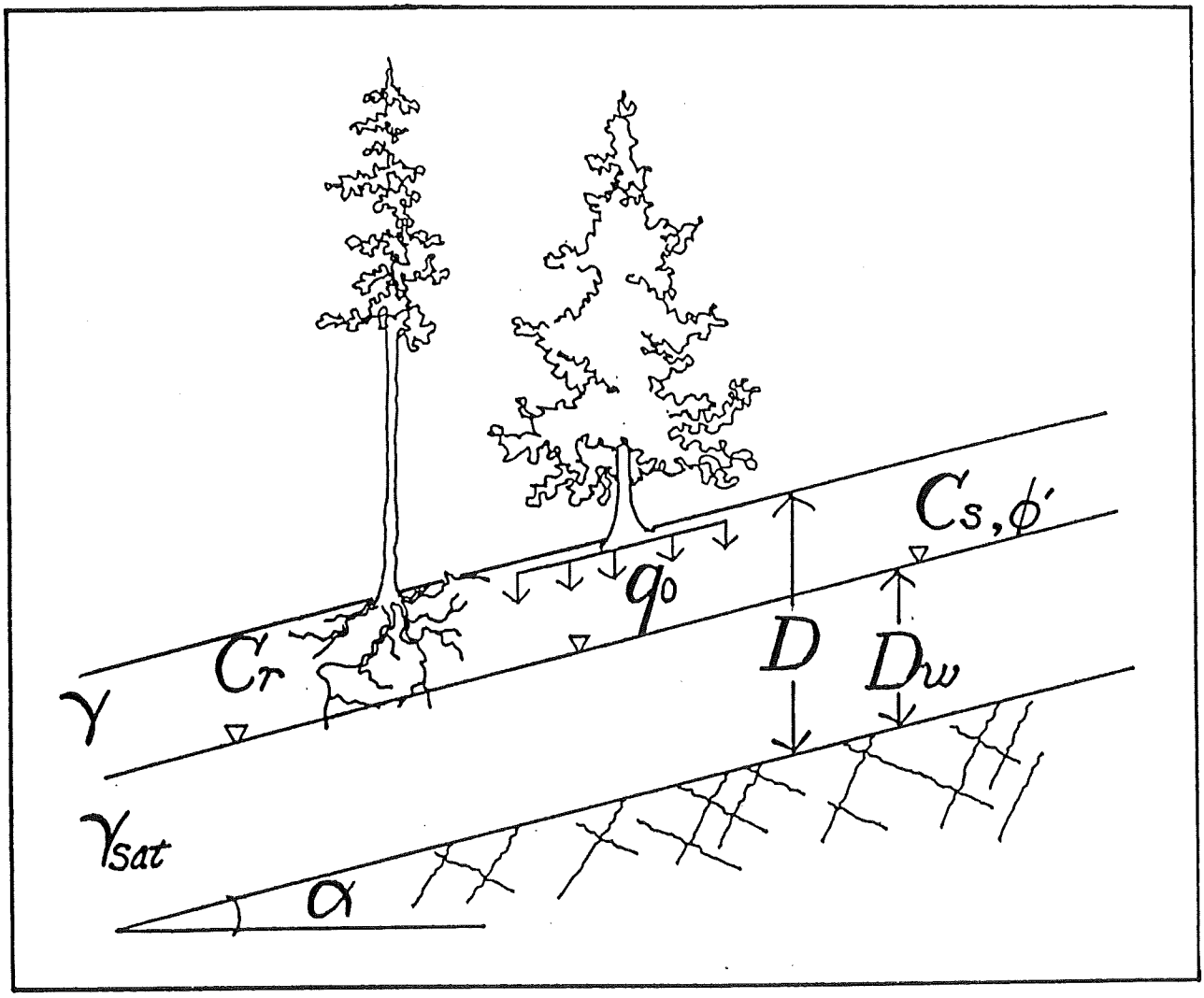
Part 2—Program Operation



CHAPTER 1 — INSTALLATION INSTRUCTIONS

We have assumed in writing these instructions that users know basic DOS tasks (such as how to format a floppy disk, make and change directories on a hard disk, copy files, and view or print disk directories and the contents of ASCII files), and that users are familiar with DOS filename syntax. If the user is unfamiliar with these tasks, some assistance may be required.

1.1 Hardware Requirements

To use LISA, the user will require:

- An IBM PC or near compatible, with at least 444 kilobytes of *available* random access memory (RAM).
- Preferably one floppy disk drive (of at least 360 kilobytes capacity) and a hard disk drive or equivalent; or two floppy disk drives, one of which must be of at least 720 kilobytes capacity. (No floppy disk drives are required if LISA is acquired through the computer's serial port, as it would be if it were RISed from the Data General computer as described in appendix A. One is still recommended, however.)
- MS-DOS or PC-DOS disk operating system 2.0 or later.

The following are highly recommended, but not essential:

- A floating-point math coprocessor (8087, 80287, or 80387). LISA will take advantage of the coprocessor if one is installed.
- An IBM-compatible VGA, EGA, or CGA graphics adapter and an appropriate monitor. Without graphics capability, you will not be able to view plots of the input distributions or scatter plots of simulated values, but LISA will still function.
- An IBM-compatible printer for hardcopy output.

1.2 LISA Installation

LISA version 2.00 is distributed as one "self-extracting" file[1] called `LISA200.EXE`.[2] When you run `LISA200`, it will generate several files, which are described in section 1.3.

TO INSTALL LISA ONTO A HARD DISK

- Create an appropriate subdirectory on the hard disk for the program, and change to that subdirectory. For example, type

```
MD C:\SS\LISA [ENTER]
CD C:\SS\LISA [ENTER]
```

- Place the disk containing `LISA200.EXE` into a floppy drive (say, drive A) and run `LISA200` by typing, for example,

```
A:LISA200 [ENTER]
```

TO INSTALL LISA ONTO A DUAL-FLOPPY SYSTEM

- Format a floppy disk for at least 720 kilobytes capacity, and copy the DOS file `COMMAND.COM` onto the disk. Place this disk in an appropriate disk drive, and make that drive the current drive.

---

[1] PKWARE's PKZIP and ZIP2EXE version 1.1 were used. The USDA Forest Service has a site license for use of PKZIP.

[2] The name of the self-extracting file will change with future updates. For example, if a version 2.05 of LISA were released, it would be called `LISA205.EXE`.

- Place the disk containing `LISA200.EXE` into the other drive, and run `LISA200` by typing, for example,

  `B:LISA200` ENTER

1.2.1 Data File Location

LISA saves its data files in subdirectories corresponding to map unit names specified by the user when running LISA. The subdirectories may reside on the hard disk under either the program directory or a separate directory, or on a floppy disk. The user specifies the path to the data subdirectories from within LISA, and LISA creates the data subdirectories as needed, giving them filename extensions of `.MPU`, as discussed in section 3.4. The path may be changed any time LISA is run. This method allows great flexibility in the use of LISA, and allows the disk operating system to handle data file management.

1.2.2 Running LISA From Any Subdirectory

You can run LISA from any subdirectory, as long as DOS's `PATH` includes the subdirectory in which LISA is stored. LISA will create in each subdirectory from which it is started a configuration file, `CONFIG.L1`, specifying the location of data files and the screen color selection. Thus, each user can customize LISA simply by running LISA from his or her own subdirectory.

1.2.3 Running LISA from Windows 3.0

LISA can be run as a "nonwindow" (full screen) or a "window" application under WINDOWS 3.0. The plots of input distributions and the scatter plots of simulated values cannot be displayed while running LISA in a window, because they use EGA graphics, but they *can* be viewed by switching from a window to a full screen application using ALT-ENTER and CTRL-ENTER.

LISA can be run as a background task if you create a WINDOWS PIF file and turn the background option on. For more information on running DOS applications under WINDOWS, see the WINDOWS 3.0 documentation.

1.2.4 Customizing LISA With Environment Variables

LISA is aware of two DOS environment variables. `LISALIST` tells LISA what program to use for viewing the output files `RESULTS.OUT` and `SIMULATE.OUT`, and `LISAGRAPH` affects the content of the output file `RESULTS.OUT` created in the simulation.

Environment variables are `SET` from the DOS prompt before invoking LISA. If they are to be set consistently, you may want to put the `SET` command in either your `AUTOEXEC.BAT` file (near the bottom of the file, but before any calls to hard disk management programs) or the `LISA.BAT` file (anywhere before the `LISARA /L` line).

You may list the values of all current DOS environment variables by typing `SET` ENTER at the DOS prompt.

1.2.4.1 Specifying Your Own File Viewer

Unless it is told otherwise, LISA uses a program called BROWSE[3] to view the RESULTS and SIMULATED DATA files. If you tell LISA to use a file editor, you can format the output files as you desire before printing them, without leaving LISA.[4]

To specify a different viewing or editing program, use the DOS `SET` command to create an environment variable called `LISALIST` and give as its value the name of the viewing or editing program as it would be called from DOS. The file viewer or editor that you specify must meet the following requirements:

---

[3] Petzold (1986). BROWSE may be freely copied and used for noncommercial use only.

[4] Another way to edit the RESULTS and SIMULATED DATA files is to save them and edit them after leaving LISA. Editors not directly compatible with LISA may be used in this way.

- It can be invoked from the DOS command line with the name (including the path) of the file to be loaded.
- It reads ASCII files.
- It can be called from any subdirectory.
- It is not a "memory hog"; if LISA is being run on a machine with 640 kilobytes of RAM, about 250 kilobytes will be available for the viewer or editor.

PC-WRITE is one program that meets these requirements, and it will be used here to illustrate how to specify a viewer or editor. If the PC-WRITE editor `ED` is stored on the `C` drive in subdirectory `\WP\PCW`, you would type

```
SET LISALIST=C:\WP\PCW\ED ENTER
```

1.2.4.2 Specifying IBM Graphics Characters

When LISA saves histogram plots in the output file `RESULTS.OUT`, it assumes that you need standard ASCII characters rather than the IBM line graphics characters that are displayed on the screen. If you would prefer to have the graphics characters stored in the file, set the DOS environment variable `LISAGRAPH` to the value `IBM`. To do this, type the following at the DOS prompt before you start LISA:

```
SET LISAGRAPH=IBM ENTER
```

You must not have any spaces around the = sign or after `IBM`, and `IBM` must be in uppercase letters.

1.3 LISA Program Files

The following files will be generated when `LISA200` is run:

1.	`LISARA.EXE`	Executable code for LISA and SARA
2.	`LISA.BAT`	Starts LISA
3.	`BRUN45.EXE`	Runtime library for LISA and SARA
4.	`BROWSE.COM`	File viewing utility
5.	`DEMO.BAT`	Creates `DEMO.MPU` and copies demonstration data files to it

6.	`DEMO.SIT`
	`DEMO.MTL`
	`DEMO.HYD`
		Data files for the demonstration problem

7.	`DLISA.EXE`	Executable code for Deterministic LISA
8.	`README`	Describes program or manual revisions

`LISARA.EXE`, `LISA.BAT`, and `BRUN45.EXE` are required to run the LISA program. `BROWSE.COM` is also required, unless the `SET LISALIST` command has been used to specify another file-viewing utility (see section 1.2.4.1). The DOS file `COMMAND.COM` must also be available on one of the floppy disks for a dual-floppy system or on the hard disk; see section 1.2. The `DEMO` files are optional and are used for working through the demonstration problem in this manual. The `README` file, if it exists, discusses program changes or manual revisions, or both, and should be reviewed before you proceed. The single file `DLISA.EXE` is required to run the deterministic version of LISA, DLISA. Chapter 4 discusses installation and use of DLISA.

CHAPTER 2 — GENERAL EXECUTION INSTRUCTIONS

Just knowing how to run LISA is not enough. We *strongly* recommend that you read Part 1 before attempting any LISA runs for project work. *Part 1 gives the background needed to understand what* LISA *is doing and how to properly use and interpret the results.* However, you may find it helpful in understanding Part 1 to be familiar with the operation of LISA first.

2.1 Screen Structure of LISA

Several screens in the LISA program aid the user in option selection and data entry (see fig. 2.1). These screens are designed to be self-explanatory so that little reference need be made to this manual. However, detailed descriptions of each screen and the options available are presented in chapter 3, "Detailed Execution Instructions", should they be needed.

2.2 Data File Structure

Three types of data files are used in LISA. They are:

Site	Specifies the probability distributions for soil depth, ground surface slope, tree surcharge, and root cohesion.
Material	Specifies the probability distributions for friction angle, soil cohesion, dry unit weight, and moisture content of soil above the phreatic surface, and the value of specific gravity of solids.
Groundwater	Specifies the probability distribution for groundwater–soil depth ratio.

The data files have file extensions of `.SIT`, `.MTL`, and `.HYD`, respectively. Data files are separated in this manner to allow easy use of one material file with several site files. This makes file editing and selection more convenient when the site conditions change but the soil type remains fairly uniform over an area, or when the same soil type is found in numerous locations across a forest.

For each input variable, a constant value or a distribution type is specified by the user. The available distributions are uniform, normal, lognormal, triangular, beta, histogram, and, for C_s' and ϕ', bivariate normal. Groundwater–soil depth ratio is limited to constant, uniform, triangular, beta, and histogram distribution types. Only a constant value can be entered for specific gravity.

Data files are grouped into *map units* (subdirectories on disk with an extension of `.MPU`). A map unit can be thought of as a study or analysis area, or as a geomorphic landtype. The map unit serves as a bookkeeping mechanism under which data files are organized (see sections 1.2.1 and 3.4 for more information). Data files can be created, modified, and saved from within LISA, but they cannot be erased.

2.3 General Principles

Some general principles to keep in mind when creating data files and running LISA are listed below.

- LISA makes extensive use of highlighted menus and options in its user interface. The highlight is moved by pressing SPACE or the arrow keys (← → ↑ ↓). Pressing ENTER selects the highlighted file name or option.

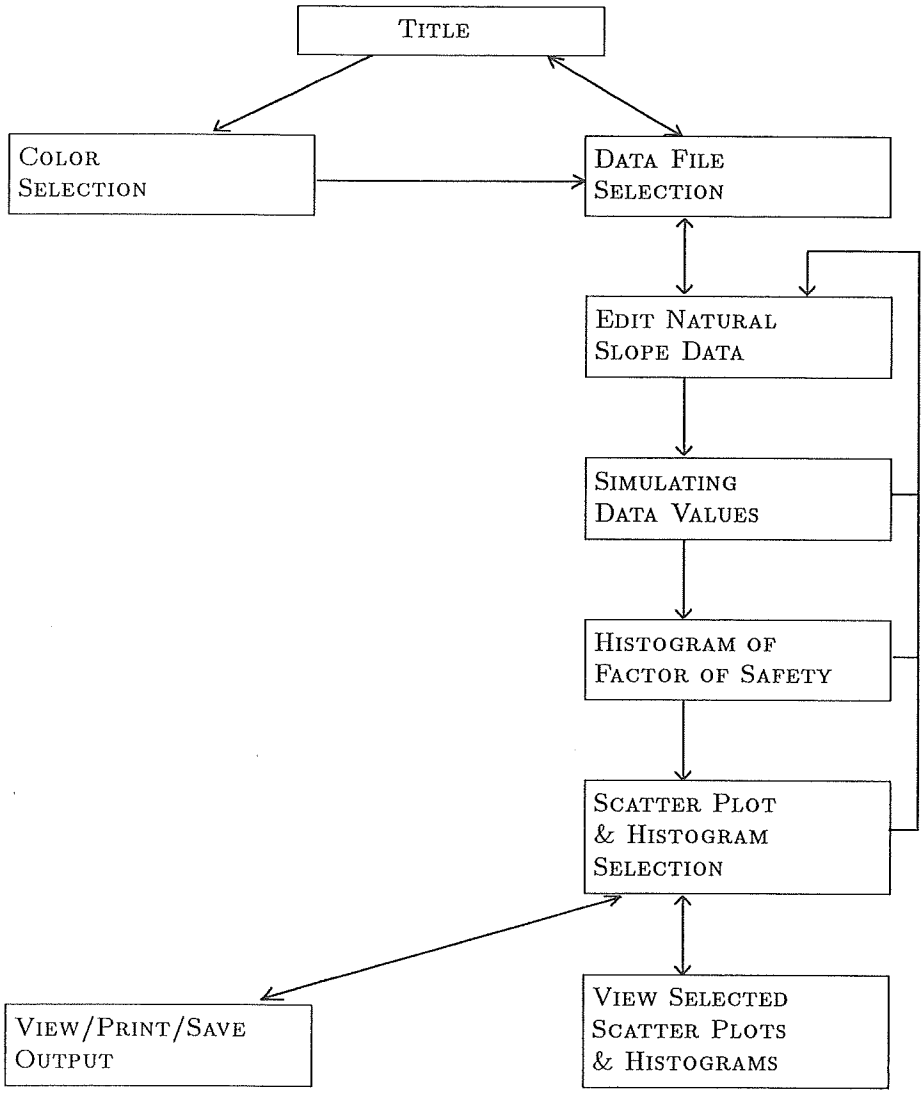


Figure 2.1—LISA screen structure.

- Single-character responses require that you press only that character, *without* pressing ENTER. Examples include selecting distribution **Plot** or file **Save** functions and answering yes-no questions. Single-character responses are displayed by a highlighted character. A default response for a yes-no question will be given and may be accepted by pressing ENTER. Either uppercase or lowercase is acceptable for single-character letter responses.
- An input that requires or allows more than a single-character response is typed into a highlighted input field and accepted by pressing ENTER. The length of the highlight indicates the maximum number of characters allowed for that entry. Invalid keystrokes are ignored. The previous response used is usually displayed in the highlighted field. Generally, this response may be edited by first pressing the backspace key,[5] thereby delet-

[5]The destructive backspace key looks similar to the nondestructive cursor left key. In this manual, we will reserve the symbol ← for the nondestructive cursor left key.

ing the character to the left of the cursor. Pressing a valid number or letter key first erases what had been in the highlight. Pressing [ENTER] at any time enters the response in the highlight at that time. An exception to the above behavior occurs when saving RESULTS or SIMULATED DATA files. Here valid characters are appended to the path shown in the highlighted filed without the need to first press the backspace key, and [ESC] clears the highlighted field (see section 3.20).

- Pressing [ESC] will back you up to the previous prompt, input field, or screen. Generally, pressing [ESC] while editing a highlighted input field will cancel any changes made for that input. If you have made changes to values of the input variables from the EDIT NATURAL SLOPE DATA screen and then press [ESC] to return to the DATA FILE SELECTION screen, you will be asked whether you want to save the changes.
- The bottom line or two on each screen display the currently available options that are selected by single keystrokes. Warning and error messages are displayed in windows in the middle of the screen and require pressing any key to continue program operation.
- [F10] is a quick exit to DOS. If any of the three data files has been modified, all three will be saved automatically, as `QUICK.SIT`, `QUICK.MTL`, and `QUICK.HYD`, in the appropriate map unit subdirectory. You may rename or erase these files from DOS. Pressing [ESC] from the TITLE screen will also return you to DOS.

CHAPTER 3 — DETAILED EXECUTION INSTRUCTIONS

This chapter is a detailed user guide for executing LISA. It shows screen images and describes program prompts, valid responses, and messages. In addition, demonstration entries are shown to illustrate some of the features of the program. To run the demonstration, you must first run `DEMO.BAT` from the LISA subdirectory. `DEMO.BAT` will create a subdirectory called `DEMO.MPU` under the LISA directory and copy the demonstration data files (`DEMO.SIT`, `DEMO.MTL`, and `DEMO.HYD`) to it.

3.1 Executing LISA

The system date and time should be set properly before invoking LISA, because LISA records the date and time of the simulation in the output files. In addition, system time is used to generate a seed (starting number) for the random number generator.

If you are running LISA from floppy disks, put the program disk in drive A and a formatted disk for data in drive B, make drive A the current drive, and at the DOS prompt, type `LISA` and press [ENTER]. If LISA is installed on a hard disk, change to the subdirectory containing the program, type `LISA` and press [ENTER]. (As discussed in section 1.2.2, you may run LISA from any directory as long as the DOS `PATH` statement includes the path to the subdirectory containing `LISARA.EXE`, `LISA.BAT`, and `BRUN45.EXE`.)

LISA will display the TITLE screen (fig. 3.1). From the TITLE screen, you may select the colors used in LISA by pressing [C] (see section 3.2), return to DOS by pressing [ESC], or proceed to the DATA FILE SELECTION screen by pressing any other key.

DEMONSTRATION

Execute `LISA` from the LISA subdirectory or another subdirectory as desired.

ERROR MESSAGE

```
Input run-time module path:
```

DOS issues this message upon trying to load LISA if it cannot find the file `BRUN45.EXE`. Press [CTRL]-[C] to return to the DOS prompt, and ensure that `BRUN45.EXE` is in the current directory or in DOS's `PATH`.

