# TRANSMISSION LOSSES ON WALNUT GULCH WATERSHED

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Where flows are highly ephemeral and stream beds contain coarse textured alluvium, the decrease of flow volume in the downstream direction due to transmission losses is frequently a significant factor in hydrologic evaluation of watersheds. Only very limited field data are available on this subject for natural streams in the Southwestern United States[2/, 3/]. The purpose of this presentation is to report and discuss some preliminary results on transmission losses which have been obtained at Walnut Gulch Watershed in Arizona.

General conformation, vegetation, and channel characteristics of the Walnut Gulch Watershed are fairly typical of the mixed grass and brush rangelands of Southern Arizona and Southwestern New Mexico.

Transmission losses have been measured for several runoff events from two different reaches of channel:

(a) The reach between measuring stations 2 and 1 (reach 2--1)
(b) The reach between stations 5 and 2 (reach 5--2)

Flow is highly ephemeral, with both reaches being dry about 99% of the time. Several feet of unconsolidated sand and gravel deposits overlie conglomerate bedrock in much of the channel system. Average width of these alluvial deposits in channel reach 2--1 is 217 feet; channel length between stations 2 and 1 is 4.0 miles. For reach 5--2, average width is 147 feet for stages of less than 2 feet, and 180 feet for stages greater than 2 feet, with a channel length of 5.0 miles. A typical particle size distribution curve is shown in Figure 1. It will be seen that the channel sediments are coarse-textured, with over 60% in the gravel range (>2mm). Also present at most channel sections is a small percentage in the cobble and small boulder range.

Although several ungaged tributaries enter the main stem in both of the channel reaches mentioned above, the small size of the runoff producing thunderstorms permits selection of individual events for which no tributary inflow has occurred into the reach in question. Figures 2 and 3 illustrate a typical case. Figure 2 is the isohyetal map of the August 10, 1959, thunderstorm, which occurred on the upper

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2/ Babcock, H. M., and Cushing, E. M. "Recharge to Ground Water from Floods in a Typical Desert Wash, Pinal County, Arizona". Transactions A.G.U. Vol. 23, Part I, pp. 49-56, 1942.

3/ Pratt, Lawrence F. "Flow Losses in the Lower Gila River". Proceedings A.S.C.E., Vol. 86, No. HY 6, pp. 23-28, June 1960.

Should be 3

end of the watershed. Also shown are locations of the gaging stations. Total volume of precipitation falling to depths of greater than 0.9 inches was 185 acre feet. If we assume that half of this volume is "on-site" runoff, we have 92.5 acre feet of runoff entering the channel system at a point some 10 miles upstream from gaging station 2. Figure 4 shows the hydrographs at stations 2 and 1 for this event. Nearly the entire flow volume of 56.9 acre feet which passed station 2 was absorbed by the channel alluvium before reaching station 1.

Transmission losses have been evaluated for several such events. They range from 1.4 to 25 acre feet per mile of channel. In Figure 4, transmission loss per mile of channel is plotted against peak discharge at the upstream station. Peak discharge was used rather than maximum flow depth since for the smaller flows the depth-discharge relationship is not consistent. Observations have indicated that for discharges of less than about 1,000 cfs, the flow cross section is dependent upon the configuration of the sand and gravel bars laid down by preceding flows. At discharges greater than 1,000 cfs, essentially all of the coarse-textured channel bottom is wetted. For both reaches of channel there is a tendency for the transmission loss curves of Figure 5 to flatten out somewhat at a discharge of 1,000 to 1,500 cfs. This tendency is even more pronounced when transmission loss per hour of flow duration is plotted against peak discharge (Figure 5). For the reach 2--1, the loss is essentially constant at about 4.3 acre feet per mile of channel per hour of flow duration for the 3 events having discharges greater than 850 cfs. For reach 5--2, loss per mile per hour increased from 3 to 5 acre feet as the discharge increased from 1,500 to 5,000 cfs. It should be pointed out that the 5,000 cfs event followed a period of no runoff of 6 weeks duration, and probably represents about the maximum loss which can be expected in reach 2--5. No comparable event of high peak discharge and low antecedent runoff has been experienced for reach 2--1. On the contrary, antecedent runoff ranged from moderate to high for the 3 constant loss-rate events shown, with the largest discharge event having the highest antecedent runoff. It is likely that these differences in antecedent runoff are responsible for the difference in the shape of the curves for the 2 channel reaches, and it is logical to expect that the upper curve will approach the shape of the lower one as more records become available in the higher discharge range.

