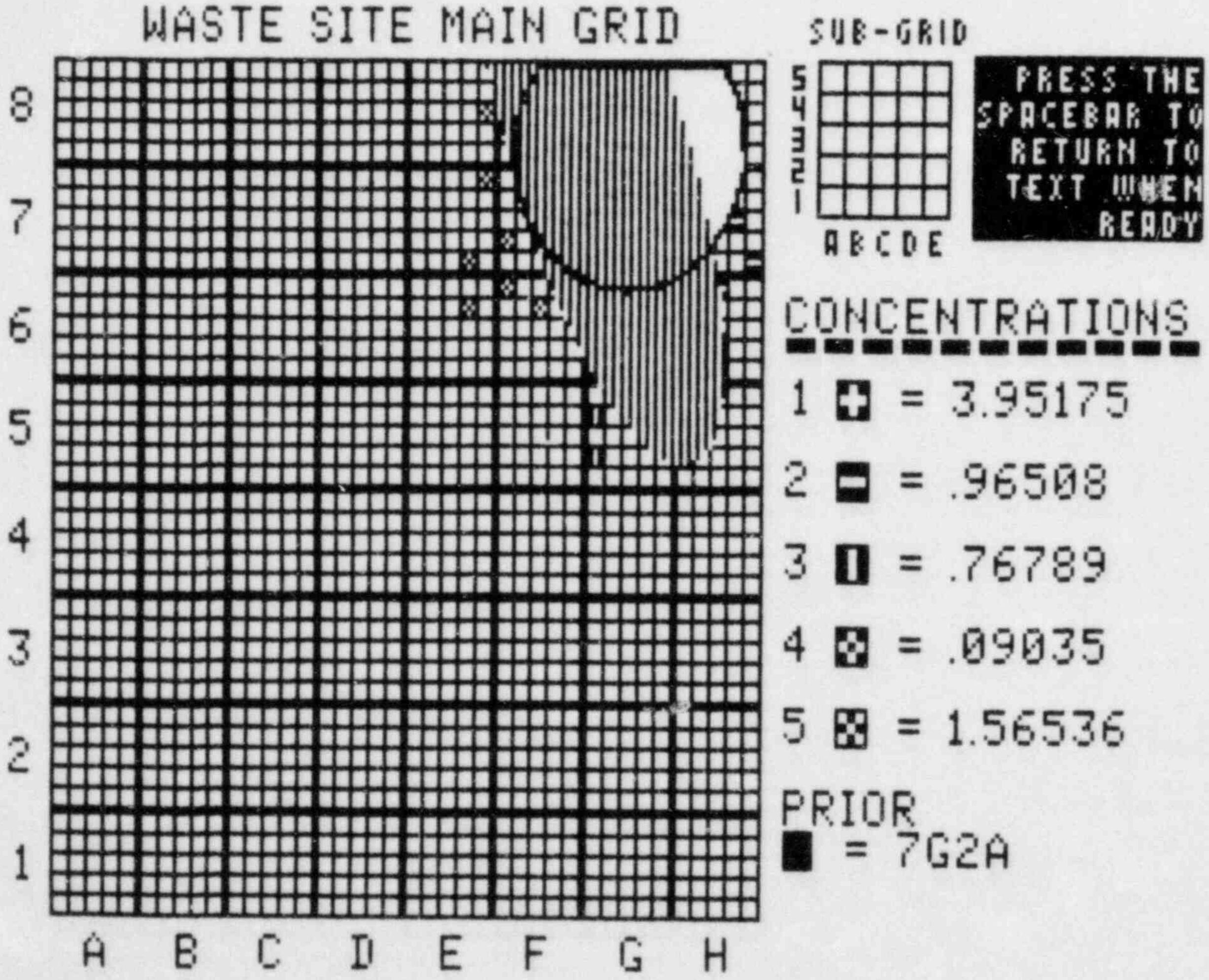

FIGURE 7. Ellipse Represents Contaminated Area

PROBLEMS

Since we could not anticipate all the ways in which DIGMAN might be used, we cannot be responsible for its complete accuracy. We would appreciate learning of problems experienced with DIGMAN or of suggestions for enhancing future versions. Extension of DIGMAN to other computer systems will be considered as funding permits. Please send comments to :