3.2 Selecting Colors

Pressing [C] from the TITLE screen brings up the COLOR SELECTION screen (fig. 3.2). From this screen you can select the colors for LISA to use for its menus, general text, prompts, and warnings by repeatedly pressing [M], [T], [P], and [W]. This screen is an exception to the general rule—it is case-sensitive. Each of menu,

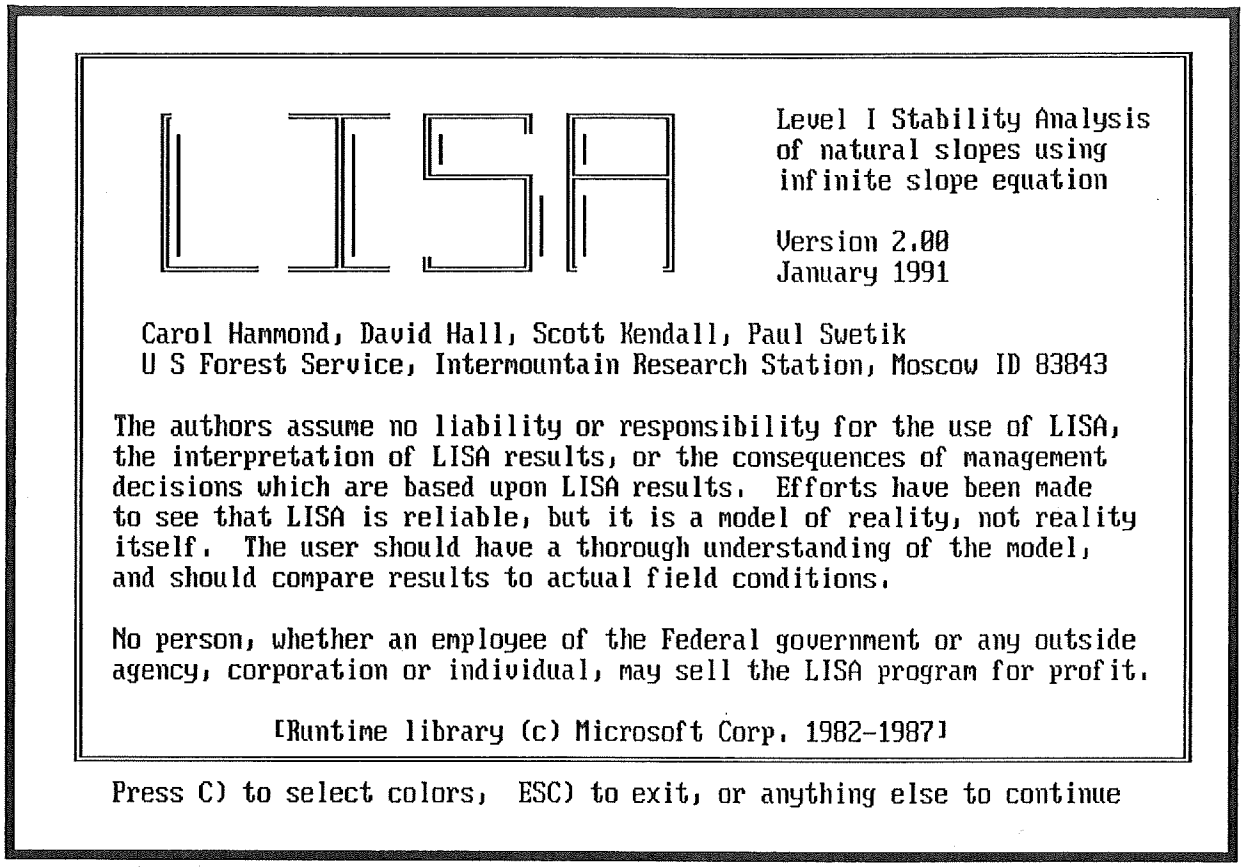


Figure 3.1—TITLE screen.

text, and prompts has two associated colors; by pressing the uppercase letter you change one of the colors, and by pressing the lowercase letter, you change the other. [<] causes the colors to cycle one direction, and [>] causes them to cycle the other way; the current direction is displayed highlighted in the lower right corner of the screen. The keys [,] and [.], the unshifted counterparts to [<] and [>], also work.

Press [Z] to select colors appropriate for monochrome display systems. Press [U] or [ENTER] to use the displayed colors for the current session only, or press [S] to save the color selection in the LISA configuration file `CONFIG.L1` in the subdirectory from which LISA was started. Press [ESC] to cancel any changes made and use the last set of colors saved. LISA will display the DATA FILE SELECTION screen after [U], [ENTER], [S], [Z], or [ESC] has been pressed.

3.3 Entering a User Name

The first prompt on the DATA FILE SELECTION screen is for a user name (fig. 3.3). A user name may be from 1 to 20 characters in length, and almost any character will be accepted. The name entered is stored in any site files the user saves and in the output files created during simulation. Type your name or initials and press [ENTER]. Pressing [ESC] from the `User name` prompt will return you to the TITLE screen.

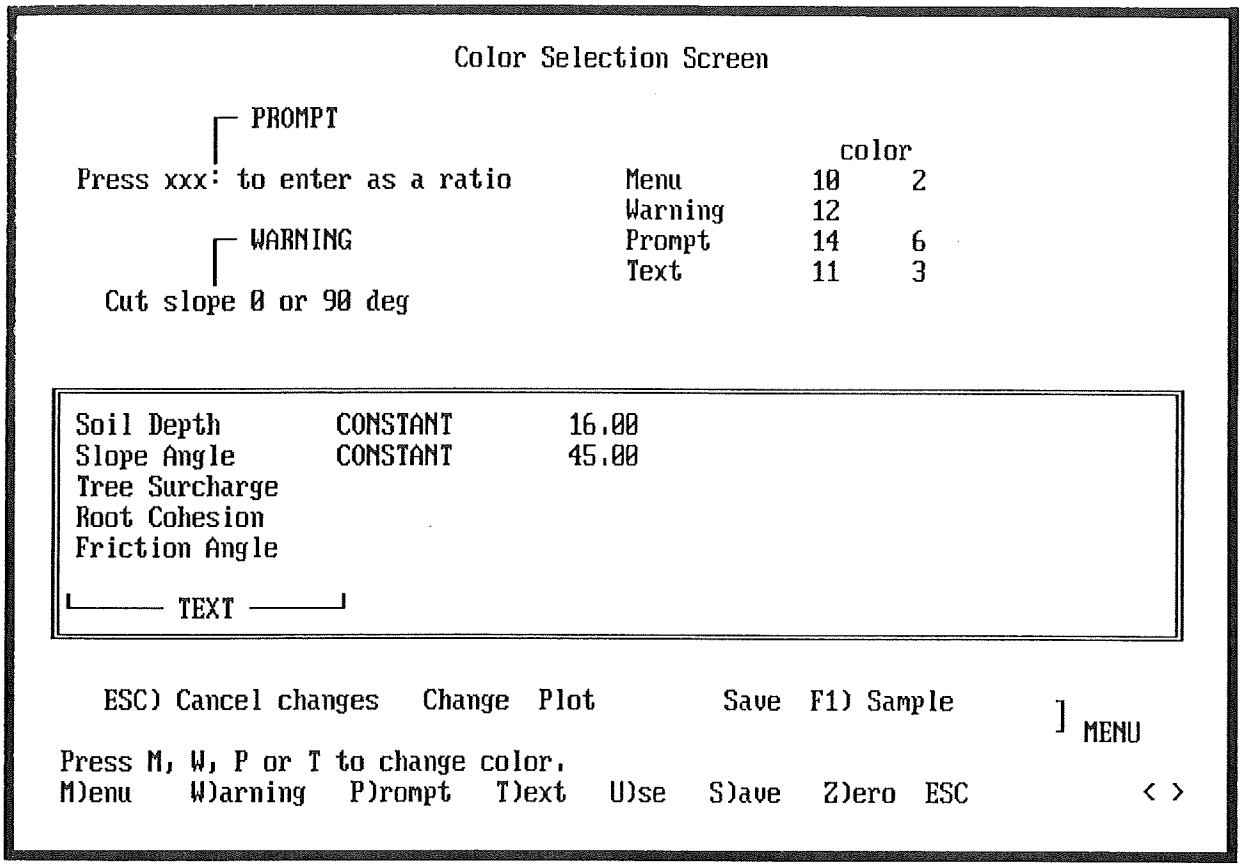


Figure 3.2—COLOR SELECTION screen.

ERROR MESSAGES

A name is required Press any key to continue

LISA will not let you proceed without entering a name.

DEMONSTRATION

Type your name and press ENTER.

3.4 Selecting the Path to Data (Map Unit) Subdirectories

After the user name is entered, LISA will display the current path to the data (.MPU) subdirectories and will prompt for the name of the map unit you want to use. It is under this path that any map units created and data files saved will be placed. All of the available map units will be shown in a window below the prompt.

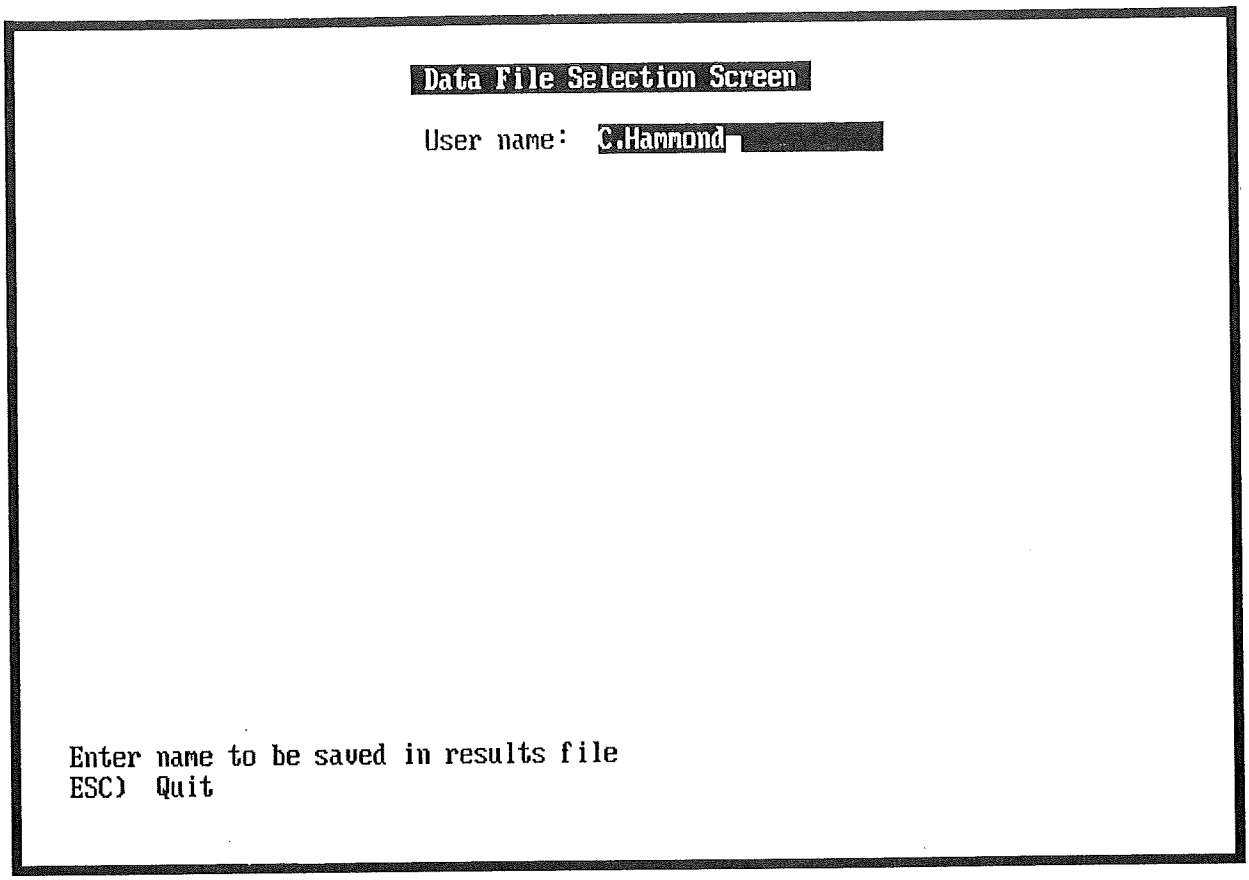


Figure 3.3—Entering a user name.

The first time LISA is started from a particular subdirectory, the path will be to that subdirectory. If you want to save data files to another disk or subdirectory, press ESC or ↑ to move the highlight up to the current path, and type the new path. As with any highlight, the current path can be edited by first pressing the backspace key. Pressing any other valid key first erases the current path. Pressing ENTER accepts the path in the highlight. The path to the data subdirectories may be changed any time LISA is executed, and the last path used will be displayed the next time LISA is run from the same directory.

ERROR MESSAGES

```
Invalid Path - drive or directory does not exist.
        Press any key to continue
```

This message occurs when an invalid path is entered. Be sure that you conform to DOS's naming convention for subdirectories and that the path that you specify names an existing subdirectory.

DEMONSTRATION

To have access to the data files for the demonstration, the path must point to the LISA program subdirectory, where `DEMO.MPU` was created and the demonstration data files stored. `DEMO.MPU` will be displayed in the window of available map units if the path is correct. Change the data path if necessary.

3.5 Selecting an Existing Map Unit

At the `Map unit to analyze:` prompt, the user has four choices:

1. Press [ENTER] or [↓] before entering a name at the map unit prompt, and the highlight will move into the window displaying the available map units. Use [SPACE] or the cursor-control keys ([←] [→] [↑] [↓] [PG UP] [PG DN] [HOME] and [END]) to move the highlight to the desired map unit and press [ENTER] to select it. The available map units are listed in alphabetical order from left to right, top to bottom. If you press [ENTER] at the map unit prompt when there are no available map units listed in the window, LISA will ask you to create a new map unit by displaying the message

```
Please create a new map unit by entering a name
        Press any key to continue
```

   There will be no available map units if the current path points to a subdirectory with no `.MPU` subdirectories. Either enter a name for a new map unit subdirectory, or press [ESC] to enter a different data path.
2. Type the name of the desired map unit and press [ENTER] (fig. 3.4). If the map unit entered does not exist, you will be asked whether you want to create it (see section 3.6).
3. Use DOS's wildcard convention to limit the list of available map units displayed in the window. Use `?` to match exactly one character, or `*` to match 1 or more characters. For example, an entry of `NEW*` would display all available map units whose names start with the letters `new` (as is shown in fig. 3.5); an entry of `NEW?1` would match such map unit names as `NEW11`, `NEW21`, and `NEW31`, but not `NEW231`. The desired map unit then may be selected by moving the highlight and pressing [ENTER].
4. Press [ESC] or [↑] to specify a different map unit path, as described in section 3.4.

ERROR MESSAGES

```
More than 100 map units found.
Press any key to continue
```

LISA can display no more than 100 map unit names at once. If more are found, only the first 100, in the order that they are stored in the disk directory, will be displayed as available map units. You should

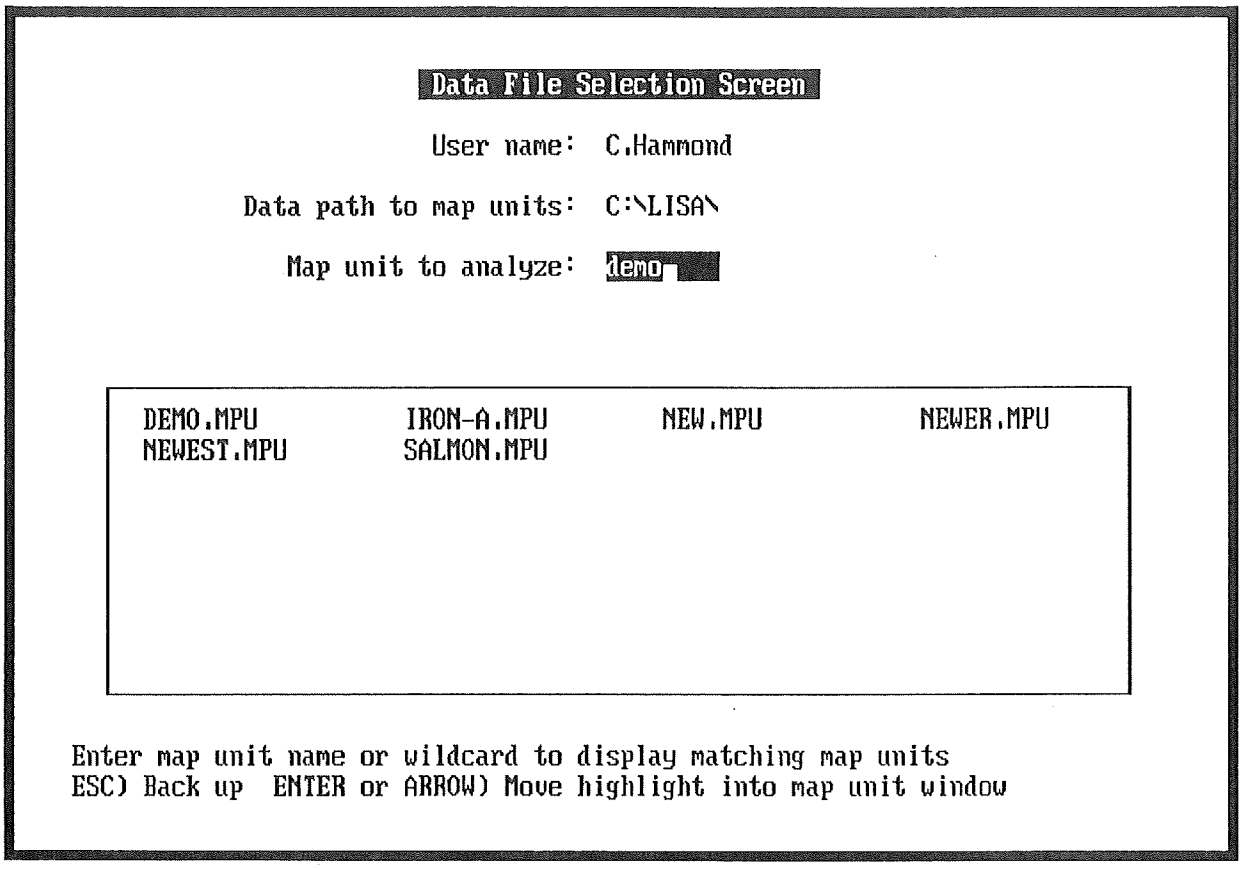


Figure 3.4—Selecting the DEMO map unit.

either move some of the .MPU subdirectories and their data files into another subdirectory, which cannot be done within LISA, or use the wildcard feature to limit the number of map units displayed.

```
More than 50 type data files found
Press any key to continue
```

LISA can display no more than 50 data files of any file type at one time (sections 2.2 and 3.8 explain file types). If more files are found when the map unit is selected, this message (with *type* being SITE, MATERIAL, or GROUNDWATER) will be displayed, and you will be able to access only the first 50 files in the map unit, in alphabetical order by file name. In order to access the rest of the files, you will have to delete some data files or move them into another map unit subdirectory. Section 3.9 describes how to delete data files from within LISA.

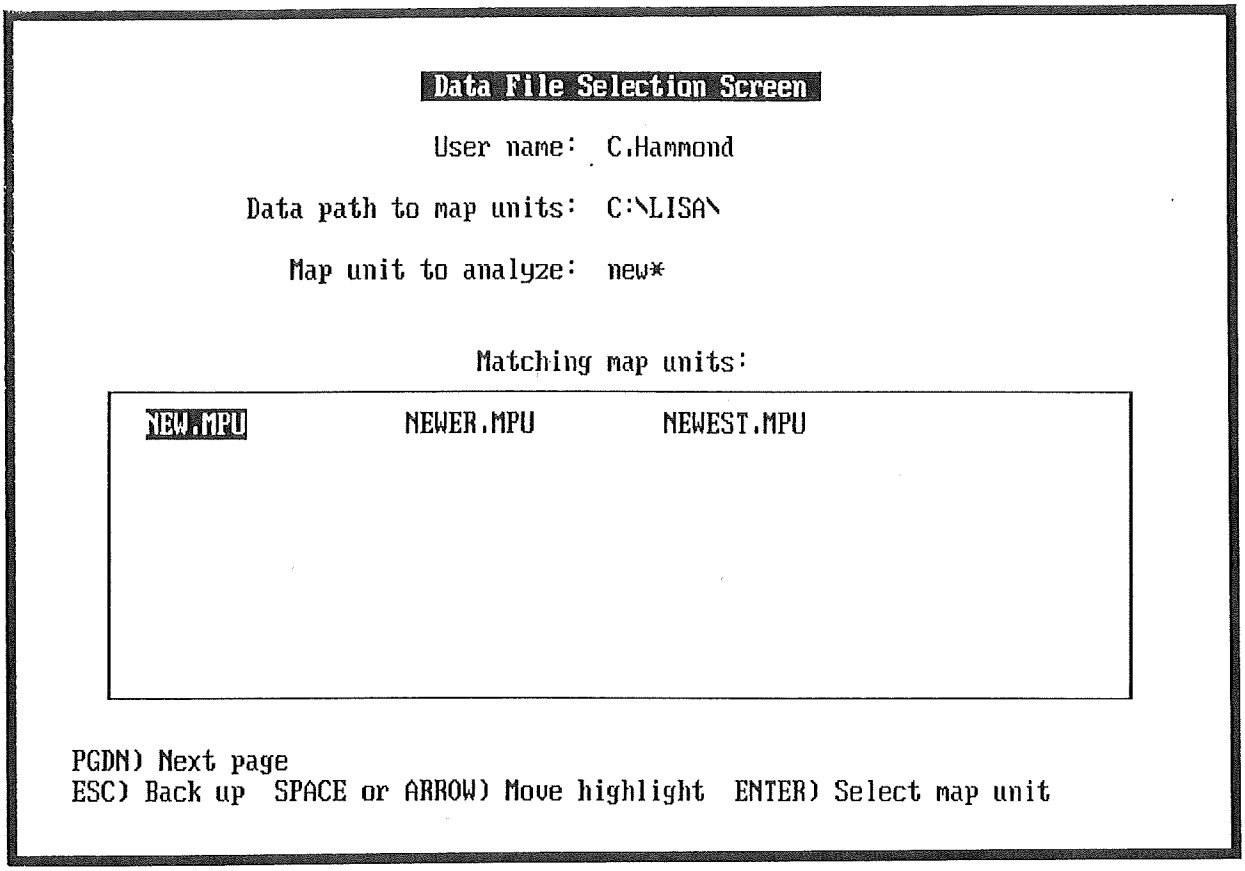


Figure 3.5—Displaying names of map units matching NEW*.