For the highest discharge event in reach 2--1, average infiltration rate into the channel alluvium was 2.0 inches per hour, compared with a rate of 3.0 inches per hour for the largest event in reach 5--2. As stated earlier, it is probable that this difference in rate is due to differences in antecedent runoff.

It is apparent that the data presented are limited, and that no firm conclusions may be drawn from the information now available. The magnitude of the transmission losses measured thus far emphasizes their importance in the overall hydrology of many arid-land watersheds. Whether or not the transmission-loss water is truly lost as far as beneficial use is concerned depends on the geology immediately beneath

the stream bed. Where conditions are favorable to recharge, a substantial portion of the transmission losses may percolate to the regional ground water table. Under geologic conditions which are unfavorable to recharge, the transmission-loss water is stored temporarily in the channel alluvium and removed by evapotranspiration. On Walnut Gulch Watershed, records of ground water levels in shallow perched aquifers located beneath the stream bed would indicate that riparian vegetation removes significant quantities of the transmission-loss water.

Additional instrumentation recently installed and further geologic investigations planned on the study area should facilitate more precise evaluation of transmission losses in terms of the pertinent channel parameters, and should define more completely the disposition processes involved in the removal of the transmission-loss water.

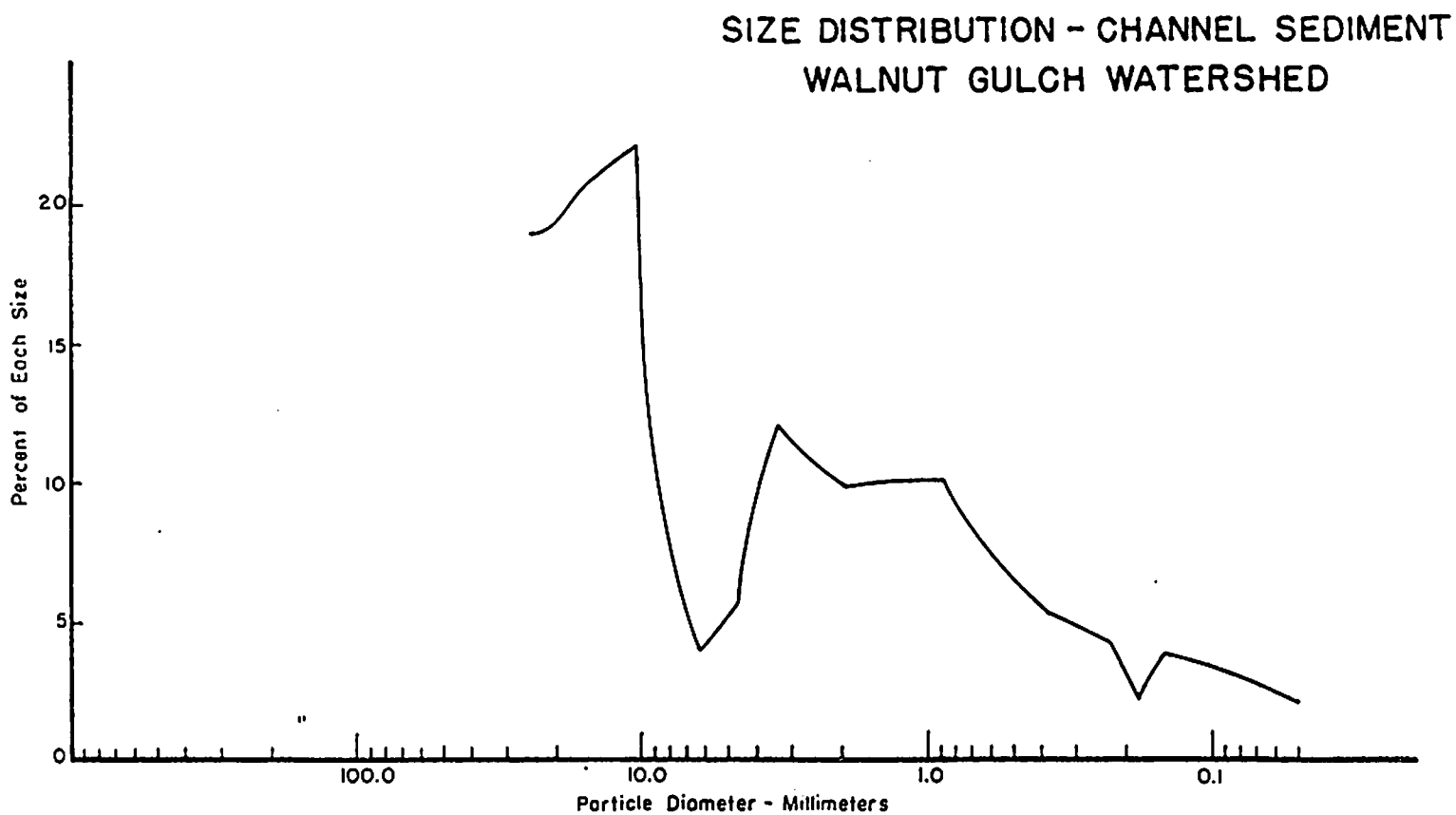
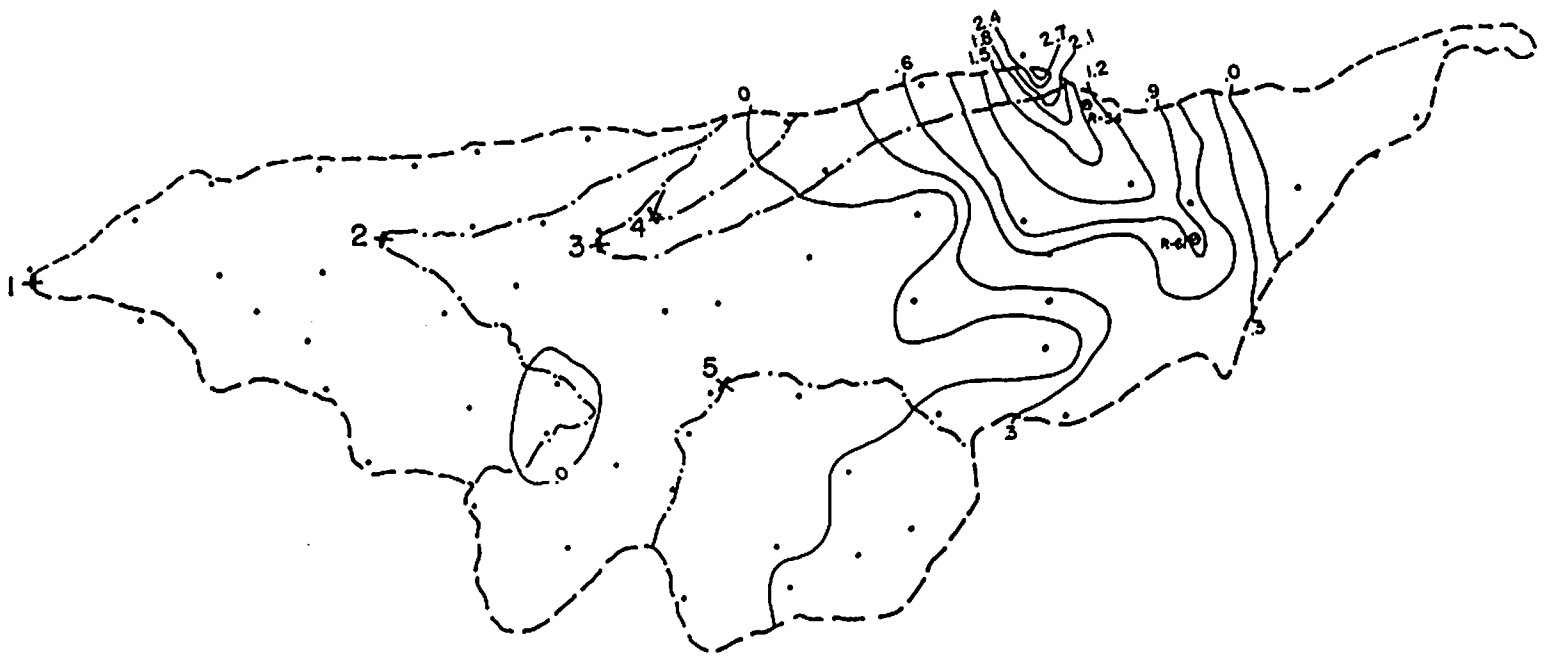

