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Frequency analysis (Cont.)

Lecture 17, 05/28/2013

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Adapted from textbook and notes of Philip B. Bedient

In-class Assignment 5

(2)

Student Name:

A stream channel was built to convey 200 m^3/s, which is the peak flow of the 20-yr storm-event of the watershed. What is the probability that the banks of the channel will be overtopped (in percentage):

a) at least twice in the next 20 years
b) in any year
c) exactly four times in the next 20 years
d) at least once in the next 200 years

As part of a flooding prevention program, it is planned to build levees along the stream channel to withstand the 100 yr-storm event. If the service life of the levees will be 20 years,

e) what is the reliability of the levees in %?
f) what is the probability that the levees will be overtopped at least once in the next 20 years in %?

Normal Probability Paper

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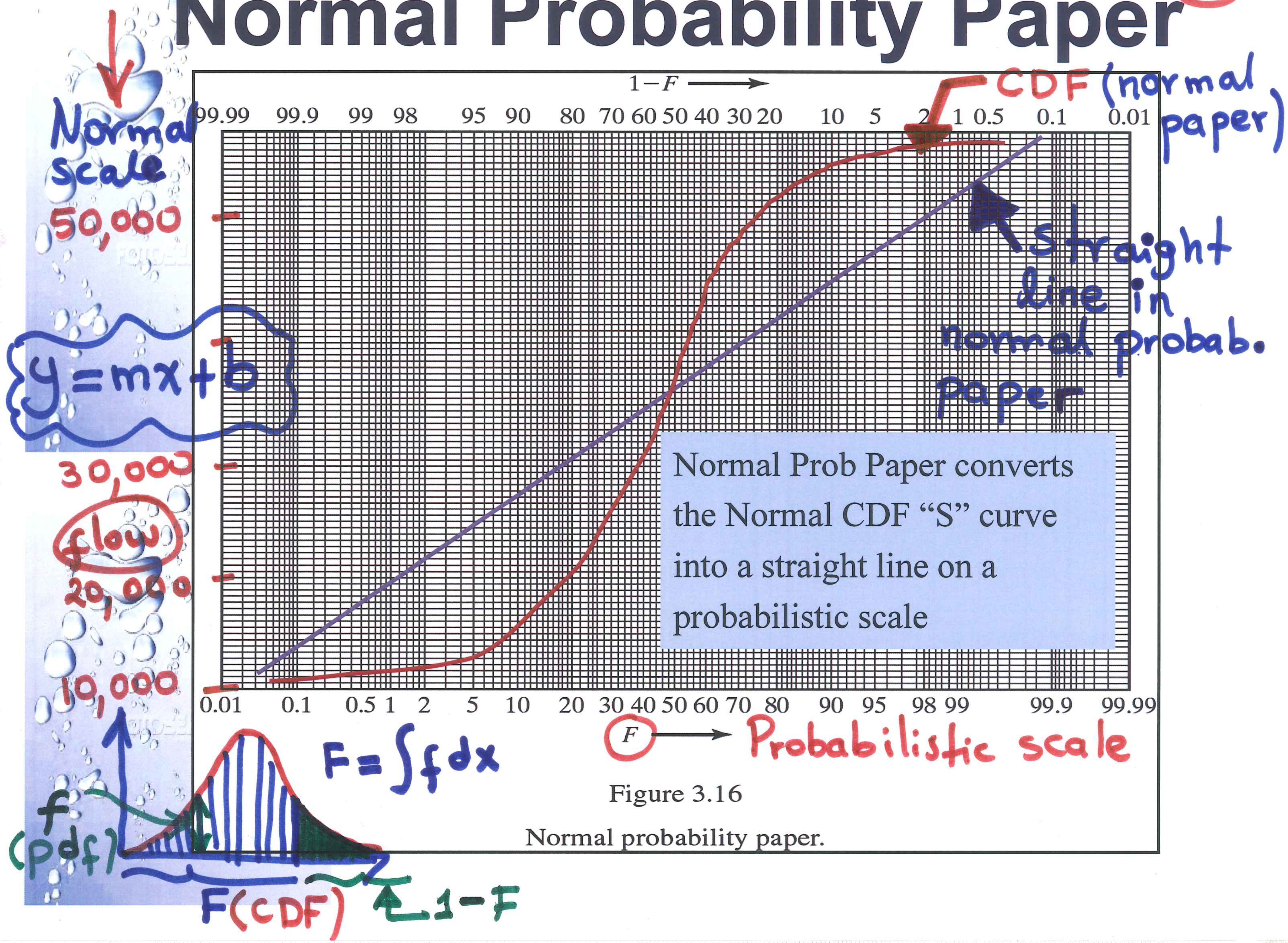