DEMONSTRATION

Select the DEMO map unit, as shown in figure 3.4, by typing demo at the `Map unit to analyze:` prompt.

3.6 Creating a New Map Unit

To create a new map unit, type a new name into the highlight at the `Map unit to analyze:` prompt and press [ENTER]. LISA will respond with:

`Create:` *drive*`:\`*datapath*`\`*map-unit-name*`.MPU? (Y/n)`

where the applicable drive, data path, and map unit name are shown. *Yes* is the default. Press [Y] or [ENTER] to create the map unit. Press [ENTER] again to select the new map unit, and LISA will go to the EDIT NATURAL SLOPE DATA screen where you can begin entering data. Because a map unit is actually a DOS subdirectory, the name you use must conform to DOS filename standards; that is, it must be one to eight characters long without blanks or punctuation. The program will ignore invalid characters in the input field, and an extension of .MPU is automatically added to the name.

3.7 Deleting an Existing Map Unit

Map units cannot be removed from within LISA. To delete a map unit subdirectory using DOS, the data files within that map unit must first be deleted and then the subdirectory removed.

3.8 Selecting Existing Data Files

LISA stores data in three types of files — site, material, and groundwater files. After a map unit has been selected, a window for each file type listing the names of available data files will be displayed, as shown in figure 3.6. You may proceed directly to the EDIT DATA screen to start a new problem, or you may select one or more existing data files to use or modify.

To select a data file, use SPACE or ← or → to first select a file type, and then ↑ or ↓ to highlight the desired file name, and press ENTER. PG UP and PG DN will display more file names if the window is full. After a file has been selected, its name will be displayed above the window. To "unselect" a selected data file, highlight the name of the selected file in the window and press ENTER.

DEMONSTRATION

Select the `DEMO` data file for each file type and press F1.

3.9 Deleting an Existing Data File

You may delete any LISA data file by highlighting the name of the file when it is displayed in the DATA FILE SELECTION screen and pressing DEL. LISA will ask you for confirmation with the message

`Delete` *drive*`:\`*datapath*`\`*filename* `(y/N)?`

Press Y to delete the file or any other key to keep the file.

3.10 Entering or Editing Data

Press F1 from the DATA FILE SELECTION screen to go to the EDIT NATURAL SLOPE DATA screen (fig. 3.7). If existing data files have been selected, the name of the file will be shown next to the file type title, and the distribution type and the values for the distribution parameters will be displayed next to each input variable name.

To enter or edit data, move the highlight to the desired variable and press ENTER. A window listing the available distribution types will be displayed, with the current distribution type highlighted (fig. 3.8). The current distribution is indicated also by a highlighted letter after the `Choose distribution (C-V):` prompt at the bottom of the window. Select a distribution type either by moving the highlight to the desired type and pressing ENTER or by pressing the letter indicated next to the distribution type.

The available distribution types are uniform, normal, lognormal, triangular, beta, histogram, and, for C_s' and ϕ', bivariate normal. Groundwater–soil depth ratio is limited to uniform, triangular, beta, and histogram to avoid simulation of D_w/D values that are negative or greater than 1. A constant value may also be specified for any variable.

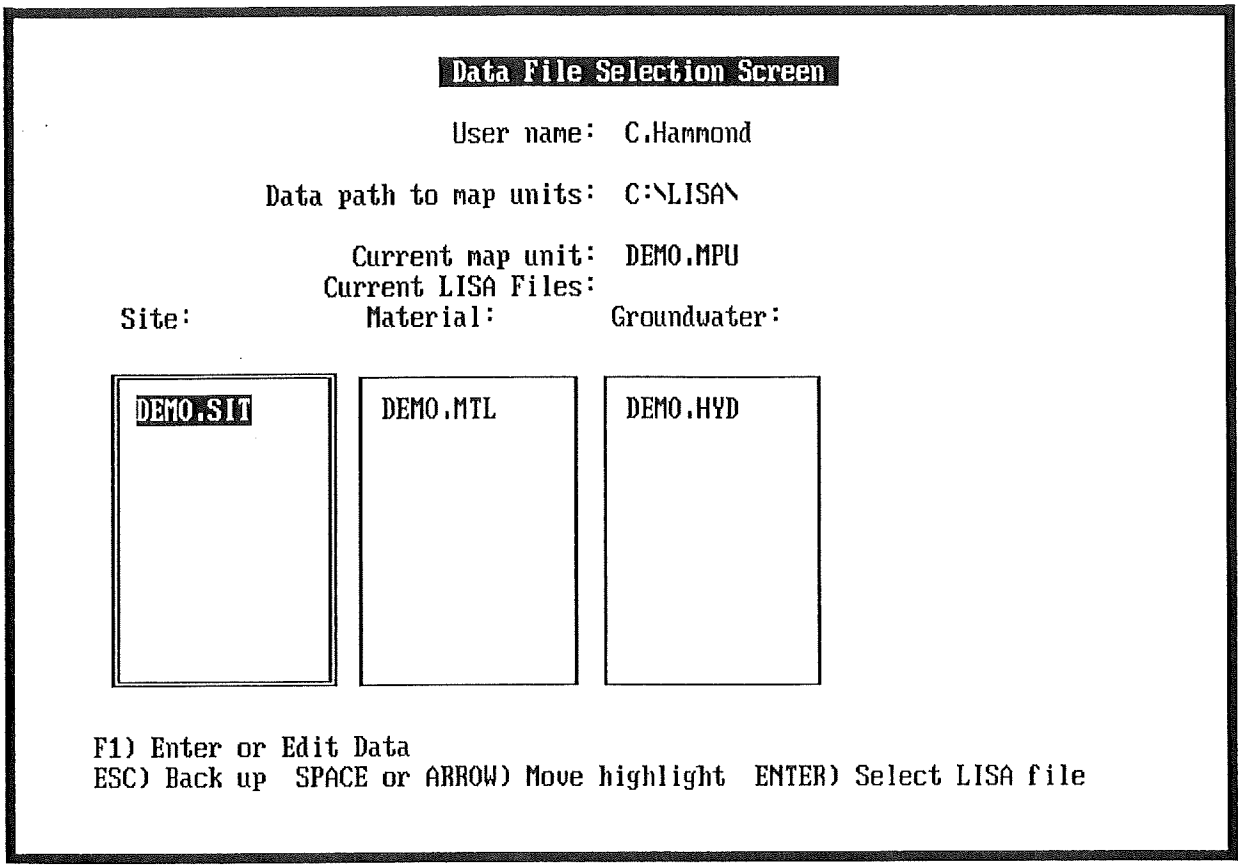


Figure 3.6—Windows listing the available files for each file type.

After selecting a distribution type, highlighted input fields prompting for values for the appropriate distribution parameters will appear to the right of the variable name. Figure 3.9 illustrates data entry for a triangular distribution. Any nonnegative number up to six characters in length, including an optional decimal point, may be entered into the input field. The backspace key may be used to edit the value in the highlight before pressing ENTER. ESC will return you to the previous prompt.

If you select the same distribution type for a variable as is currently specified (or, for soil cohesion and friction angle, you switch between normal and bivariate normal), the current values will be shown in the highlights. You may use these values by pressing ENTER, edit them by using the backspace key, or replace them by typing a new number.

F4 will take you to the DOS shell, which is handy for running DLISA or for issuing DOS commands, such as deleting or moving files, while LISA remains in memory. You must type EXIT at the DOS prompt to return to LISA. F4 is active only in the EDIT DATA and SCATTER PLOT AND HISTOGRAM screens.

To return to the DATA FILE SELECTION screen, press ESC. The names of the data files originally selected will be kept as the current files even if new data files have been saved. If you press ESC to return to the DATA FILE SELECTION screen without saving modified data files, the following message will be displayed:

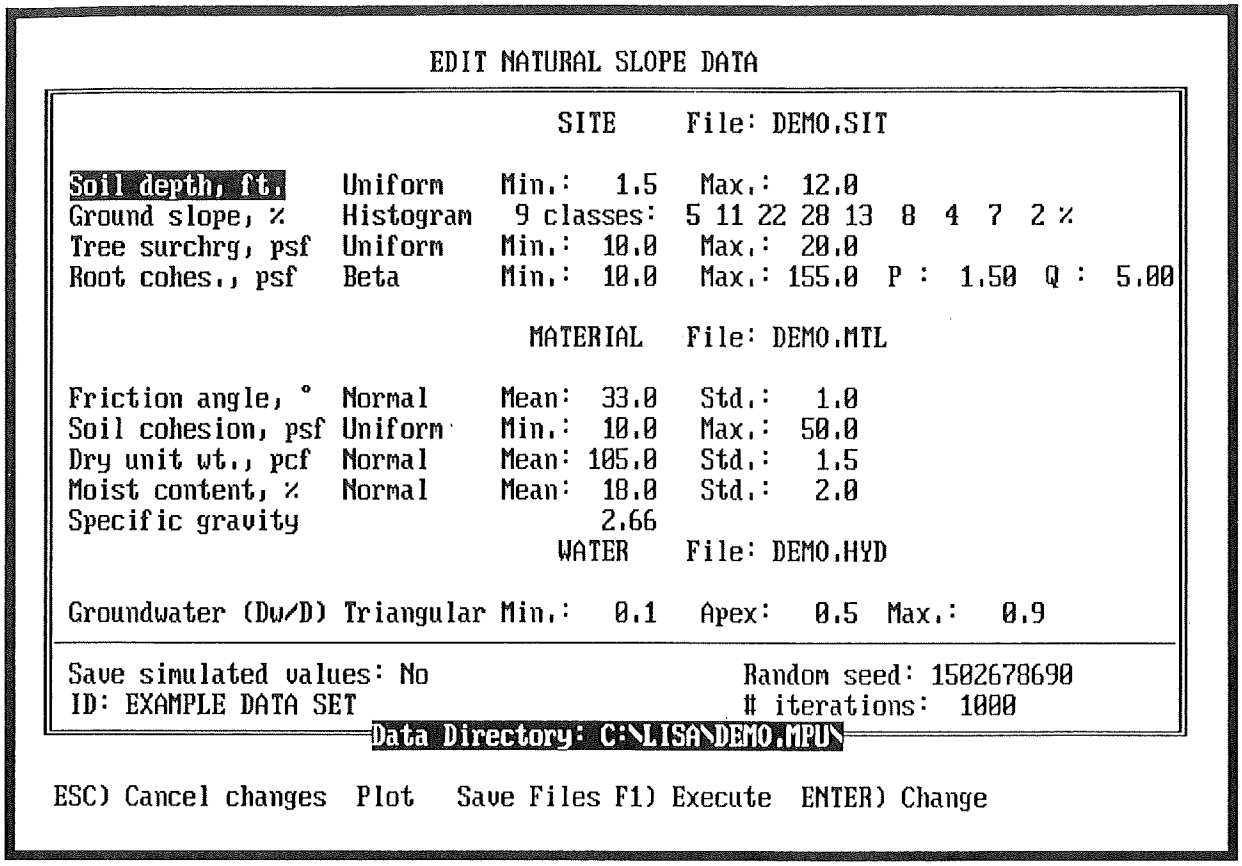
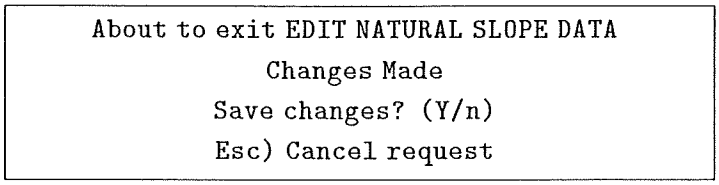


Figure 3.7—The content of the DEMO data files displayed on the ENTER NATURAL SLOPE DATA screen.



If you press N, any changes made will be lost. Section 3.13 explains how to save data files.

In sections 3.10.1 through 3.10.8, we comment on each distribution type and explain the required inputs and the error messages that might occur during data entry.

DEMONSTRATION

To illustrate editing data (as shown in fig. 3.9):

- Move the highlight to `Soil depth` and press ENTER.
- Move the highlight to `Triangular` and press ENTER, and the prompt for the minimum value for the distribution will appear next to `Soil depth`.
- Press 1 . 5 ENTER, and the prompt for the apex value will appear.
- Press 4 ENTER, and the prompt for the maximum value will appear.
- Press 1 2 ENTER, and the changed distribution will be shown for soil depth. The highlight will move down automatically to the next variable (ground slope).

DEMONSTRATION

To illustrate changing values with the same distribution type:

- Move the highlight to `Friction angle` and press ENTER.
- Press ENTER again to select `Normal`, which is the current distribution type. The prompt for the mean value will have the current value (33°) as the default.
- Press the backspace key, then 4 ENTER to change the mean value from 33° to 34°.
- Press ENTER to accept the default (current) value for the standard deviation.

3.10.1 Constant Value

Any input variable may be given a constant value. No error message is issued.

3.10.2 Uniform Distribution

The uniform distribution is specified by a minimum value and a maximum value.

ERROR MESSAGES

```
Maximum must be greater than minimum
Press any key to continue
```

3.10.3 Normal Distribution

The normal distribution is specified by the mean and standard deviation. The normal distribution used in LISA is a "constrained" distribution—no values less than the mean minus 3.09 standard deviations nor greater than the mean plus 3.09 standard deviations are returned. In addition, you are not allowed to specify a distribution that would return negative values within this range.

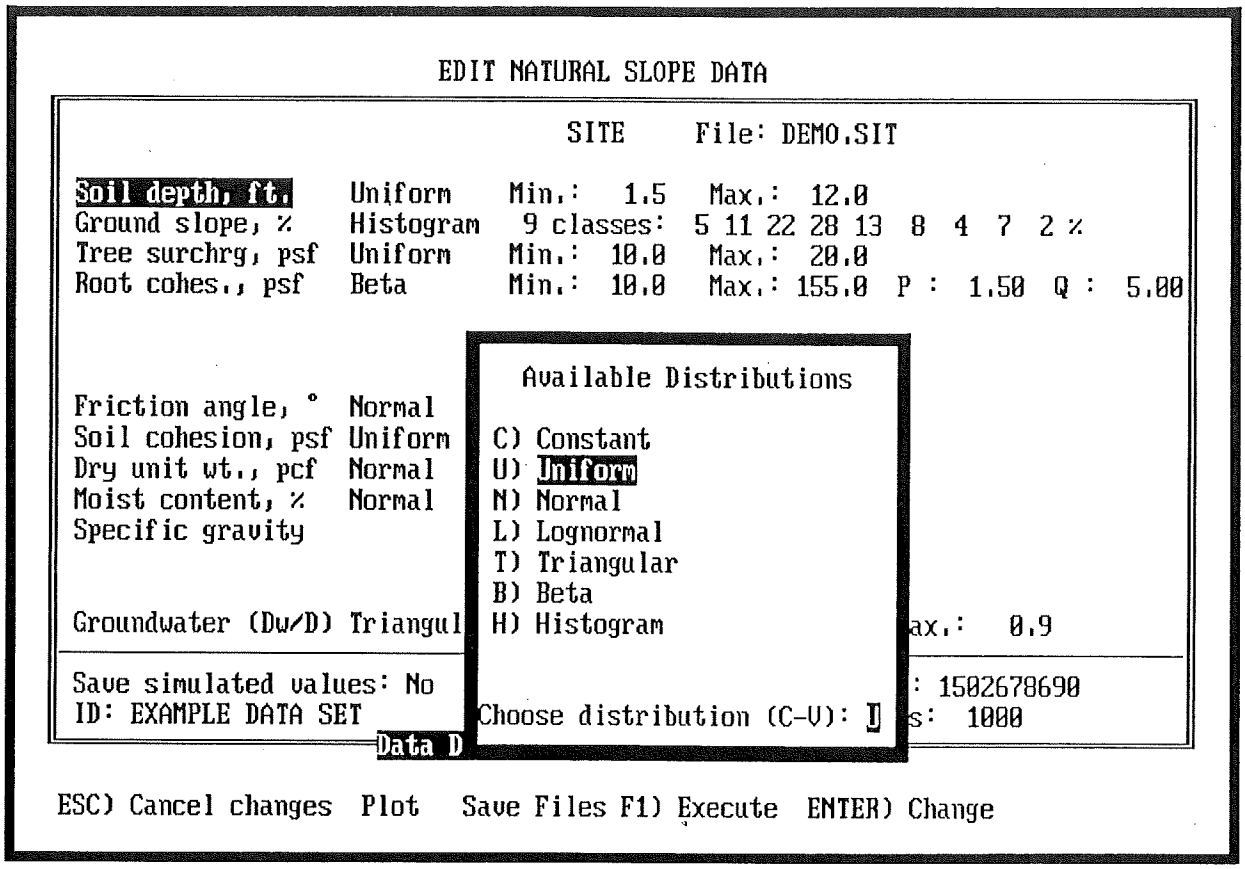


Figure 3.8—Selecting a probability distribution type.

ERROR MESSAGES

```
Values < 0 possible (mean - 3.09s <= 0)
Press any key to continue
```

To prevent the sampling of negative values, LISA checks to ensure that the mean (μ) minus 3.09 times the standard deviation (s) is positive. If it is not, this message will be displayed. After pressing a key, enter either a larger mean or a smaller standard deviation such that $\mu - 3.09s > 0$.

```
Standard deviation must be greater than zero
Press any key to continue
```

LISA will not allow you to specify a normal distribution with a standard deviation of zero.

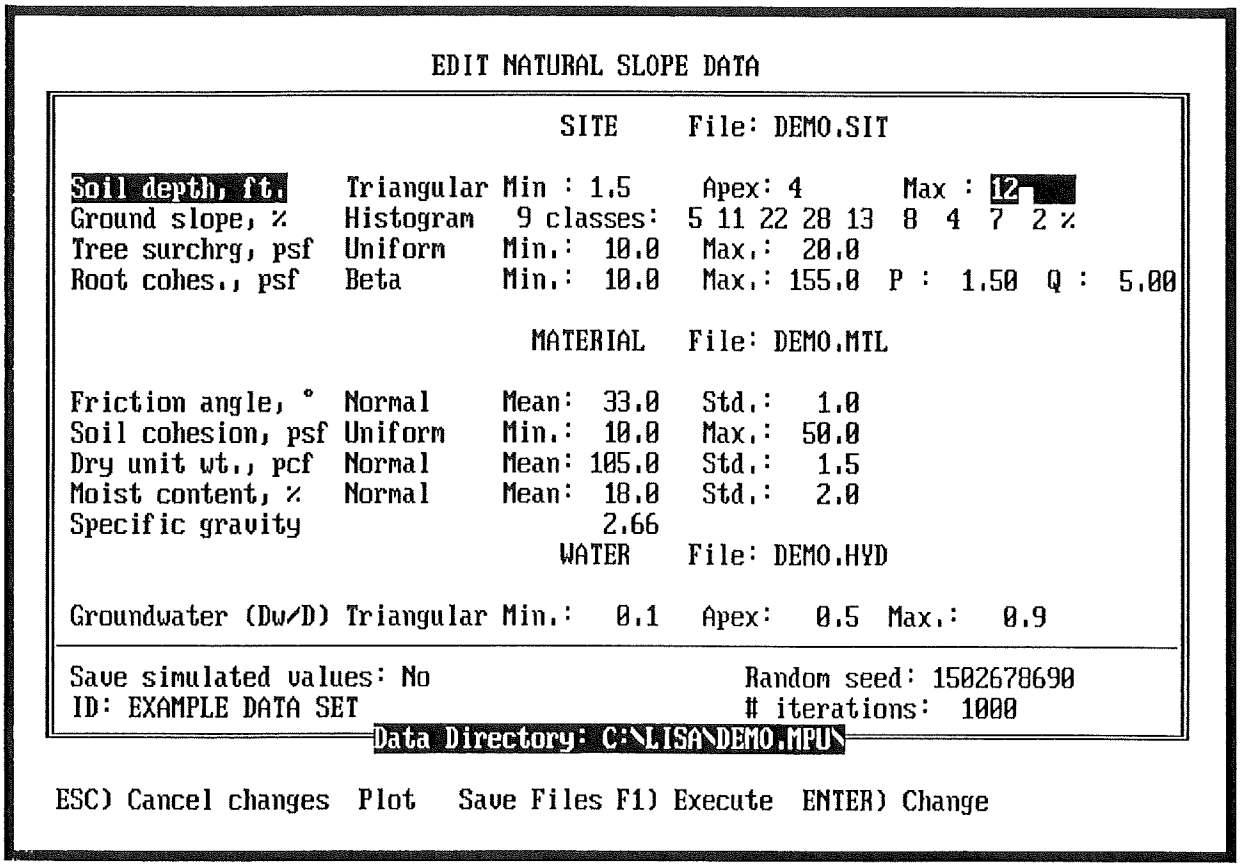


Figure 3.9—Editing the triangular distribution for soil depth.

