A TEST OF RAINFALL DEPTH-DURATION STATISTICS

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Abstract

Rainfall depth estimates of a particular return frequency and peak storm duration (e.g., 3-hours), are usually developed by fitting an adopted probability distribution function to rain gauge data, and regionalization of particular parameters of the distribution across a region of study.

In this paper, we introduce a simple procedure to test the validity of the statistical estimates derived from the usual adopted statistical methods. The procedure is simple to apply, and requires little statistical manipulation.

As a case study, the County of Orange, California, is examined by application of the test.

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of Orange, California, for the chosen peak duration of 3-hours. Note that in the January 1995 event, although a significant portion of the storm fell outside of the study region, Ω, only the area of the storm inside the region is measured for use in Eq. (1).

The values from Eq. (1), R_j, $j = 1,2,\ldots,N$, are all assumed to be mutually independent. The expected (or mean) area coverage proportion, $\overline{R}$, for the selected storm peak duration and return frequency, T_o, is simply the usual average usual of the R_j values from Eq. (1).

The next component needed in our procedure is the number of the severe storm events, N, that are used in Eq. (1). It is assumed that the severe storm events under study are all mutually independent (given zero intersection of storm aerial coverages for any given single year) or, if more than one such event occurs in one storm season, any storm overlap in area is excluded from being double counted (that is, analogous to computing the probability of the union of the two sets A and B by $P_r(A \cup B) = P_r(A) + P_r(B) - P_r(A \cap B)$). Then, for M years of rainfall history, we have N events, giving an estimate of a proportion, ρ, defined by

$$\rho = \frac{N}{M} \tag{2}$$

where ρ can be directly used in the standard binomial distribution (which is used for many applications including how to analyze the flipping of a coin). Here, ρ can be interpreted as an estimate of the probability of a severe storm in Ω (i.e., greater than or equal to T_o) being born in any one year. For the case of Orange County, California, $M = 50$ (years) and $N = 8$. Table 1 lists the eight severe storm events, the rain gauges impacted, and the return frequency estimates of the peak 3-hour duration, provided by a regionalized statistical estimation procedure of the available rainfall data in Ω. It is noted that the December 1997 event contained return frequency estimates in the several thousand year category. The question arises whether the statistical estimates might be underestimating the rainfall depths; that is, "are we really having such rare events, or should the estimated rainfall depths be increased?"

Another Visit With The Orange County 100-year Storm Rainfall Data

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- Is the number of 3-hour 100-year exceedances, in 25 years, consistent with the definition of 100-year events?

- If there are a large number of sites, there are probably a few with 25 years of record, that "seem" to contain too many 100-year events.

- Events at various sites are correlated:
  A 100-year event at one site may also occur at another site.

- In Orange County, the 8 severe storms experienced in 25 years, produced coverages of 2.6%, 3.1%, 3.8%, 6.5%, 17.7%, 20.0%, and 21.9%.

- Interpret coverage as the probability that each storm would produce an exceedance at a randomly chosen site; then the expected number of exceedances observed at this hypothetical site is:

$$\mathbf{.026 + .031 + .038 + .065 + .177 + .200 + .219 = .823}$$

- Probability of occurrence is :

$$\frac{\mathbf{0.823}}{\mathbf{25}} = \mathbf{0.03292}$$

or, a return frequency of 30.37 years.

- Is the hypothetical number of events so unlikely that p = 0.01 (100-year storm) can be rejected?

