August 19, 1983

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Docket No. 50-244
LS05-83

Mr. John E. Maier, Vice President
Electric & Steam Production
Rochester Gas & Electric Corporation
89 East Avenue
Rochester, New York 14649

Dear Mr. Maier:

SUBJECT: INTEGRATED PLANT SAFETY ASSESSMENT REPORT (IPSAR)
SECTION 4.5, PLANT FLOODING BY DEER CREEK -
R. E. GINNA NUCLEAR POWER PLANT

In Section 4.5 of the Integrated Plant Safety Assessment Report for your facility (NUREG-0821), the staff concluded that further analysis was needed so that you could provide, as a minimum, protection against local site flooding to a level equivalent to a Standard Project Flood plus one foot, and justify on a cost-benefit basis why protection should not be provided for flooding levels up to the Probable Maximum Flood (PMF). You responded to this issue in letters dated January 31, 1983 and May 20, 1983.

Enclosed is the staff's evaluation of your analysis of the potential for flooding of the plant by Deer Creek. Based on an independent assessment of regional watershed characteristics, the staff concludes that your proposal to provide physical protecton to 273.8 ft mean sea level (equivalent to a discharge flow of about 26,000 cfs) is acceptable. However, the staff will require that you develop and implement emergency procedures to (1) identify a flooding elevation corresponding to a discharge flow of about 10,000 cfs and (2) install flood protection devices within 45 minutes after flooding reaches that elevation.

These conclusions will be reflected in the staff's supplement to the IPSAR for your facility.

Sincerely,

Original signed by/ J. Shea

Dennis M. Crutchfield, Chief
Operating Reactors Branch #5
Division of Licensing

EHEB:DE
RBallard
8/19/83

XA

XA Copy Has Been Sent to PDR

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Enclosure:
As stated

cc w/enclosure:
See next page

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R. E. GINNA NUCLEAR POWER PLANT
IPSAR SECTION 4.5
PLANT FLOODING BY DEER CREEK

I. INTRODUCTION

The Integrated Plant Safety Assessment Report (IPSAR) for R. E. Ginna Nuclear Power Plant (Reference 1), concluded in Section 4.5 that a design-basis flood on Deer Creek based on current licensing criteria (275 ft. mean sea level [msl]), would inundate safety-related equipment in the auxiliary building, turbine building and screenhouse. Deer Creek is a stream with a 13.9 square mile watershed that flows past the south side of the power plant.

The staff concluded that the licensee should complete an analysis of the flooding of Deer Creek and, as a minimum, provide protection against flooding to the level of a Standard Project Flood (SPF) plus one foot. Further, the staff required that the licensee perform a cost-benefit evaluation for flooding protection up to the Probable Maximum Flood (PMF), the current licensing criteria.

The staff has concluded that the SPF plus one foot is comparable to the original design-basis for the plant with a nominal margin. The cost-benefit evaluation was intended to identify additional protection which could be economically implemented to offset the uncertainties in the recurrence intervals for severe flooding events.

The licensee submitted the results of their analysis and determinations of flood levels using the staff's SPF and PMF values by letter dated January 31, 1983 (Reference 2). In that report, the licensee concluded that the SPF plus one foot would be contained within the banks of Deer Creek and, therefore, no plant modifications were necessary. The staff did not agree with that assessment, but did conclude that the SPF would be below the level of plant protection. In addition, the staff found that the licensee had not adequately addressed either the cost-benefit evaluation or the uncertainty in the recurrence interval. For example, disaster control procedures and portable equipment might provide additional protection for a substantially lower cost.

The licensee subsequently proposed, in a letter dated May 20, 1983 (Reference 3) to provide protection to an elevation of 273.8 ft. msl, which is equivalent to a discharge flow of about 26,000 cfs or about 80% of the licensee's calculated PMF. The staff's analysis indicates that the flow at this elevation would be about 25,000 cfs or 65% of the PMF. This protection requires several permanent structural modifications and two prompt actions, the installation of a portable dam around the service rollup door and the connection of an alternate cooling water supply for the diesel generators. The permanent modifications are 1.5 foot curbs in front of access doors, a water seal between containment and auxiliary building walls, and upgrading of some masonry walls. The licensee calculated that protection to the flooding elevation for the staff's PMF of 38,700 cfs would cost more than $2 million. This cost estimate was based on channel widening and improvements (excavation of about 106,000 yd^{-3} of material), construction of a new bridge and installation of about 31 waterproof doors. (See Reference 2.) The licensee (Reference 3) also estimated that protection to the PMF, beyond that proposed as part of the Structural Upgrade Program, would cost in excess of $2 millon for either replacing block walls with concrete walls to the proper height or dredging about 70,000 yd^3 from Deer Creek.