3.10.4 Lognormal Distribution

The lognormal distribution is specified by the mean and standard deviation of the distribution, in the units of the variable to be simulated (*not* in the logarithm of the units of the variable).

ERROR MESSAGES

```
Zero mean not allowed
Press any key to continue
```

LISA will not allow you to specify a lognormal distribution with a mean of zero.

```
Standard deviation must be greater than zero
Press any key to continue
```

LISA will not allow you to specify a lognormal distribution with a standard deviation of zero.

3.10.5 Triangular Distribution

The triangular distribution is specified by a minimum value, a most likely (apex) value, and a maximum value.

ERROR MESSAGES

```
Apex must not be less than minimum
Press any key to continue
```

```
Maximum must not be less than apex
Press any key to continue
```

```
Maximum must be greater than minimum
Press any key to continue
```

3.10.6 Beta Distribution

The beta distribution is specified by a minimum value, a maximum value, and two shape parameters, P and Q. P and Q may be any positive real number, but values greater than 1 produce distribution shapes that better model the typical spatial distributions of the physical factors in the infinite slope model.

It takes approximately 2.5 minutes on an 8086 machine, 70 seconds on an 80286 machine, 15 seconds on an 80386 machine, and 7 seconds on an 80486 machine to simulate 1,000 values from a typical beta distribution if the machine has a math co-processor; without one, expect to wait about 10 times as long. Beta distributions with one shape parameter (P or Q) less than 1 take somewhat longer to simulate. Because the beta distribution takes longer to simulate than do the other distributions, LISA displays the message

```
Simulating Beta nnnn
```

and displays the iteration number to assure the user that the program is operating.

ERROR MESSAGES

```
Maximum must be greater than minimum
Press any key to continue
```

```
P must be greater than zero
Press any key to continue
```

```
Q must be greater than zero
Press any key to continue
```

3.10.7 Histogram Distribution

The histogram distribution is specified by the number of classes to be used, the minimum and maximum value for each class, and the percentage of observations in each class. LISA allows at most 10 classes to be used, and the classes are assumed to be contiguous (therefore, the minimum for one class is the maximum of the preceding class); however, any class may have zero observations specified.

Only the number of classes and the percentage of observations in each class are displayed on the EDIT NATURAL SLOPE DATA screen. To see the minimum and maximum values for each class, you must either plot or edit the distribution. Figure 3.10 shows a nearly completed entry for a nine-class histogram distribution for ground slope.

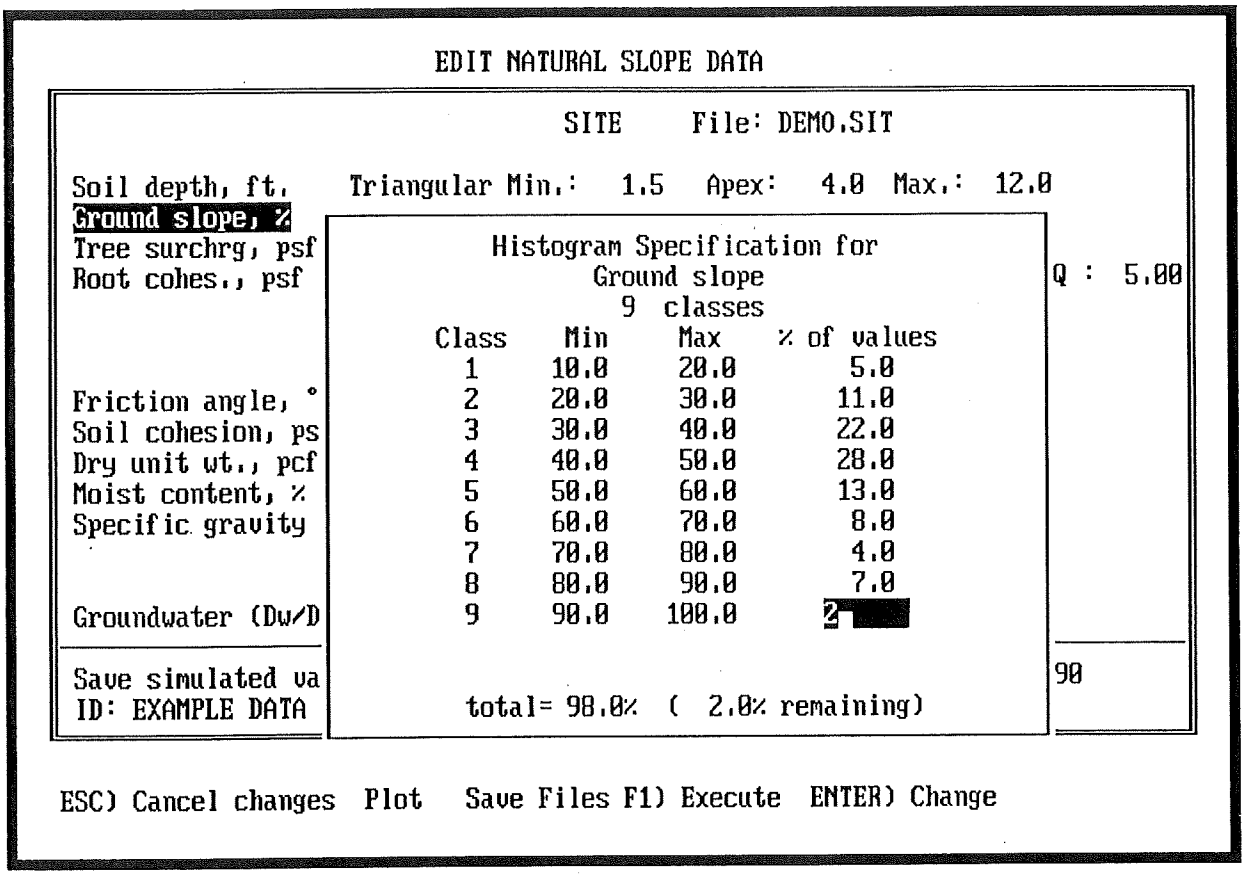


Figure 3.11—Entering values for the histogram distribution.

When entering a new histogram, LISA assumes that the histogram is to have classes of equal width. If this is the case, you need enter only the minimum and maximum for the first class, and the percentage in each class. As you step through the input, the correct minimum (the previous class's maximum) and a suggested maximum (for a class of the same width as the first class) are displayed. You may change the class widths as you go. In addition, a running sum of the percentages from each class and the value needed to make the total equal 100 percent are displayed at the bottom of the window. The default value for percentage for the last class will make the total 100 percent.

ERROR MESSAGES

```
# of classes must be between 1 and 10
Press any key to continue
```

The number of classes must be between 1 and 10, inclusive.

```
Maximum must be greater than minimum
Press any key to continue
```

Classes of zero or negative width are not allowed.

```
% must be between 0 and 100
Press any key to continue
```

No class may have more than 100 percent of the observations.

```
Total percentage exceeds 100%
Press any key to continue
```

```
Total percentage less than 100%
Press any key to continue
```

One of these messages is displayed if the total percentage of all classes in the histogram does not equal 100 percent.

3.10.8 Bivariate Normal Distribution

In LISA version 2.0, linear correlation between C_s' and ϕ' can be considered only with the bivariate normal distribution. When bivariate normal is selected for either C_s' or ϕ', you will be prompted for the mean and standard deviation for each variable, and the correlation coefficient (r) between the two.

Although the lower limit of the marginal normal is checked to see that the mean minus 3.09 times the standard deviation is greater than or equal to zero, it is still possible to get a negative value using the bivariate normal if the lower limit is equal to (or very close to) zero. If this occurs, the negative value will be shown on the STATISTICS OF SIMULATED DATA screen. The user should then adjust the mean or standard deviation to give a slightly larger minimum value for the marginal distribution, or run the simulation again with a new random number seed until no negative values are simulated.

WARNING AND ERROR MESSAGES

```
Friction angle will be changed to normal
Press any key to continue
```

If $C_s' - \phi'$ is specified as bivariate normal and you change C_s' to a univariate distribution, LISA automatically changes ϕ' to a univariate normal with the same mean and standard deviation it had in the bivariate normal.

```
Soil cohesion will be changed to normal
Press any key to continue
```

If C'_s — ϕ' is specified as bivariate normal and you change ϕ' to a univariate distribution, LISA automatically changes C'_s to a univariate normal with the same mean and standard deviation it had in the bivariate normal.

```
Values < 0 possible (mean - 3.09s <= 0)
Press any key to Continue
```

As with the normal distribution, LISA will not allow you to enter a mean (μ) and standard deviation (s) that would cause $\mu - 3.09s$ to be negative. This reduces the likelihood of returning negative values for C'_s or ϕ'. Enter a larger mean value or a smaller standard deviation such that $\mu - 3.09s > 0$.

```
Make phi bivariate also
Press any key to continue
```

If you select the bivariate normal distribution for soil cohesion and enter all of the values for C'_s, then press ESC while entering the mean for ϕ', LISA will display this message. You must enter a mean and standard deviation value for ϕ'.

```
Make Cs bivariate also
Press any key to continue
```

If you select the bivariate normal distribution for friction angle and enter all of the values for ϕ', then press ESC while entering the mean for C'_s, LISA will display this message. You must enter a mean and standard deviation value for C'_s.

```
r must be between -1 and 1
Press any key to continue
```

The correlation coefficient r must be between -1 and 1, inclusive.

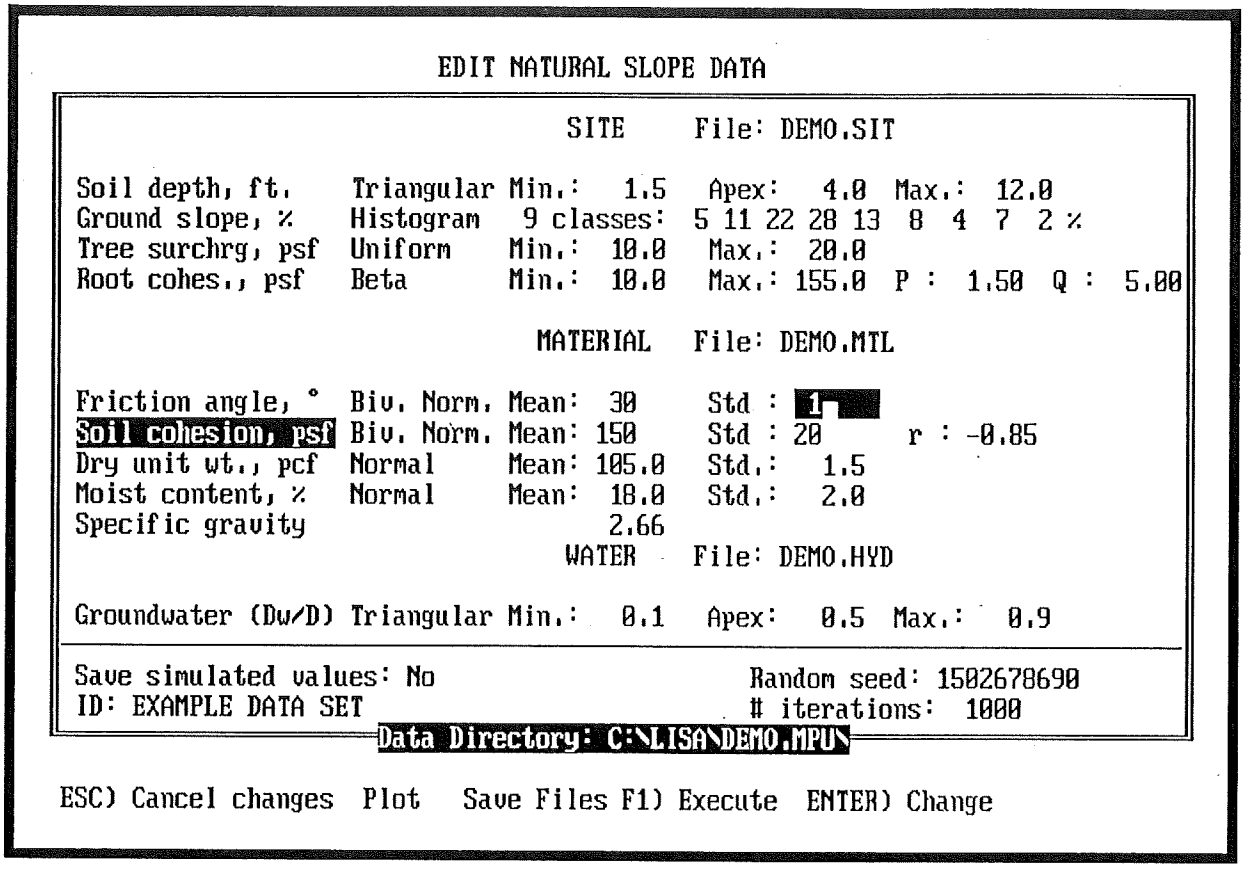


Figure 3.11—Entering values for a bivariate normal distribution for C_s' and ϕ'.

DEMONSTRATION

The highlight should be on soil cohesion after making changes to friction angle. To illustrate the use of the bivariate normal distribution for C_s' and ϕ' (see fig. 3.11):

- Press ENTER, move the highlight to `Bivariate Normal`, and press ENTER (or simply press V).
- Enter `150` for the mean, `20` for the standard deviation, and `-0.85` for r.
- A prompt for the mean friction angle will appear. Enter `30` for the mean and `1` for the standard deviation.

The bivariate normal distribution is now shown as the current distribution for both soil cohesion and friction angle, with the value for r shown once for each variable.

DEMONSTRATION

We will now change friction angle to be a uniform distribution:

- Move the highlight to `Friction Angle` and press [ENTER].
- Select `Uniform`.
- Enter 20 for the minimum and 30 for the maximum.
- Notice the message in the center of the screen. Press any key, and the cohesion specification will change to a normal distribution with a mean of 150 and a standard deviation of 20.

3.11 Plotting Distributions

To plot the shape of the specified probability density function (PDF) for any variable (except G_s) from the EDIT DATA screen, highlight the desired variable and press [P]. Plotting the PDF is particularly helpful for previewing the shape of the beta and lognormal distributions; the limits of data simulation for the normal, bivariate normal, and lognormal distributions; the effect of the correlation coefficient for the bivariate normal distribution; and the classes and limits for the histogram distribution. If unequal class widths are used, the plot of the histogram PDF might appear different from the relative-frequency histogram (see part 1, section 2.18); the PDF is true to what will be sampled. A plot of the bivariate normal distribution (for C'_s and ϕ') shows a rough contour plot of the probability surface. The limits of the bivariate normal plot are $\mu \pm 3s$ (the mean plus or minus three times the standard deviation) for each variable; sampled values generally fall within this range, but a few outliers may be expected. Figure 3.12 shows an example of a plot of a normal distribution.

If the **Plot** option is not shown on the bottom line of the screen, then LISA does not recognize that your system supports graphics and it will ignore your plot request. In some cases, LISA may not recognize that your system supports graphics when it actually does; for example, if you are using a video board that emulates CGA graphics on a monochrome monitor. In this case, try switching the active display adapter to the Color/Graphics Monitor Adapter by typing `MODE CO80` from DOS before invoking LISA.

To return to the EDIT DATA screen after viewing the plot of a uniform, triangular, or histogram distribution, press any key. These three distributions cannot be modified while viewing the plot. Section 3.12 discusses how to return after viewing the other distribution types.

ERROR MESSAGES

```
Zero standard deviation
Press any key to continue
```

This message is displayed when you try to plot a normal, bivariate normal, or lognormal distribution with a standard deviation of zero. It should never be displayed unless the input data files have been modified outside of LISA.

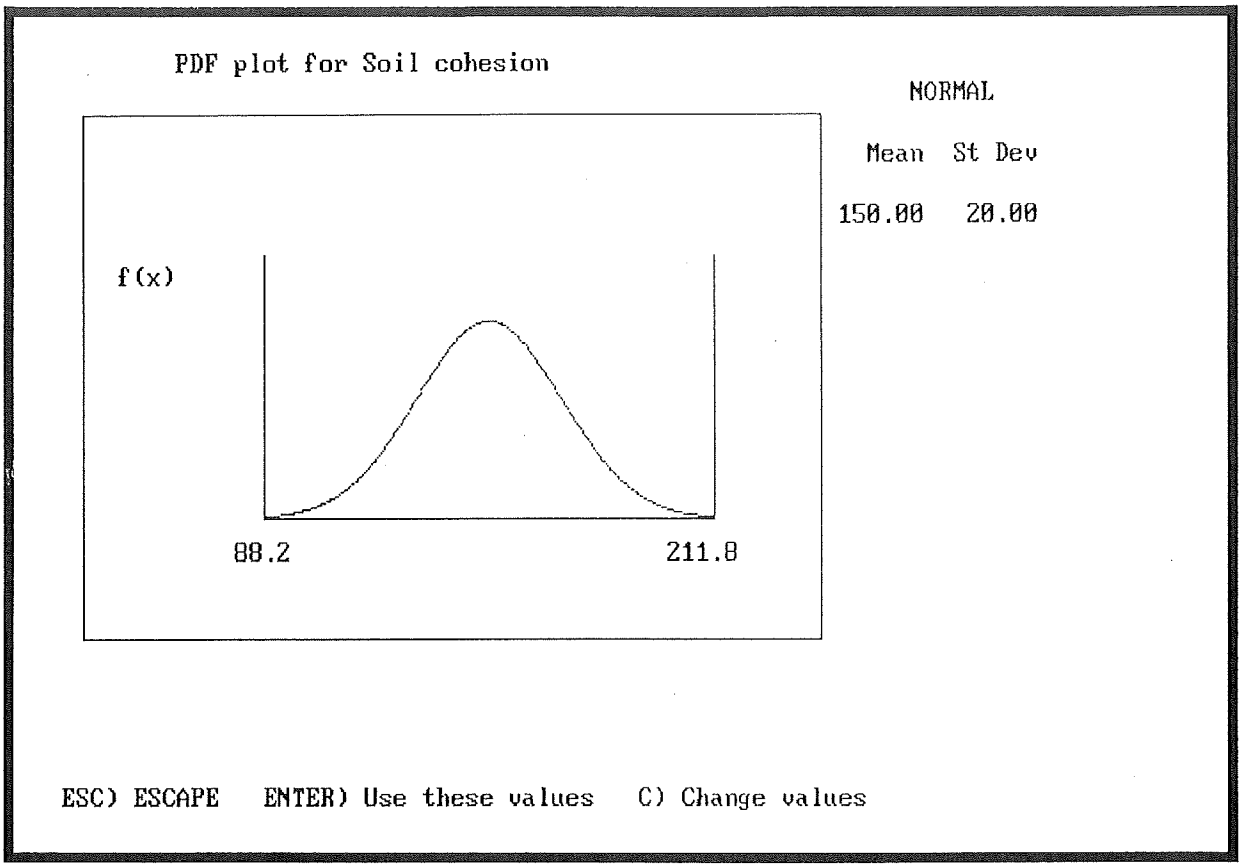


Figure 3.12—A plot of a normal distribution with mean 150 and standard deviation 20. LISA will sample values between 88.2 and 211.8 (the mean plus and minus 3.09 times the standard deviation).

```
Selected parameter is a constant
Press any key to continue
```

This message is displayed when [P] is pressed for a variable that has been defined to be a constant.

DEMONSTRATION

With `soil cohesion` highlighted, press [P] to view the normal distribution. It should look like figure 3.12. Press [ENTER] to return to the EDIT DATA screen.

3.12 Modifying Distributions While Plotting

The shape of distributions and sampled endpoints can change as the values of the parameters describing the distribution are changed. For the uniform and triangular distributions, the changes in shape and endpoints should be obvious; for

the others, the changes are not as obvious. To help in selecting proper values, you can change some parameter values while viewing the plot of the normal, lognormal, beta, and bivariate normal distributions and observe the change in shape or endpoints or both. LISA does not allow you to change parameter values for the uniform, triangular, or histogram distribution while viewing the plot; you will have to return to the DATA ENTRY screen to modify these distribution types.

For the beta distribution, the mode and skewness change as you change the values of the shape parameters P and Q. LISA does not allow you to change the endpoints of the beta while displaying the plot. If you make multiple changes to the beta distribution parameters, each curve will be shown on the same plot until you press SPACE to erase previous plots. For the lognormal distribution, the mode, skewness, and limiting values can all change as you change the values of mean and standard deviation. The current lognormal distribution plot will be erased before a new one is displayed. Only the sampling endpoints change as the mean and standard deviation of the normal distribution change. The values for the new endpoints will be displayed. The normal distribution routine will not return values outside the displayed range. The endpoints and surface shape of the bivariate normal PDF will change as the standard deviations and correlation coefficient change. (LISA does not allow you to change the mean values while displaying the bivariate normal plot.) Unlike the normal distribution routine, the bivariate distribution routine does not limit the range of returned values, so a small percentage of values may be expected to fall outside the indicated range.

