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RATING GAGING STATIONS AND COMPUTING RECORDS -- DISCUSSION

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Obtaining discharge records for alluvial sand channel streams has been and probably always will be a problem because a unique relation between stage and discharge does not exist. Not only is the stage-discharge relation affected by local scour and fill of the bed, but also by the fact that the bed form, and hence resistance to flow varies with changes in flow, fluid, bed material, and channel characteristics. The various bed forms that can occur in alluvial sand channels; the factors that affect the bed forms; and the resultant change in resistance of flow and stage and depth discharge relations have been presented by Simons and Richardson, 1960, Colby, 1960, Simons and others, 1961, Dawdy, 1961, and Simons and Richardson, 1961, and need but little elaboration here. The various bed forms that can occur in alluvial sand channels have been classified into two flow regimes, on the basis of similarity in bed form, resistance to flow and mode and magnitude of sediment transport. The two flow regimes and their bed forms are illustrated in Figure 1. Between the two flow regimes there is a connecting transition where the bed form ranges from those typical of the lower flow regime, to those bed forms typical of the upper flow regime.

In sand bed flume experiments the resistance to flow, as measured by Manning n, ranged from 0.020 to 0.035 in the lower flow regime, from 0.010 to 0.018 in the upper flow regime, and from 0.035 to 0.010 in the transition connecting the two regimes. However, when slope and the characteristics of the bed material are constant, or nearly so, as they are at most gaging reaches, the variation in resistance to flow is not large in either the upper or lower flow regime. Although there is considerably more variation in resistance to flow in the lower flow regime than in the upper flow regime. In the transition region when slope and bed material are constant, or nearly so, there still exists a large variation in resistance to flow. Gaging reaches that are consistently in the upper or lower flow regimes should yield fairly consistent depth-discharge relations, and methods proposed by Troxell (1139, p. 503) and Haines (857, p. 40) should yield fair discharge records. Their methods should also work for gaging reaches where the flow regime changes if the change occurs fairly rapid. In using their methods for reaches where the flow regime changes, two depth-discharge curves exist and the shift from one curve to the other must be determined by careful observation of the gage high trace. Records for these stations could be further improved if methods were developed to obtain a continuous record of depth instead of stage. New developments in sonic depth sounders should make this possible.

The methods proposed by Troxell and Haines should not be expected to work for gaging reaches where the bed form is always in the transition range or for reaches where the change from one flow regime to another is not rapid. For these cases the method proposed by Mr. LeFever appears to be the only practical solution at this time. His proposed velocity-index method, which as he states is an abbreviated discharge measurement, makes it possible to obtain a discharge record from periodic measurements. The limitations of the method are the accuracy of the abbreviated discharge measurements and the variation in discharge that may occur between measurements. Thus, the water-discharge records for gaging reaches where the bed form is in the transition region are comparable to sediment-discharge records, which are also based on periodic measurements.

A possible method of obtaining water-discharge records for gaging reaches in the transition region would be to plot the depth-velocity index on the gage-height trace and then sketch in a discharge curve in the same manner that a gage-height trace for a non-recording station or a sediment concentration curve are drawn. Because the bed form may change with changes in temperature and with changes in the characteristics and concentration of fine sediment, a change in the gage-height may occur without a change in water discharge. Hence a continuous record of water temperature and when available periodic suspended sediment concentration measurements would help in sketching in a water-discharge curve. In summary, the concentration of suspended sediment, when available, the water temperature, the gage-height trace, and the partial discharge measurement should all be considered when constructing water-discharge curves. Discharge records established using this method should be superior to those obtained using a gage-height trace and a nonexistent stage-discharge relation.

The methods conceived by Troxell, Haines and LeFever, are in the best engineering tradition and certainly would improve discharge records. However, the extent of improvement is limited by the cost of obtaining and analyzing the necessary data. Recognizing the importance of water to the nation and the number of streams that flow in alluvial sand channels, it seems imperative that controls should be developed and utilized to more accurately determine both the water and sediment discharge. These controls should have a stable depth-discharge relation, not seriously effect the behavior of the stream, and provide a means of measuring total sediment discharge.

