Appendix 6I-1 Joint Probability – Flood Frequency Analysis

a) Concept

One of the most frequently occurring hydrologic and hydraulic problems about which little literature is available is the problem of joint or coincidental occurrence of two or more events. If the events are caused by the same factors, then the events may be assumed to occur coincidentally. On the other hand, if the events are mutually independent and they leave probabilities of P_1 and P_2, then the probability of a coincidental occurrence is $P_1 \times P_2$. In many cases, the events are somewhat related so that the probability of a joint occurrence is something other than $P_1 \times P_2$.

The ideal solution to this problem would be a frequency analysis segregated with respect to the second variable. Unfortunately, unless long records are available, the number of primary events in any class interval of the secondary variables may be so limited that reliable analysis is not possible.

b) Antecedent and sequential conditions

- AMC II
- Type II Storm Distribution
- 1- to 10-day Storms

c) Outlet blockage

Tides –The Norfolk District has developed a coincidental frequency analysis of the tide and precipitation. The results of this study are shown in appendices 6I-2 and 6I-3. A stage-frequency analysis of all tides is shown in appendix 6I-4. Tide and precipitation are not totally independent and in fact, the severity of joint occurrences is less than if the variables were total independent.

For design purposes the following combinations of tide and precipitation may be used.

Frequencies for Coincidental Occurrences
(Norfolk Harbor)

10-Year Design

Tide	Ppt.
6.3	0.0
2.5	1-year
2.0	5-year
1.5	10-year

100-Year Design

Tide	Ppt.
8.4	0.00
5.4	1-year
4.2	5-year
1.5	100-year

The combinations of events at the extremities of the tables will usually be critical and often the intermediate combinations may be ignored.

d) Channel Flow

For the case of a tributary stream its relative independence may be qualitatively evaluated by a comparison of its drainage area with that of the mainstream. A short duration storm which causes peak discharge on a small basin may not be critical for a larger basin. Also, it may safely be assumed that if the same storm causes peak discharge on both basins, the peaks will be out of phase.

The Norfolk District of the U.S. Army Corps of Engineers developed the following criteria for a single project in the city of Virginia Beach, Va., and it should be used with extreme caution for other locations and/or situations.[*]

Joint Probability Analysis

Area Ratio	Frequencies for Coincidental Occurrence			
	10-year Design		100-year Design	
	Main Stream	Tributary	Main Stream	Tributary
10,000 to 1	1	10	2	100
	10	1	100	2
1,000 to 1	2	10	10	100
	10	2	100	10
100 to 1	5	10	25	100
	10	5	100	25
10 to 1	10	10	50	100
	10	10	100	50
1 to 1	10	10	100	100
	10	10	100	100

The design frequencies suggested in the table represent the extreme combinations of frequencies for each event. Experience has shown that these combinations will usually be critical. For example, the combinations of frequency for a 1,000 to 1 area ratio and a 100-year design frequency area 10- and 100-year frequencies. A 20- and 50-year frequency combination would have the same joint frequency, but the stage elevations, for instances, for these combinations will usually be less than the stages for the given combinations. Maximum stages should be reached when the 100-year storm on the tributary is coincident with the 10-year storm on the mainstream (greatest channel flow with moderate backwater effects) or when the 10-year storm on the tributary is coincidental with the 100-year storm on the mainstream (greatest backwater effect with moderate channel flow). Both cases must be analyzed.

[*] Rev 7/09