U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

LOGRAF:
Lognormal Graph for Resource Assessment Forecast

By

Robert A. Crovelli[1] and Richard H. Balay[1]

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A -- Documentation (paper copy)
B -- Executable program (5.25" diskette)

[1]U.S. Geological Survey, Box 25046, MS 971, DFC, Denver, Colorado 80225

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ABSTRACT

Lognormal Graph for Resource Assessment Forecast (LOGRAF) is a computer program that calculates and plots graphs of the conditional and unconditional resource potential of an assessment study area. It produces complementary (more-than) cumulative distribution function curves for one or two three-parameter lognormal distributions on the same graph. Examples of two probability curves on the same graph are (1) conditional and unconditional oil potential, and (2) recoverable and economically recoverable (conditional) gas potential. The system is completely generic because the user determines the resource type which is not restricted to petroleum.

Program LOGRAF plots the graph described above on an IBM-PC compatible computer from input supplied by the user. It accepts user input, computes the parameters of the graph, displays the graph on the computer screen, and transfers the image to a PostScript laser printer. LOGRAF requires a minimum 400 Kbytes free memory, MS-DOS 3.3 or higher, a VGA graphics adapter, and a PostScript laser printer. A numeric coprocessor is not required.

INTRODUCTION

Lognormal Graph for Resource Assessment Forecast (LOGRAF) is a computer program that plots graphs of the conditional and unconditional resource potential of an assessment study area. LOGRAF is basically a PC version of the main-frame program EXACTDIS with several improvements. The probabilistic methodology was originally derived in Crovelli (1981). The program EXACTDIS was used to generate probability graphs in the national assessment of undiscovered conventional oil and gas resources by the U.S. Geological Survey (Dolton and others, 1981; Crovelli, 1984). EXACTDIS was again applied to produce probability graphs in a more recent national assessment of undiscovered petroleum resources (Mast and others, 1989). LOGRAF is designed to replace EXACTDIS in any future application to generate probability graphs for oil and gas resource assessment. LOGRAF could be used in conjunction with two petroleum play analysis systems FASPU (Crovelli and Balay, 1990) and APRAS (Crovelli and Balay, 1992).

The program EXACTDIS used a graphics support package called DISSPLA which was later replaced by the commercial computer package TELL-A-GRAF. EXACTDIS wrote its graphical output onto a Tektronix DVST display terminal. Printouts of screen graphics were made on a Tektronix hard copy device. Written originally in FORTRAN, EXACTDIS ran on a VAX-11/780. The objective of this study was to create a PC version of EXACTDIS. Any use of trade, product or firm names in this document is for descriptive purposes only and does not imply endorsement by the U.S. Government.

PROBABILISTIC METHODOLOGY

LOGRAF produces complementary (more-than) cumulative distribution function curves for one or two three-parameter lognormal distributions on the same graph. The probabilistic methodology was originally derived in Crovelli (1981).

The input into LOGRAF consists of estimates of the following parameters for each distribution: shift parameter, marginal probability, 95th fractile, and 5th fractile. Other descriptive inputs are plot title, resource type, units, and assessment date. The system is completely generic in that the user determines the resource type; it is not restricted to petroleum. The shift parameter represents the minimum quantity of resources assessed and specifies the location of the lower end-point of the conditional distribution's range of values. The marginal probability is the probability that the resource is present in an amount at least the shift parameter. The 95th and 5th fractiles are conditional estimates of resource amounts that have, respectively, a 19 in 20 chance and a 1 in 20 chance of at least these estimated amounts. These fractiles establish the conditional distribution, which is a lognormal distribution with the specified shift parameter. Note that when the shift

parameter is equal to zero, then we have a two-parameter lognormal distribution. If the marginal probability is (or is set) equal to 1, the conditional distribution is plotted. If the marginal probability is less than 1, the unconditional distribution is plotted. With the graph, the following estimates are computed: mean, median, mode, standard deviation, and five fractiles (F_{95}, F_{75}, F_{50}, F_{25}, F_5).

For a mathematical development of the equations, let

X: Quantity of undiscovered resource,

and

θ: Shift parameter.

Suppose we consider the following probabilistic relationship of the unconditional probability distribution

$$P(X > x) = P(X > \theta)\, P(X > x \mid X > \theta) \qquad x \geq \theta$$

where

$P(X > \theta)$ is the marginal probability,

and

$P(X > x \mid X > \theta)$ is the conditional probability distribution.

The conditional distribution is taken to be a lognormal distribution with shift parameter θ. Given the conditional fractiles F^c_{95} and F^c_5, the parameters of the two-parameter lognormal distribution can be calculated from the equations

$$\mu = [\ln (F^c_5 - \theta) + \ln (F^c_{95} - \theta)] / 2$$

and

$$\sigma = [\ln (F^c_5 - \theta) - \ln (F^c_{95} - \theta)] / 3.29$$

From the parameters, any conditional fractile $F^c_{100\alpha}$ can now be computed for a given α from the formula

$$F^c_{100\alpha} = \exp (\mu + z_\alpha \sigma) + \theta$$

where $P(Z > z_\alpha) = \alpha$ and Z is a standard normal random variable.

The following conditional estimates can also be calculated:

Conditional mean $\equiv \mu_c = \exp(\mu + \sigma^2/2) + \theta$

Conditional median $\equiv m_c = \exp(\mu) + \theta$

Conditional mode $\equiv M_c = \exp(\mu - \sigma^2) + \theta$

Conditional variance $\equiv \sigma_c^2 = [\exp(\mu + \sigma^2/2)]^2 [\exp(\sigma^2) - 1]$

Recall that the marginal probability of a resource is applied to its corresponding conditional probabilty distribution to produce the unconditional probability distribution. The unconditional fractiles $F_{100\alpha}$ are determined by a transformation to conditional fractiles as follows. Given the marginal probability $P(X > \theta) \equiv p \neq 0$ and specified α, find $F_{100\alpha}$.

Case I: $\alpha \leq p$, then $F_{100\alpha} = F^c_{100\alpha/p}$.

Example: $\alpha = 0.05 < p = 0.20$, then $F_5 = F^c_{25}$

Case II: $\alpha > p$, then $F_{100\alpha} = 0$.

Example: $\alpha = 0.95 > p = 0.20$, then $F_{95} = 0$.

The following unconditional estimates are also computed:

Unconditional mean $\equiv \mu_u = p\mu_c$

Unconditional variance $\equiv \sigma_u^2 = p\sigma_c^2 + p(1-p)\,\mu_c^2$

EXAMPLES

Examples of two probability curves on the same graph are (1) conditional and unconditional resource potential, and (2) recoverable and economically recoverable resource potential.

Example 1

LOGRAF is used to duplicate the probability graphs that were originally generated by EXACTDIS for the national assessment of undiscovered conventional oil and gas resources by the U.S. Geological Survey (Mast and others, 1989).

Figure 1a consists of cumulative probability distributions for undiscovered recoverable and undiscovered economically recoverable conventional **crude oil** resources of the United States. Figure 1a' is a summary of the input and output of the assessment, including the lognormal parameters and the conditional and unconditional estimates for each probability curve. The input into LOGRAF are estimates of the following parameters for each distribution:

Recoverable resources--p = 1, $\theta = 0$, $F^c_{95} = 33.2$, $F^c_5 = 69.9$

Economically recoverable--p = 1, $\theta = 0$, $F^c_{95} = 20.7$, $F^c_5 = 53.8$

and with units of billions of barrels.