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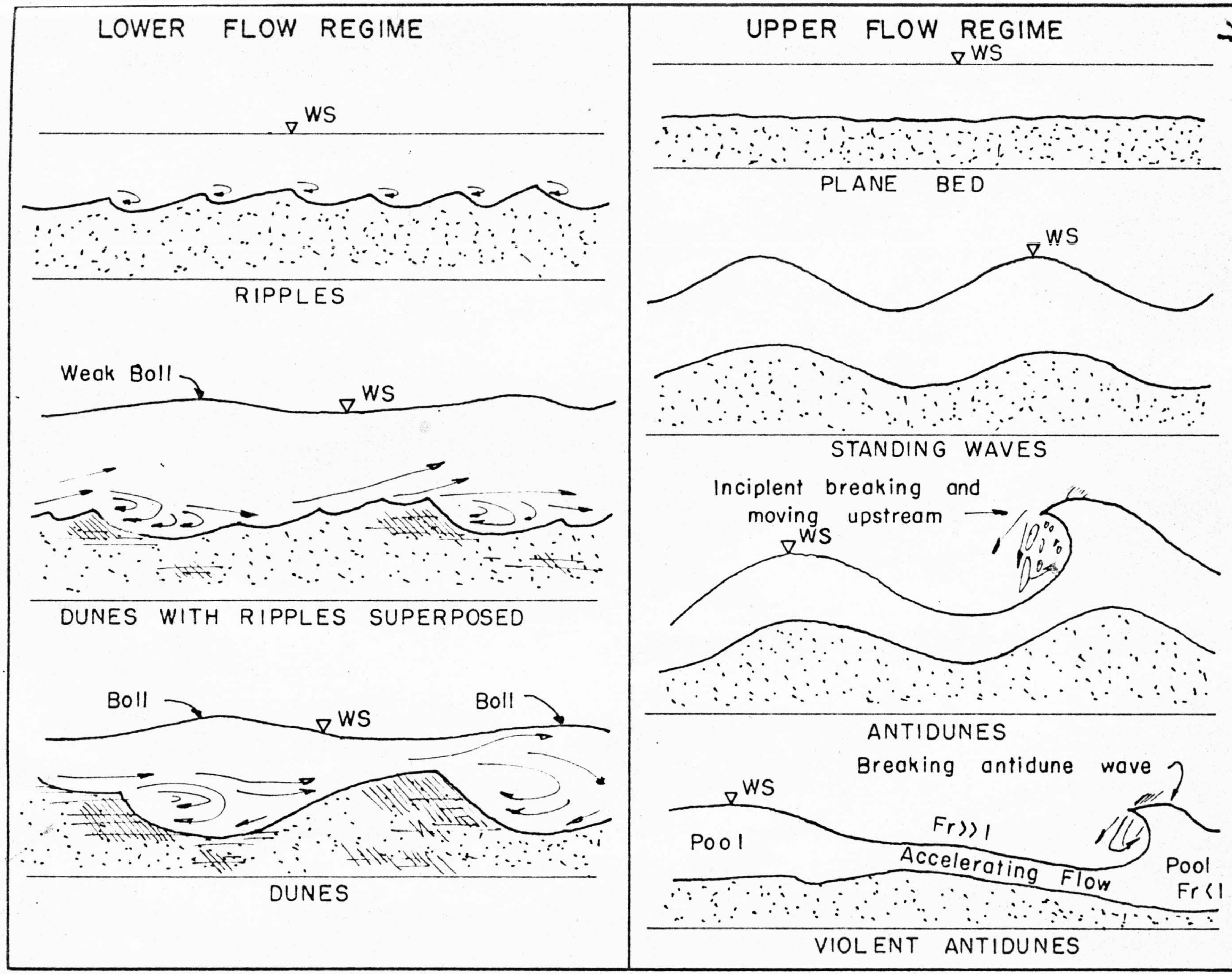

Fig. 1 Forms of Bed Roughness and Regimes of Flow