In order to determine whether additional actions should be required, the staff reviewed the conservatisms of the probable maximum flood estimates and estimated the probability of flooding at the proposed protection level.

II. EVALUATION

The flooding analysis submitted by the licensee as part of the topic evaluation (Reference 4) estimated Deer Creek flood flow discharges using the HEC-1 surface runoff modeling routine. This computer program uses the Soil Conservation Services Runoff Curve Number concept and a developed unit response hydrograph, that is combined with a selected total storm depth and a rain storm distribution (obtained from U. S. Corps of Engineers) to estimate the watershed flood hydrograph.

The 24 hour rainfall depths having return periods of 5 to 100 years were obtained from a rainfall frequency atlas and return periods of 500 years and greater were estimated from a straight line projection on Gumbel extreme probability paper. The license then used these rainfalls in HEC-1 to predict peak discharge rates for maximum 24 hour rainfall depths having return periods of 100, 500, 15000, 350000, 10^{-7} years and for the PMP. Their estimated PMF is 32,500 cfs. Flooding elevations about the plant were then predicted using the HEC-2 flood routing routine.

The topic evaluation (Reference 5), prepared by Franklin Research Center (FRC), questioned the recurrence probabilities and the 24 hour rainfall amount for a 13.9 sq. mi. watershed. FRC assembled runoff records from eight small New York State watersheds varing in size from 1.5 to 44.4 sq. mi., tabulated the maximum discharge of record and calculated the discharge per unit area and individual watershed return perioas by Log Pearson III procedures. The largest discharge per unit area of 223 cfs/sq. mi. was for a 13.6 (recently revised from 14.1 by USGS) square mile, watershed 140 miles from the plant near the Catskill Mountains.

FRC also predicted the PMF using the same HEC-1 computer program model used by the licensee, but with variations in antecedent moisture and rainfall distribution which resulted in a maximum discharge of 38,700 cfs. Flooding depths at the plant were estimated using the same HEC-2 model with some changes in roughness coefficients.

The licensee's response to the topic evaluation (Reference 6) qualitatively assessed the conservatisms in the analysis but did not form a sufficient basis to determine what corrective actions were warranted. As a result, the staff concluded in the integrated assessment (Reference 1, Section 4.5) that further analyses should be performed, as previously described.

In summary, the licensee's analysis estimates that the plant site begins flooding at 14,000 cfs, the SPF is 13,100 cfs, and the PMF is 32,500 cfs; whereas the staff estimates that the site begins flooding at 12,000 cfs, the SPF is 15,000 cfs, and the PMF is 38,700 cfs.

These various estimates of flood flows result in corresponding estimates of the flooding elevation (or flood stage) around the plant site, which vary both between analyses and with location because the site is sloped. Despite the differences between the licensee's analysis and the staff's analysis, the flooding elevations for the PMF would cause a sufficient number of systems and equipment to fail such that safe plant shutdown could not be accomplished. The PMF corresponds to an maximum elevation of 275.2 ft. msl at the turbine building and 262.0 ft msl at the screenhouse, while equipment begins to fail at 254.9 ft msl at the screenhouse (Note: The licensee's calculated PMF level at the turbine building is 274.8 ft msl and at the screenhouse is 262.3 ft msl.)

In response to issues raised by the staff regarding the validity of the statistical approach used by the licensee to estimate the recurrance interval, the licensee proposed to provide protection an elevation of 273.8 ft msl. This corresponds to a discharge of about 26,000 cfs. Physical protection against higher flows would require a major renovation of structures, as evidenced by the staff's review of Topic III-3 A, "Effects of High Water Level on Structures."

The staff recognizes that there are inherent conservatisms in the estimate of the PMF. These conservatisms result in a flood with virtually no chance of being exceeded. In order to determine whether the corrective action proposed by the licensee provides sufficient protection or whether additional protection should be required, the staff has reviewed the various conservatisms in the elements of the estimation of the PMF, and made additional estimates of the probability of flooding at the level of protection.

A. PMF

The construction of the probable maximum flood (PMF) for an ungaged area consists of two elements: selection of the Probable Maximum Precipitation (PMP), and developing the runoff hydrograph from this precipitation. From the "Standards for Determining

Design Basis Flooding at Power Reactor Sites" (Reference 7) a PMP is defined as "the estimated [precipitation] depth for a given duration, drainage area, and time of year for which there is virtually no risk of exceedance. The Probable Maximum Precipitation for a given duration and drainage area approaches and approximates the maximum which is physically possible within the limits of contemporary hydrometeorological knowledge and techniques."

The selected PMP rainfall is then transformed into a flood hydrograph by methods that result in a PMF that is a "hypothetical flood (peak discharge, volume and hydrograph shape) that is considered to be the most severe reasonably possible based on comprehensive hydrometeorological application of Probable Maximum Precipitation and other hydrologic factors favorable for maximum flood runoff such as sequential storms and snow melt" (Reference 7).