Figure 1b consists of cumulative probability distributions for undiscovered recoverable and undiscovered economically recoverable conventional **natural gas** resources of the United States. Figure 1b' is a summary of the input and output of the assessment, including the lognormal parameters and the conditional and unconditional estimates for each probability curve. The input into LOGRAF are estimates of the following parameters for each distribution:

Recoverable resources--p = 1, $\theta = 0$, $F^c_{95} = 306.8$, $F^c_5 = 507.2$

Economically recoverable--p = 1, $\theta = 0$, $F^c_{95} = 208.2$, $F^c_5 = 325.5$

and with units of trillions of cubic feet.

Undiscovered Conventional Crude Oil Resources - Total U.S.

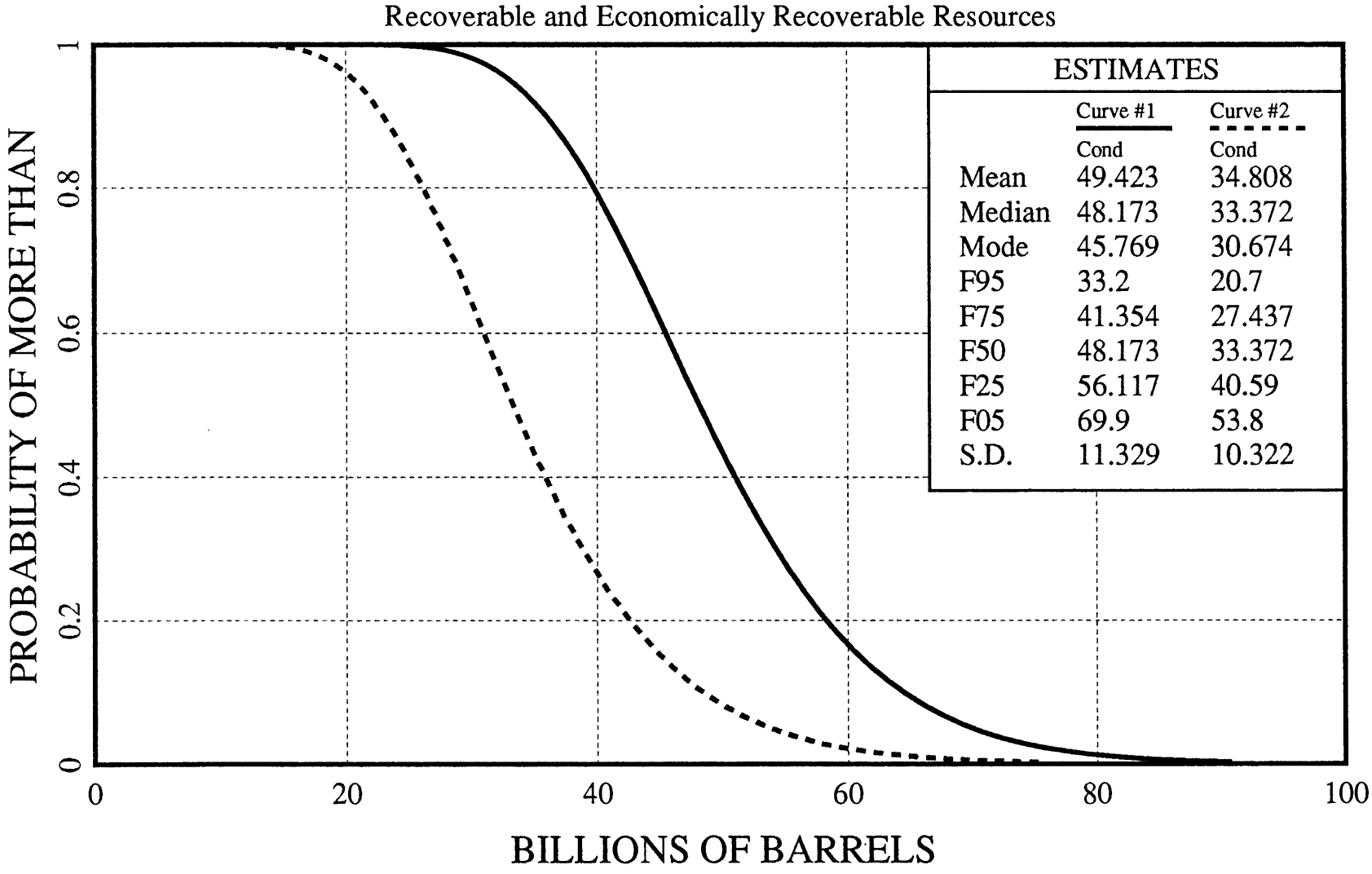

Figure 1a.--LOGRAF output of cumulative probability distributions for undiscovered recoverable (curve #1) and undiscovered economically recoverable (curve #2) conventional **crude oil** resources of the United States. Both curves are conditional (cond) probability distributions. For additional output see figure 1a'. (Curves duplicated from Figure 10 in Mast and others, 1989.)

LOGRAF 92.7 15-Dec-1992 17:09:09 C:\LOGRAF\GEOTECH\USOIL.DAT

Title : Undiscovered Conventional Crude Oil Resources - Total U.S.
Subtitle : Recoverable and Economically Recoverable Resources
Units : BILLIONS OF BARRELS

INPUT: Probability curve #1

Marginal probability	1
Shift parameter	0
Conditional F95	33.2
Conditional F05	69.9

OUTPUT:

Lognormal parameters

Mu	3.8748
Sigma	0.2263

Conditional estimates

Mean	49.423
Median	48.173
Mode	45.769
F95	33.2
F90	36.045
F75	41.354
F50	48.173
F25	56.117
F10	64.383
F05	69.9
S.D.	11.329

Unconditional estimates *

Mean	49.423
Median	48.173
Mode	45.769
F95	33.2
F90	36.045
F75	41.354
F50	48.173
F25	56.117
F10	64.383
F05	69.9
S.D.	11.329

INPUT: Probability curve #2

Marginal probability	1
Shift parameter	0
Conditional F95	20.7
Conditional F05	53.8

OUTPUT:

Lognormal parameters

Mu	3.5077
Sigma	0.2903

Conditional estimates

Mean	34.808
Median	33.372
Mode	30.674
F95	20.7
F90	23.003
F75	27.437
F50	33.372
F25	40.59
F10	48.415
F05	53.8
S.D.	10.322

Unconditional estimates *

Mean	34.808
Median	33.372
Mode	30.674
F95	20.7
F90	23.003
F75	27.437
F50	33.372
F25	40.59
F10	48.415
F05	53.8
S.D.	10.322

* Because the marginal probability is equal to 1, the unconditional and conditional estimates are equal.

Figure 1a'.--LOGRAF summary of input and output estimates for undiscovered recoverable (curve #1) and undiscovered economically recoverable (curve #2) conventional **crude oil** resources of the United States. For additional output see figure 1a.