Normal Prob Paper converts the Normal CDF "S" curve into a straight line on a probabilistic scale

Figure 3.16

Normal probability paper.

Normal Prob Paper

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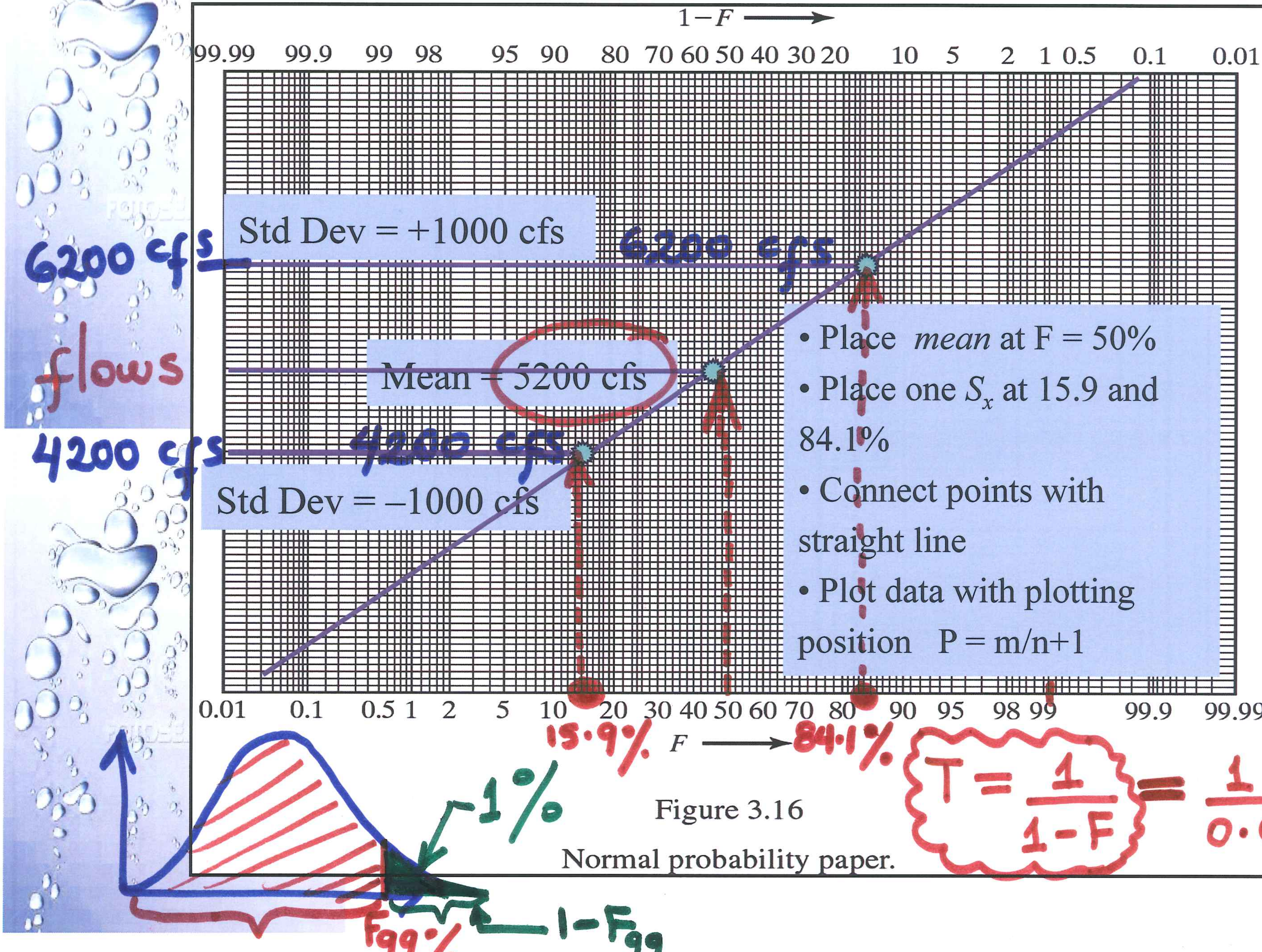

Figure 3.16

Normal probability paper.