B. Flood Probability

In order to determine whether additional corrective actions should be required beyond those proposed by the licensee, the staff had to estimate the probability of flooding to the level of protection. The FRC analysis (Reference 5) had an evaluation of discharges from eight small New York State watersheds, six of which encircled the plant at about 50 miles distance and two are located about 130 miles to the southeast near the Catskill mountains (see Figure 1), because Deer Creek is an ungaged stream. Figure 2 shows the average discharges per unit area plotted versus watershed area. The staff used this information to make a first estimate of the probability of flooding to the level of protection.

These data were used in a regional (or ensemble) determination of parameters for the Wakeby distribution by the method given by Landwehr et al. (Reference 8). It has been argued that this distribution is flood-like and, furthermore, is more conservative than the commonly used thinner-tailed flood frequency distributions, because it is "thick-tailed;" i.e., for a given extreme flood value it gives a greater probability of occurrence. Therefore, the staff used this approach, making use of 196 station-years of date, to estimate the probability for a flood discharge flow of 26,000 cfs (i.e., the licensee's estimate of the level of protection).

The predicted discharges for given recurrence probability depends on the mean annual maximum flow ($\bar{Q}am$) from the ungaged Deer Creek watershed. The discharges for a sequence of probabilities from 10^{-2} to 10^{-8} and a range of $\bar{Q}am$ from 100 to 1300 cfs are shown in Table 1. The mean annual maximum discharge ($\bar{Q}am$) of the eight gaged watersheds have been plotted versus watershed area in Figure 3. A solid vertical line has been placed on the figure at area equal 13.9 (the area of the ungaged Deer Creek watershed) between

$\overline{Q}$am of 100 and 1300 cfs. Lighter solid lines envelope the points of the eight gaged sites. By virtue of location, point number 3 appears to be most similar watershed to the Deer Creek watershed and if a straight line is drawn between it and the origin it crosses the Deer Creek line at $\overline{Q}$am = 350 cfs. However, using the station with the longest period of record (no. 6) and projecting back to the origin, a $\overline{Q}$am of 700 cfs is measured at the Deer Creek line. Note that one of the watersheds near the Catskills with an area of 13.9 mi^2 has a $\overline{Q}$am of 911 cfs. From Table 1, the proposed protection level (26,000 cfs) has a probability of occurrence of less than 10^{-8} for a $\overline{Q}$am of 350 cfs, but increases to slightly less than 10-2 for $\overline{Q}$am 900 cfs and to somewhat less than 10-5 for an arbitrary top end of the calculated range of $\overline{Q}$am equal 1300 cfs. Note in Figure 2 that with the amount of information available and analysis done, the two watersheds may be in a separate group from the others or just part of a wide continum, but whatever the situation, the inclusion of these data add another degree of conservatism to the analysis. The probability of occurrence for the other levels of flooding (site flooding, standard project flood [SPF] and the probable maximum flood [PMF]) can also be interpreted from Table 1. Based on this analysis, the probability of flooding beyond the level of protection appears to be sufficiently low.

However, because the validity of extrapolating any statistical distribution to such low probabilities is questionable for such hydrologic phenomena, the staff then attempted to verify this conclusion with an approach which is being developed generically for probabilistic risk assessments (PRAs). This estimate is based on the following assumptions:

1. The flood flow in Deer Creek corresponding to el 273.8 is 25,000 cfs as determined by the staff (licensee's estimate was 26,000 cfs).

2. The exceedance probability of the PMF is no greater than 10^{-5} per year.

3. A conservative estimate of the PMF is 38,700 cfs.

4. The 100 year flood is about 3,000 cfs.

5. The probability of any flow between the 100 year flood flow and the PMF can be approximately estimated by a straight line interpolation on log-normal probability paper (Figure 4).

From this plot of the 100 year flood and the PMF on log-normal probability paper, the exceedance probability of a flood flow of 25,000 cfs on Deer Creek was determined to be about 5×10^{-5} per year.

III. CONCLUSION

The equipment required for safe plant shutdown is located in the auxiliary building and turbine building. The licensee has committed to provide protection in this area to 273.8 ft msl, 1.4 ft below the staff's PMF in this area of 275.2 ft msl. The staff believes that its PMF estimate may be very conservative. Because the probability of flooding beyond the proposed level of protection is low, it is the staff's judgment that this accident sequence would not dominate events leading to core melt. In addition, based on the licensee's cost estimates, the staff concludes that additional protection would not be cost-effective. Therefore, the staff concludes that the licensee's proposal is acceptable.