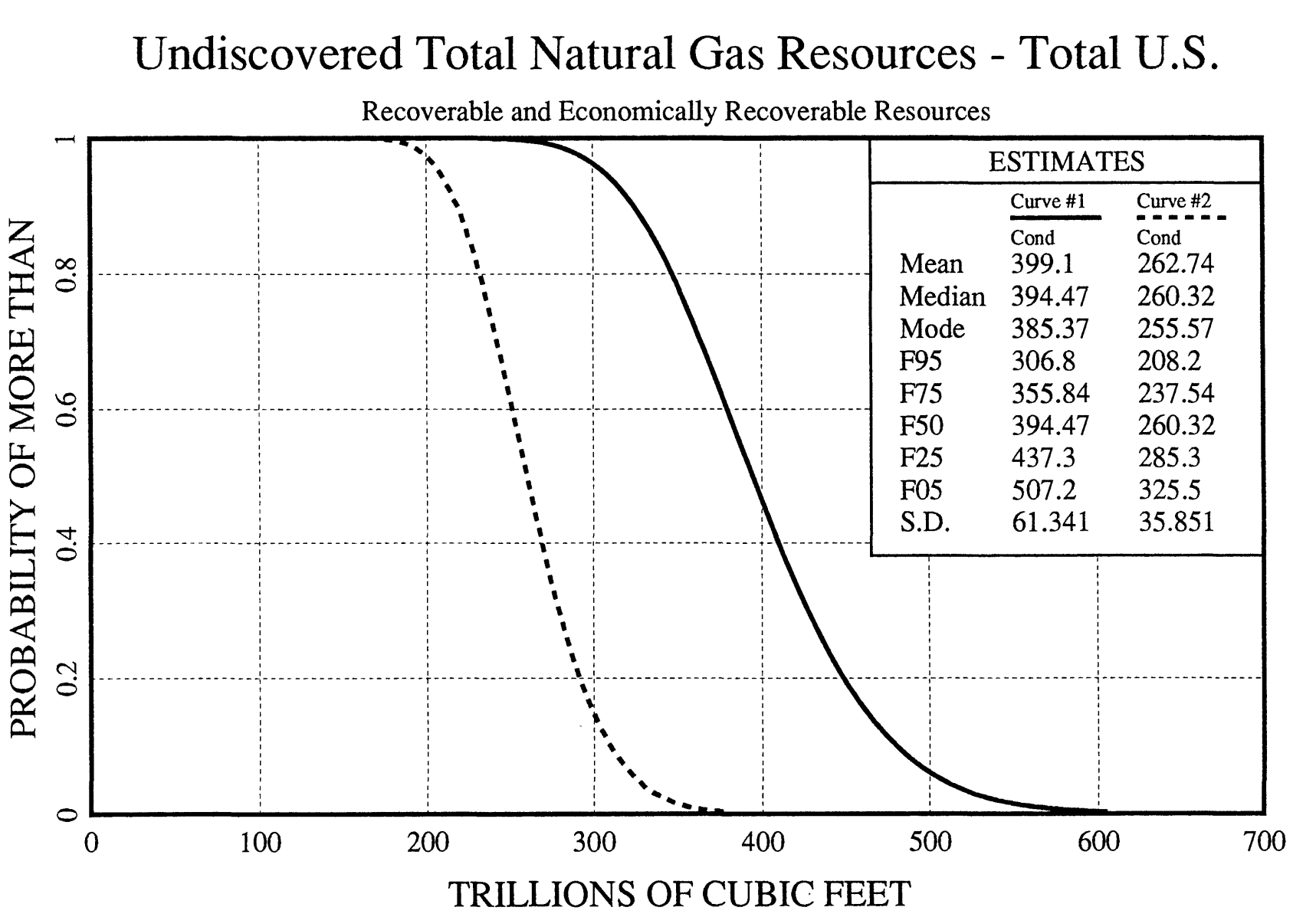

Figure 1b.--LOGRAF output of cumulative probability distributions for undiscovered recoverable (curve #1) and undiscovered economically recoverable (curve #2) conventional **natural gas** resources of the United States. Both curves are conditional (cond) probability distributions. For additional output see figure 1b'. (Curves duplicated from Figure 11 in Mast and others, 1989.)

LOGRAF 92.7 15-Dec-1992 17:09:16 C:\LOGRAF\GEOTECH\USGAS.DAT

Title : Undiscovered Total Natural Gas Resources - Total U.S.
Subtitle : Recoverable and Economically Recoverable Resources
Units : TRILLIONS OF CUBIC FEET

INPUT: Probability curve #1

Marginal probability	1
Shift parameter	0
Conditional F95	306.8
Conditional F05	507.2

OUTPUT:

Lognormal parameters

Mu	5.9776
Sigma	0.1528

Conditional estimates

Mean	399.1
Median	394.47
Mode	385.37
F95	306.8
F90	324.31
F75	355.84
F50	394.47
F25	437.3
F10	479.81
F05	507.2
S.D.	61.341

Unconditional estimates *

Mean	399.1
Median	394.47
Mode	385.37
F95	306.8
F90	324.31
F75	355.84
F50	394.47
F25	437.3
F10	479.81
F05	507.2
S.D.	61.341

INPUT: Probability curve #2

Marginal probability	1
Shift parameter	0
Conditional F95	208.2
Conditional F05	325.5

OUTPUT:

Lognormal parameters

Mu	5.5619
Sigma	0.1358

Conditional estimates

Mean	262.74
Median	260.32
Mode	255.57
F95	208.2
F90	218.73
F75	237.54
F50	260.32
F25	285.3
F10	309.83
F05	325.5
S.D.	35.851

Unconditional estimates *

Mean	262.74
Median	260.32
Mode	255.57
F95	208.2
F90	218.73
F75	237.54
F50	260.32
F25	285.3
F10	309.83
F05	325.5
S.D.	35.851

* Because the marginal probability is equal to 1, the unconditional and conditional estimates are equal.

Figure 1b'.--LOGRAF summary of input and output estimates for undiscovered recoverable (curve #1) and undiscovered economically recoverable (curve #2) conventional **natural gas** resources of the United States. For additional output see figure 1b.

Example 2

LOGRAF is used to generate probability graphs for resource estimates that were the output of the petroleum play analysis program APRAS (Crovelli and Balay, 1992) when applied in an assessment of oil and gas potential of the National Petroleum Reserve in Alaska (Bird and others, 1991).

Figure 2a consists of cumulative probability distributions for undiscovered conditional and unconditional recoverable conventional **crude oil** resources in the Paleotopographic Lisburne play of the National Petroleum Reserve in Alaska. Figure 2a′ is a summary of the input and output of the assessment, including the lognormal parameters and the conditional and unconditional estimates for each probability curve. The input into LOGRAF are estimates of the following parameters for each distribution:

Conditional resources--p = 1, $\theta = 1$, $F^c_{95} = 6.6885$, $F^c_5 = 211.65$

Unconditional resources--p = 0.468, $\theta = 1$, $F^c_{95} = 6.6885$, $F^c_5 = 211.65$

and with units of millions of barrels.

Figure 2b consists of cumulative probability distributions for undiscovered conditional and unconditional recoverable conventional **natural gas** resources in the Paleotopographic Lisburne play of the National Petroleum Reserve in Alaska. Figure 2b′ is a summary of the input and output of the assessment, including the lognormal parameters and the conditional and unconditional estimates for each probability curve. The input into LOGRAF are estimates of the following parameters for each distribution:

Conditional resources--p = 1, $\theta = 0.0071$, $F^c_{95} = 1.0077$, $F^c_5 = 7.044$

Unconditional resources-- p = 0.5, $\theta = 0.0071$, $F^c_{95} = 1.0077$, $F^c_5 = 7.044$

and with units of trillions of cubic feet.