- Place *mean* at F = 50%
- Place one S_x at 15.9 and 84.1%
- Connect points with straight line
- Plot data with plotting position P = m/n+1

$$T = \frac{1}{1-F} = \frac{1}{0.01} = 100 \text{ yrs}$$

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Normal Dist'n Fit

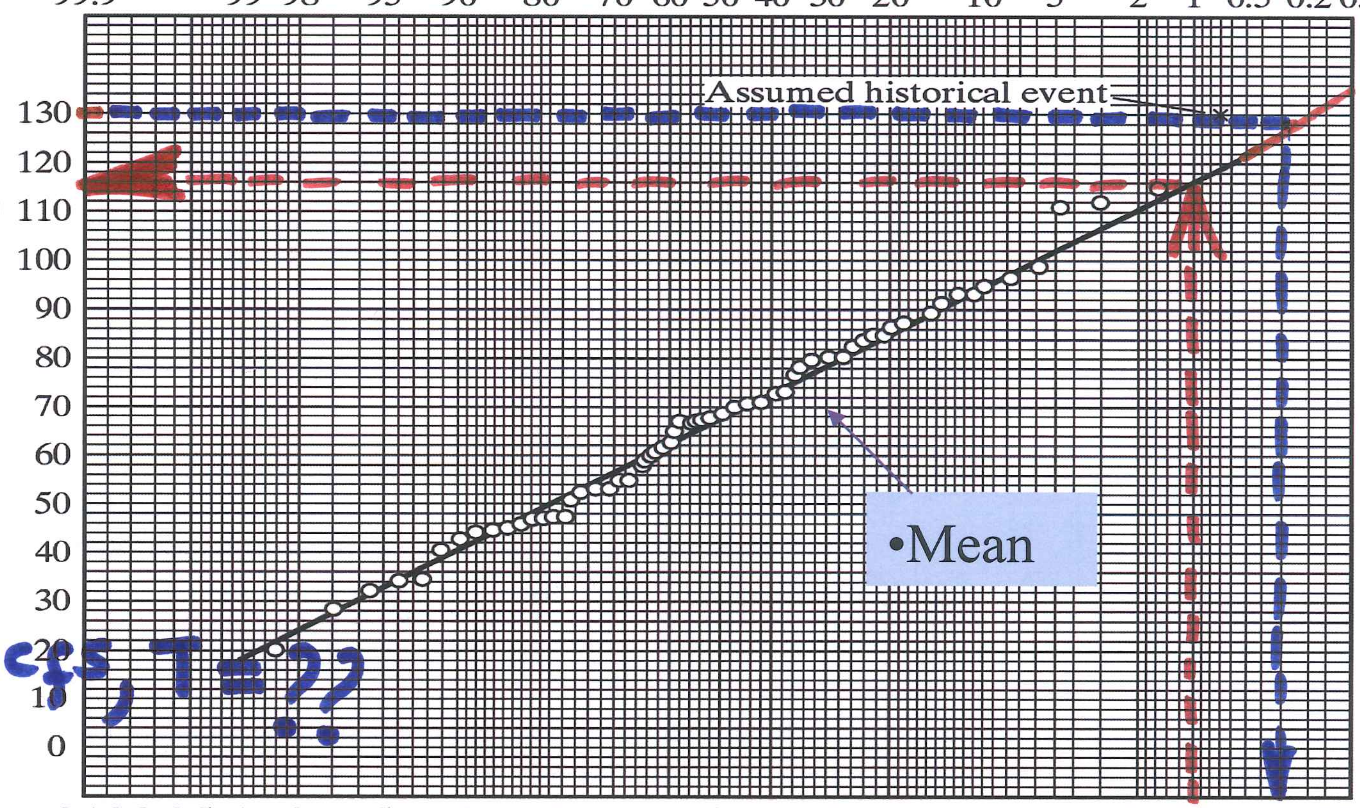


Figure P3.19

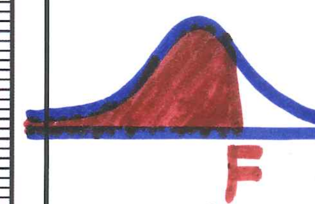
Normal probability plot for Kentucky River data. (From Haan, 1977, p. 137.)

$F_{99} = 115{,}000$ cfs

$T_{F_{99}} = 100$ yrs

$Q = 130{,}000$ cfs, $T = ??$

$T_{F_{99.7}} = \frac{1}{1 - 0.997} = 333$ years.



$F = \int f\,dx$

Frequency Analysis of Peak Flow Data

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- Take Mean and Variance (S.D.) of ranked data
- Take Skewness C_s' of data (3rd moment about mean)
- If C_s near zero, assume normal dist'n
- If C_s large, convert $Y = \mathrm{Log}_{10}\, x$ [Compute Mean and Var of Y]
- Take Skewness of Log data [$C_s(Y)$]
- If C_s near zero, then fits Lognormal
- If C_s not zero, fit data to Log Pearson III

accounts for skewness (most recommended in Hydrology practice).

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Frequency Analysis of Peak Flow Data

Year	Rank	Ordered cfs
1940	1	42,700
1925	2	31,100
1932	3	20,700
1966	4	19,300
1969	5	14,200
1982	6	14,200
1988	7	12,100
1995	8	10,300
2000	……	…….

larger

smaller

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Siletz River Example
75 data points

	Original Q	$Y = \text{Log}_{10} Q$