However, in order to assure that the proposed flood protection can be achieved, the staff will require that the licensee develop associated emergency procedures. These procedures should identify a point at which the flooding elevation corresponds to approximately 10,000 cfs, at which time the plant personnel should begin installing the flood protection devices. Installation should be complete within 45 minutes thereafter, to ensure they will be in place well before the rising floodwater jeopardizes safe shutdown capability.

IV. REFERENCES

1. NUREG-0821, Integrated Plant Safety Assessment, Systematic Evaluation Program, R. E. Ginna Nuclear Power Plant. Final Report, U. S. Nuclear Regulatory Commission, December 1982.

2. Letter from J. E. Maier (RG&E) to D. M. Crutchfield (NRC), Subject: SEP Topic II-3.B, Deer Creek Flooding - R. E. Ginna Nuclear Power Plant; with attachment, Ginna Station Deer Creek Overflow Flooding Study - SEP Topic II-3.B, dated January 31, 1983.

3. Letter from J. E. Maier (RG&E) to D. M. Crutchfield (NRC), dated May 20, 1983. Subject: SEP Topic II-3.B, Deer Creek Flooding, R. E. Ginna Nuclear Power Plant.

4. Letter from J. E. Maier (RG&E) to D. M. Crutchfield (NRC), dated August 18, 1981. Subject: SEP Topics II-3.A, II-3.B, II-3.B.1, III-3.A - R. E. Ginna Nuclear Power Plant with attachment - Ginna Station Design Basis Flooding Study for Rochester Gas and Electric Corporation, August 1981, NUS Corporation.

5. Technical Evaluation Report, Hydrologic Considerations, Rochester Gas & Electric Corporation, R. E. Ginna Nuclear Power Plant, J. S. Scherrer, J. Turner, W. Erikson, S. Roberts, G. J. Overbeck, Franklin Research Center, March 26, 1982.

6. Letter from J. E. Maier (RG&E) to D. M. Crutchfield (NRC), dated June 25, 1982. Subject: SEP Topics II-3.B, II-3.B.1, II-3.C, III-3.C - Flooding Potential - Deer Creek, with attachment - Ginna Station Standard Project Flooding Study.

7. "Standards for Determining Design Basis Flooding at Power Reactor Sites," ANSI N170-1976, ANS-2.8..

8. Quantile Estimation with More or Less Flood-like Distributions. J. M. Landwehr, N. C. Matalas and J. R. Wallis. Environmental Sciences Research Report, IBM Thomas J. Watson Research Center, April 27, 1979.