To change the distribution values while viewing the plot, press C and the cursor (a small block) will appear in the display of distribution values in the upper right corner of the screen. The input field is not in reverse video, as it is in most other LISA screens; as always, however, the current value may be edited by pressing the backspace key, accepted with ENTER, or replaced by a new value. Figure 3.13 shows an example of a plot of two beta distributions.

You may return to the EDIT DATA screen in one of two ways—by pressing ESC to return with the original distribution parameter values, or by pressing ENTER to return with the current distribution parameter values.

ERROR MESSAGES

```
Zero mean not allowed.
```

```
Non-positive standard deviation.
```

LISA allows only strictly positive values for the mean and standard deviation for normal, lognormal, and bivariate normal distributions.

```
Values < 0 possible (mean-3.09s <= 0).
```

LISA truncates the normal distribution at the mean plus and minus 3.09 times the standard deviation, and checks the lower limit to see that it is not negative. The bivariate normal distribution is not truncated, but the check is still made to reduce the likelihood of sampling negative values.

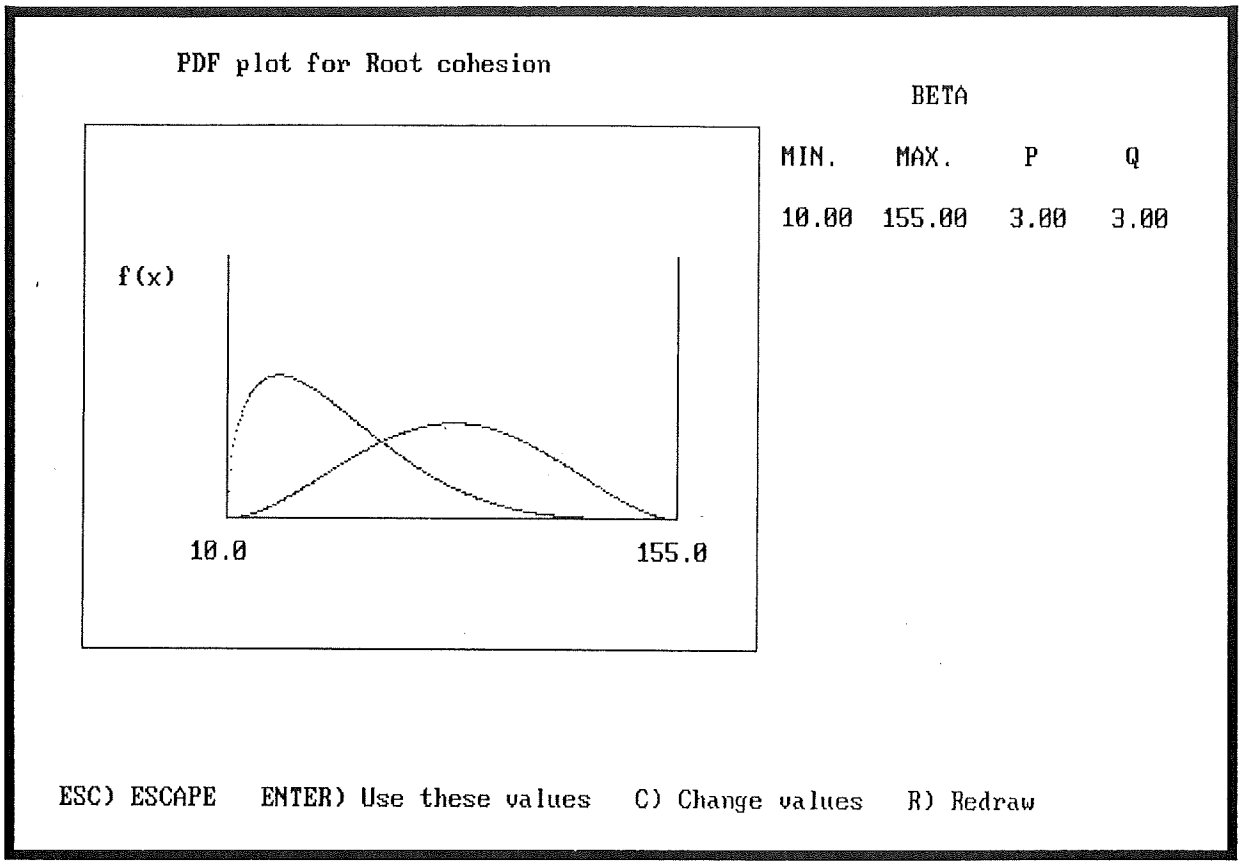


Figure 3.13—A plot of two beta distributions, one with shape parameters P and Q of 1.5 and 5; the other with P and Q of 3 and 3.

P must be greater than zero.

Q must be greater than zero.

Both shape parameters for the beta distribution must be greater than zero.

DEMONSTRATION

- Move the highlight to `Root cohesion` and press [P] to display the shape of the PDF for the specified beta distribution.
- Press [C] to change P and Q.
- Enter [3] for both P and Q, and a symmetrically shaped beta PDF will be shown (fig. 3.13).
- Press [ESC] to return to the EDIT DATA screen keeping the original P and Q values.

3.13 Saving Data Files

To save the current data to disk, press [S] from the EDIT DATA screen, and a window listing the three file types and the current file name, if any, for each will be displayed. Using [↑] and [↓], move the highlight to the type of file that you want to save, and enter a file name using the standard LISA approach. File names must conform to DOS's filenaming conventions (one to eight characters long without spaces or punctuation). Do not include a file extension. You do not need to save all three types of files nor use the same file name for each file type.

If you enter the name of an existing file, LISA will respond with "`Overwrite File (y/N)?`". To keep from losing the existing file of that name, press [N] or [ENTER] or [ESC] and LISA will allow you to enter another file name. To save the current parameter specifications under the same file name, thereby losing the previous contents of the file, press [Y].

You do not have to save the data to disk before you start the simulation. This allows you to run LISA in an iterative manner, making several LISA runs and saving to disk only those datasets you feel are important for future use. To prevent unintentional loss of data, you will be asked when you leave the EDIT DATA screen by pressing [ESC] whether you want to save the current data (see section 3.9). In addition, if any changes have been made to the data, the datasets will be saved as files `QUICK.SIT`, `QUICK.MTL`, and `QUICK.HYD` in the current map unit subdirectory when you exit LISA using [F10], as explained in section 3.21.

DEMONSTRATION

- Press [S] from the EDIT DATA screen.
- Type `NEW` and press [ENTER] for the site file name, and the site data will be saved as file `NEW.SIT`. (Note that if someone has already run through the demonstration, file `NEW.SIT` may already exist and LISA will ask whether to overwrite it. Press [Y] or press [N] and enter a different name.) The material file name will now be highlighted.
- Press [ENTER] to save the modified material data as file `DEMO.MTL`. Because file `DEMO.MTL` already exists, LISA will ask whether you want to overwrite it (see figure 3.14). Press [N], and enter a different name.
- Press [ESC] to return to the EDIT DATA screen, since we do not want to save the groundwater data to disk.

3.14 Saving Simulated Values

You may ask LISA to save the sampled (simulated) values of all of the input variables and the calculated factors of safety in a file called `SIMULATE.OUT` in the current map unit subdirectory. `SIMULATE.OUT` will be sorted from lowest to highest value of factor of safety, facilitating examination of the combinations of input variables that generated the lowest factors of safety to determine whether those combinations actually exist in nature. If they do not, the simulation results may be unrealistic. Because histograms of the simulated values for any variable and scatter plots of any pairing of variables are available from within LISA, you may rarely need this option. However, we feel that it is important to

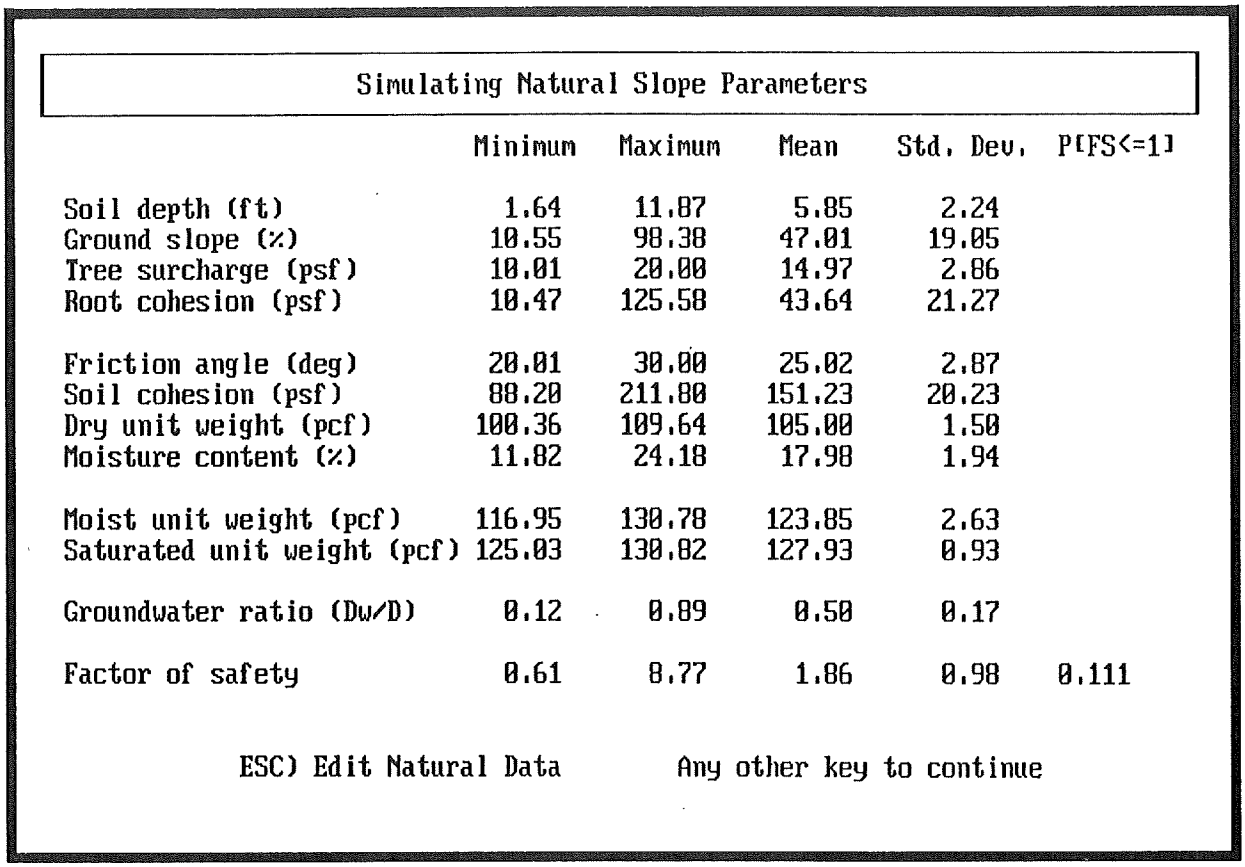


Figure 3.14—Screen for saving data files. The user has just saved the site data as file NEW and has asked to save the material data as file DEMO, which already exists.

have available the actual numbers used. `SIMULATE.OUT` will be about 80 kilobytes long for a simulation of 1,000 iterations. Section 3.21 shows part of an example `SIMULATE.OUT` file and describes how to view, print, and rename it.

To tell LISA whether to save the sampled values, highlight the `Save simulated values:` prompt on the EDIT DATA screen and press ENTER. You will then be asked to press Y if you want to save the values, or N if not.

DEMONSTRATION

Move the highlight to `Save simulated values:` and press ENTER followed by Y.

3.15 Entering a Descriptive Comment ("ID")

You may add a descriptive comment of up to 40 characters in length for the run. The comment will be stored in the results file (`RESULTS.OUT`), and stored in the site file and simulated data file if they are saved. To edit the existing comment or enter a new comment, move the highlight to the `ID:` prompt and press ENTER. The existing comment will be displayed in an input field for you to edit.

3.16 Changing the Random Seed

LISA uses a pseudorandom number generator in sampling values for each input variable from the probability distribution specified by the user. The *random number seed* specifies a starting point for sampling. At the beginning of each session, LISA generates a suggested seed value based on the date and time found in the computer system clock. Each variable has its own seed value, hidden from the user and based on the main random number seed, from which its values are sampled. This ensures that sampling is repeatable and allows the user to see the effect of changing the values of a variable without introducing the effect of sampling using a different seed.

LISA will sample values for all variables the first time you press [F1] from the EDIT DATA screen. Thereafter, to increase the execution speed of LISA, only those variables that you have modified will be resampled. You may force LISA to resample all variables by changing either the random number seed or the number of iterations. *We recommend that, once you are satisfied with all of the input distributions, you run* LISA *several times with different seed values to observe the variation in simulation results due to random variation (see part 1, section 4.4).*

To change the random seed, highlight `Random seed:` and press [ENTER]. LISA will generate a new seed value and display it in an input field. You may press [ENTER] to accept it, press [ESC] to cancel the change request and keep the old seed, or type a number between 1 and 2,147,483,646 inclusive and press [ENTER]. Entering your own seed value allows you to duplicate exactly a previous run.

The seed number used for a simulation is reported in the results file `RESULTS.OUT` and, if it is created, in `SIMULATE.OUT`.

ERROR MESSAGE

```
Seed must be between 1 and 2,147,483,646
Press any key to continue
```

The seed you enter must be an integer greater than 0 and less than 2,147,483,647.

DEMONSTRATION

To duplicate the results for the demonstration exercise exactly, enter `1502678690` as the random seed.

3.17 Entering the Number of Iterations

We recommend that 1,000 iterations be used for all final LISA runs to increase repeatability between runs (see part 1, section 4.4). However, you may want to use a smaller number for initial runs to speed execution. To change the number of iterations, move the highlight to the `# iterations` option, press [ENTER], and enter a number between 1 and 1,000 (inclusive) into the highlight.

ERROR MESSAGES

```
No more than 1000 iterations allowed.
Press any key to continue
```

```
At least 1 iteration required.
Press any key to continue
```

One of these messages is displayed if you ask for 0 or more than 1,000 iterations. Enter a number between 1 and 1,000 inclusive.

DEMONSTRATION

To duplicate the results of the demonstration exactly, use 1000 iterations.

3.18 Starting the Simulation

Press F1 from the EDIT DATA screen to begin sampling a set of possible input values for each variable. Each input variable must be given a distribution type or a constant value befor LISA will start the simulation. All of the variables will be sampled only the first time you press F1, or when the random number seed or number of iterations have changed; otherwise, only those variables you have modified will be resampled. After each variable is sampled, the minimum, maximum, mean, and standard deviation of the sampled values will be displayed on the SIMULATING DATA VALUES screen. If the variable being sampled has a beta distribution, LISA will display the message `Simulating beta` and count the number of completed iterations, because sampling from the beta distribution takes noticeably longer than does sampling from the other distribution types (see section 3.9.6). You may stop the simulation and return to the EDIT DATA screen by pressing ESC. LISA will complete sampling of the current parameter before it responds.

After all input values have been sampled, the factors of safety will be calculated and the probability of failure ($P[FS \leq 1]$) will be displayed. The message

```
One Moment Please
```

will be displayed while LISA sorts the factor of safety values and writes output files to disk.

After the simulation is complete, press any key (except F10 and ESC) to examine the results, as described in the next three sections.

Alternatively, it may be easier when doing many runs to simply write down the probability of failure value or press PRTSC to print a copy of the results shown on the screen, and then return directly to the EDIT DATA screen by pressing ESC; however, you will lose access to the results files (`RESULTS.OUT` and `SIMULATE.OUT`).

```
Not all variables have been specified
Press any key to continue
```

This message is displayed when F1 is pressed before distributions have been specified for all input variables.

DEMONSTRATION

Press F1, and observe the values being sampled. For this example, the $P[FS \leq 1]$ should be `0.111` unless you made changes other than those described in the demonstration or you did not use the same random number seed. Figure 3.15 shows the simulation screen for the demonstration.

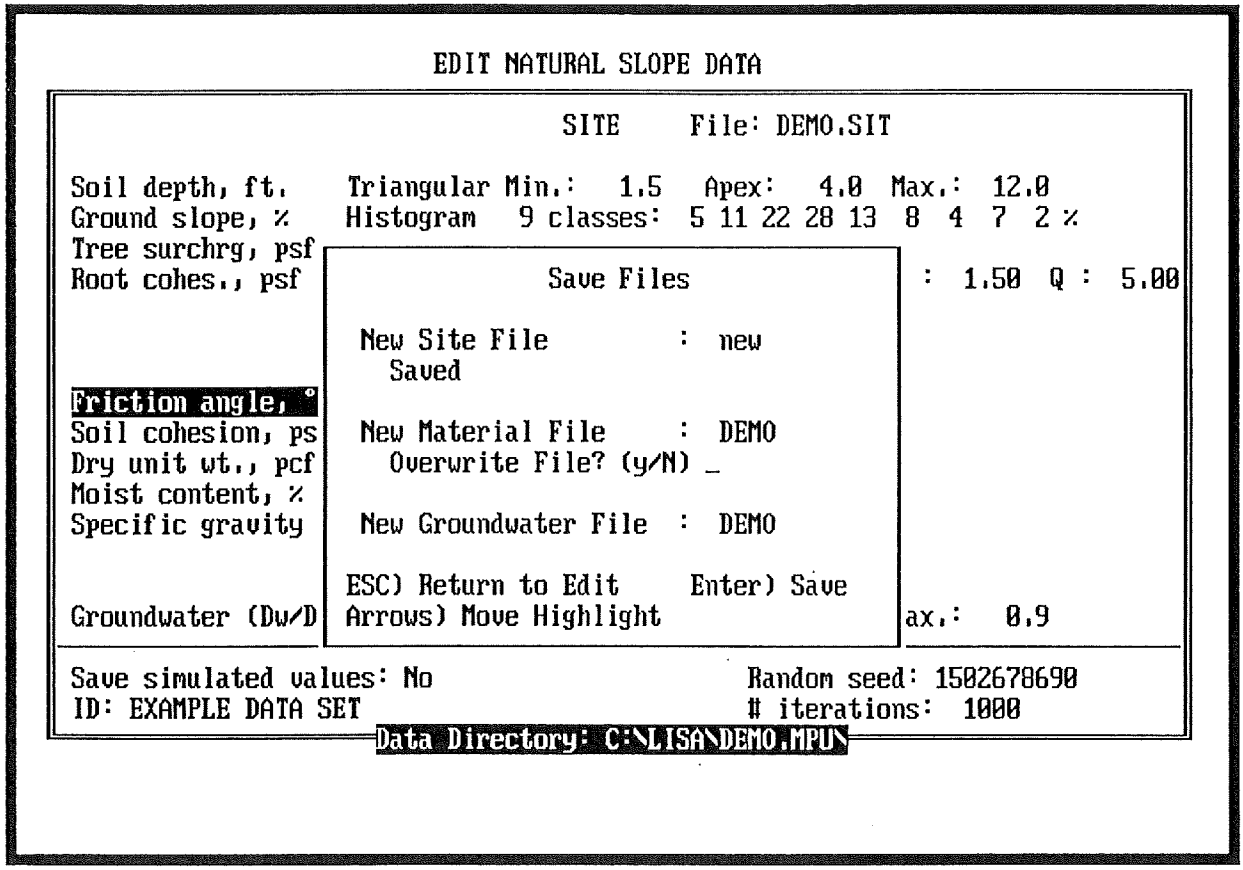


Figure 3.15—The minimum, maximum, mean, and standard deviation of the sampled values and of the factors of safety, and the probability of failure, $P[FS \leq 1]$, are displayed.

3.19 Viewing and Modifying the Factor of Safety Histogram

Upon pressing a key from the SIMULATING DATA VALUES screen, the histogram of the factor of safety values will appear.[6] The factor of safety histogram is stored automatically in the results file; it also may be printed directly by using the PRTSC key. (Note: a screen print will not show the same characters as are displayed on the screen if your printer does not print the IBM graphics characters.)

You may press ESC to return to the EDIT DATA screen; C to change the minimum and maximum values for the histogram; or any other key (except F10) to continue on to the SCATTER PLOT AND HISTOGRAM screen. Viewing a histogram of a portion of the factor of safety values can be useful for removing the tail of highly skewed histograms and for looking more closely at the distribution of values less than or equal to 1. The minimum and maximum values calculated during the simulation will remain as the defaults to make it easy to recall the original histogram.

If you want to save any modified histogram in the results file, press S. If the DOS environment variable `LISAGRAPH` has been set to `IBM` before LISA was started, then the characters as displayed on the screen will be saved in the results file; otherwise, the graphics characters will be converted to standard ASCII characters. The `LISAGRAPH` environment variable is discussed further in section 1.2.4.2.

DEMONSTRATION

Press any key to view the histogram of the factor of safety values (shown in fig. 3.16). Since the histogram for this example is highly skewed, we want to remove part of the tail from the plot. To change the maximum value of the histogram to be displayed:

- Press C.
- Press ENTER to accept the minimum value displayed.
- Enter `3.5` for the maximum value and view the partial distribution of factor of safety values. The distribution is still skewed right, but with the tail removed, the distribution of the majority of the values is better displayed (as shown in fig. 3.17).
- Press S to store the modified histogram in the results file.
- Press SPACE (or any key other than C, S, F10, and ESC) to go to the SCATTER PLOT AND HISTOGRAM screen.