SIZE DISTRIBUTION - CHANNEL SEDIMENT
WALNUT GULCH WATERSHED
Percent of Each Size
0
5
10
15
20
100.0
10.0
1.0
0.1
Particle Diameter - Millimeters

Figure 1




WALNUT GULCH WATERSHED
Isohyetal Map
Storm of August 10, 1959

Figure 2

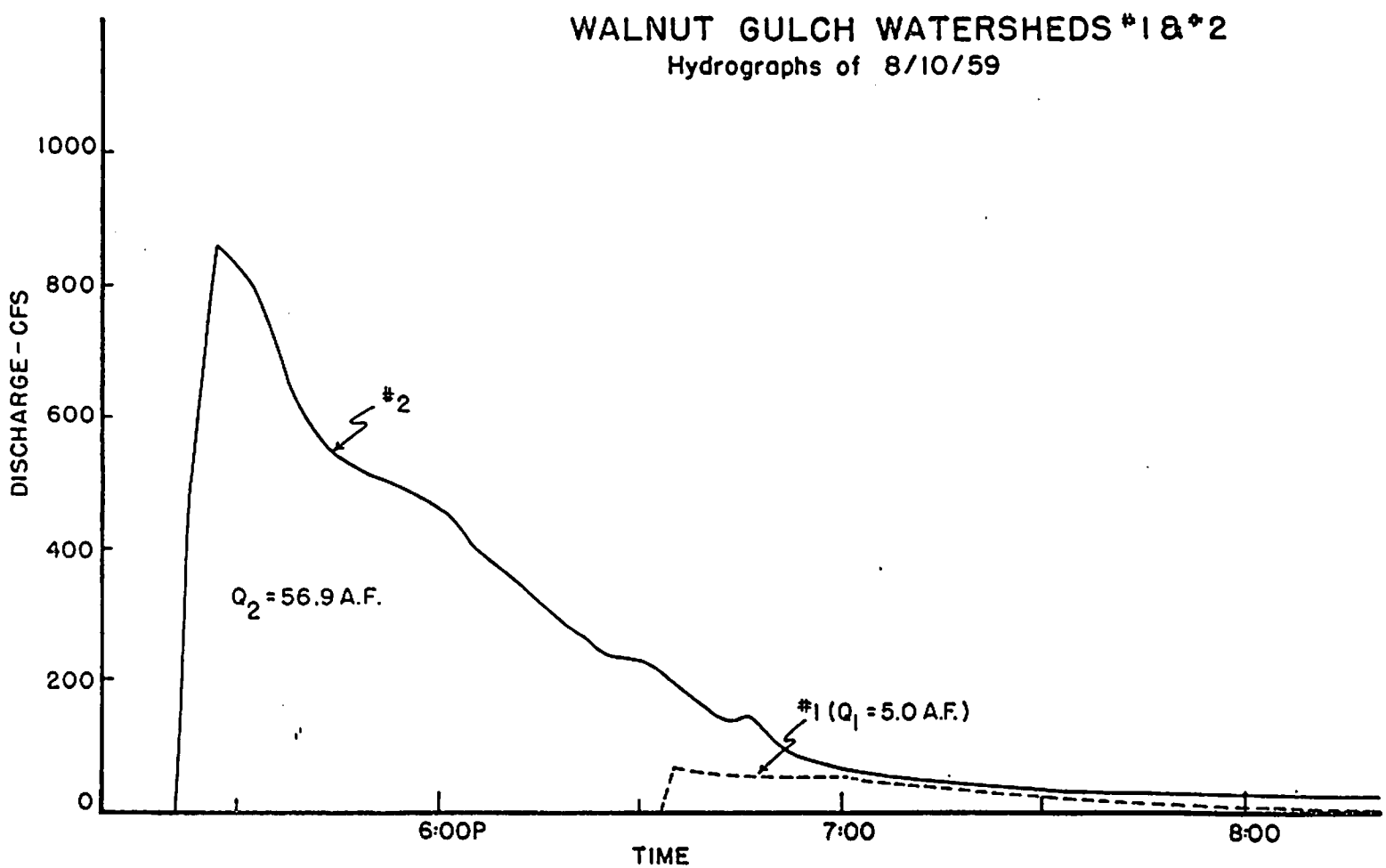

WALNUT GULCH WATERSHEDS #1 & #2
Hydrographs of 8/10/59
DISCHARGE - CFS
1000
800
600
400
200
0
#2
$Q_2$ = 56.9 A.F.
#1 ($Q_1$ = 5.0 A.F.)
6:00P
7:00
8:00
TIME

