FORREST SERVICE MANUAL
WASHINGTON , D. C.

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CHAPTER: 7720 DEVELOPMENT ROADS

POSTING NOTICE: This is the first ID issued in FSM 7700.

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This interim directive reinstates certain instructions previously in FSM 7710.

7723.04 - Responsibility. The Chief will establish basic design criteria and policy, and will review progress and efficiency through inspections. The Regional Forester will establish design procedure best suited to the local climatic conditions, terrain, and available data.

7723.21 - Transportation Drainage Engineering. Transportation drainage engineering is that engineering required to hydrologically and hydraulically design road and trail bridges, culverts, and related structures. It includes cross-drainage, subdrainage, channel improvement, and erosion control structures as related to the transportation system. It involves a hydrologic analysis to determine runoff volumes, and flood frequencies; a hydraulic analysis to obtain waterway areas, backwater stages, culvert inlet and outlet conditions, velocities, scour, and open channel shapes and an economic comparison of alternative flood frequencies and strucutres. The objective is to provide the most efficient drainage facility consistent with resource protection, the importance of the road or trail, legal obligations and total cost, including construction, maintenance, and service interruption and estimated damage if the capacity of the structure is exceeded.

7723.22- Design Criteria. Drainage engineering generally relies heavily on judgment and, for an acceptable degree of accuracy, must be entrusted to the experienced engineer. He should actively solicit information and advice from all available sources and disciplines. The hydrologic surveys and analyses, and the soil management reports prepared by the watershed and soil scientists, should be included. See FSM 2531, 2532, and 2550. The engineer also should consider the possibility and effect of upstream development, use, and fire damage.

Rarely can design discharges and velocities be predicted simply. Where several methods of analysis are available, the one supported by the most reliable data shall be chosen as the primary method and checked against as many others a practicable.

7723.23 - Hydrology

1. Design Discharge. Listed below are a number of methods which may be used for obtaining the design discharge.

a. Streamflow Records. Stream gage records have been maintained on most of the large streams. If available, these records should be used to obtain flow data.

b. Formulas (Rational, State Highway Formulas, Etc.). Formulas, charts, nomographs, and tables hould be used with utmost care. The formulas generally attempt to determine runoff frequency by some relationship to rainfall frequency. The designer must assure himself that the formula will apply for the particular area and that all factors, such as vegetative cover, relief, infiltration, and surface storage, are considered.

Formulas, such as Talbot's, which consider only one factor, should not be used.

c. Direct Observations. High-water marks generally should be used to check the primary method. The performance of existing structures, including those damaged by floods, should also be considered. An estimate of the recurrence interval of the flood which produced the high-water mark should be made.

d. Correlation of Areas. Runoff quantities may be obtained by correlating an area with a similar hydrologic area for which a runoff record has been established.

2. Flood Frequency Analysis. When sufficient data are available, a flood frequency curve, prepared by the graphical or mathematical method, shall be used. Regional frequency curves have been prepared and are periodically revised by the United States Geological Survey (USGS). These may be used but should be checked by plotting a curve for the site when site records are available. The following is recommended as reference maer

a. Regional Frequency Curves - USGS Water-Stupply papers, titled, "Magnitude and Frequency of Floods in the United States," W. S. P. 1671 through 1689.

b. "Frequency Curves," chapter A2, Book 4 of Techniques of Water-Sources Investigations of the U. S. Geological Survey, Department of Interior, Washington, D. C. This material discusses graphical and mathematical methods.

c. "A Uniform Technique for Determining Flood Flow Frequencies," Bulletin 15, Water Resources Council, 1025 Vermont Avenue, NW, Washington, D. C. This material describes the mathematical method (109 Pearson Type III adopted by the Council's Hydrology Committee as the base method for determining flood frequencies).

When using the frequency curves, the designer must be aware of two aspects affecting the selected design discharge; the curve may not accurately represent the distribution of events and the probability of the flood selected being exceeded a short time after construction. Both introduce the element of risk, since it is rarely possible to design for all magnitudes of floods, an acceptable degree of risk must be established. Structure costs for the design discharges of several flood recurrence intervals should be compared with resulting flood damages. The type of flood damage or the estimated cost of the damage may indicate use of a large design discharge.

3. Flood Frequency Interval. As a minimum, culverts shall be designed for a 10-year flood (flow of 10-year recurrence interval) without a head at the entrance. They should also be designed to carry a 50-year flood without exceeding the allowable headwater.

The allowable headwater is the maximum water elevation for which the resulting flood damages are considered to be acceptable. Major culverts (end area greater than 35 square feet) and minor bridges (spans on the order of 30 feet and less) should be designed for a 20-year flood and checked for a 50-year flood. All other bridges should be designed to pass a 50-year flood and checked for a 100-year flood.

The above values, other than the 10-year minimum for culverts, are not given with the intent of restricting use of other recurrence intervals if use is indicated by an analysis. Selection of the ideal recurrence interval involves an economical comparison of several structures and appurtenances designed for different intervals. The analysis must include:

a. First costs of the structure and fills.

b. Annual maintenance costs.

c. The expected flood damage costs, upstream and downstream, of the structure, road, streambed, and adjacent property; and the road user loss or detour costs resulting from the flood damage. These must be modified by a factor representing the probability of the flood-recurrence interval. How detailed the analysis must be for a particular site must be left to the judgment of the designer, but is somewhat proportional to the cost of the structure and the type and cost of the expected damage.

7723.24 - Hydraulics. All structures and channels shall be sized and shaped to carry the design discharge economically and at any acceptable velocity.

Design considerations are:

1. Control or passage of ice and deris.

2. Controlling backwater stages to acceptable degrees of damage to the surrounding land, road embankments, and streambanks.

3. Controlling velocities above, through, and below the struc structure to minimize the effect on the stream channel and the drainage facility.

4. Control for fish passage.

5. Preservation of natural streambanks and bottom for fish habitat and esthetic purposes.

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