3.20 Viewing Scatter Plots and Variable Histograms

The SCATTER PLOT AND HISTOGRAM screen has two functions:

- To display a scatter plot of the sampled or calculated values of any of the listed variables against any other variable, and to display a histogram of the sampled or calculated values for any of the variables, as discussed below.
- To display, print, and save the LISA results and simulation output files, as discussed in section 3.20.

[6] If you specified 1 iteration, or all input variables were set to constants, LISA will display the message `Cannot display histogram of constant or 1 value.` In this case, a keypress takes you to the SCATTER PLOT AND HISTOGRAM screen, described in section 3.19.

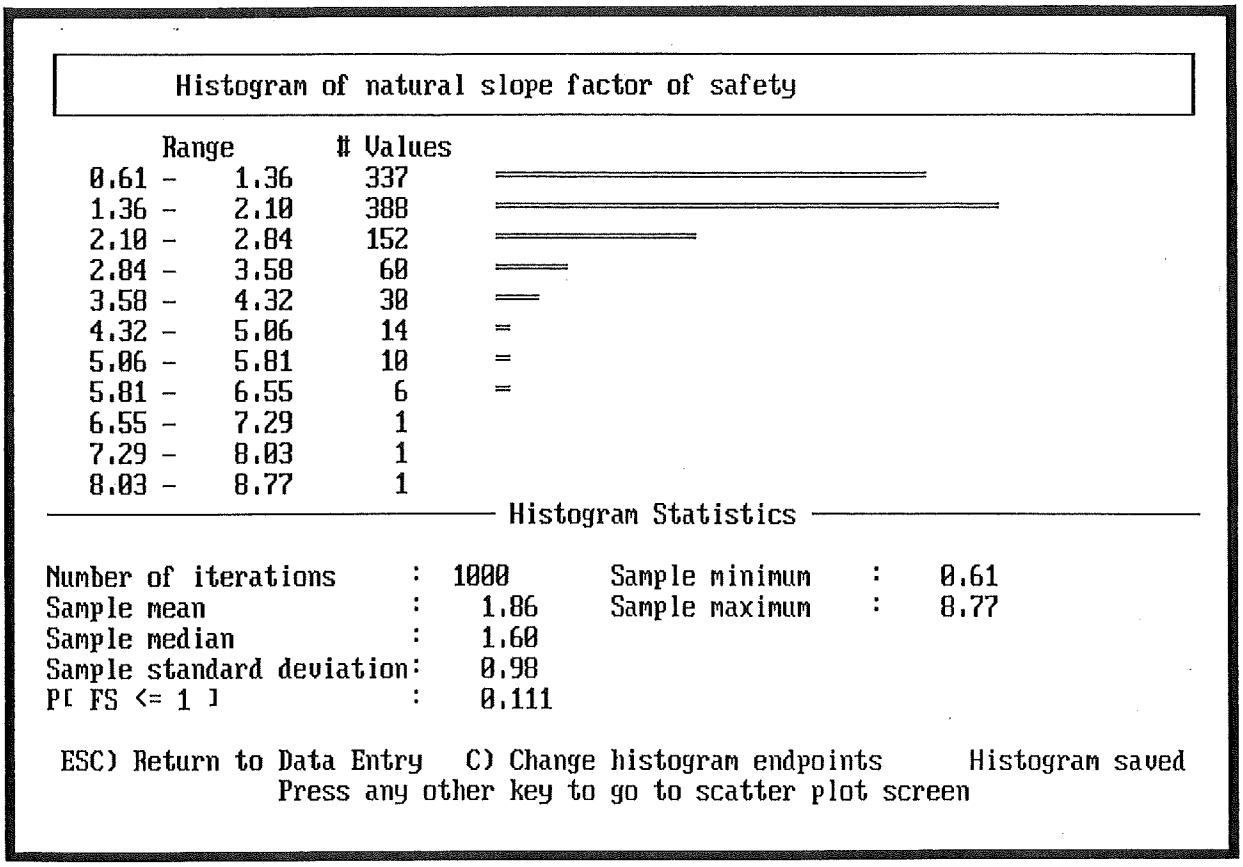


Figure 3.16—Histogram of the factor of safety values for the demonstration problem.

Neither scatter plots nor histograms may be generated for constant-value variables. The variables that were assigned a constant value are indicated by a different color on the SCATTER PLOT AND HISTOGRAM screen.

To view the histogram of any of the listed variables, highlight the variable name and press ENTER twice. Viewing the histogram of the input variables is helpful in comparing the sampled values to the distribution specified in the EDIT DATA screen. The minimum and maximum values for the displayed histogram may be changed by pressing C. Any of the histograms may be stored in the results file by pressing S while the histogram is displayed. The character set used in the file depends upon the value of the DOS environment variable **LISAGRAPH**, as explained in sections 1.2.4.2 and 3.18.

To view the scatter plot of any two variables (values of one variable plotted against values of another variable), highlight the name of the first (X-axis) variable and press ENTER, then highlight the name of the second (Y-axis) variable and press ENTER. The scatter plot will be displayed, and LISA will calculate the correlation coefficient, r, which measures *linear* dependence between two variables. If the factor of safety is selected as the second variable, a horizontal line representing a factor of safety of 1.00 will be displayed (if it falls within the range of the plot).

In general, scatter plots between two input variables will show little correlation. Exceptions are the positive correlation between friction angle and dry,

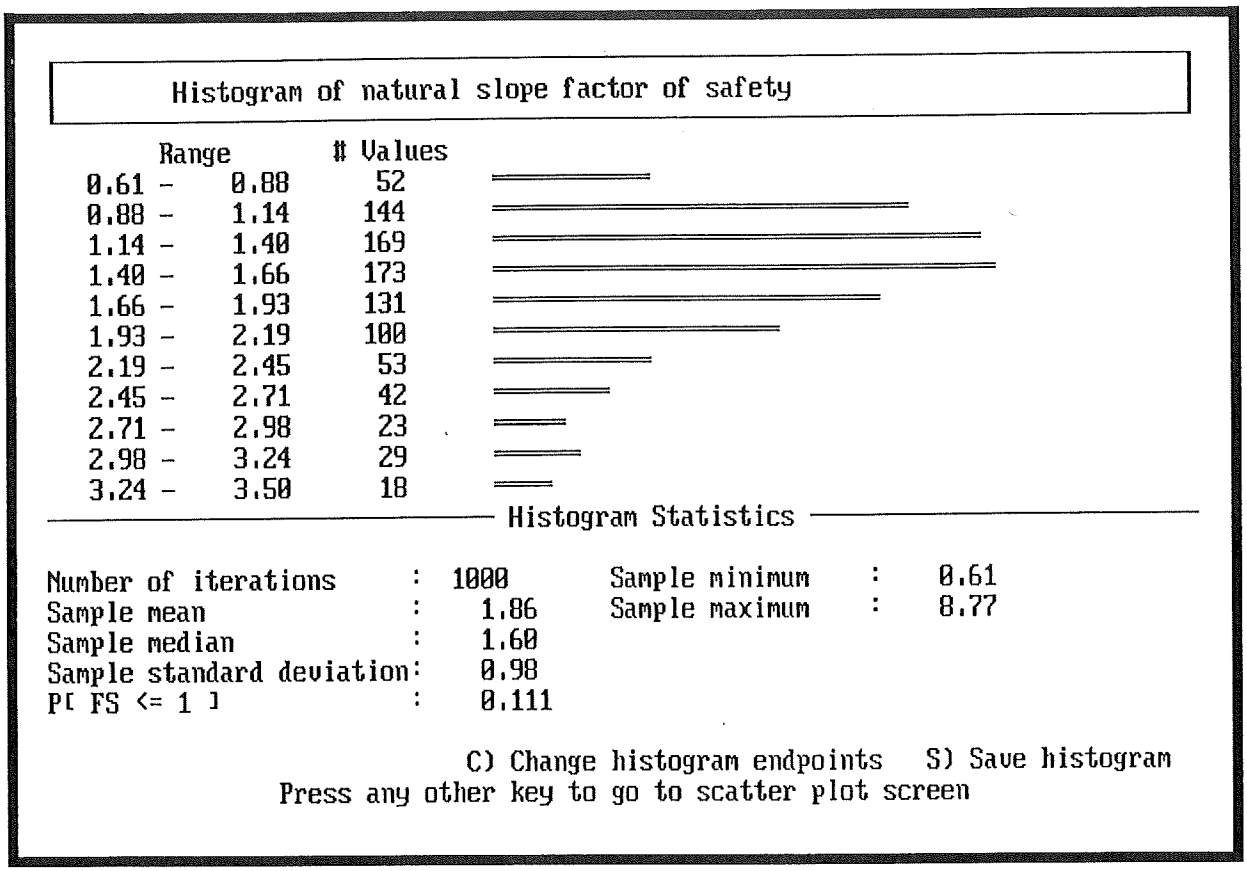


Figure 3.17—Histogram of the factor of safety values less than 3.5.

moist, and saturated unit weight; and the (inverse) correlation between soil cohesion and friction angle if a bivariate normal distribution is used. Scatter plots are particularly useful for examining the dependence of the factor of safety on individual input variables. Variables to which factor of safety is insensitive will show little or no correlation, while variables to which factor of safety is sensitive should show a fairly high (although not necessarily linear) correlation, depending on the range of values used.

A scatter plot of shear strength (τ) against effective normal stress (σ') is useful in illustrating the effects of a C'_s–ϕ' correlation on the simulation results; a larger negative value for r between C'_s and ϕ' will increase the correlation (reduce the scatter) between τ and σ' (see discussion in part 1, section 4.2).

Scatter plots are also useful for showing the scatter of the values sampled for two variables you might consider somewhat correlated in nature (such as surface slope and soil depth). If there are many points that seem like unreasonable pairings, you may want to restrict the range of one or both variables (see discussion in part 1, section 4.2).

The scatter plot is displayed at EGA resolution, and cannot be displayed as a windowed application in Windows 3.0. See section 1.2.3 for some hints if you are running LISA under Windows 3.0.

When you have finished viewing plots and viewing, printing, and saving output files, press ESC to return to the EDIT NATURAL SLOPE DATA screen.

ERROR MESSAGES

```
Cannot display histogram of a constant or 1 value
Press any key to continue
```

This message is displayed when you try to view a histogram of a variable that was specified as a constant or when one iteration was specified.

```
X is constant, cannot make scatterplot
Press any key to continue
```

```
Y is constant, can't make scatterplot
Press any key to continue
```

One of these messages is displayed when you request a scatter plot when one or both of the variables has a constant value.

DEMONSTRATION

- Highlight **Groundwater ratio** and press ENTER twice. The histogram shown in figure 3.18 will appear in a moment. It should resemble the triangular distribution that was entered.
- Press SPACE to return to the SCATTER PLOT OR HISTOGRAM screen.
- Highlight **Ground slope** and press ENTER, then highlight **Factor of safety** and press ENTER. The scatter plot shown in figure 3.19 will appear, demonstrating the dependence of the factor of safety on ground slope.
- Press SPACE to return to the SCATTER PLOT OR HISTOGRAM screen.

3.21 Viewing, Saving, and Printing the Output Files

LISA automatically saves temporary output files from each run in the current map unit subdirectory. The distributions for input variables, the summary of sampled data values, the probability of failure, and the histogram of the factor of safety values, along with any other histograms you may have stored, are saved in a file called **RESULTS.OUT**. The sampled data values are saved in a file called **SIMULATE.OUT**, if you requested that they be saved. These output files can be viewed, printed, or saved from the SCATTER PLOT AND HISTOGRAM screen.

To view a results or simulated data file, move the highlight to the **View** prompt next to the desired file type and press ENTER. By default, LISA uses a program called BROWSE to let you view the output files (this can be changed; see section 1.2.4). When BROWSE is called, the top 25 lines of the selected file are displayed on the screen. BROWSE allows you to look at different parts of the file by using the cursor-control keys (↑ → ↓ ← PG UP PG DN HOME and END). To return to the SCATTER PLOT AND HISTOGRAM screen, press ESC.

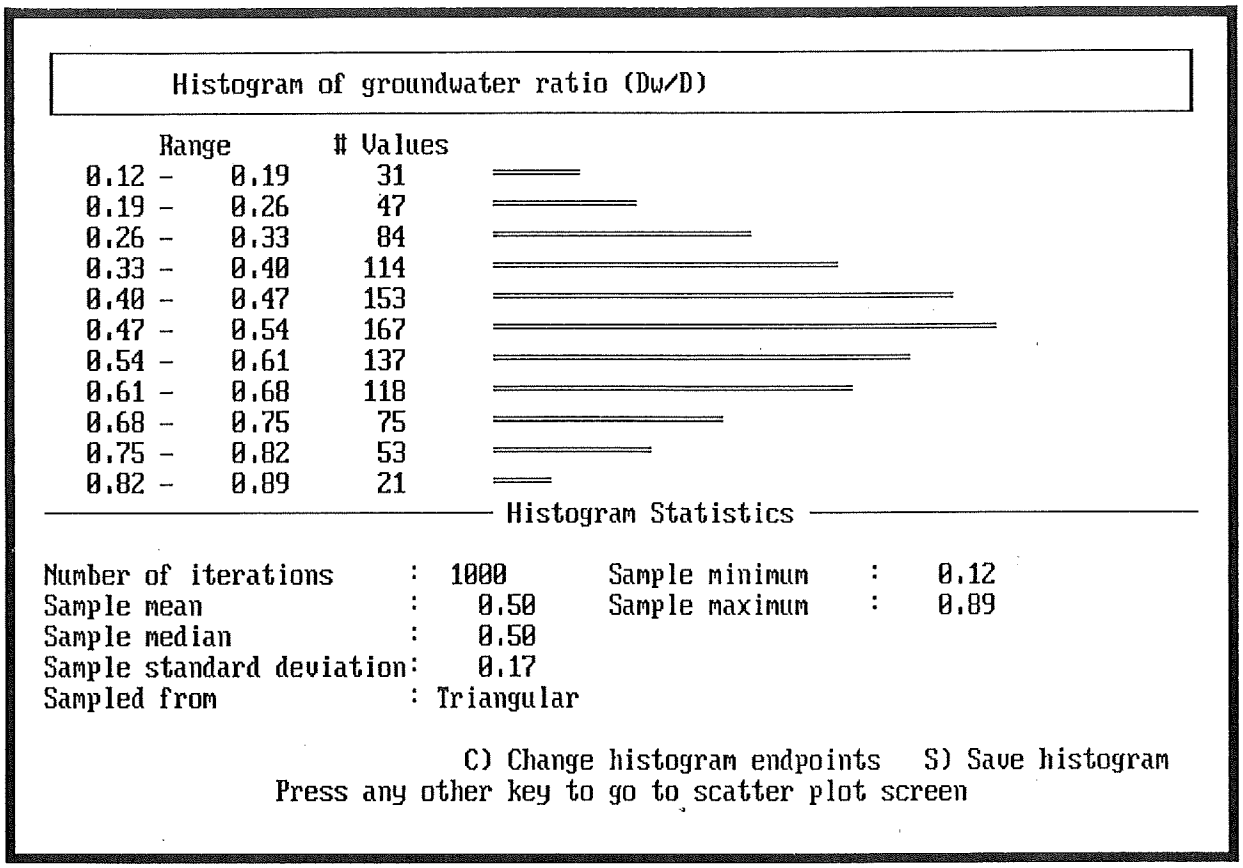


Figure 3.18—Histogram of the groundwater–soil depth ratio values sampled in the demonstration problem.

To print a results or simulated data file, move the highlight to the **Print** prompt beside the desired file type and press ENTER.

Because the output files **RESULTS.OUT** and **SIMULATE.OUT** will be overwritten the next time a LISA simulation is run within the same map unit, they must be saved under a different name if you want to keep a copy permanently. To save a results or simulated data file, move the highlight to the **Save** prompt beside the desired file type, and press ENTER. The current path for the results or simulated data file will be displayed in a highlighted input field. Type a legal filename (to save the file in the current map unit subdirectory as given in the highlight), or edit the entry to specify another drive, existing path, and file name (fig. 3.20). *Note that this input field works differently than do the other input fields in* LISA. Here, typed characters will be appended to the path in the input field; ESC clears the input field; the backspace key deletes characters to the left; and ESC, when pressed in a clear input field, backs you out of the save request.

Once you press ESC to leave the SCATTER PLOT AND HISTOGRAM screen, you can no longer save the output files from within LISA. If you return to the EDIT DATA screen prematurely, you can save the output files by pressing F4 to go to the DOS shell to copy or rename the files and then return to LISA by typing **EXIT** at the DOS prompt when you are done. You may also press F4 from the SCATTER PLOT AND HISTOGRAM screen to change output file format, or to perform other file management tasks (see section 3.22).

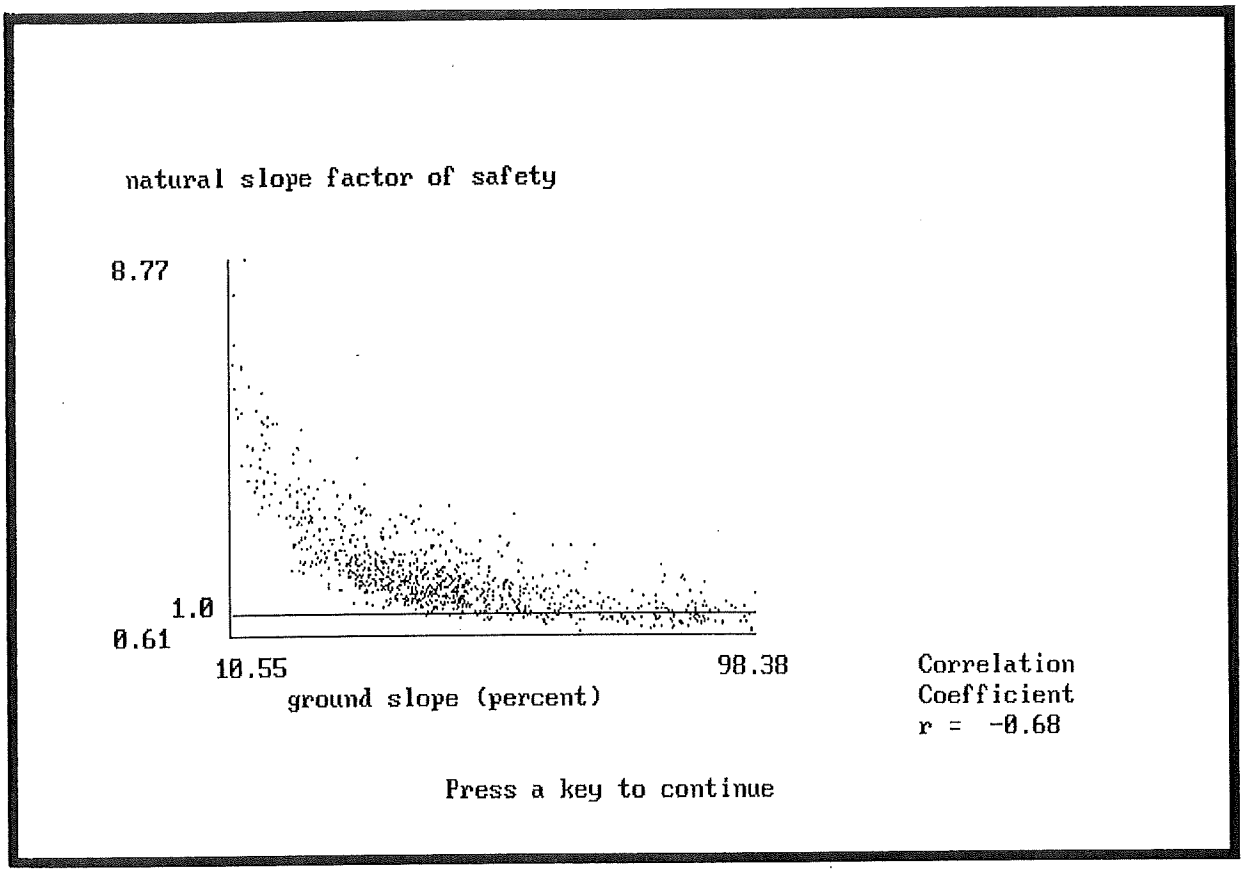


Figure 3.19—Scatter plot of factor of safety against ground slope illustrating a non-linear dependence.

ERROR MESSAGES

```
Simulated data not saved
Press any key to continue
```

This message is displayed when you ask to view, print, or save the simulated values but did not ask LISA to save them.

```
Printer needs attention. Fix problem, or <ESC> to cancel.
```

When you ask LISA to print a file, it checks to see that the printer is ready before trying to print the file. If the printer is turned off, is off-line, is out of paper, or is not connected to the computer, this message will be displayed on the top line of the screen, and LISA will wait for you to either fix the problem or press ESC to cancel the print request and return to the SCATTER PLOT AND HISTOGRAM screen. If you have a print spooler installed, the print request may be executed normally without an error message even when the is printer off-line; the hard copy will be produced when the printer is turned on-line or activated by your local procedures.

