CHAPTER 14

RIPRAP

14-1. Riprap protection. Riprap protection should be provided adjacent to all hydraulic structures placed in erodable materials to prevent scour at the ends of the structure. The protection is required on the bed and banks for a sufficient distance to establish velocity gradients and turbulence levels at the end of the riprap approximating conditions in the natural channel. Riprap also can be used for lining the channel banks to prevent lateral erosion and undesirable meandering. Consideration should be given to providing an expansion in either or both the horizontal and vertical direction immediately downstream from hydraulic structures such as drop structures, energy dissipators, culvert outlets, or other devices in which flow can expand and dissipate its excess energy in turbulence rather than in a direct attack on the channel bottom and sides.

14-2. Failures. There are three ways in which riprap has been known to fail: movement of the individual stones by a combination of velocity and turbulence, movement of the natural bed material through the riprap resulting in slumping of the blanket, and undercutting and reveling of the riprap by scour at the end of the blanket. Therefore, in design, consideration must be given to selection of an adequate size stone, use of an adequately graded riprap or provision of a filter blanket, and proper treatment of the end of the riprap blanket.

14-3. Stone size.

a. Uses. Presented in figure 14-1 are curves for the selection of stone size required for protection with Froude numbers and depths of flow in the channel shown. Two curves are given, one to be used for riprap subject to direct attack or adjacent to hydraulic structures such as side inlets, confluences, and energy dissipators, where turbulence levels are high, and the other for riprap on the banks of a straight channel where flows are relatively quiet and parallel to the banks. With the depth of flow and average velocity in the channel known, the Froude number can be computed and a d_{50}/D value determined from the appropriate curve. Curves for determining the riprap size required to prevent scour downstream from culvert outlets with scour holes of various depths are shown in figure 14-2. The thickness of the riprap blanket should be equal to the longest dimension of the maximum size stone or 1.5 times d_{50}, whichever is greater. When the use of very large rock is desirable but impracticable, substitution of a grouted reach of smaller rock in areas of high velocities or turbulence may be appropriate. Grouted riprap should be followed by an ungrouted reach.

b. Gradation. A well-graded mixture of stone sizes is preferred to a relatively uniform size of riprap. A recommended gradation is shown