Figure 3

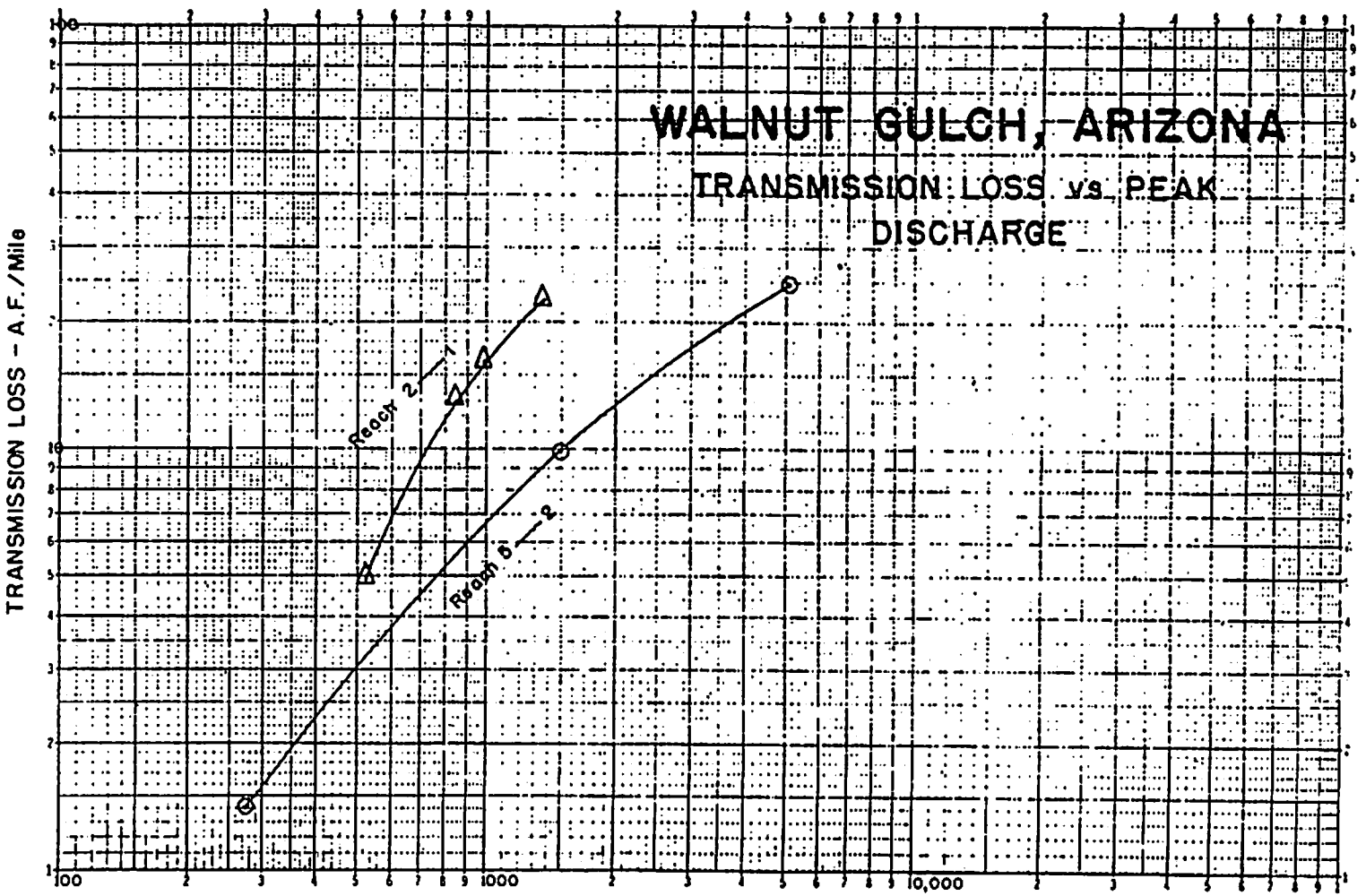

WALNUT GULCH, ARIZONA
TRANSMISSION LOSS vs PEAK DISCHARGE
Reach 2 — 1
Reach 6 — 2
TRANSMISSION LOSS - A.F./Mile
PEAK DISCHARGE at UPSTREAM STATION-cfs
100
1000
10,000