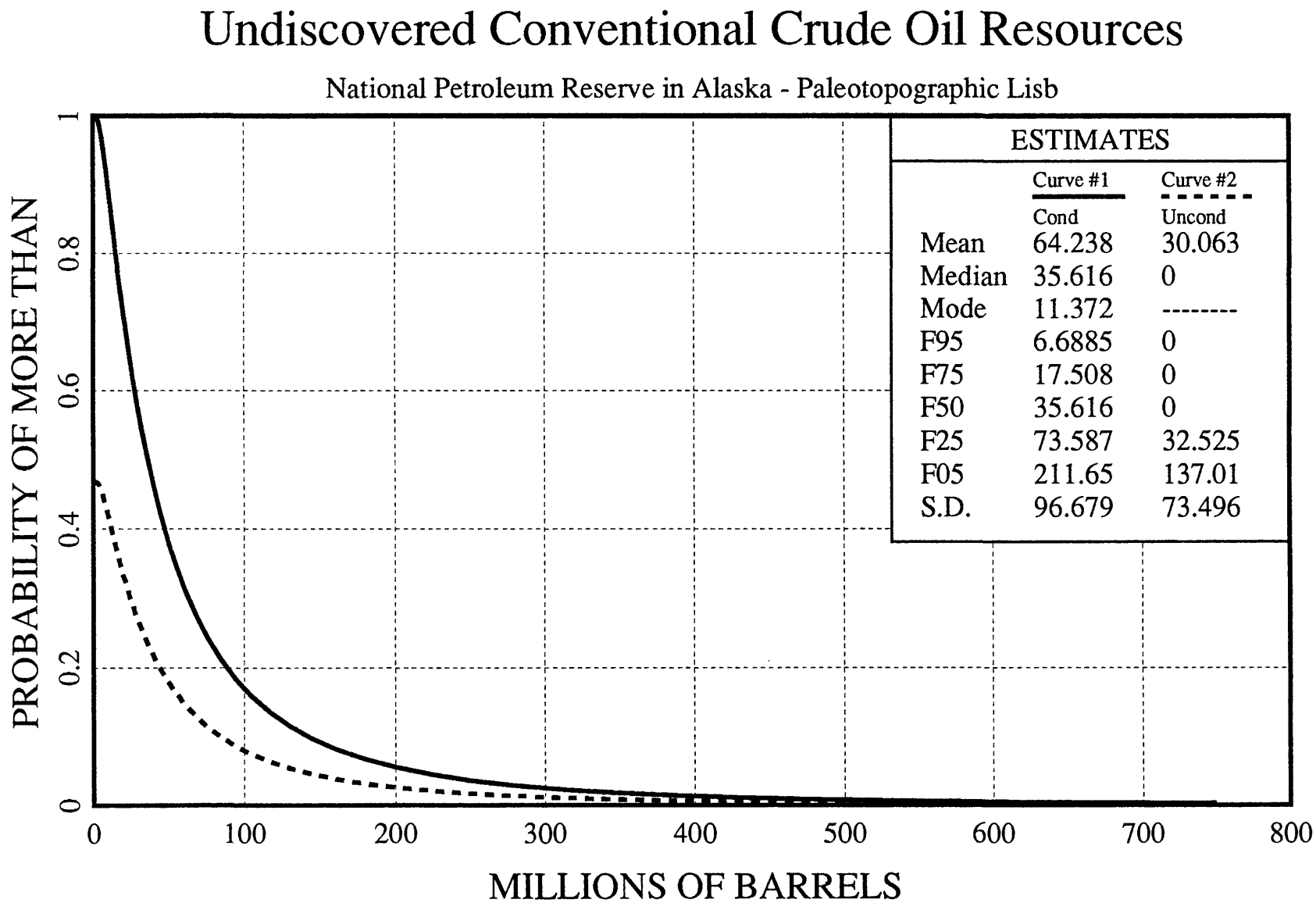

Figure 2a.--LOGRAF output of cumulative probability distributions for undiscovered conditional (curve #1) and unconditional (curve #2) recoverable conventional **crude oil** resources in the Paleotopographic Lisburne play of the National Petroleum Reserve in Alaska. For additional output see figure 2a'.

LOGRAF 92.7 15-Dec-1992 17:09:28 C:\LOGRAF\GEOTECH\NPRAOIL.DAT

Title : Undiscovered Conventional Crude Oil Resources
Subtitle : National Petroleum Reserve in Alaska - Paleotopographic Lisb
Units : MILLIONS OF BARRELS

INPUT: Probability curve #1

Marginal probability	1
Shift parameter	1
Conditional F95	6.6885
Conditional F05	211.65

OUTPUT:

Lognormal parameters

Mu	3.5443
Sigma	1.0978

Conditional estimates

Mean	64.238
Median	35.616
Mode	11.372
F95	6.6885
F90	9.4763
F75	17.508
F50	35.616
F25	73.587
F10	142.37
F05	211.65
S.D.	96.679

Unconditional estimates *

Mean	64.238
Median	35.616
Mode	11.372
F95	6.6885
F90	9.4763
F75	17.508
F50	35.616
F25	73.587
F10	142.37
F05	211.65
S.D.	96.679

INPUT: Probability curve #2

Marginal probability	0.468
Shift parameter	1
Conditional F95	6.6885
Conditional F05	211.65

OUTPUT:

Lognormal parameters

Mu	3.5443
Sigma	1.0978

Conditional estimates

Mean	64.238
Median	35.616
Mode	11.372
F95	6.6885
F90	9.4763
F75	17.508
F50	35.616
F25	73.587
F10	142.37
F05	211.65
S.D.	96.679

Unconditional estimates

Mean	30.063
Median	0
Mode	--------
F95	0
F90	0
F75	0
F50	0
F25	32.525
F10	83.798
F05	137.01
S.D.	73.496

* Because the marginal probability is equal to 1, the unconditional and conditional estimates are equal.

Figure 2a'.--LOGRAF summary of input and output estimates for undiscovered conditional (curve #1) and unconditional (curve #2) recoverable conventional **crude oil** resources in the Paleotopographic Lisburne play of the National Petroleum Reserve in Alaska. For additional output see figure 2a.

