Rob Norman NCR
C. Irwin
Bill

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
Regional Technical Service Center
Upper Darby, Pennsylvania 19082

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TSC TECHNICAL NOTE - WATERSHEDS UD-22

SUBJECT: Economics - Floodwater Damages to Roads and Bridges

The purpose of this technical note is to update an earlier 1961 Memorandum, EWP-59, which had been cancelled, to provide planning staffs with a list of the types of data needed to appraise floodwater damages to roads and bridges and conditions likely to cause bridge failure.

Basic to the analysis of floodwater damage is the determination of the elevation at which damages begin, the elevation at which maximum damage is most likely to occur, and damage estimates at intermediate elevations.

The following is a list of data that needs to be obtained and developed by the engineer, hydrologist, geologist, and economist to make a joint appraisal of floodwater damages:

Roads and Railroads

Floodwater damage estimates for roads are based on the following kinds of road damages:

1. Debris and sediment removal.
2. Erosion of shoulders and embankment.
3. Washout of guardrails and road surface.
4. Undermining of pavement.
5. Cutting back of fill, culverts, drain pipes, etc.

cc
R. N. Lane

To appraise road damages, the following information is needed:

1. Location and classification of all roads (concrete, blacktop, gravel, etc.) that are subject to flooding recorded on photos, a map, or flood plain profile.

2. A narrative description and photograph or sketch of the above roads, considering:

   a. Erodibility of embankment, shoulders, and surface.

   b. Height of road embankments above flood plain and bank elevations.

   c. Streambank erosion affecting road fills.

   d. Flood stage at which damage begins.

   e. Position of road in relation to flood plain.

3. Damage (physical and monetary) information from road officials or nearby residents for specific past flood events recorded on damage schedules, including:

   a. Scouring or road surface by various depths of flow.

   b. Scouring of embankments and washout of guardrails.

   c. Debris and sediment accumulation on roads and in ditches.

   d. Replacement or modifications made since last damaging flood.

4. Estimates of physical damages from engineering and geologic technicians, if historical data is not available, for two or more flood stages, considering the same sub-items as in "3" above.

   Historical data should be used to estimate floodwater damages to roads whenever practical and used as a guide for estimating damages for other flood stages.

The following costs for roads and railroads may be used as a guide for damage estimates. As you acquire local data from interviews and watershed operations, adjust the below data to reflect current information and price levels.

Road Damage [2]	Cost per Mile
Debris removal	100 - 700 [1]
Shoulder repair and cleanout of roadside ditches	3,000 - 14,000 [1]
Road, shoulders, and ditches	20,000 - 50,000 [1]

Railroad Branch Line [2]	
1. Track	150,000 - 400,000
2. Tracks	250,000 - 500,000

1/ Based on estimates made by Corps of Engineers for the Susquehanna River Basin Study for flood stages up to five feet over primary paved highway roads.

2/ For more detailed cost estimates, see TSC Technical Note - Watersheds - UD-8, February 3, 1967.

Bridges

Floodwater damage estimates for bridges are based on the following information:

1. The location and classification (primary, railroad, and secondary) of all bridges subject to flooding. This can be shown on a map and flood plain profile.
2. A photograph, drawing, or word description showing:
   a. Type of bridge.
   b. Dimensions and elevations of bridge deck.
   c. Type, strength, spacing, and foundation conditions of piers and abutments.

d. Height of superstructure above the channel and flood plain.

e. Direction of piers and abutments in relation to direction of flow.

f. Size of bridge opening.

g. Age and remaining useful life of the bridge.

h. Replacement or modifications made since last damaging flood.

i. Type and elevation of bridge approaches relative to the elevations of the bridge deck.

j. Dimensions of bridge deck.

k. Value of bridge.

3. Flood damage and cost information from highway and railroad officials, maintenance foreman, and adjacent residents. Care should be taken when relating historical information to existing structures.

4. The gradient of the channel.

5. The potential channel filling and bridge plugging by debris from the area above the bridge. Are buildings located in the flood plain? Are logs, hay, straw, lumber, and other floatable objects located in the flood plain? These items contribute to potential debris deposition on bridges and should be considered in calculating various water surface profiles.

6. The stage at which damage begins. Effects of damage to the bridge approaches should not be overlooked.

7. The stage at which bridge failure is likely to occur.

8. The estimated damage related to the stage (elevation) at which the bridge is likely to be destroyed (item 7) and for stages between beginning damage and failure.

9. A stage-damage curve.

Bridge failure can be related to the effects of flood stages and associated flood velocities on bridge approaches, abutments, and the superstructure. The failure of primary road bridges and railroad bridges is frequently caused by washouts of abutments. However, when bridges are

built higher than the road and the approaches are ramped, bridges may not be damaged but approaches may wash out before flood stages reach the superstructure. The approaches to railroad bridges and primary road bridges usually maintain the grade of the road and are not ramped.

One foot of flooding over railroad bridge approaches may usually cause failure. However, failure may also occur at lower depths depending on the stability of fill material.

The following velocity-stage relationship combinations are critical and may cause failure of primary and secondary highway bridges and railroad bridges.

VELOCITY 1/	FLOOD DEPTH 2/		
	Bridge	Railroad Approach	Road Approach
Greater than 15 feet per second	2 feet below low bridge cord	Over 1 foot	2-4 feet & over
10 to 15 feet per second	1 foot below low bridge cord	Over 1 foot	2.5-4 feet & over
5 to 10 feet per second	At bridge floor level	Over 1 foot	Over 3 feet
2 to 5 feet per second	2 feet over bridge floor	Over 1 foot	Over 4 feet

1/ Channel velocity at bridge for superstructure flooding and velocity around bridge for approach failure.

2/ Depth of flooding in low point of road at start of approach ramp.

Neil F. Bogner
Head, EWP Unit

Prepared by: O. Wesley Hofstad and Thomas C. G. Hodges, Economists