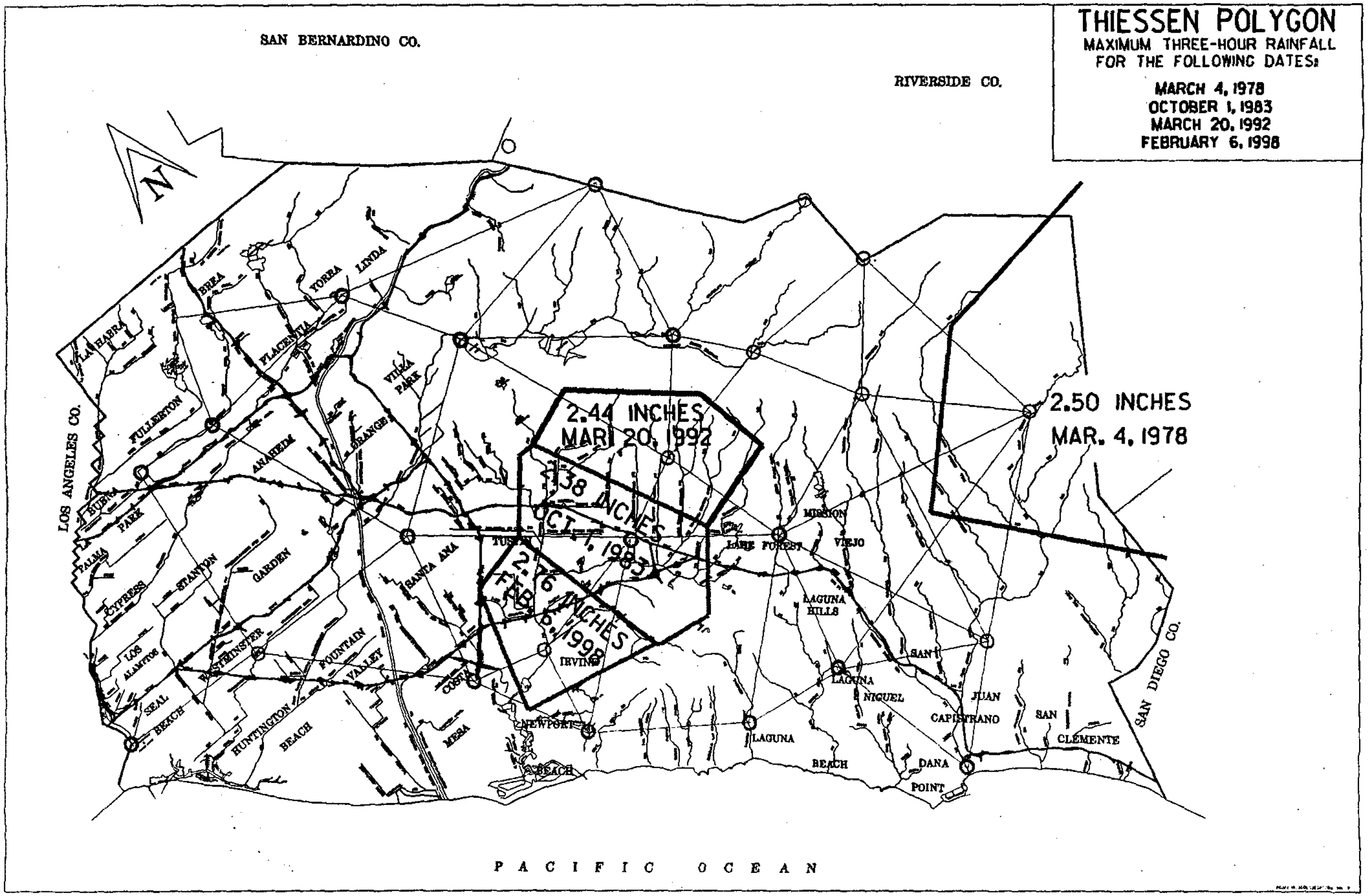
- The probability (1 or more events in 25 years), at $p = 0.01$, is:

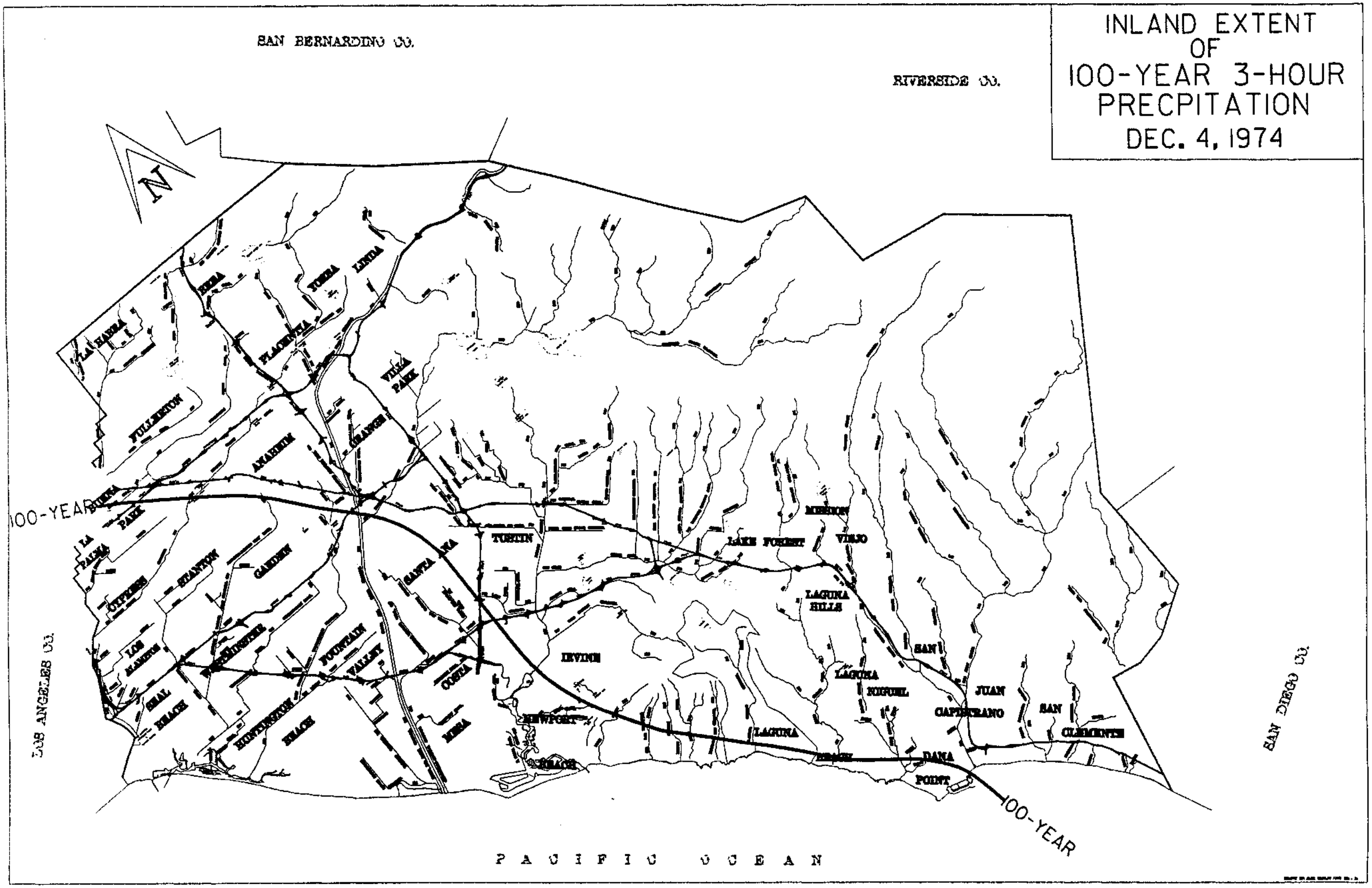
$$1 - (0.99)^{25} = 0.222$$

(Note: 1 event used, not 0.823)

- Thus, if p is 0.01, then about 22% of the time, we would experience what has occurred.