Mean	20,452	4.2921
Std Dev	6089	0.129
Skew	0.7889	- 0.1565
Coef. of (cv) Variation	0.298	0.03

CV is Reduced

$CV = \frac{\sigma}{\mu}$

Siletz River Example - Fit Normal and LogN

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100-year flow?

$T = \frac{1}{1-F}$

$100 = \frac{1}{1-F}$

$\boxed{F = 0.99}$

z	F
2.33	0.9901
2.32	0.9898
?	0.99

$0.01 - 0.0003$

$x - 0.0002$

$x = 0.006$

$\boxed{z = 2.326}$

$2.32 + 0.006$

Normal Distribution

$Q = Q_m + z\,S_Q$

$Q_{100} = 20452 + 2.326(6089) = \underline{34,620 \text{ cfs}}$

Mean + z (S.D.)

by interpolation

Appendix D

Where z = std normal variate - tables

Log N Distribution

$Y = Ym + k\,SY$

$Y_{100} = 4.29209 + 2.326(0.129) = 4.5923$

Same as normal

k = freq factor and $Q = 10^Y = \underline{39,100 \text{ cfs}}$

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Cs	K
-0.1	2.252
-0.2	2.178
-0.15	2.215

Log Pearson Type III

100 year flow?

Log Pearson Type III $Y = Y_m + k\,S_Y$

K is a function of Cs and Return Period (T)

Table 3.4 lists values for positive and negative skews

For Cs = -0.15, thus K = 2.215 from Table 3.4

$$Y_{100} = 4.29209 + \underbrace{2.215}_{\text{K (by interpolation)}}(0.129) = 4.5778$$

$$Q = 10^Y = 37{,}829 \text{ cfs for LP III}$$

Plot several points on Log Prob paper

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$Q = c\,p^{\alpha} q^{\beta} r^{\gamma} \rightarrow \log Q = \log c + \alpha \log p + \beta \log q + \gamma \log r$