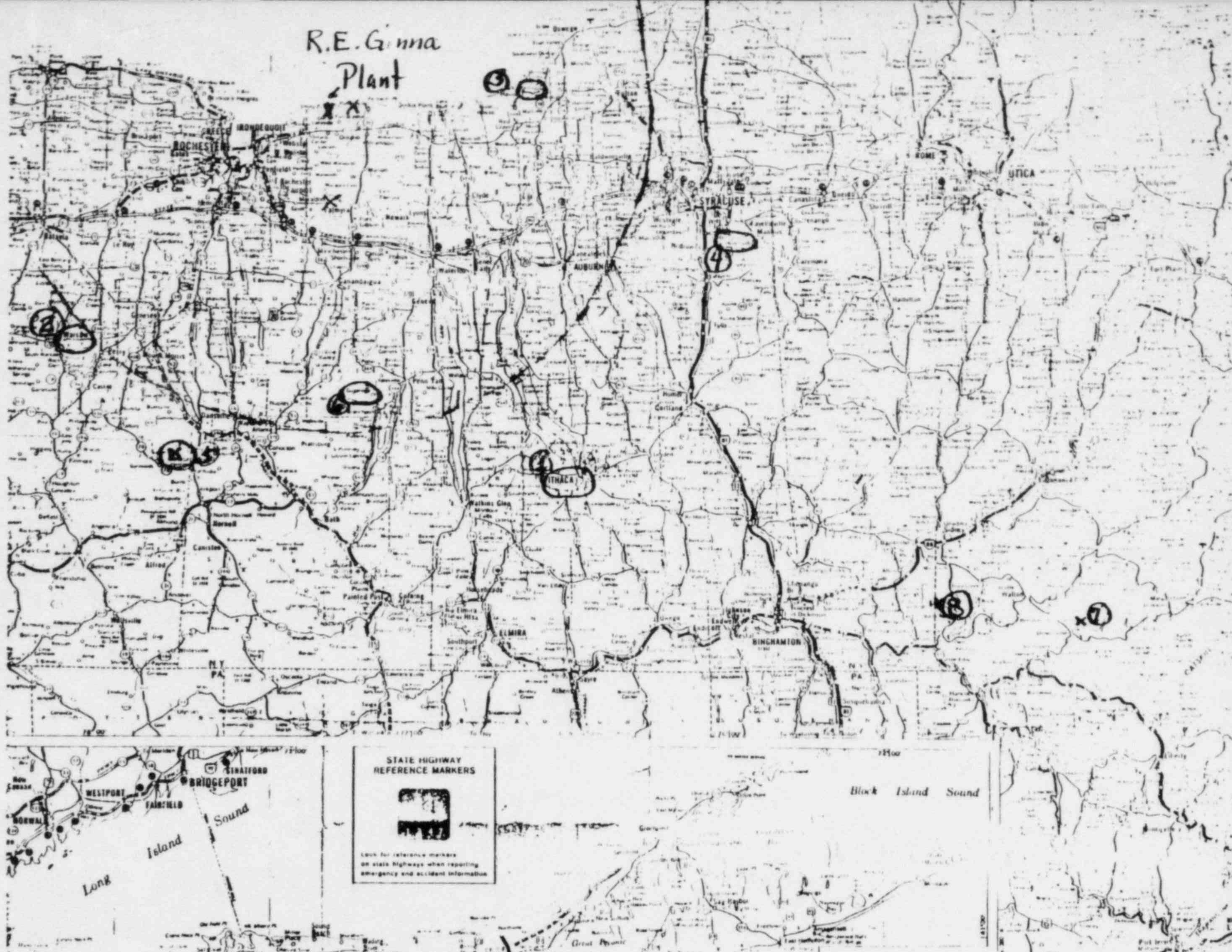


Figure 1. Locations of small gaged watersheds with respect to RE Ginna Nuclear Power Plant

K·E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. C4212 - 99 0702

Figure 2. Average Unit Discharge versus Watershed Area for New York State Small Watersheds near R.E. Ginna Nuclear Power Plant