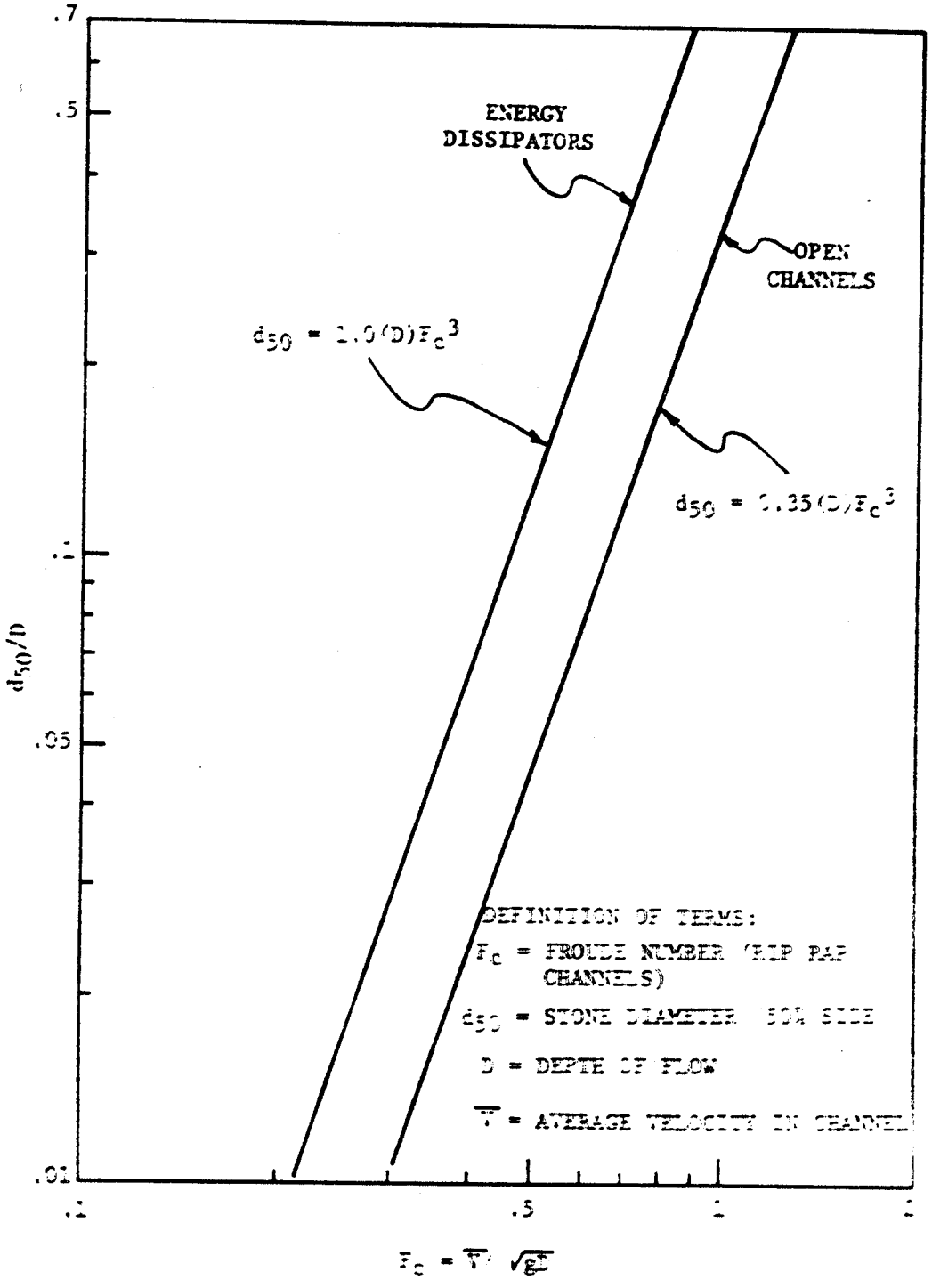

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FIGURE 1-1. RECOMMENDED RIPRAP SIZES, GULLY SCOUR

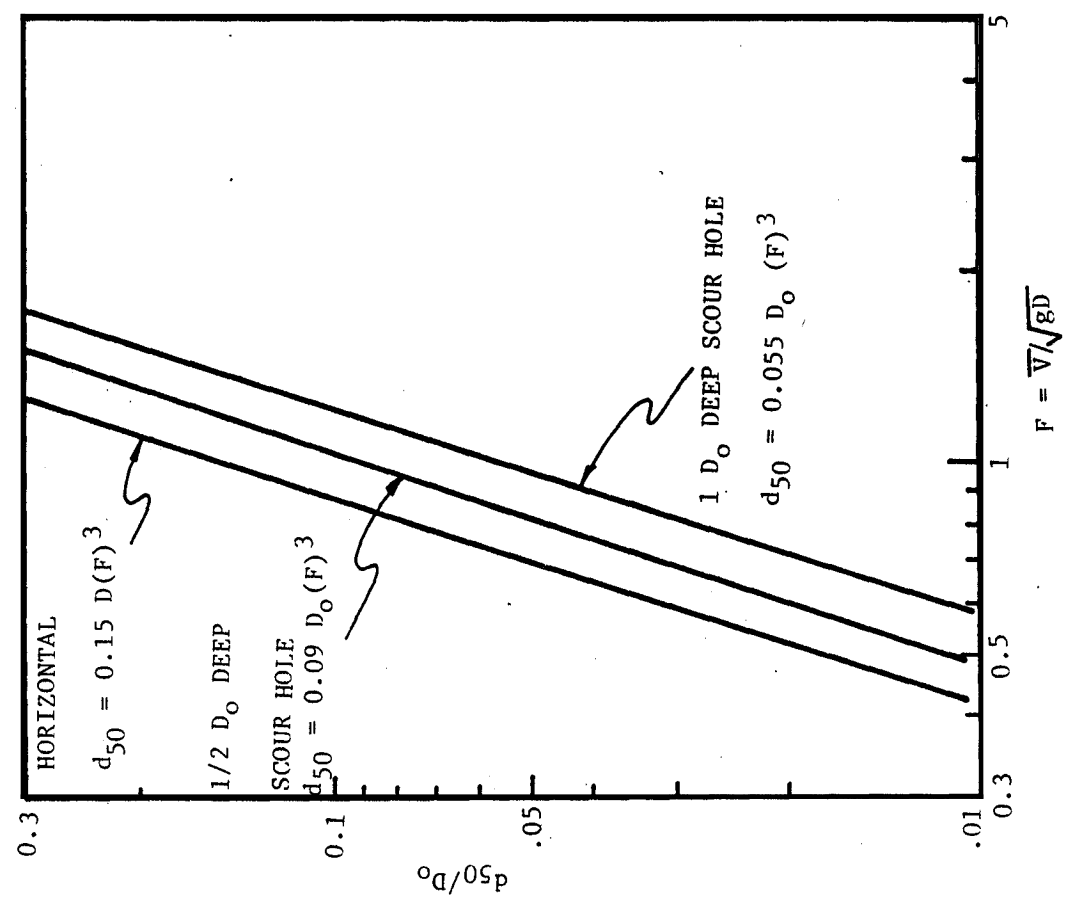

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FIGURE 14-2. RECOMMENDED RIPRAP SIZES, SCOUR HOLE

in figure 14-3. However, in certain locations the available material may dictate the gradation of riprap to be used. In such cases, the gradation should resemble as closely as possible the recommended mixture. Consideration should be given to increasing the thickness of the riprap blanket when locality dictates the use of gradations with larger percents of small stone than shown by the recommended plot. If the gradation of the available riprap is such that movement of the natural material through the riprap blanket would be likely, a filter blanket of sand, crushed rock, gravel, or synthetic cloth must be placed under the riprap. The usual blanket thickness is 6 inches, but greater thickness is sometimes necessary.