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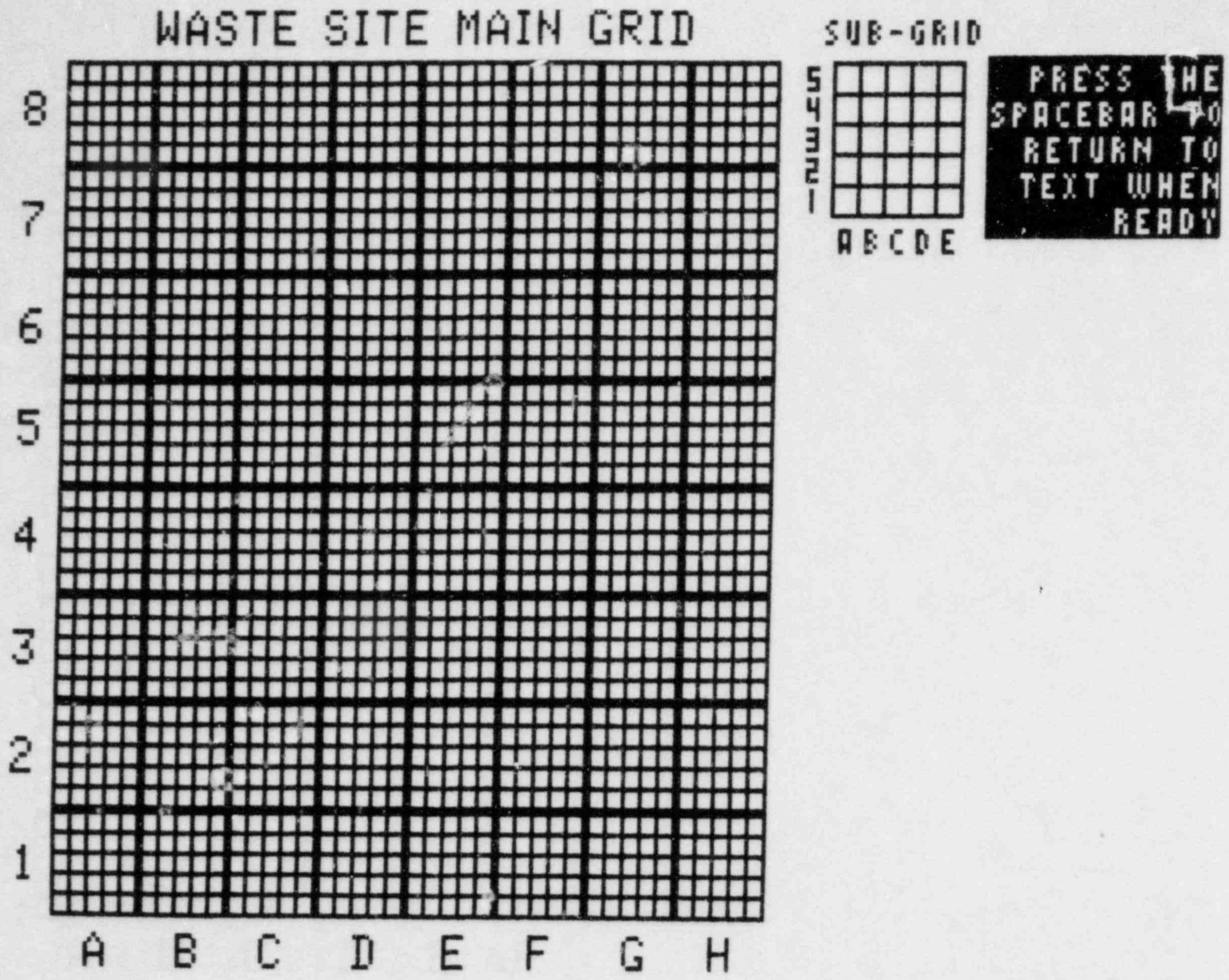
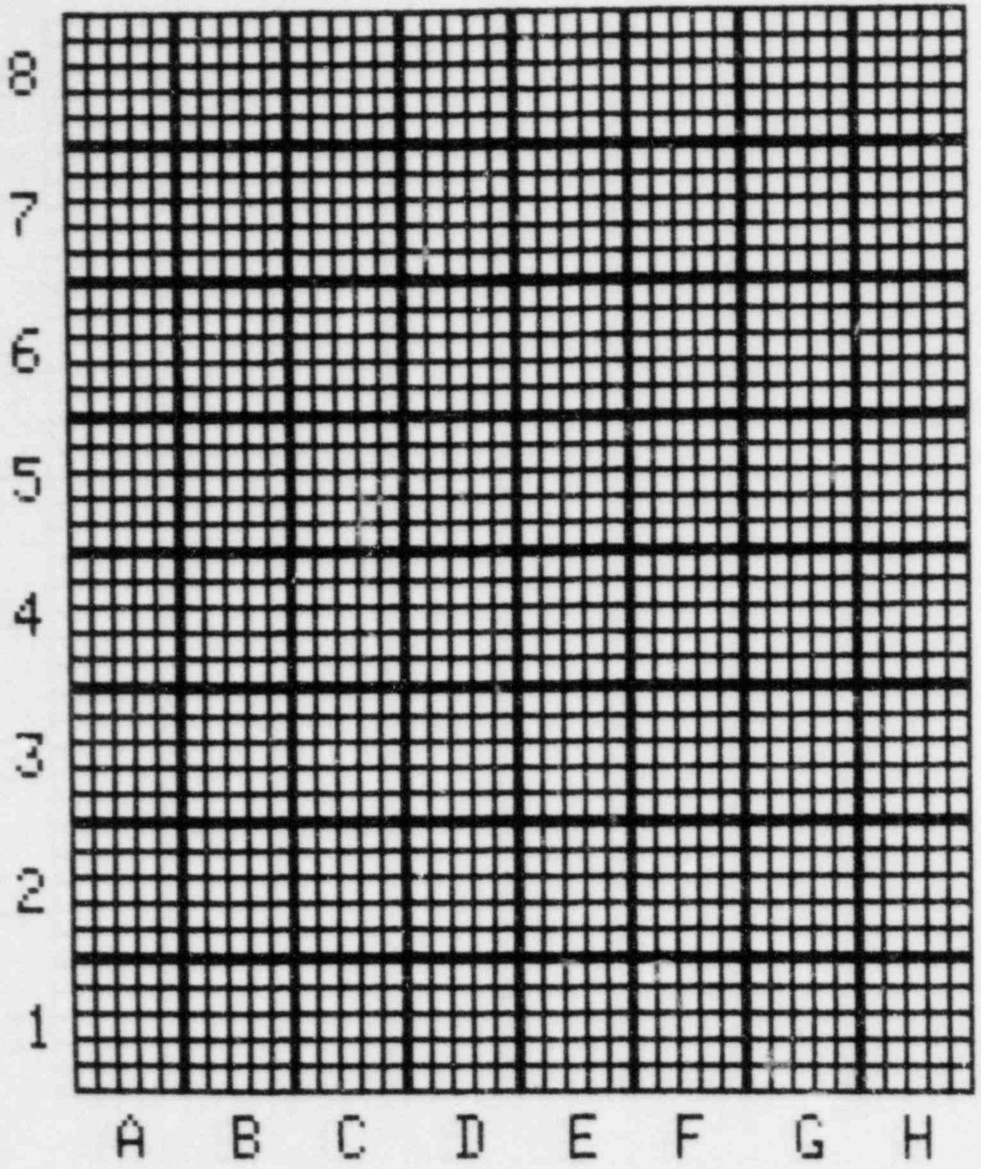
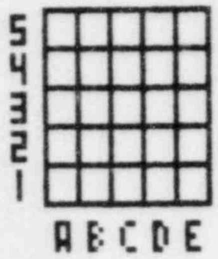

WASTE SITE MAIN GRID
8
7
6
5
4
3
2
1
A B C D E F G H
SUB-GRID
5 4 3 2 1
A B C D E
PRESS THE
SPACEBAR TO
RETURN TO
TEXT WHEN
READY

WASTE SITE MAIN GRID



SUB-GRID



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DIGMAN is an interactive computer program which allows the user to sample a hypothetical waste site. Using sample results, the user is then required to determine the area contaminated by a waste spill or migration. The report contains instructions for running the program and a sample session to aid the novice user. DIGMAN is programmed for an Apple II computer with a minimum of 64K RAM and one disk drive. A disk containing a copy of the program is available from the authors.

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