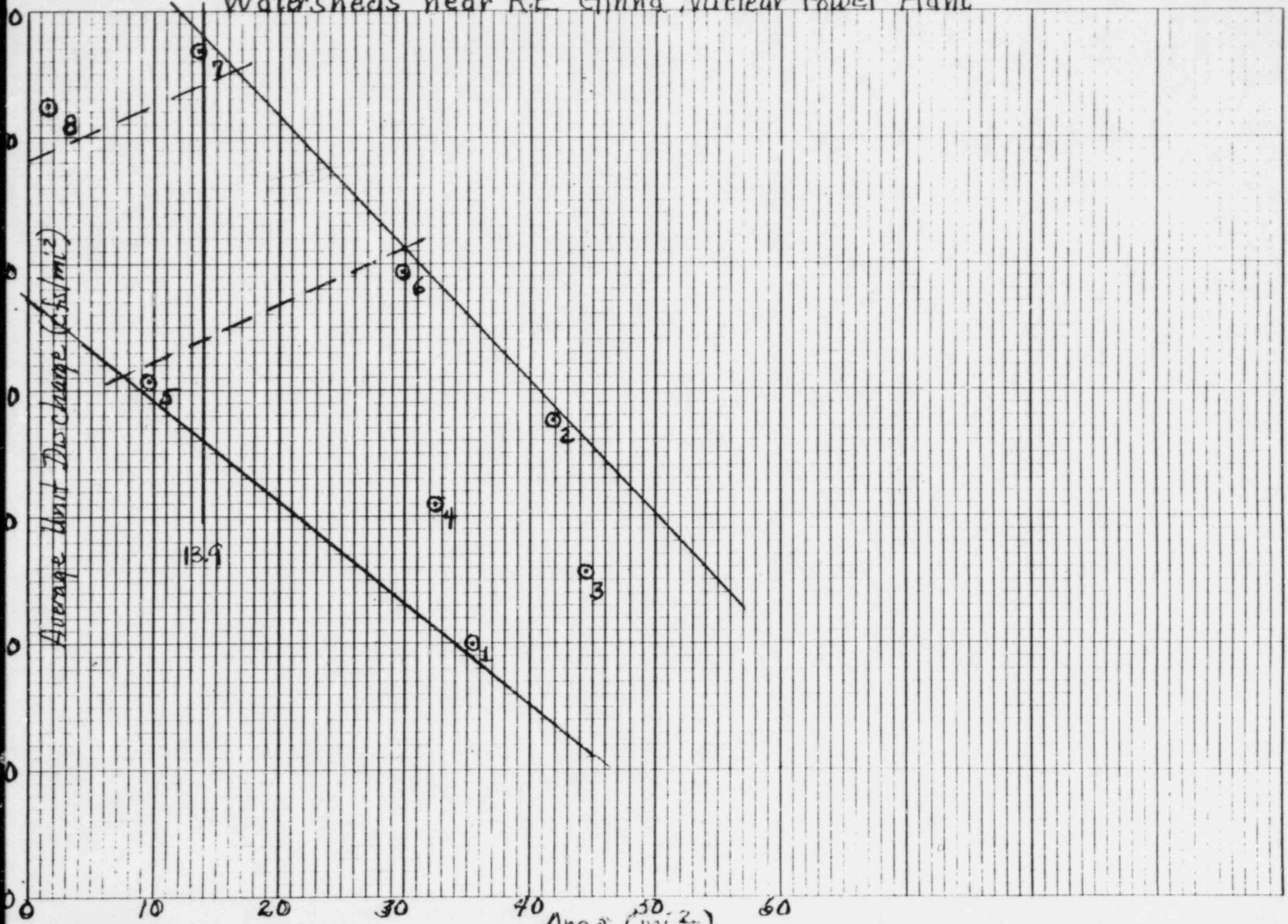
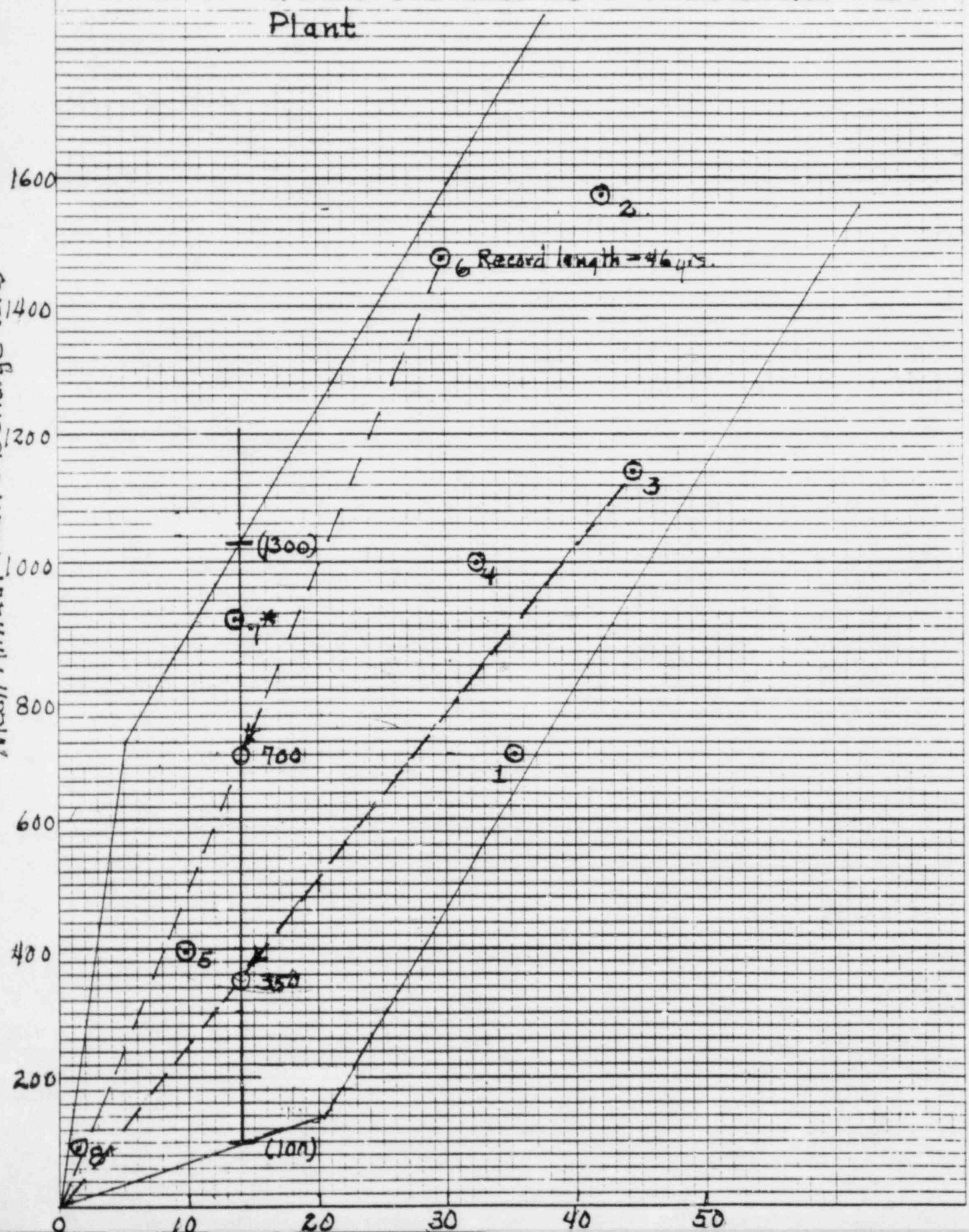


Figure 3. Mean Annual Peak Discharge versus Watershed Area for New York State Small Watersheds near R.E. Ginna Nuclear Power Plant