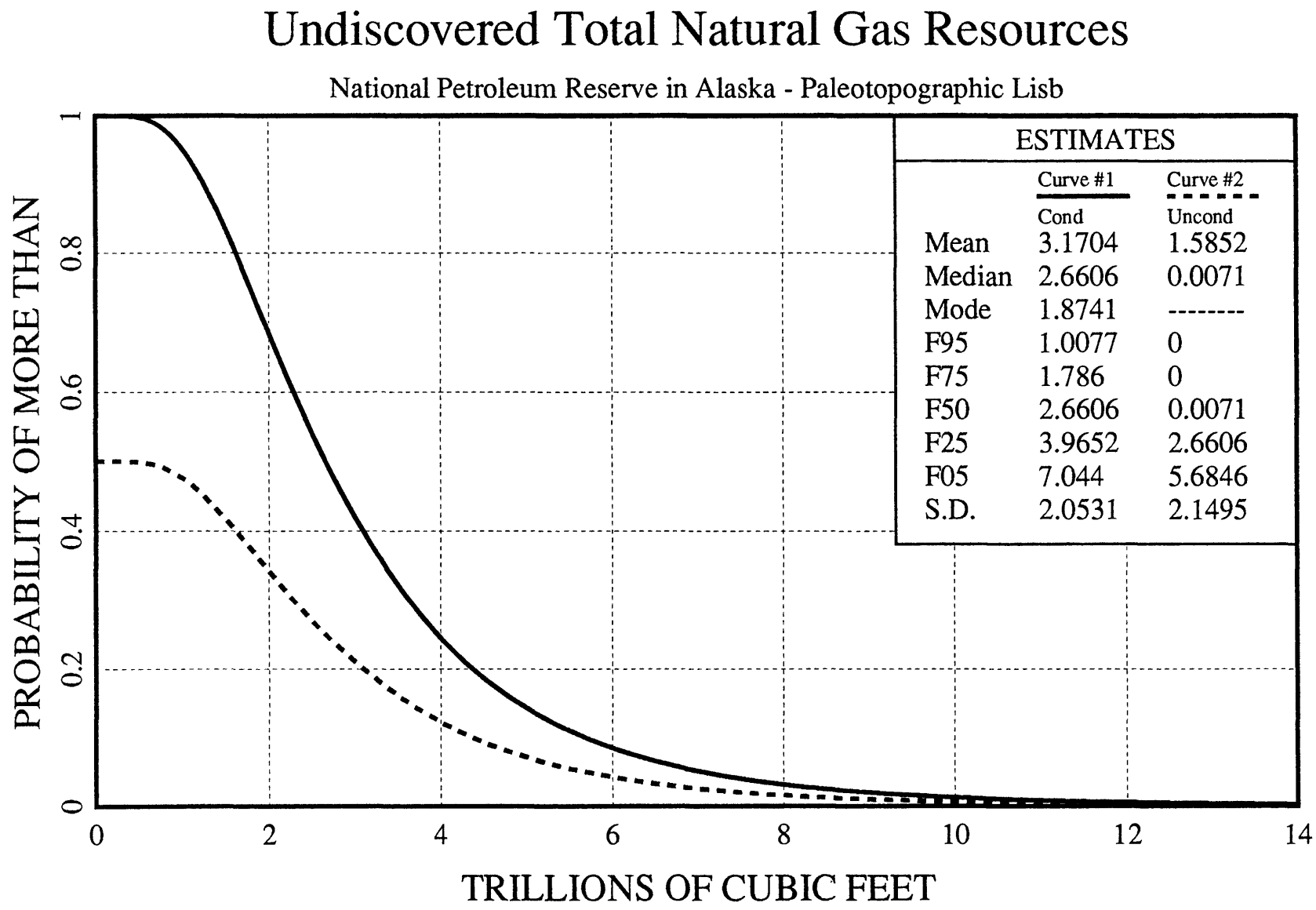

Figure 2b.--LOGRAF output of cumulative probability distributions for undiscoverd conditional (curve #1) and unconditional (curve #2) recoverable conventional **natural gas** resources in the Paleotopographic Lisburne play of the National Petroleum Reserve in Alaska. For additional output see figure 2b'.

LOGRAF 92.7 15-Dec-1992 17:09:37 C:\LOGRAF\GEOTECH\NPRAGAS.DAT

Title : Undiscovered Total Natural Gas Resources
Subtitle : National Petroleum Reserve in Alaska - Paleotopographic Lisb
Units : TRILLIONS OF CUBIC FEET

INPUT: Probability curve #1

Marginal probability	1
Shift parameter	0.0071
Conditional F95	1.0077
Conditional F05	7.044

OUTPUT:

Lognormal parameters

Mu	0.9759
Sigma	0.5929

Conditional estimates

Mean	3.1704
Median	2.6606
Mode	1.8741
F95	1.0077
F90	1.2482
F75	1.786
F50	2.6606
F25	3.9652
F10	5.6804
F05	7.044
S.D.	2.0531

Unconditional estimates *

Mean	3.1704
Median	2.6606
Mode	1.8741
F95	1.0077
F90	1.2482
F75	1.786
F50	2.6606
F25	3.9652
F10	5.6804
F05	7.044
S.D.	2.0531

INPUT: Probability curve #2

Marginal probability	0.5
Shift parameter	0.0071
Conditional F95	1.0077
Conditional F05	7.044

OUTPUT:

Lognormal parameters

Mu	0.9759
Sigma	0.5929

Conditional estimates

Mean	3.1704
Median	2.6606
Mode	1.8741
F95	1.0077
F90	1.2482
F75	1.786
F50	2.6606
F25	3.9652
F10	5.6804
F05	7.044
S.D.	2.0531

Unconditional estimates

Mean	1.5852
Median	0.0071
Mode	--------
F95	0
F90	0
F75	0
F50	0.0071
F25	2.6606
F10	4.3825
F05	5.6846
S.D.	2.1495

* Because the marginal probability is equal to 1, the unconditional and conditional estimates are equal.

Figure 2b'.--LOGRAF summary of input and output estimates for undiscovered conditional (curve #1) and unconditional (curve #2) recoverable conventional **natural gas** resources in the Paleotopographic Lisburne play of the National Petroleum Reserve in Alaska.For additional output see figure 2b.

Example 3

LOGRAF is used to generate probability graphs for resource estimates that were the result of a direct assessment (or Delphi approach) in a national assessment of undiscovered conventional oil and gas resources (Dolton and others, 1981).

Figure 3a consists of cumulative probability distributions for undiscovered conditional and unconditional recoverable conventional **crude oil** resources in the Montana Overthrust Belt province. Figure 3a′ is a summary of the input and output of the assessment, including the lognormal parameters and the conditional and unconditional estimates for each probability curve. The input into LOGRAF are estimates of the following parameters for each distribution:

Conditional resources--$p = 1, \theta = 0, F^c_{95} = 0.08, F^c_5 = 2.17$

Unconditional resources--$p = 0.86, \theta = 0, F^c_{95} = 0.08, F^c_5 = 2.17$

and with units of billions of barrels.

Figure 3b consists of a cumulative probability distribution for undiscovered conditional recoverable conventional **natural gas** resources in the Montana Overthrust Belt province. Figure 3b′ is a summary of the input and output of the assessment, including the lognormal parameters and the conditional and unconditional estimates for the probability curve. The input into LOGRAF are estimates of the following parameters for the distribution:

Conditional resources--$p = 1, \theta = 0, F^c_{95} = 2.46, F^c_5 = 22.94$

and with units of trillions of cubic feet.

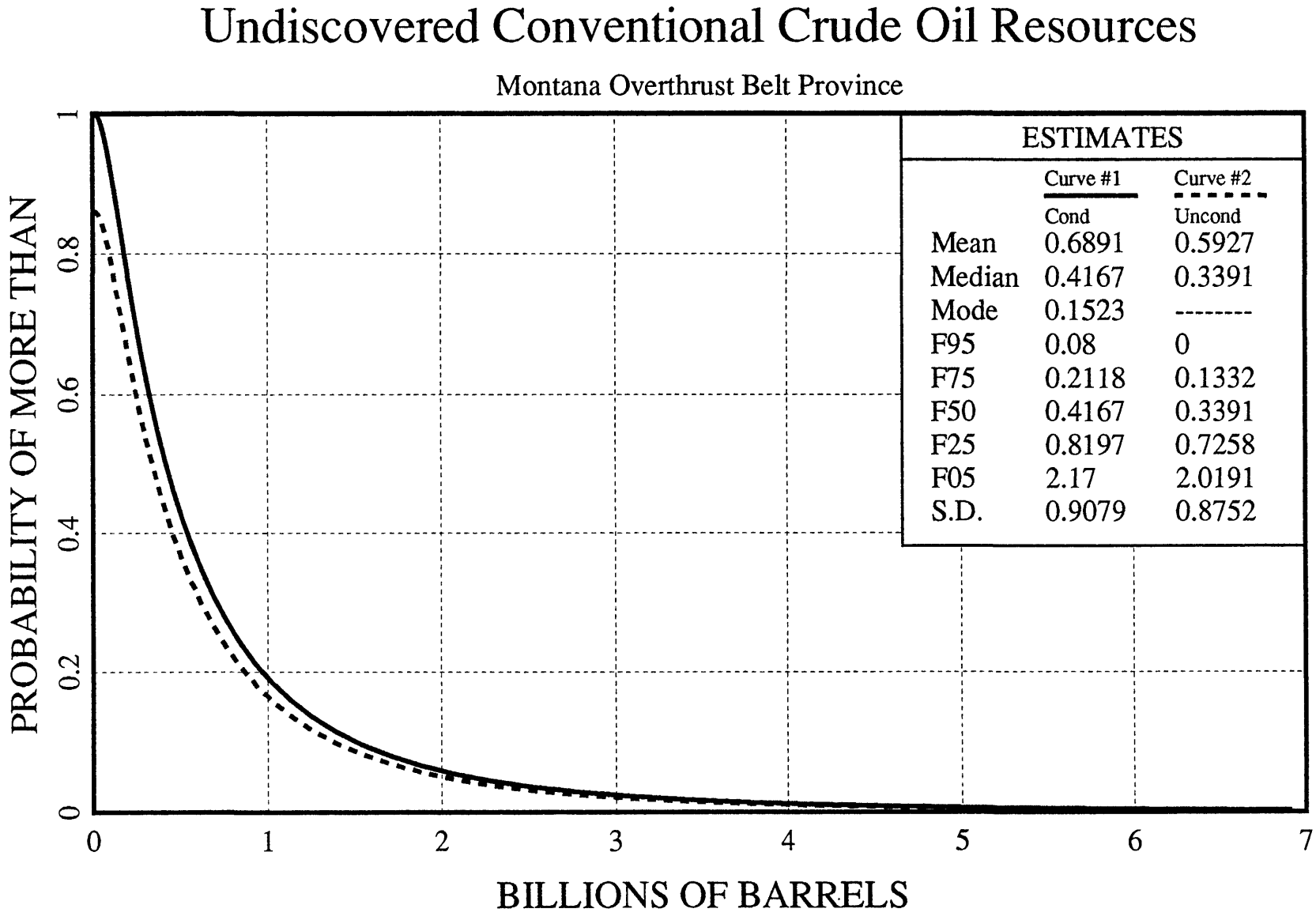

Figure 3a.--LOGRAF output of cumulative probability distributions for undiscovered conditional (curve #1) and unconditional (curve #2) recoverable conventional **crude oil** resources in the Montana Overthrust Belt province. For additional output see figure 3a'.