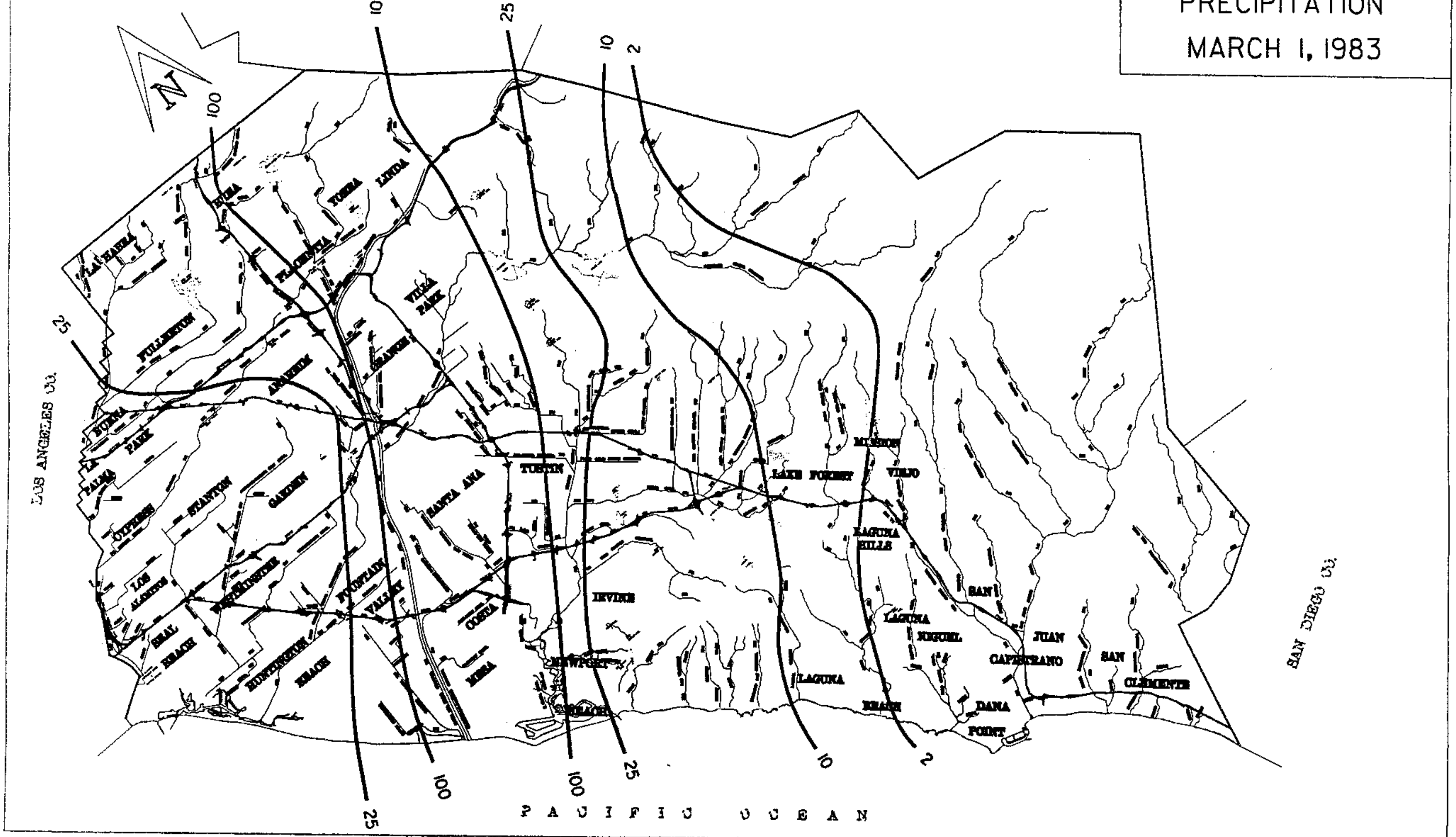
- The data makes one suspicious, but not confident, that the true return frequency is less than 100 years.


THIESSEN POLYGON
MAXIMUM THREE-HOUR RAINFALL
FOR THE FOLLOWING DATES:
MARCH 4, 1978
OCTOBER 1, 1983
MARCH 20, 1992
FEBRUARY 6, 1998
SAN BERNARDINO CO.
RIVERSIDE CO.
LOS ANGELES CO.
SAN DIEGO CO.
PACIFIC OCEAN
N
2.50 INCHES
MAR. 4, 1978
2.44 INCHES
MAR. 20, 1992
1.38 INCHES
OCT. 1, 1983
2.76 INCHES
FEB. 6, 1998
LA HABRA
BREA
YORBA LINDA
PLACENTIA
FULLERTON
VILLA PARK
ANAHEIM
ORANGE
BUENA PARK
LA PALMA
CYPRESS
STANTON
GARDEN GROVE
SANTA ANA
TUSTIN
LOS ALAMITOS
WESTMINSTER
FOUNTAIN VALLEY
SEAL BEACH
HUNTINGTON BEACH
COSTA MESA
IRVINE
NEWPORT BEACH
LAKE FOREST
MISSION VIEJO
LAGUNA HILLS
LAGUNA NIGUEL
LAGUNA BEACH
SAN JUAN CAPISTRANO
DANA POINT
SAN CLEMENTE