K·E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. C4212 - 99 (070)

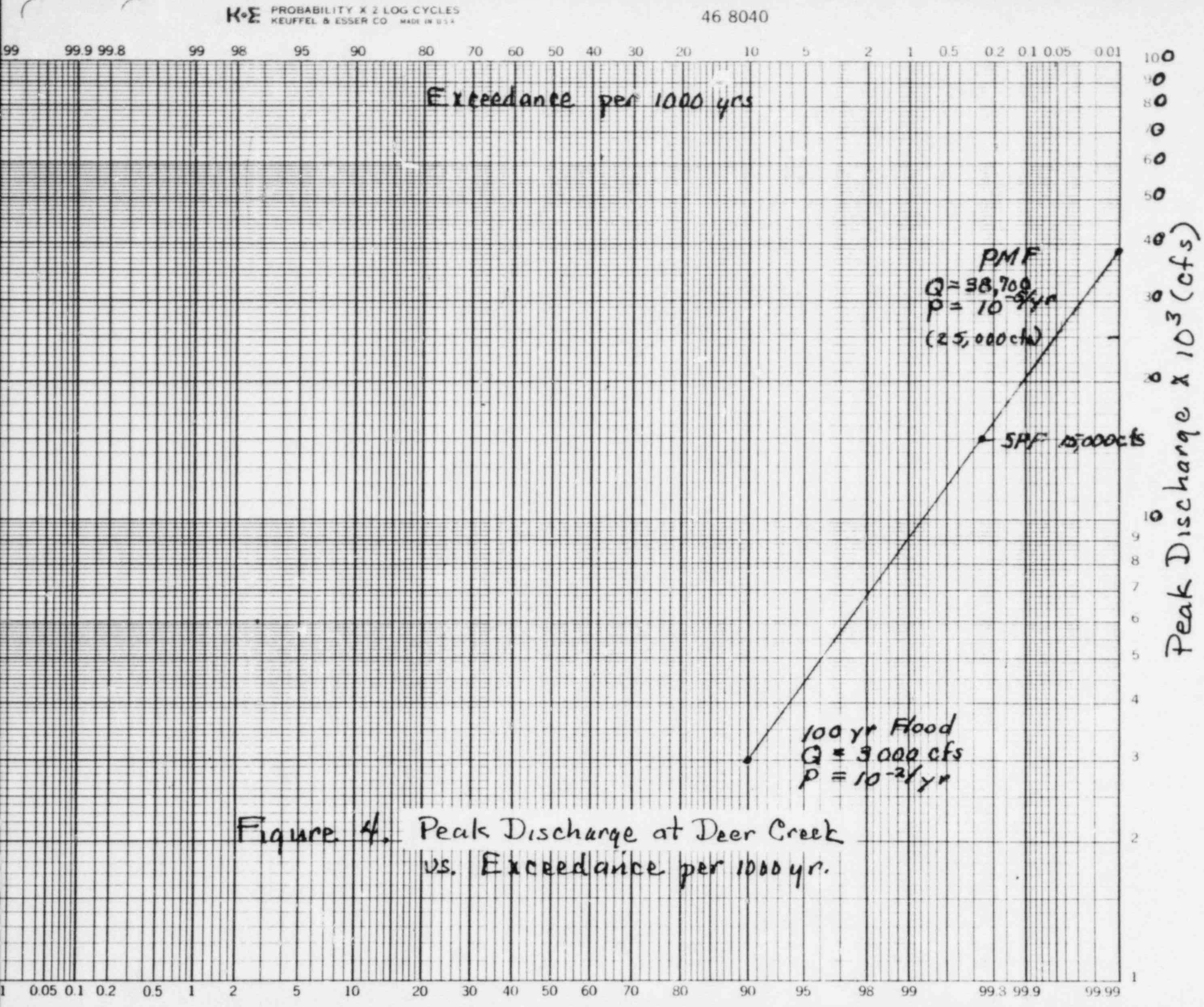


Figure 4. Peak Discharge at Deer Creek vs. Exceedance per 1000 yr.