LOGRAF 92.7 15-Dec-1992 17:08:53 C:\LOGRAF\GEOTECH\MTOIL.DAT

Title : Undiscovered Conventional Crude Oil Resources
Subtitle : Montana Overthrust Belt Province
Units : BILLIONS OF BARRELS

INPUT: Probability curve #1

Marginal probability	1
Shift parameter	0
Conditional F95	0.08
Conditional F05	2.17

OUTPUT:

Lognormal parameters

Mu	-0.8755
Sigma	1.0032

Conditional estimates

Mean	0.6891
Median	0.4167
Mode	0.1523
F95	0.08
F90	0.1152
F75	0.2118
F50	0.4167
F25	0.8197
F10	1.5072
F05	2.17
S.D.	0.9079

Unconditional estimates *

Mean	0.6891
Median	0.4167
Mode	0.1523
F95	0.08
F90	0.1152
F75	0.2118
F50	0.4167
F25	0.8197
F10	1.5072
F05	2.17
S.D.	0.9079

INPUT: Probability curve #2

Marginal probability	0.86
Shift parameter	0
Conditional F95	0.08
Conditional F05	2.17

OUTPUT:

Lognormal parameters

Mu	-0.8755
Sigma	1.0032

Conditional estimates

Mean	0.6891
Median	0.4167
Mode	0.1523
F95	0.08
F90	0.1152
F75	0.2118
F50	0.4167
F25	0.8197
F10	1.5072
F05	2.17
S.D.	0.9079

Unconditional estimates

Mean	0.5927
Median	0.3391
Mode	--------
F95	0
F90	0
F75	0.1332
F50	0.3391
F25	0.7258
F10	1.381
F05	2.0191
S.D.	0.8752

* Because the marginal probability is equal to 1, the unconditional and conditional estimates are equal.

Figure 3a'.--LOGRAF summary of input and output estimates for undiscovered conditional (curve #1) and unconditional (curve #2) recoverable conventional **crude oil** resources in the Montana Overthrust Belt province. For additional output see figure 3a.

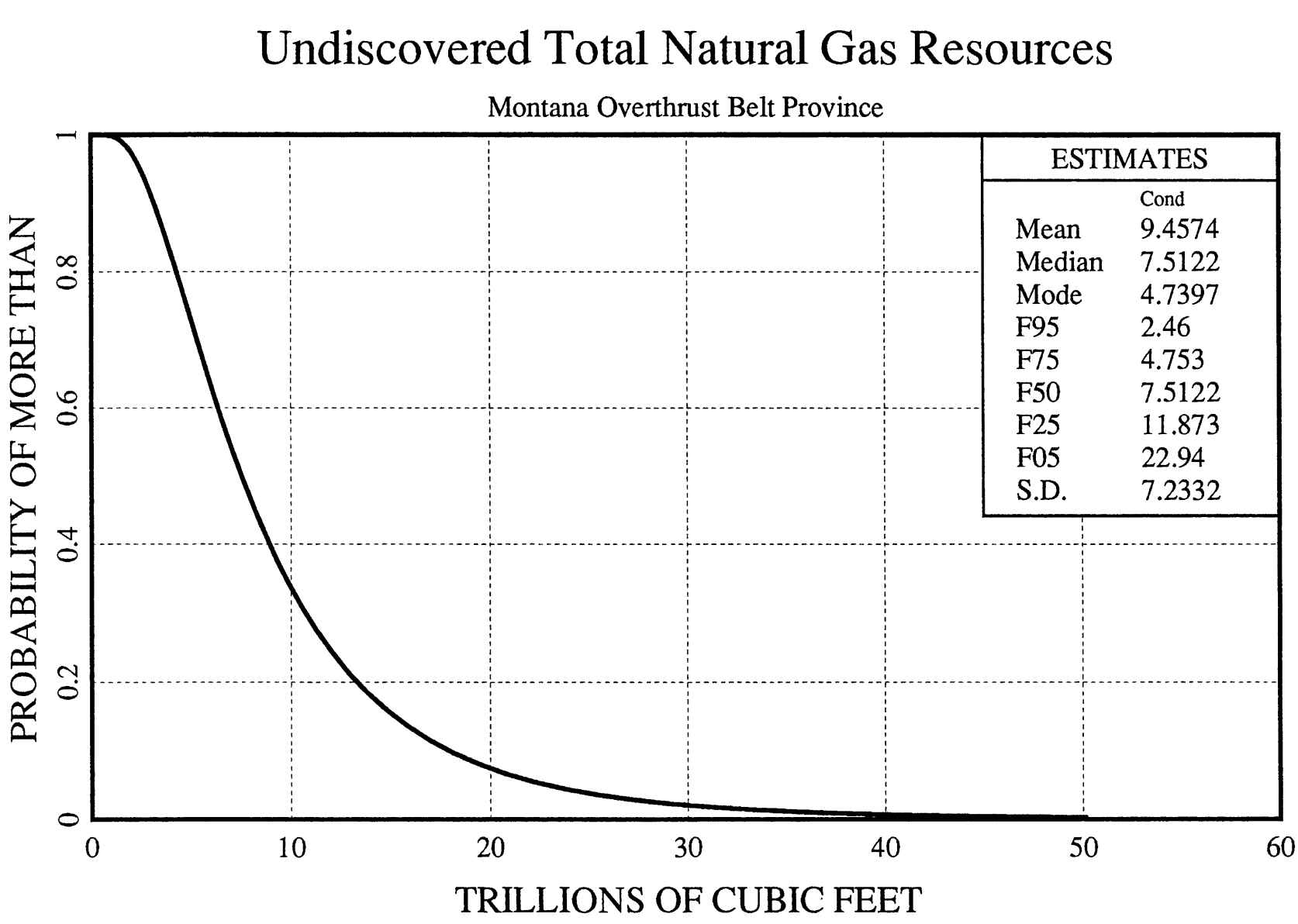

Figure 3b.--LOGRAF output of cumulative probability distribution for undiscovered conditional (cond) recoverable conventional **natural gas** resources in the Montana Overthrust Belt province. For additional output see figure 3b'.

LOGRAF 92.7 15-Dec-1992 17:09:01 C:\LOGRAF\GEOTECH\MTGAS.DAT

Title : Undiscovered Total Natural Gas Resources
Subtitle : Montana Overthrust Belt Province
Units : TRILLIONS OF CUBIC FEET

INPUT:

Marginal probability	1
Shift parameter	0
Conditional F95	2.46
Conditional F05	22.94

OUTPUT:

Lognormal parameters

Mu	2.0165
Sigma	0.6786

Conditional estimates

Mean	9.4574
Median	7.5122
Mode	4.7397
F95	2.46
F90	3.1478
F75	4.753
F50	7.5122
F25	11.873
F10	17.927
F05	22.94
S.D.	7.2332

Unconditional estimates *

Mean	9.4574
Median	7.5122
Mode	4.7397
F95	2.46
F90	3.1478
F75	4.753
F50	7.5122
F25	11.873
F10	17.927
F05	22.94
S.D.	7.2332

* Because the marginal probability is equal to 1, the unconditional and conditional estimates are equal.