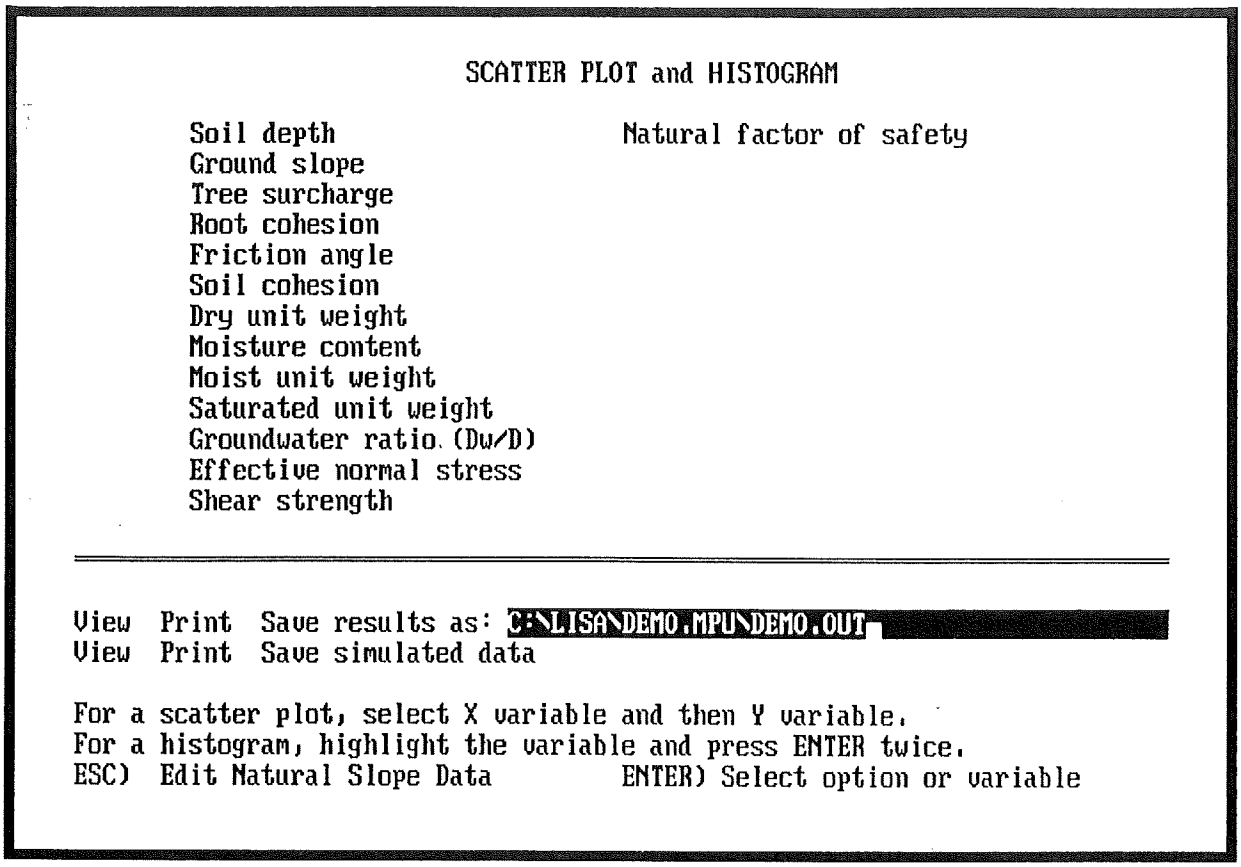


Figure 3.20—Saving the results file from the demonstration problem to disk as DEMO.OUT.

Bad command or file name

This DOS message may be displayed momentarily when you select the view option if DOS cannot find the file viewer (either BROWSE.COM or the program specified by environment variable LISALIST). You may exit to the DOS shell by pressing F4, type SET to have DOS display the current values of environment variables, find the file viewer and copy it into the LISA subdirectory or another subdirectory in the DOS path, and type EXIT to return to LISA. You cannot effectively change the values of the environment variables while in the DOS shell, because the changes will be lost when you return to LISA.

Invalid directory

This DOS message may be displayed momentarily if you give an invalid file name in the save option. The file *has not* been saved. Select save again, and enter a valid file name.

DEMONSTRATION

The results file, `RESULTS.OUT`, for the demonstration exercise is shown in figure 3.21. A portion of the simulated data file, `SIMULATE.OUT`, is shown in figure 3.22. View your results and simulated data files and compare them to those in the figures.

3.22 Exiting LISA

There are two ways to exit LISA. One is to repeatedly press [ESC] until you back out of LISA. As is discussed in section 3.9, when you press [ESC] from the EDIT DATA screen and any changes have been made to the data since the datasets have been saved, you will be asked whether you want to save the data.

There is also a quick exit from LISA—from almost anywhere, you may press [F10] and be returned directly to DOS. If any dataset has been modified but not saved, all three datasets will be saved automatically in the current map unit subdirectory under the names `QUICK.SIT`, `QUICK.MTL`, and `QUICK.HYD`. The `QUICK` files will be overwritten the next time you quick-exit from the same map unit in LISA. Therefore, if you want to keep the data from the `QUICK` files, they should be renamed (either from DOS or from within LISA by loading the three `QUICK` files and saving them with different names *before* you quick-exit again).

LISA allows you to enter a DOS shell from the EDIT DATA screen and the SCATTER PLOT AND HISTOGRAM screen by pressing [F4]. LISA will remain in memory, leaving approximately 250,000 to 300,000 bytes of RAM free on a 640 kilobyte machine to perform other tasks. You must type `EXIT` at the DOS prompt, preferably from the subdirectory from which you started LISA, to return to LISA.

Level One Stability Analysis
LISA Version 2.00

ID: EXAMPLE DATA SET

User name	C.Hammond
Time of simulation	05-22-1991 09:16:57
Map unit	DEMO.MPU
Number of iterations	1000
Random number seed	1502678690
Probability of failure	.111

INPUT DATA

NATURAL DATA

Soil depth (ft) Triangular Min.: 1.50 Apex: 4.00 Max.: 12.00

Ground slope (%) Histogram 9 classes

Class	Minimum	Maximum	Percent
1	10.00	20.00	5.00
2	20.00	30.00	11.00
3	30.00	40.00	22.00
4	40.00	50.00	28.00
5	50.00	60.00	13.00
6	60.00	70.00	8.00
7	70.00	80.00	4.00
8	80.00	90.00	7.00
9	90.00	100.00	2.00

Tree surcharge	(psf)	Uniform	Min.:	10.00	Max.:	20.00		
Root cohesion	(psf)	Beta	Min.:	10.0	Max.:	155.0	P: 1.5	Q: 5.0
Friction angle	(deg)	Uniform	Min.:	20.00	Max.:	30.00		
Soil cohesion	(psf)	Normal	Mean:	150.00	Std.:	20.00		
Dry unit weight	(pcf)	Normal	Mean:	105.00	Std.:	1.50		
Moisture content	(%)	Normal	Mean:	18.00	Std.:	2.00		
Specific gravity		Constant	Value:	2.66				
Groundwater ratio	(Dw/D)	Triangular	Min.:	0.10	Apex:	0.50	Max.:	0.90

LISA Version 2.00
EXAMPLE DATA SET

DESCRIPTIVE STATISTICS OF SIMULATED VALUES -- NATURAL SLOPE

		MINIMUM	MAXIMUM	MEAN	S.D.
Soil depth	(ft)	1.64	11.87	5.85	2.24
Ground slope	(%)	10.55	98.38	47.01	19.05
Tree surcharge	(psf)	10.01	20.00	14.97	2.86
Root cohesion	(psf)	10.47	125.58	43.64	21.27
Friction angle	(deg)	20.01	30.00	25.02	2.87
Soil cohesion	(psf)	88.20	211.80	151.23	20.23
Dry unit weight	(pcf)	100.36	109.64	105.00	1.50
Moist unit weight	(pcf)	116.95	130.78	123.85	2.63
Saturated unit wt.	(pcf)	125.03	130.82	127.93	0.93
Moisture content	(%)	11.82	24.18	17.98	1.94
Groundwater ratio	(Dw/D)	0.12	0.89	0.50	0.17
Factor of safety		0.61	8.77	1.86	0.98

Figure 3.21—Results file (RESULTS.OUT) from the demonstration, printed at 16.67 characters per inch, 80 lines per page (con.)

Histogram of natural slope factor of safety

Range			# Values
0.61	-	1.36	337
1.36	-	2.10	388
2.10	-	2.84	152
2.84	-	3.58	60
3.58	-	4.32	30
4.32	-	5.06	14
5.06	-	5.81	10
5.81	-	6.55	6
6.55	-	7.29	1
7.29	-	8.03	1
8.03	-	8.77	1

Histogram Statistics

Number of iterations	:	1000	Sample minimum	:	0.61
Sample mean	:	1.86	Sample maximum	:	8.77
Sample median	:	1.60			
Sample standard deviation	:	0.98			
P[FS <= 1]	:	0.111			

LISA Version 2.00
EXAMPLE DATA SET

Histogram of natural slope factor of safety

Range			# Values
0.61	-	0.88	52
0.88	-	1.14	144
1.14	-	1.40	169
1.40	-	1.66	173
1.66	-	1.93	131
1.93	-	2.19	100
2.19	-	2.45	53
2.45	-	2.71	42
2.71	-	2.98	23
2.98	-	3.24	29
3.24	-	3.50	18

Histogram Statistics

Number of iterations	:	1000	Sample minimum	:	0.61
Sample mean	:	1.86	Sample maximum	:	8.77
Sample median	:	1.60			
Sample standard deviation	:	0.98			
P[FS <= 1]	:	0.111			

Figure 3.21—(con.)

Level One Stability Analysis
LISA Version 2.00

==========

ID: EXAMPLE DATA SET

User name	C.Hammond
Time of simulation	05-22-1991 09:16:52
Map unit	DEMO.MPU
Number of iterations	1000
Random number seed	1502678690
Probability of failure	.111

soil depth	ground slope	tree surch.	root cohes.	frict. angle	soil cohes.	dry un. wt.	moist un. wt.	Dw/D	FS
11.40	97.71	14.84	25.24	21.87	157.63	103.67	19.80	0.26	0.61
9.10	68.86	18.11	19.04	20.21	112.18	101.96	17.40	0.63	0.62
8.85	84.45	10.36	15.91	21.70	153.34	103.57	13.67	0.58	0.65
10.04	80.88	10.51	43.54	24.82	157.16	104.93	17.94	0.77	0.68
8.78	97.75	19.88	55.48	21.78	154.15	103.62	16.72	0.56	0.68
8.09	84.67	11.97	18.83	21.05	171.12	103.12	16.74	0.64	0.69
8.36	82.63	14.18	37.77	26.19	127.98	105.45	18.48	0.75	0.69
9.42	87.18	19.41	19.73	27.10	134.08	105.83	16.27	0.52	0.70
7.95	79.17	16.89	32.98	22.51	161.80	103.99	16.16	0.81	0.71
11.55	81.45	19.37	43.81	28.22	170.69	106.38	18.29	0.72	0.72
8.53	85.92	19.30	29.93	24.65	181.27	104.87	15.96	0.71	0.74
6.33	76.92	14.46	26.34	21.95	134.58	103.71	17.87	0.76	0.75
9.14	92.88	16.84	55.86	22.52	176.54	104.00	16.04	0.49	0.75
8.28	86.22	19.57	40.66	29.21	150.09	107.11	19.11	0.81	0.75
10.24	68.44	17.93	54.77	22.69	145.53	104.08	16.42	0.62	0.76
7.49	89.32	17.25	16.57	29.29	140.29	107.20	16.45	0.65	0.76
8.58	63.12	18.08	51.62	21.82	134.40	103.64	17.20	0.78	0.77
6.58	89.92	16.58	40.92	20.41	172.27	102.39	18.41	0.73	0.78
7.98	91.76	16.37	66.79	23.23	159.35	104.31	20.13	0.57	0.79
7.89	89.42	12.28	20.61	26.61	161.81	105.62	14.18	0.52	0.79
6.45	88.72	15.48	35.89	29.40	119.73	107.33	19.41	0.73	0.79
10.00	85.73	18.84	23.33	27.97	173.54	106.24	18.00	0.46	0.79
9.34	85.84	11.01	63.18	25.44	166.10	105.16	18.45	0.54	0.80
7.81	95.99	19.87	32.51	22.11	185.29	103.79	15.47	0.37	0.80
6.12	93.03	15.42	17.64	20.98	152.00	103.06	15.12	0.33	0.80
8.47	84.56	19.11	36.60	29.80	144.26	108.10	18.93	0.64	0.80
6.64	75.41	17.69	20.81	22.94	136.26	104.19	19.17	0.50	0.81
8.12	62.80	16.70	11.53	20.54	114.45	102.59	16.17	0.22	0.82
5.89	76.76	10.34	24.96	24.07	129.63	104.65	18.50	0.66	0.82
6.96	96.74	10.37	29.17	25.29	175.03	105.11	18.91	0.51	0.83
10.33	82.17	14.94	57.12	29.50	158.86	107.46	18.06	0.56	0.83
9.84	87.43	15.32	76.46	29.92	166.98	108.60	18.89	0.66	0.83
9.11	73.49	12.05	98.46	20.02	151.68	100.77	18.67	0.52	0.84
8.06	84.28	17.91	62.31	26.55	142.47	105.60	20.26	0.56	0.84
10.95	52.76	12.41	32.30	22.07	164.35	103.78	18.33	0.72	0.84
11.04	63.06	13.13	59.87	25.82	173.25	105.31	19.43	0.77	0.84
11.27	64.05	19.00	18.51	26.52	155.19	105.59	18.41	0.53	0.84
6.52	88.49	17.74	23.71	29.63	143.10	107.69	22.05	0.63	0.85
7.66	69.03	13.52	46.87	20.08	135.73	101.41	19.69	0.35	0.85
9.15	74.33	12.67	90.81	26.86	149.63	105.72	17.81	0.77	0.85
10.31	69.51	10.67	10.47	26.51	179.72	105.58	17.68	0.49	0.86
9.88	53.43	17.39	31.20	21.13	138.82	103.18	20.79	0.55	0.86
5.32	62.73	14.50	15.63	21.91	117.15	103.69	18.01	0.70	0.86
6.22	73.68	18.76	29.08	23.02	142.03	104.22	21.79	0.59	0.86
8.35	76.13	18.99	43.81	26.02	147.97	105.39	20.44	0.48	0.86

Figure 3.22—A portion of the simulated data file (`SIMULATE.OUT`) from the demonstration.

CHAPTER 4 — DLISA EXECUTION INSTRUCTIONS

4.1 Introduction

The deterministic slope stability program DLISA can solve the infinite slope equation for:

soil depth
surface slope
root cohesion
groundwater height
friction angle
soil cohesion
factor of safety

If you supply a single value for each of the other variables, DLISA will return one value for the solution variable, along with the associated dry, moist, and saturated unit weights; saturated moisture content; and moisture content of the soil above the groundwater surface. Alternatively, you may give a range of values for any one variable and a single value for the rest, and DLISA will display a table of results. The automatic calculation of several results is useful in performing sensitivity analyses and back-analyses. Appendix C gives the equations used for each of the solution variables.

Figure 4.1 illustrates the use of DLISA to calculate combinations of C'_s and ϕ' which yield a factor of safety of 1.00. Figure 4.2 shows an output file illustrating solution of groundwater heights in order to find the critical groundwater height that gives a factor of safety of 1.00. These types of back-analyses performed on the estimated prefailure conditions of existing failures can aid in selecting ranges of values to use in LISA.

4.2 Installation

DLISA is an executable program compiled with the Microsoft QuickBASIC compiler for microcomputers running the MS-DOS operating system. Although DLISA is supplied with LISA, it is a separate, stand-alone program. One file, **DLISA.EXE**, is required for running DLISA; it may be placed on any available subdirectory on any disk. DLISA does not need any special installation and does not read or write any data files. The optional output report may be written to disk or printed directly. DLISA uses EGA-resolution graphics if it is available, but graphics capability is not necessary. A math coprocessor is not required. DLISA uses the DOS environment variable **DLPRINTER** to tell it whether to include the output plot in the printed or filed report.

4.3 Starting DLISA

To start DLISA, change to the drive and subdirectory that contains the DLISA program and, at the DOS prompt, type **DLISA** ENTER. As with LISA, if the DOS **PATH** includes the path to the drive and subdirectory in which DLISA is stored, then you may start DLISA from any subdirectory on your system. After a moment, the DLISA title screen will be displayed; press any key to proceed to the DATA ENTRY screen. You may bypass the title screen by including an argument on the command line when you start DLISA; the argument can be any string of characters that DOS won't misinterpret (as file redirection commands, for example).

DETERMINISTIC LEVEL I STABILITY ANALYSIS

Infinite Slope Equation

	Soil depth (ft)	7.00				
	Surface slope (%)	55.00				
	Tree surcharge (psf)	15.00				
	Root cohesion (psf)	40.00				
VARY	Groundwater height (ft)	0.00	To	7.00	By	0.70
	Friction angle (deg)	32.00				
	Soil cohesion (psf)	50.00				
	Dry unit weight (pcf)	105.00				
	Moisture content (%)	20.00				
	Specific gravity	2.65				
SOLVE FOR	Factor of safety					

Groundwater ratio (ft)	Factor of safety	Dry unit wt. (pcf)	Moist unit wt. (pcf)	Saturated unit wt. (pcf)	Saturated moist. cont. (pcf)	Moisture content (%)
0.00	1.37	105.00	126.00	127.78	21.69	20.00
0.70	1.32					
1.40	1.26					
2.10	1.21					
2.80	1.15					
3.50	1.10					
4.20	1.04					
4.90	0.99					
5.60	0.93					
6.30	0.88					
7.00	0.82					

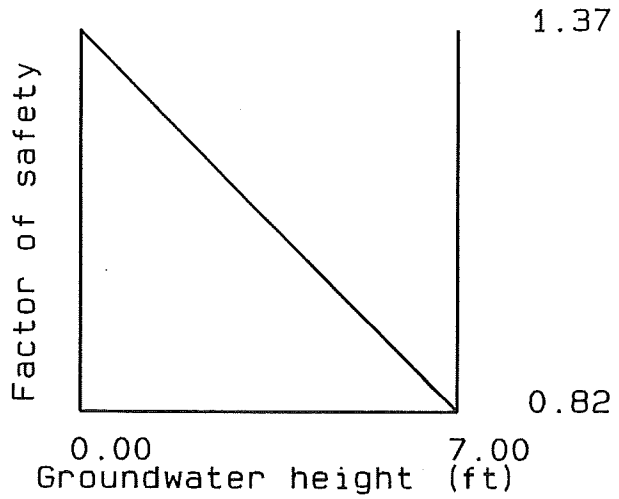


Figure 4.1—Calculation of critical combinations of C'_s and ϕ' for the prefailure conditions of an existing failure.

To print an X–Y plot of the solutions, you must use a LaserJet III or any other printer which understands Hewlett Packard's HP-GL/2 language, and you must tell DLISA that you are using such a printer by defining a DOS environment variable **DLPRINTER**. To do so, type **SET DLPRINTER=HPLJ3** at the DOS prompt before starting DLISA(see section 4.6). Similarly, you can change the colors that DLISA uses on screen by defining the DOS environment variable **DLCOLOR**. The color of the six screen objects given in the following table may be specified. The syntax is **SET DLCOLOR=**$n_1/n_2/n_3/n_4/n_5/n_6$ where the n_i are integers between 1 and 15 representing the color to use, and i is the number for the screen element in the table.

DETERMINISTIC LEVEL I STABILITY ANALYSIS

Infinite Slope Equation

	Soil depth (ft)	5.00				
	Surface slope (%)	75.00				
	Tree surcharge (psf)	15.00				
	Root cohesion (psf)	40.00				
	Groundwater height (ft)	3.00				
VARY	Friction angle (deg)	30.00	To	40.00	By	1.00
SOLVE FOR	Soil cohesion (psf)					
	Dry unit weight (pcf)	105.00				
	Moisture content (%)	20.00				
	Specific gravity	2.65				
	Factor of safety	1.00				

Friction angle (deg)	Soil cohesion (psf)	Dry unit wt. (pcf)	Moist unit wt. (pcf)	Saturated unit wt. (pcf)	Saturated moist. cont. (pcf)	Moisture content (%)
30.00	101.03	105.00	126.00	127.78	21.69	20.00
31.00	94.06					
32.00	86.95					
33.00	79.67					
34.00	72.23					
35.00	64.61					
36.00	56.81					
37.00	48.80					
38.00	40.58					
39.00	32.14					
40.00	23.45					

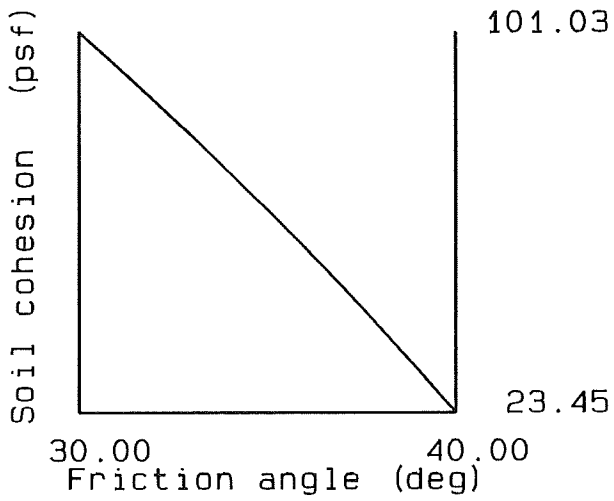


Figure 4.2—DLISA output file illustrating solution for the critical groundwater height to give a factor of safety of 1.00

i	Screen object	i	Screen object
1	menu text	4	X–Y plot axis titles
2	report heading	5	X–Y plot axis labels
3	report body	6	X–Y plot axes

The colors represented by the integers 1 to 15 will vary somewhat among monitors and graphics cards. Any n_i may be omitted, leaving the color unchanged for that object. Thus, you would type `SET DLCOLOR=12//3` at the DOS prompt to have DLISA use color 12 (red) for menu text and color 3 (cyan) for the report body.