Figure 4

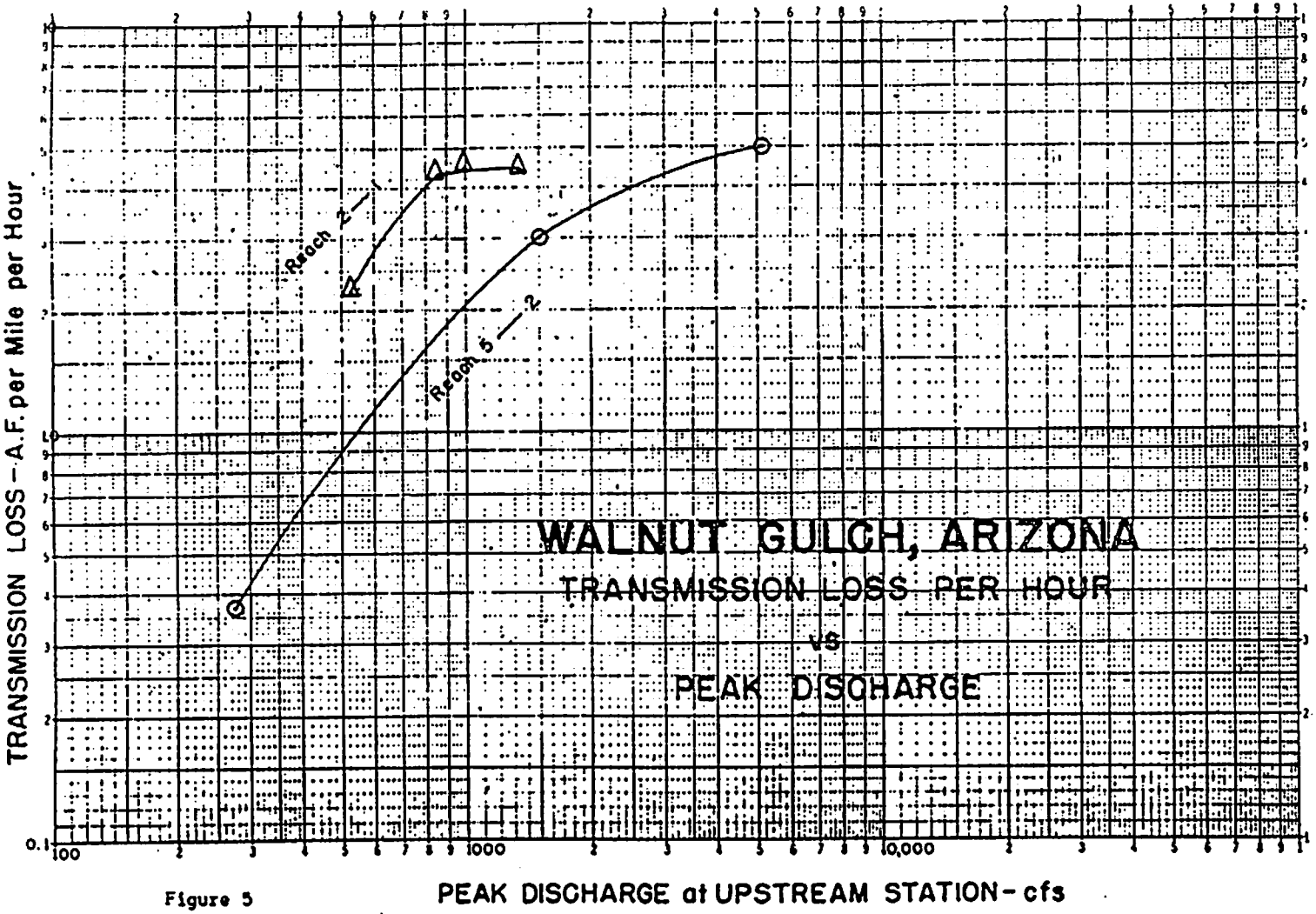



Figure 5

Logarithmic, 3 X 3 Cycles