Figure 3b'.--LOGRAF summary of input and output estimates for undiscovered conditional recoverable conventional **natural gas** resources in the Montana Overthrust Belt province. For additional output see figure 3b.

PROGRAM DESCRIPTION

The LOGRAF package contains an executable program, a documentation file, scripts of commands for installing the software on a user's computer, and a file of sample data for testing the installed system.

LOGRAF requires an IBM-PC compatible computer with at least 400 Kbytes of memory, a VGA graphics adapter and monitor, an MS-DOS operating system version 3.3 or higher, and a PostScript laser printer. A numeric coprocessor is not required, but it is supported if present. The program does not require any additional software support other than standard utilities provided by MS-DOS.

LOGRAF runs from the DOS command prompt or as a DOS application under Microsoft Windows version 3.0 or 3.1. When operating under Windows, LOGRAF does not use mouse controls. The program running time is negligible, but a PostScript printer may take up to 30 seconds to produce a final plot.

The program includes a data entry module in which the user can enter and edit input parameters for either one or two variables, for example, geologic resources. LOGRAF monitors all keyboard input and reports errors detected in the data entered so the user can make corrections before moving on. When data input is complete, the user escapes from data entry mode and submits the data to the computation and graphics module which generates the final plot.

After LOGRAF analyzes the input data, it displays a curve showing an estimate of the magnitude of the variable or variables on the horizontal axis against the probability of exceeding that magnitude on the vertical axis. If the plot is satisfactory, the user can ask LOGRAF to transfer the image to a PostScript laser printer. Then the program downloads onto the printer a script of commands for reconstructing the plot in maximum laser printer resolution. If the graph displayed on the screen is not satisfactory, the operator can return to data entry mode to modify and refine the input parameters.

LOGRAF keeps input data in a permanent file on the user's disk in a form suitable for future revision. It generates a printable output file that summarizes user input and the computed output estimates. At user option, the output file can be printed by a command built into the program.

COMPUTER REQUIREMENTS

The computer system used to run LOGRAF should include:

- IBM PC compatible computer
- 8086 compatible CPU
- MS-DOS 3.3 operating system or higher, or equivalent PC-DOS
- VGA monitor
- hard disk and 5.25" floppy drive, or two diskette drives (one of which must be 5.25")
- 512 Kbyte memory
- PostScript laser printer with at least 2 Mbyte memory

LOGRAF does not require a math coprocessor.

Although LOGRAF is not designed specifically for the Microsoft Windows™ environment, it does run under Windows version 3.0 in full screen mode. A Windows program item should be installed to run the batch script \LOGRAF.BAT created by the LOGRAF installation program described below. The only visual enhancement in the program that is not honored under Windows is blinking text. The mouse cannot be used with LOGRAF.

LOGRAF INSTALLATION

An IBM-PC compatible 5.25" diskette containing the executable programs and documentation files for LOGRAF is distributed with this Open-File Report. The diskette is a separate Open-File Report, number 92-679B. The files on the diskette are:

-READ.ME	General information and disclaimer;
LG927.EXE	The main program;
LOGRAF.DOC	The documentation file;
INSTALL.EXE	The installation program;
TEST1.DAT TEST2.DAT	Two files of sample data for testing the installed LOGRAF system.

The LOGRAF.DOC file contains most of the present Open-File Report. It can be copied onto an ASCII printer (not a PostScript printer) using the DOS command

```
PRINT  disk:LOGRAF.DOC
```

where *disk* should be replaced by the drive letter of the disk drive containing the LOGRAF issue disk. For example, if the issue disk is in drive B, the command would be `PRINT B:LOGRAF.DOC`.

Following are instructions for installing executable files to generate a LOGRAF working system. Information on running the LOGRAF system after it is installed appears below. In all the instructions that follow, italics are used to show a part of a command that you must replace with a phrase that fits your application.

Running the Installation Program

LOGRAF comes with a program named INSTALL that copies files from the disk on which LOGRAF is delivered (the *source* disk) to the working disk onto which LOGRAF is being installed (the *destination* disk). The destination disk can be a hard disk or a diskette. INSTALL creates a new directory named \LOGRAF on the destination disk. If there already exists a directory with that name on the hard disk, INSTALL copies files into it.

- Insert the LOGRAF issue diskette into a diskette drive.

- Run the LOGRAF installation program by typing

  disk:INSTALL

  In place of *disk* substitute the drive letter of the drive containing the issue disk. Include the colon after the drive letter. An example of the install command is A:INSTALL.

- INSTALL runs through several menus for specifying the source disk, the destination disk, and the name of the computer port connected to the PostScript printer.

After requesting the needed options, INSTALL creates a directory named \LOGRAF on the destination disk, copies the LOGRAF files into the directory, and creates a batch script (in a file named LOGRAF.BAT in the root directory of the destination disk) for running the installed system.

Be sure the root directory is included in the PATH command in the AUTOEXEC.BAT file (stored in the root directory of the default disk). For example, if the default disk is C:, then directory C:\ should have a file named AUTOEXEC.BAT that contains a PATH command. The PATH command should include C:\.

During operation, LOGRAF uses a small amount of the DOS environment space. If the message "out of environment space" appears on the screen during an attempt to run LOGRAF, the program may malfunction. To remedy this, edit the CONFIG.SYS file in the root directory of the startup disk to contain the command

```
SHELL = COMMAND.COM  /E:512  /P
```

If necessary, use a number larger than 512 in this command.

LOGRAF OPERATION

LOGRAF can be run from any directory on the system disk. It generates a file for each data set created, and stores the file in the current directory.

Starting LOGRAF

- If necessary, change to the disk where LOGRAF was installed.
- Change to any directory on that disk.
- Run LOGRAF by typing the command

```
LOGRAF
```

- When LOGRAF asks for the name of a data file for the assessment, type either the name of an existing file for editing and reassessment, or the name of a nonexistent file for creating a new assessment. Type a name of the form

```
drive:datafile.ext
```

  In place of *drive* substitute the drive letter of the disk where data files are to be stored. Omit the drive prefix if it agrees with the default drive.

  In place of *datafile* substitute a data file name. The name must be 8 or fewer letters or digits.

  In place of *ext*, substitute an extension of the file name. The extension is from one to 3 letters or digits.

  Examples of file names are `DATA.TXT` or `B:FILE5.DAT`. The extension suffixes .TXT and .DAT suggest "text" and "data," respectively; but any suffixes are acceptable. Every LOGRAF data file must have an extension; if it is omitted, LOGRAF supplies the extension .DAT.

  The file name may also include a directory path, as in the example `C:\LOGDATA\FREEGAS.DAT`.

Operation of LOGRAF

If the specified data file is an old one, LOGRAF gives the options of editing the file or sending it directly to the LOGRAF assessment and printing program. The details of this are given later.

If the specified data file does not already exist, LOGRAF asks if you want to create a new file with that name. Answer Y (for Yes) or N (for No). The N response is provided as an escape in case the user wanted an existing file but typed its name incorrectly.

The first data entry screen appears. It includes a bar at the top of the screen with the name of the file being edited, and a bar at the bottom showing a menu of the control keys described fully in a table below. The details of working with the data input editor are described next.