REGIONAL PROBABILITY WEIGHTED MOMENTS, UNIFORM WEIGHTS FOR EACH SITE
1.000000 0.355105 0.211552 0.145023 0.108613

WAKEBY PARAMETERS FOR ABOVE REGION
A= .34491935
B= 5.1118351
C= 1.5584634
D= .20854405
M= .30035928

MOMENTS 1.0000000 .58037883 4.0288437 70.201471

	100	500	1000	5000	10,000				
	10^{-2}	2×10^{-3}	10^{-3}	2×10^{-4}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}
CUM. PROB.	0.990000	0.998000	0.999000	0.999800	0.999900	0.999990	0.999999	0.9999999	0.99999999
REG. QUANT	3.16	4.78	5.67	8.29	9.73	16.28	26.88	44.01	71.71
SITE				QUANTILES					
4233000	2222.	3364.	3993.	5834.	6841.	11454.	18909.	30960.	50439.
4230380	4972.	7528.	8922.	13053.	15306.	25626.	42307.	69270.	112852.
4232100	3604.	5457.	6467.	9462.	11095.	18576.	30667.	50212.	81803.
4245200	3159.	4782.	5668.	8293.	9724.	16281.	26878.	44008.	71697.
4247000	1261.	1909.	2263.	3310.	3882.	6499.	10730.	17566.	28621.
4232460	4557.	7052.	8358.	12228.	14339.	24006.	39632.	64890.	105717.
1415500	2876.	4358.	5165.	7557.	8862.	14336.	24494.	40104.	65335.
1425500	294.	445.	528.	772.	905.	1515.	2502.	4096.	6673.

UNGANGED SITE WITH MEAN AS SHOWN

SITE		0.990000	0.998000	0.999000	0.999800	0.999900	0.999990	0.999999	0.9999999	0.99999999
REG. QUANT		3.16	4.78	5.67	8.29	9.73	16.28	26.88	44.01	71.71
					QUANTILES					
MEAN=	100.	316.	478.	567.	829.	973.	1628.	2688.	4401.	7171.
MEAN=	150.	474.	717.	850.	1244.	1459.	2442.	4032.	6602.	10756.
MEAN=	200.	632.	957.	1134.	1659.	1945.	3257.	5376.	8803.	14341.
MEAN=	250.	790.	1196.	1417.	2073.	2431.	4071.	6720.	11004.	17927.
MEAN=	300.	946.	1435.	1701.	2488.	2918.	4885.	8065.	13204.	21512.
MEAN=	350.	1106.	1674.	1984.	2903.	3404.	5699.	9409.	15405.	25097.
MEAN=	400.	1264.	1913.	2268.	3318.	3890.	6513.	10753.	17606.	28682.
MEAN=	450.	1422.	2152.	2551.	3732.	4377.	7327.	12097.	19806.	32268.
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MEAN=	550.	1738.	2631.	3118.	4562.	5349.	8956.	14785.	24208.	39438.
MEAN=	600.	1895.	2870.	3401.	4976.	5835.	9770.	16129.	26408.	43024.
MEAN=	650.	2053.	3109.	3685.	5391.	6322.	10584.	17473.	28609.	46609.
MEAN=	700.	2211.	3348.	3968.	5806.	6808.	11398.	18817.	30810.	50194.
MEAN=	750.	2369.	3587.	4252.	6220.	7294.	12212.	20161.	33011.	53780.
MEAN=	800.	2527.	3825.	4535.	6635.	7781.	13026.	21506.	35211.	57365.
MEAN=	850.	2685.	4066.	4819.	7050.	8267.	13840.	22850.	37412.	60950.
MEAN=	900.	2843.	4305.	5102.	7464.	8753.	14655.	24194.	39613.	64536.
MEAN=	950.	3001.	4544.	5385.	7879.	9239.	15469.	25538.	41813.	68121.
MEAN=	1000.	3159.	4783.	5669.	8294.	9726.	16283.	26882.	44014.	71706.
MEAN=	1050.	3317.	5022.	5952.	8709.	10212.	17097.	28226.	46215.	75291.
MEAN=	1100.	3475.	5261.	6236.	9123.	10698.	17911.	29570.	48415.	78877.
MEAN=	1150.	3633.	5501.	6519.	9538.	11184.	18725.	30914.	50616.	82462.
MEAN=	1200.	3791.	5740.	6803.	9953.	11671.	19539.	32258.	52817.	86047.
MEAN=	1250.	3949.	5979.	7086.	10367.	12157.	20354.	33602.	55018.	89633.
MEAN=	1300.	4107.	6218.	7370.	10782.	12643.	21168.	34947.	57218.	93218.

26,000

26,000

EACH SITE N

Table 1. Regional Probability Weighted Moments Wakeby Flood Frequency Distribution, Data from 8 small New York State Watersheds near R.E. Ginna Nuclear Power Plant

103.72417

.99800	0.999900	0.999990	0.999999	0.9999999	0.99999999
9.08	10.73	18.39	31.10	52.18	87.14
QUANTILES					
388.	7545.	12936.	21877.	36105.	61297.
292.	16880.	28943.	48948.	82125.	137146.
360.	12236.	20980.	35481.	54530.	99413.
080.	10724.	18388.	31097.	57175.	87131.
625.	4281.	7340.	12414.	20828.	34782.
389.	15813.	27113.	45853.	76932.	128475.
275.	9773.	16756.	28338.	47546.	79400.
845.	998.	1711.	2894.	4356.	8110.