4.4 Data Entry

All of the variables in the infinite slope equation are listed in the DATA ENTRY screen. You may move the highlight bar freely among the variables (using the space bar and cursor-control keys) and give them values in any order. With the name of the desired variable highlighted, you may press

- [ENTER] to specify a single value
- [V] to specify a range of values
- [S] to specify the solution variable

After you press [ENTER] or [V], you will be asked to enter a single value or range of values for the variable, using the standard LISA method. If you already have a variable marked as *varying* (or one to *solve for*), and then you select V (or S) for another variable, the previously marked variable will revert to a single value. To clear the current problem so that all variables are undeclared, press [C].

You may load a demonstration problem for learning how DLISA works by pressing [D]. *Note that the values used in the demonstration problem are not recommended for any particular purpose other than becoming familiar with the operation of the program.*

A one-line menu

```
ESC) Exit   ENTER) Constant  V) Vary       S) Solve for   F1) Execute   C) Clear
```

is displayed on the bottom line of the screen. The menu will not show the S) Solve for option when dry unit weight, moisture content, specific gravity, or tree surcharge is highlighted because DLISA cannot solve for these variables.

ERROR MESSAGES

```
Cannot solve for Dry unit weight
Press any key to continue
```

```
Cannot solve for Moisture content
Press any key to continue
```

```
Cannot solve for Specific gravity
Press any key to continue
```

```
Cannot solve for Tree surcharge
Press any key to continue
```

DLISA cannot solve the infinite slope equation for these four variables.

4.5 Entering Values

To specify a single value for a variable, highlight that variable's name and press [ENTER]. If that variable currently has a value, DLISA will display it in an input field. You may use the displayed value by pressing [ENTER] or [SPACE], edit it by

pressing the backspace key, or replace it by pressing a numeric key. Pressing [ESC] cancels the request to specify a single value.

To specify a range of values for a variable, highlight the variable's name, press [V], and enter the minimum and maximum value for the variable. DLISA solves the infinite slope equation for 11 values of the variable equally spaced between the minimum and maximum specified.

Ground surface slope may be specified either in degrees or as a slope percentage. To enter slope in degrees, type the value followed by [D]. To enter slope as a percentage, type the value followed by [%]. If you type a value and press [ENTER] or [SPACE], DLISA will use degrees or percentage slope as was used previously. If you are solving for surface slope and the units displayed for surface slope are not the units you want, set the correct unit by entering a single value for surface slope, and then set surface slope as the solution variable.

Similarly, groundwater may be specified as a groundwater–soil depth ratio (D_w/D) or as a groundwater height (D_w). To enter a groundwater–soil depth ratio, type the value followed by [:]. To enter a groundwater height, type the value followed by ['] (the apostrophe key). Use caution in specifying groundwater as a height when soil depth is allowed to vary.

The only error checking done as values are entered is to ensure that the range given for a variable is proper; all other error checking is deferred until you press [F1] to tell DLISA to solve the specified problem (see section 4.6).

ERROR MESSAGES

```
Maximum must be greater than minimum.
Press any key to continue
```

This message is displayed when the value entered for the minimum of a range is larger than or equal to the value entered for the maximum.

4.6 Execution

When you are satisfied with the problem as specified on the DATA ENTRY screen, press [F1]. You must have one variable marked for solution, and all variables must be declared. If either of these conditions is not met when [F1] is pressed, an error message will be displayed.

If a solution was found for the problem, DLISA will display a table of results, including values for moist unit weight, saturated unit weight, and moisture content. If more than one solution has been found and DLISA recognizes that your computer is capable of displaying EGA-resolution graphics, it also will draw a small plot of the results. This plot is useful for observing whether there is a positive or negative, and a linear or nonlinear relationship between the X variable and the Y variable. The slope of the line does not indicate the sensitivity of the Y variable to the X variable, because the maximum and minimum values of each variable are always placed at the extremes of the axis; thus, even a tiny change in one with respect to the other can result in a line with a 45-degree slope.

After the results are shown, you may press [P] to print the results, [S] to save the results to disk, or any other key to return to the DATA ENTRY screen. When you press [S], you will be asked for file name. Enter any valid DOS filename, or press [ESC] to cancel the request. The X–Y plot of the solutions will be printed

and saved in the output file only if the DOS environment variable DLPRINTER has the value HPLJ3 (as explained in section 4.3). The plot will consist of printer instructions in the HP-GL/2 language.

ERROR MESSAGES

variable not specified!
Press any key to continue

This message will be displayed if a variable has neither been declared as having a single value or a range of values, nor specified as the solution variable. The first undeclared variable (in the order in which they are displayed on the screen) will be named.

You must solve for one variable.
Press any key to continue

This message is displayed if you have not specified a variable for which to solve.

Groundwater ht. greater than soil depth
Press any key to continue

This message is displayed if the maximum groundwater height value specified for a range is greater than the single soil depth value, or the single groundwater height value is greater than either the single soil depth value or the minimum soil depth specified for a range.

Groundwater ratio greater one
Press any key to continue

This message is displayed if you have entered a value for groundwater–soil depth ratio that is greater than 1.00.

Printer needs attention. Fix problem, or <ESC> to cancel.

This message is displayed when you ask to print the results, but the printer is turned off, is off-line, is out of paper, or is not connected to the computer. As soon as the problem is fixed, the results will be printed. If you cannot or do not want to solve the problem, you may press [ESC] to cancel the print request. If you have a print spooler installed, the print request may be executed normally without an error message even when the is printer off-line; the hard copy will be produced when the printer is turned on-line or activated by your local procedures.

4.7 Back-calculation Error

DLISA cannot find a solution for every possible combination of input values. Some problems lead to a solution with a negative value, and others lead to a solution with a value of infinity, neither of which DLISA will accept. Other problems, specifically those problems for which surface slope is to be solved, have no

solution because the curve of the relationship between surface slope and any of the other variables can be ∪-shaped or ∩-shaped, and no solution can be found for values below the minimum or above the maximum. DLISA uses an iterative algorithm (as given in appendix C) to find a value for surface slope, and it returns a value for the flatter of the two surfaces that would solve the problem.

Figure 4.3 shows a run in which DLISA could find no solutions for soil cohesion when friction angle is greater than 34° and factor of safety is 1.00. For this set of input values, the factor of safety will be greater than 1.00 when the friction angle is greater than 34°, even when there is no soil cohesion. Thus, DLISA has been asked to solve for a combination of soil cohesion, friction angle, and factor of safety values that cannot physically exist.

WARNING MESSAGES

```
No solution found.
Press any key to continue
```

This message is displayed if no solution could be found for the specified problem.

```
No solution found
for n values.
```

This message is displayed if DLISA could find at least one solution to the problem, but could not find all of the solutions. The solutions that could be found will be displayed.

4.8 Leaving DLISA

You leave DLISA by pressing [ESC] from the DATA ENTRY screen. You will be asked to verify your request by the message

```
ESC) Confirm exit      any other key) remain in DLISA
```

Press [ESC] again to return to DOS or any other key to continue running DLISA.

DETERMINISTIC LEVEL I STABILITY ANALYSIS

Infinite Slope Equation

	Soil depth (ft)	7.00				
	Surface slope (%)	65.00				
	Tree surcharge (psf)	15.00				
	Root cohesion (psf)	40.00				
	Groundwater height (ft)	2.00				
VARY	Friction angle (deg)	30.00	To	40.00	By	1.00
SOLVE FOR	Soil cohesion (psf)					
	Dry unit weight (pcf)	105.00				
	Moisture content (%)	20.00				
	Specific gravity	2.65				
	Factor of safety	1.00				

Friction angle (deg)	Soil cohesion (psf)	Dry unit wt. (pcf)	Moist unit wt. (pcf)	Saturated unit wt. (pcf)	Saturated moist. cont. (pcf)	Moisture content (%)
30.00	56.65	105.00	126.00	127.78	21.69	20.00
31.00	43.82					
32.00	30.73					
33.00	17.35					
34.00	3.66					

No solution found for 6 values.

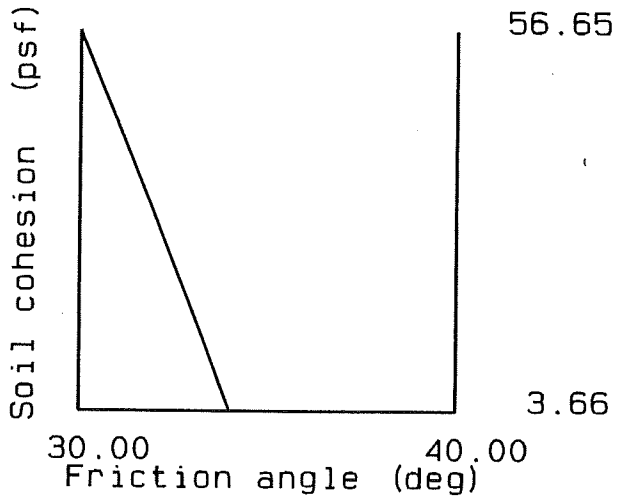


Figure 4.3—DLISA cannot find a solution to this set of values if ϕ' is greater than about 34 degrees without soil cohesion becoming negative.

REFERENCE

Petzold, C. 1986. Programming/Utilities column. PC Magazine. March 25: 253–267.

APPENDIX A — DOWNLOADING FROM THE DG

LISA can be downloaded from the Forest Service Data General computer network to your PC. Once you get it onto your PC, you will have to unarchive it.

Transfer LISA to Your DG

The procedure for retrieving LISA varies depending upon which release of IS is operating on the DG computer at your end. To transfer (RIS) a copy of LISA from the Forest Service computer at Moscow, ID, to the Forest Service computer at your site, follow the appropriate set of steps given below.

IS Versions Prior to 6.42

- Log onto the DG and go to IS.
- Find an IS drawer and folder to hold LISA temporarily on the DG system. LISA200.EXE is 217,126 bytes (2587 blocks) long.
- From the INFORMATION SYSTEM main menu, select 3--Utilities.
- Select 6--Retrieval and DCC Access.
- Select 1--Retrieval.
- Fill in the IS RETRIEVAL UTILITY screen as follows:

```
LOCATION OF FILE TO BE RETRIEVED
HOST NAME:  S22L04A
LEVEL (1. PUBLIC, 2. STAFF):  2
    STAFF NAME:  4702
    DRAWER NAME:  REMOTE
    FOLDER NAME:  LISA
    FILE NAME:  LISA200.EXE
```

Then fill in the appropriate information for the file destination, giving the level, drawer, and folder you selected for LISA200. This file is large, so you might want to delay transfer until evening to save money.

- CANCEL/EXIT out of the IS RETRIEVAL UTILITY screen to the IS main menu, and then CANCEL/EXIT out of CEO. You should get a DG mail message from "information system" or the equivalent on your system when the file has been transferred.

IS Version 6.42 or Later

- Log onto the DG and go to IS.
- Find an IS drawer and folder to hold LISA temporarily on the DG system. LISA200.EXE is 217,126 bytes (2587 blocks) long.
- From the INFORMATION SYSTEM main menu, select 3--Utilities.
- Select 6--Transfer (Information transfer and DCC Access).
- Select 1--Info transfer.
- Fill in INFORMATION TRANSFER UTILITY screen 1 as follows:

TRANSFER TYPE (1. SEND, 2. RETRIEVE): 2

LOCAL INFORMATION STRUCTURE

LEVEL (1. PUBLIC, 2. STAFF): *as appropriate*
DRAWER NAME: *drawer on your system*
FOLDER NAME: *folder on your system*
FILE NAME: LISA200.EXE

LOCAL TRANSFER ACTION (Y/N)? N

- Fill in INFORMATION TRANSFER UTILITY screen 2 as follows:

HOST NAME: S22L04A

REMOTE INFORMATION STRUCTURE

LEVEL (1. PUBLIC, 2. STAFF): 2
STAFF NAME: 4702
DRAWER NAME: REMOTE
FOLDER NAME: LISA
FILE NAME: LISA200.EXE
REMOTE INFORMATION (Y/N)? N

Answer the two remaining questions, "DO YOU WANT TO OMIT CEO MAIL NOTIFICATION (Y/N)?" and "DO YOU WANT TO SUBMIT TRANSFER REQUEST NOW (Y/N)?", as you want. This file is large, so you might want to delay transfer until evening to save money.

- CANCEL/EXIT out to the INFO SYSTEM main menu, and then CANCEL/EXIT out of CEO. You should get a DG mail message from "information system" or the equivalent on your system when the file has been transferred.

Download LISA from IS to a PC

We recommend putting the LISA200 archive file on a floppy disk so that you will have a backup copy for future use. You will need a formatted disk with about 300,000 bytes or more available. The method for downloading LISA from the DG to a PC is as follows:

- Log onto the Data General from a personal computer using CEO-CONNECTION software, and go to IS.
- From the IS main menu, select 1--Access Information and navigate to the IS drawer and folder containing file LISA200.EXE.
- From the COMMAND: prompt, press CTRL-BREAK to return to the CEO–CONNECTION main menu.
- Select 5--Retrieve a file and enter the HOST PATHNAME and MS-DOS PATHNAME for the LISA200 file. For example,

HOST PATHNAME: :STAFF:xxx:drawer:folder:LISA200.EXE
MS-DOS PATHNAME: A:LISA200.EXE

- Select 3--Terminal, to return to IS. If the DG does not respond, press CTRL-D three times.
- Delete LISA200.EXE from IS.
- Log off of the DG and leave CEO–CONNECTION.

APPENDIX B — USING THE SOFTWARE REFERENCE CENTER

Information about the slope stability computer programs available from this Research Work Unit will be stored in the Software Reference Center (SRC) located on the Forest Service's Washington Office computer. The information stored there will include a description of the program, the date and revision number of the current version, the name and DG address of whom to contact for more information, and instructions for retrieving the latest version of the program. The computer programs themselves will be stored on, and can be retrieved from, the Data General computer at the Forestry Sciences Laboratory in Moscow, ID, as described in appendix A.

The Software Reference Center can be accessed by the following steps:

- While you are in CEO on the Data General, press F5 (the CEO interrupt key).
- Select `7--User Applications` from the INTERRUPT menu.
- Type `INFO_CENTER` after the **`Application you want to run`** prompt on the SELECT AN APPLICATION menu. (Note that some systems may use a different application name for the INFORMATION CENTER ACCESS menu. To find out what it is called on your system, press **`shift-`**F2 to obtain a list of available applications.)
- Select `1--Standard` from the SELECT AN APPLICATION menu.
- Select `1--SRC` from the FOREST SERVICE INFORMATION CENTERS menu. You should get a message on the bottom line of your terminal saying that your system is **`Calling Information Center...`**, followed by a list of the folders in the SRC drawer. Be patient, responses are slow over the telephone lines.
- Select `1--List Documents` and folder **`Engineering`**[1] and the system will display a list of documents including those from this Research Work Unit matching the names of its slope stability programs **`LISA`**, **`DLISA`**, **`SARA`**, **`DSARA`**, and **`XSTABL`**. View or mail to yourself the document with the name of the program you are interested in.
- Back out of the SRC by pressing the **`Cancel/Exit`** key several times. You will pass through the DOCUMENT LIST, the FOLDER LIST, and the FILING FUNCTIONS menu, to the MAIN menu on the Washington Office computer. Press the **`Cancel/Exit`** key once more and answer **`Y`** to the **`Do you want to exit (Y/N)?`** question to log off the Washington computer and return to your regular CEO session.

[1] We hope to be able to create a folder called `Geotechnical Engineering`. If that folder is listed, select it, instead.

APPENDIX C — DLISA EQUATIONS

Factor of Safety

$$FS = \frac{C + [q_0 + \gamma d + (\gamma_{\text{sat}} - \gamma_w - \gamma)D_w]\cos^2\alpha\tan\phi}{[q_0 + \gamma d + (\gamma_{\text{sat}} - \gamma)D_w]\cos\alpha\sin\alpha}$$

Total Cohesion

$$C = [q_0 + \gamma d + (\gamma_{\text{sat}} - \gamma)D_w]\cos\alpha\sin\alpha FS - [q_0 + \gamma d + (\gamma_{\text{sat}} - \gamma_w - \gamma)D_w]\cos^2\alpha\tan\phi$$

Friction Angle

$$\phi = \tan^{-1}\left\{\frac{[q_0 + \gamma d + (\gamma_{\text{sat}} - \gamma)D_w]\cos\alpha\sin\alpha FS - C}{[q_0 + \gamma d + (\gamma_{\text{sat}} - \gamma_w - \gamma)D_w]\cos^2\alpha}\right\}$$

Soil Depth

$$d = \frac{\frac{C}{\cos\alpha} + [q_0 + (\gamma_{\text{sat}} - \gamma_w - \gamma)D_w]\cos\alpha\tan\phi - [q_0 + (\gamma_{\text{sat}} - \gamma)D_w]\sin\alpha FS}{\gamma\sin\alpha FS - \gamma\cos\alpha\tan\phi}$$

Groundwater Height

$$D_w = \frac{(q_0 + \gamma d)(\sin\alpha FS - \cos\alpha\tan\phi) - \frac{C}{\cos\alpha}}{(\gamma_{\text{sat}} - \gamma_w - \gamma)\cos\alpha\tan\phi - (\gamma_{\text{sat}} - \gamma)\sin\alpha FS}$$

Ground Surface Slope

$$\alpha \leftarrow 0$$

Do

$$\alpha' \leftarrow \alpha$$

$$\alpha \leftarrow \sin^{-1}\left\{\frac{C + [q_0 + \gamma d + (\gamma_{sat} - \gamma_w - \gamma)D_w]\cos^2\alpha'\tan\phi}{[q_0 + \gamma d + (\gamma_{sat} - \gamma)D_w]\cos\alpha' FS}\right\}$$

Loop until $\alpha \approx \alpha'$

Tree Surcharge

$$q_o = \frac{\frac{C}{\cos\alpha} + [\gamma d + (\gamma_{\text{sat}} - \gamma_w - \gamma)D_w]\cos\alpha\tan\phi - [\gamma d + (\gamma_{\text{sat}} - \gamma)D_w]\sin\alpha FS}{\sin\alpha FS - \cos\alpha\tan\phi}$$

APPENDIX D — ERROR AND WARNING MESSAGES

LISA

DLISA

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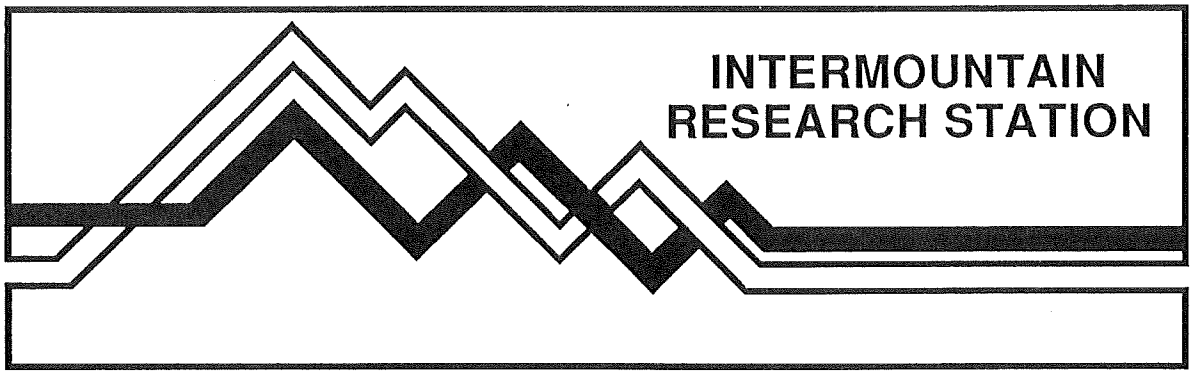
Hammond, Carol; Hall, David; Miller, Stanley; Swetik, Paul. 1992. Level I Stability Analysis (LISA) documentation for version 2.0. Gen. Tech. Rep. INT-285. Ogden, UT: U. S. Department of Agriculture, Forest Service, Intermountain Research Station. 190 p.

LISA uses Monte Carlo simulation of the infinite slope equation to estimate a probability of slope failure for use in relative stability hazard assessment of natural slopes or landforms. The manual discusses probabilistic concepts, the mathematical basis of the model, suggestions for estimating input probability distributions, and an example application, as well as instructions for program operation.

KEYWORDS: probabilistic stability analysis, landslide hazard analysis, Monte Carlo simulation, infinite slope equation, probability of failure, probabilistic computer model



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