LogN Prob Paper for CDF

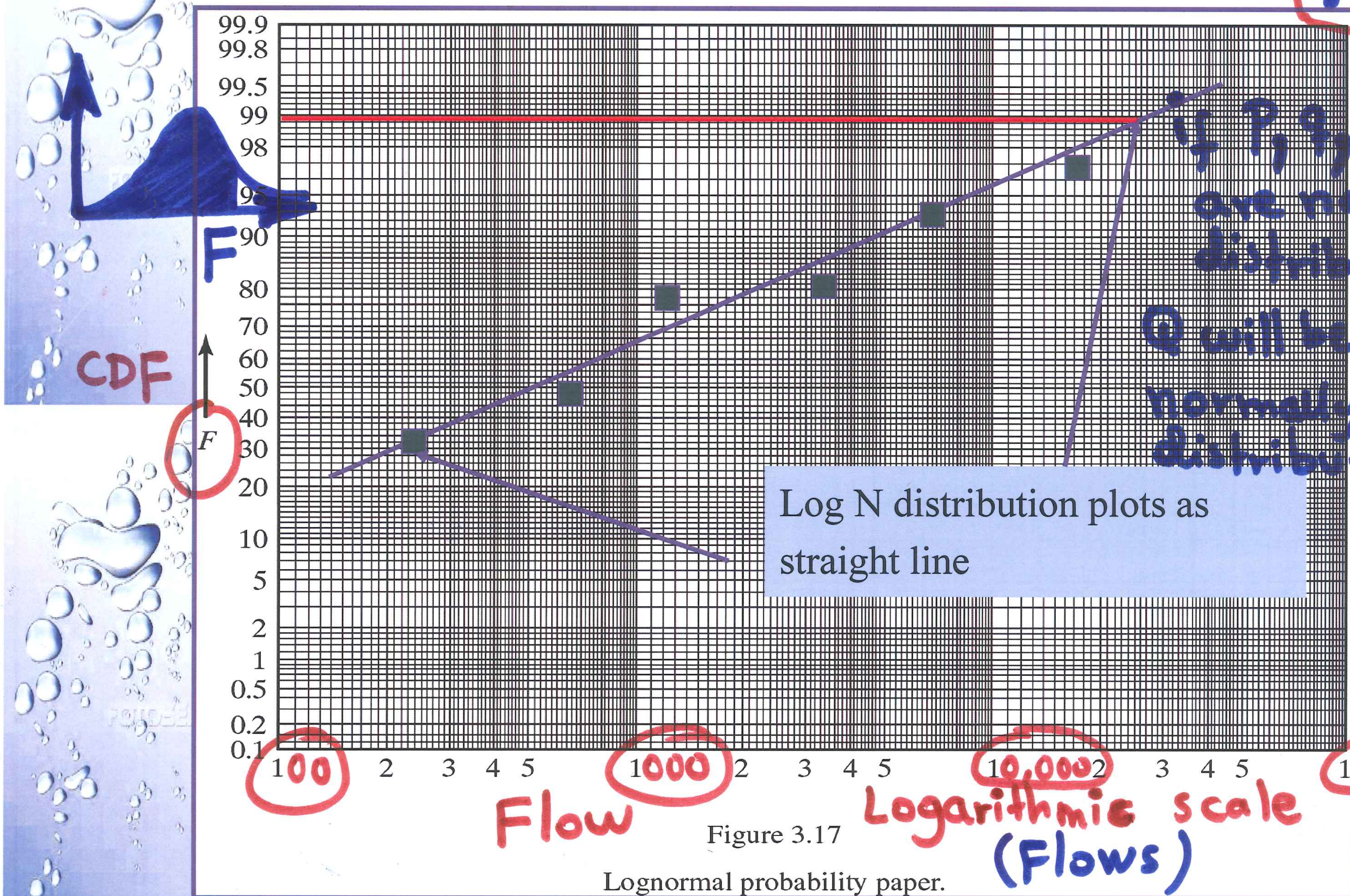

Figure 3.17

Lognormal probability paper.