14-4. Design. An ideal riprap design would provide a gradual reduction in riprap size until the downstream end of the blanket blends with the natural bed material. This is seldom justified. However, unless this is done, turbulence caused by the riprap is likely to develop a scour hole at the end of the riprap blanket. It is suggested that the thickness of the riprap blanket be doubled at the downstream end to protect against undercutting and unraveling. An alternative is to provide a constant-thickness rubble blanket of suitable length dipping below the natural stream bed to the estimated depth of bottom scour.

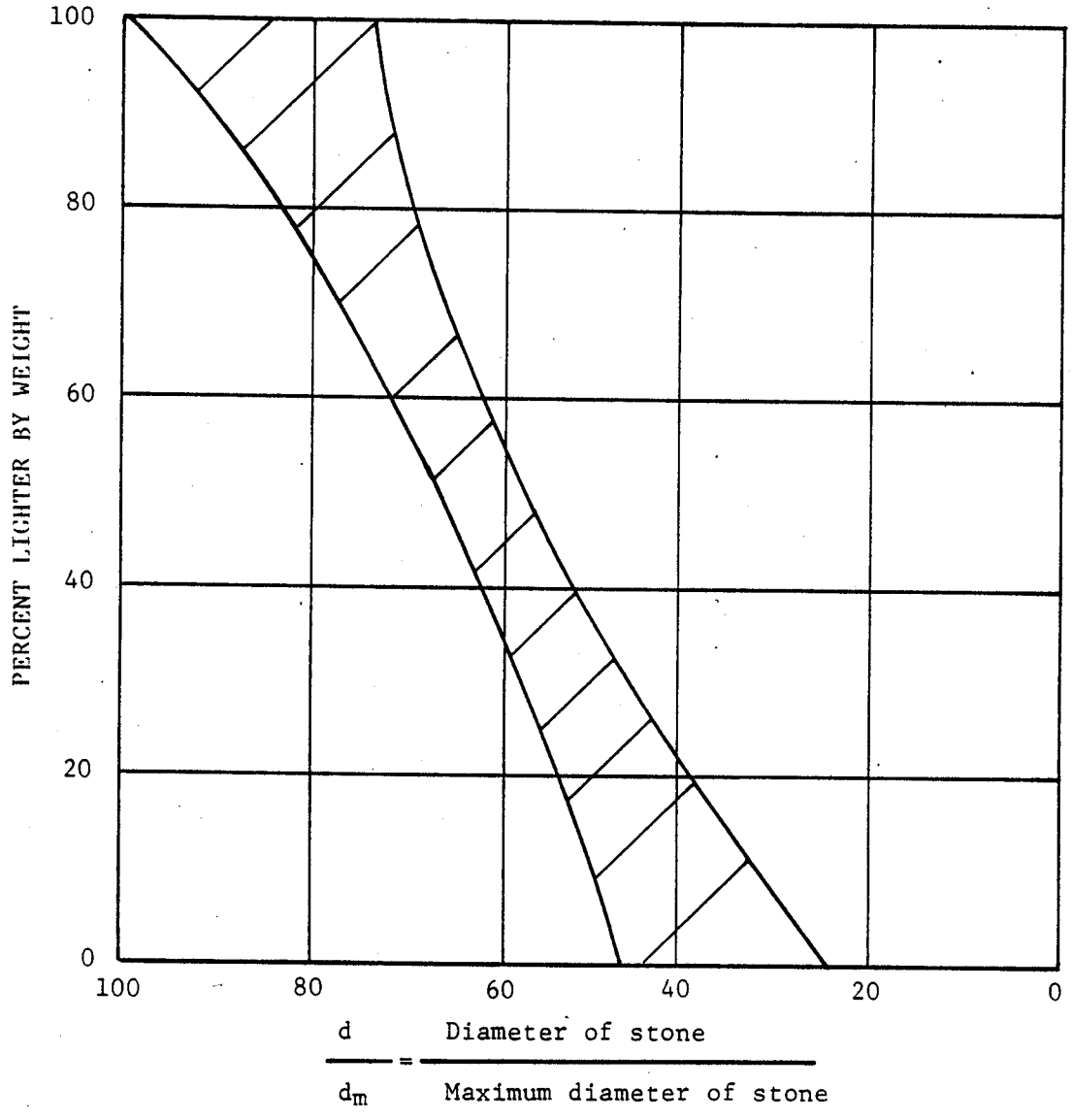

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FIGURE 14-3. RECOMMENDED GRADATION