Operation of the Data Entry Editor - New Files

The program accepts keyboard input of parameters through two display screens. Each screen contains cells for entry of a group of parameters:

Screen 1	This screen shows a representation of the page layout on which the graph will later be displayed. Cells for entry of three parameters appear here, in their positions with respect to the plotting area. These cells are: Plot main title (above the graph) Plot subtitle (just below the main title) X-axis title (below the graph; examples: million barrels or thousand acres)
Screen 2	This screen has cells for the input of four numeric parameters for either one or two probability curves to be displayed on the same plot. For each curve, the cells are: Marginal probability (probability the resource is present in an amount at least equal to the Shift parameter) Shift (minimum quantity of resource assessed) 95th fractile (conditional estimate of resource, with 0.95 probability of ≥ this estimate) 5th fractile (conditional estimate of resource, with 0.05 probability of ≥ this estimate)

Editing controls

For a new file, LOGRAF has already entered default data into the cells on screen 2. As long as the entries for Shift, 95th fractile and 5th fractile are zeros, only probability Curve #1 appears on the plot. The defaulted values provide for only one probability curve.

The editing controls are shown in the following table:

Up arrow key ↑	Steps the cursor to the next cell above the current cell. If the cursor is on the first cell of the screen, it cycles to the bottom cell in the same column.
Down arrow key ↓	Steps the cursor to the next cell below the current cell. If the cursor is on the last cell of the screen, it cycles to the top cell in the same column.
Right arrow key →	Steps the cursor to the right through the visible text in a cell to locate the desired edit point. The cursor advances only as far as the space beyond the last actual character in the cell (including trailing spaces).
Left arrow key ←	This is similar to the above, but it steps the cursor to the left.
RETURN key	This has the same effect as the down arrow key.
TAB key	On screen 1, this cycles through the 3 cells in circular fashion. On screen 2, it switches back and forth between the column of cells for Curve #1 and the column for Curve #2.
PgUp key	Jumps to the previous screen. If the cursor is already on screen 1, LOGRAF displays `No previous screen.` PgUp transfers from screen 2 to screen 1 only.
PgDn key	Jumps to the next screen. If the cursor is already on screen 2, LOGRAF displays `No following screen.` PgDn transfers from screen 1 to screen 2 only.
CTRL-G	This keycode, generated by holding down the CTRL key while pressing the G key, causes the data currently recorded in the editor to be displayed in a graph on the computer screen. This allows previewing the graph before sending it to the printer.
CTRL-Y	This keycode, generated by holding down the CTRL key while pressing the Y key, deletes all the characters in the current data cell. New data can then be entered into the cell.
DEL key	The Delete key erases the single character at the cursor. The rest of the text in the cell closes the gap.
BackSpace key	This is above the Return (or Enter) key. It deletes the character (if any) to the left of the cursor, and the rest of the text in the cell closes the gap.
ESC	This key can be pressed at any time on either screen to escape from the data entry function. LOGRAF then gives the option to return to the editor, to send the graphical output of the assessment to the PostScript printer, or to quit.

Editing cell entries

- To edit the text in a cell, move to the desired edit point using the cursor keys. Any new text entered at the keyboard will be inserted at cursor location, and existing text to the right of the cursor is pushed aside.

- The size of each cell limits the amount of space for that entry. If more text is inserted after a cell is full, characters are pushed off the right end of the cell and are lost.

Errors in data entry

- All the cells on screen 1 are purely textual, and no errors can occur in entering data there.

- The entries on screen 2 are numeric. Various errors in the form, magnitude, or interrelation of these are possible. See the following paragraphs.

- If an entry contains an error, LOGRAF sounds a buzzer, displays an error message on the screen and waits for the user to retype correctly.

Numeric entries

- If a parameter is a number, it can be entered in any reasonable form: real numbers can be in fixed point notation (like 3.1416) or in floating point scientific notation (like 2.386E+3, which means 2.386×10^3).

- Wherever LOGRAF requests real numbers, integers are also acceptable. Integers are signed whole numbers without a decimal point.

Probability entries

- If the entry in a cell is a probability, it must be entered as a real number in the range 0 to 1 (not including 0).

- A probability that is out of range causes an error message.

Shift and fractile entries

The entries for Shift, F95 and F05 for each curve on screen 2 must be in strictly increasing order. If they are not, LOGRAF gives an error message.

Viewing the graph

The graph of the current data can be previewed at any time during data entry. Key the CTRL-G code (hold down the CTRL key and press the G key). After viewing the graph, press any key to return to the edit screen.

Exiting the editor

- When all the data entries on the three screens are complete, press the ESC key. LOGRAF displays the "do-what" menu:

```
Do what with this file?

E = Return to editing
P = Print the graph (and save the file)
X = Exit and save the file (no assessment)
Q = Quit without saving
```

- Press the letter key corresponding to the action wanted. Either upper or lower case letters are accepted.

- The X key causes LOGRAF to save the data in the file directory and return to DOS; only the new version of the file is kept, and it replaces the old version, if any.

- The Q key causes LOGRAF to terminate without saving the newly created (or edited) file. This option is used if the current edits are useless and this version of the data should be discarded.

- The P key causes LOGRAF to save the file in the directory, then send the data directly to the LOGRAF assessment and printing module (see below).

- The E key causes LOGRAF to re-enter the data entry module for further review and editing. This is the same as editing an old file, and this process is described next.

Operation of the Data Entry Editor - Old Files

If you specify the name of an already existing data file when first entering LOGRAF, the system shows a do-what menu similar to the one in the paragraph above.

To edit the file before sending it to the LOGRAF assessment and printing program, press the E key. LOGRAF displays the data entry screens as before, but showing the cells filled with the parameters in the existing file. If the existing values on a screen are correct, press PgUp or PgDn to review the other screen. To change the content of a cell, move the cursor to that cell and edit it as described earlier. When the edited file is correct, press ESC to return to the "do-what" menu.

The Printed Output

For each assessment, LOGRAF sends two pages of output to the PostScript printer: a summary of the input and output of the assessment, and a graph of the output. The summary page includes a table of conditional and unconditional output estimates, and shows two columns of data if there are two probability curves in the assessment. The graphic plot includes a text box with a subset of the output estimates. The numbers displayed on the summary page, and in the box on the graphics page, are scaled up or down if necessary to keep them in a manageable range; and then LOGRAF appends a scale factor before the x-axis title. Thus if the input represents data in units of million barrels of oil and the magnitudes of the output are inconveniently large, LOGRAF may divide the magnitudes by 1000 and edit the x-axis title to read thousand million barrels of oil. In extreme cases of scaling, LOGRAF may be forced to use scale factors of the form 10^16, which means 10^{16}.

If the input data for F95 and F05 have a large spread (and the data entry editor prohibits fractiles in which F05 > F95(10^9)), the scaling above may not be able to account for the large differences in the displayed numbers. Then LOGRAF prints some parameters in scientific notation, as in 4.3E+08 (meaning 4.3(10^8)). This may happen in the data box on the graph or in the scaling numbers on the x-axis, and on the input/output summary page.

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APPENDIX
SUMMARY OF USER INSTRUCTIONS

- Type `LOGRAF`
- Enter a data file name; type, e.g., `TOPSET.DAT` or `B:\EASTOIL\VALLEY.DAT`
- Enter and edit data
  - Advance through cells; press any of `RETURN` (or `ENTER`), `TAB`, ←, →, ↑ or ↓
  - Move up/down through screens; press `PgUp` or `PgDn`
  - Correct errors in cell; insert text, `DEL` and `BackSpace` to erase characters, `CTRL-Y` to erase cells
- Exit from data edit mode; press `ESC`
- Preview the graph: key `CTRL-G`
- "Do-what" choices; press
  - `E` to return to editing
  - `P` to assess the data and print the graph
  - `X` to exit and save file
  - `Q` to quit without saving
- LOGRAF returns to the MS-DOS prompt