LogN Plot of Siletz R. 12

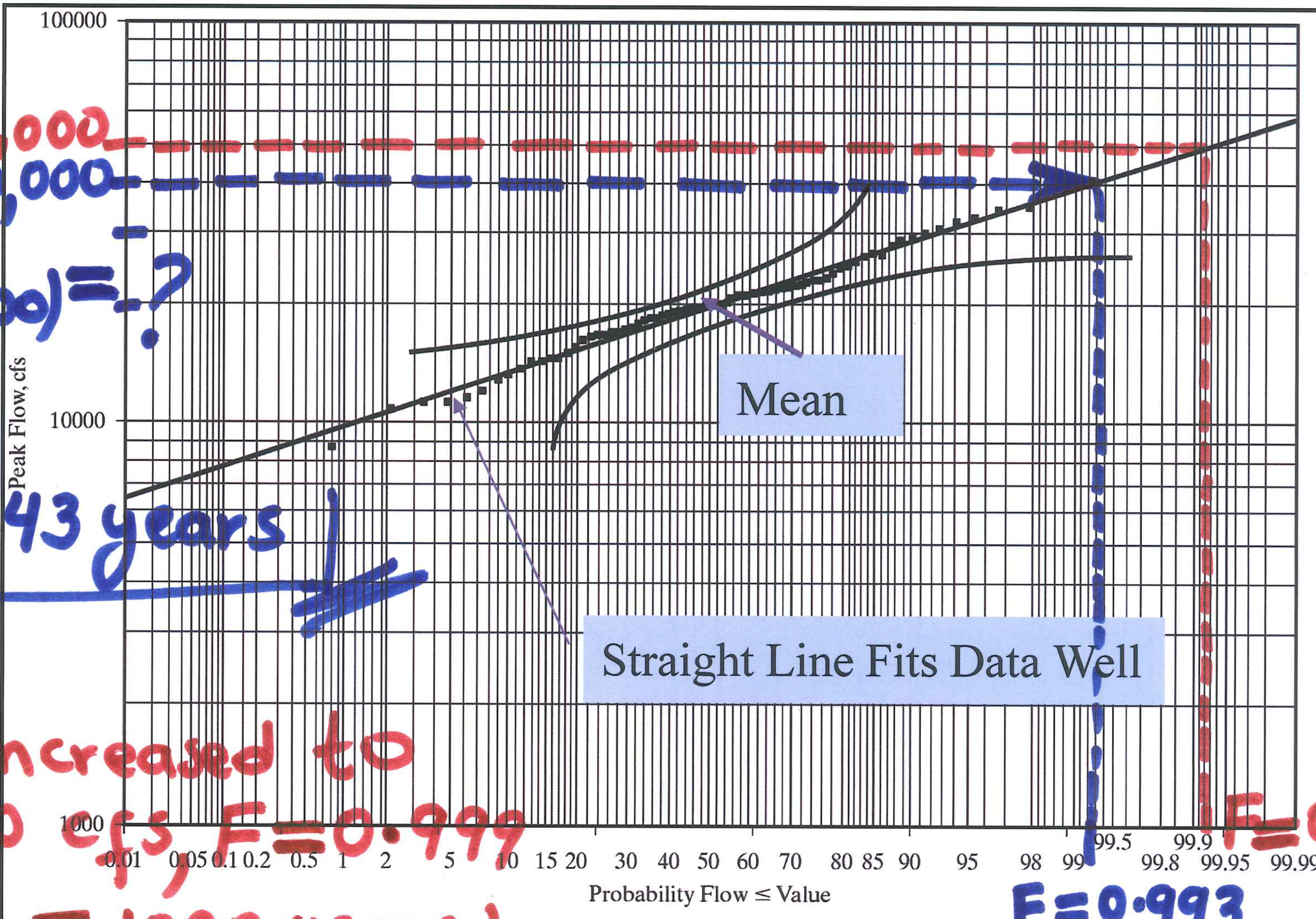

Figure 3.18

Lognormal plot of Siletz River flows, with 90% confidence intervals. Only every fifth value is plotted in the middle of the ranked series, for additional clarity.