INLAND EXTENT
OF
100-YEAR 3-HOUR
PRECPITATION
DEC. 4, 1974

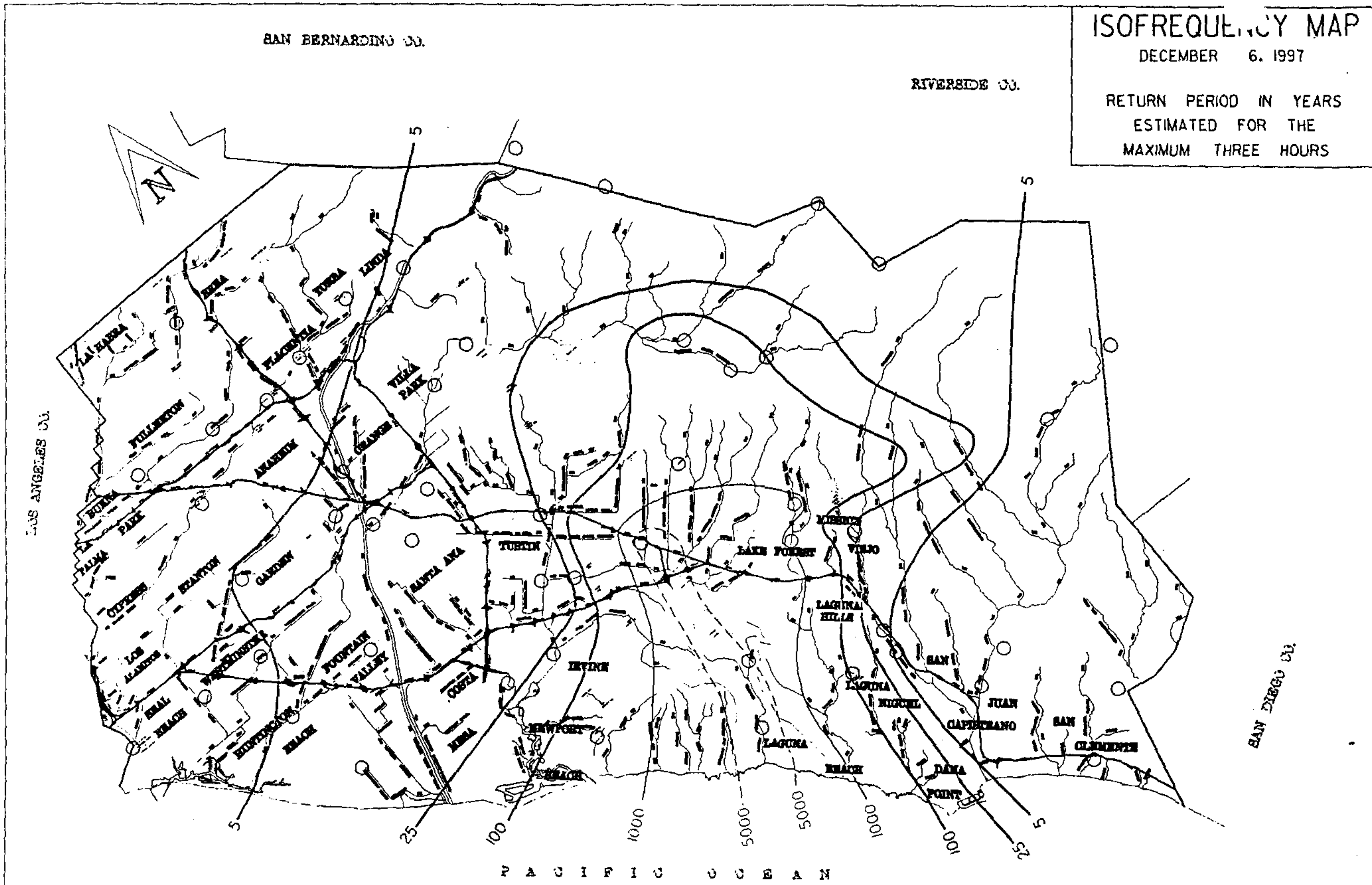
ISOFREQUENCY MAP
MAXIMUM 3-HOUR PRECIPITATION
MARCH 1, 1983



ISOFREQUENCY MAP

DECEMBER 6, 1997

RETURN PERIOD IN YEARS ESTIMATED FOR THE MAXIMUM THREE HOURS



ISOFREQUENCY MAP
JANUARY 4, 1995
3-HOUR DURATION
ENDING at 5:15 PM