$T(Q = 40{,}000) = ?$

$F = 0.993$

$T = \frac{1}{1-F} = 143$ years

If Q is increased to 50,000 cfs, $F = 0.999$

$T = \frac{1}{1-0.999} = 1000$ years

[Small increase in Q, may result in a large increase of T]

Return period

Siletz River Flow Data

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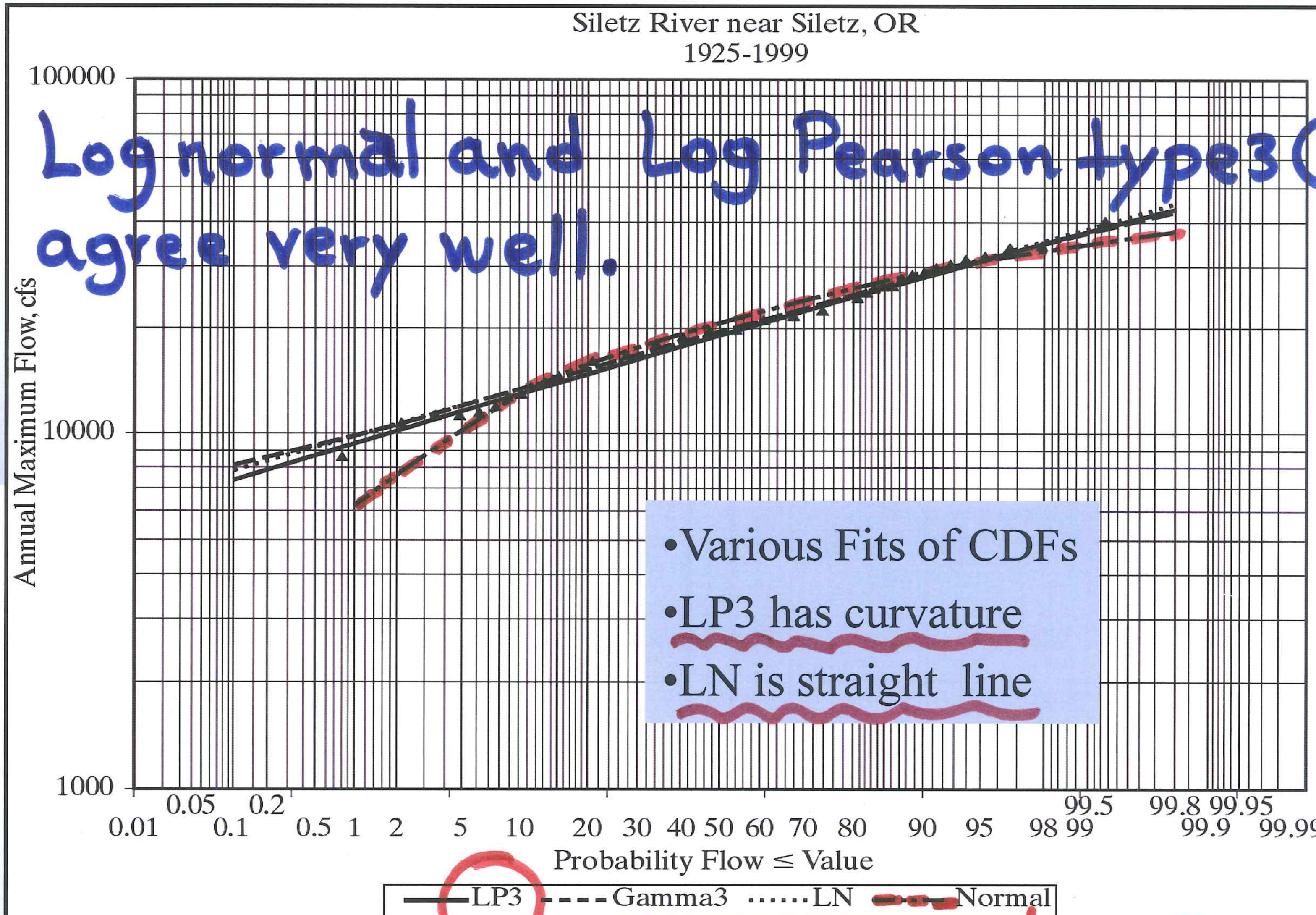
Log normal and Log Pearson type3 (LP3) agree very well.



- Various Fits of CDFs
- LP3 has curvature
- LN is straight line

Log-pearson type 3 (most recommended).

Figure 3.20

Comparison of four fitted CDFs for Siletz River flows 1925–1999.