UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
OFFICE OF CHIEF ENGINEER

COMPUTATION OF "Z's" FOR USE IN THE MODIFIED EINSTEIN PROCEDURE

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DIVISION OF PROJECT INVESTIGATIONS
HYDROLOGY BRANCH
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CHANGE IN THE MODIFIED EINSTEIN PROCEDURE TO COMPUTE "Z"

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INTRODUCTION

Numerous applications of the Modified Einstein Procedure (Colby and Hembree, 1955) have been made by the Bureau of Reclamation to compute the total sediment load of streams.

The determination of the "Z" value is one of the several factors in this procedure that must be made. "Z" is defined as the theoretical exponent for vertical distribution of sediment. The original Modified Einstein Procedure showed this value was determined by trial and error based on the data of a selected reference size. Values of "Z" for the other size ranges were then computed in proportion to the 0.7 power of the fall velocities of the geometric mean particle sizes.

Subsequent Bureau of Reclamation studies disclosed that determining the "Z" value in the above fashion was not always representative. There were pronounced deviations in the computed values when the 0.7 power of the fall velocities was applied. It was concluded this exponent uniquely described the conditions of the Niobrara River near Cody, Nebraska, where the research studies were conducted.

This paper discusses the change in the procedure to determine "Z" values adopted and applied to Bureau of Reclamation sedimentation studies.

DEVELOPMENT OF NEW "Z" PROCEDURE

The Modified Einstein Procedure prescribed a method to compute the "Z" values based upon the selection of a reference size and in proportion to the 0.7 power of the fall velocities of the geometric mean particle sizes. The reference size is defined as the size range having appreciable quantities of bedload discharge and suspended sediment load discharge in the sampled zone.

In practical applications of the procedure, Sheppard (1961) pointed out some of the difficulties that were experienced in selecting the reference size when there was relatively equal overlap in two different size ranges. For example, the data might show that the percentage in the 0.125-0.250 mm range was 30 percent in the bed material sample and

50 percent in the suspended sediment sample as compared to the 0.250-0.500-mm range which showed 40 percent in the bed and 30 percent in the suspended. Computing the total sediment load based on either reference size showed there could be as much as 20 percent difference in the answer.

Further studies and analyses made of the collected data showed that the "Z" values could be computed for those size ranges having significant percentage quantities in both the suspended and bed material sediments. The procedure to compute these values was by trial and error, as described in the original Modified Einstein Procedure. A log log plot was made of the relationship "Z" as a function of the fall velocity, V_s. Values of the fall velocity were determined for each of the geometric mean particle sizes as was done in the original procedure. The equation for this relationship is $Z = aV_s^b$. When at least three points are plotted, the line of best fit for the equation can be computed by the method of least squares. From the plotting, the "Z" values can be determined for the other size ranges having a percentage of material only in the suspended sample or only in the bed sample. Figure 1 shows a plotting of how the computed "Z" versus V_s relationship varied for three different rivers. The 0.7 power of the fall velocities ratio is also plotted to compare the deviations. Data for the three river stations are given in Table 1. Upon determining this relationship for a given set of data, the computations of total sediment load are continued in the same manner as prescribed in the original Modified Einstein Procedure.

RECOMMENDATIONS

The procedure described in this paper to determine the "Z" value is recommended for use in computing the total sediment load by the Modified Einstein Procedure.

Literature Cited

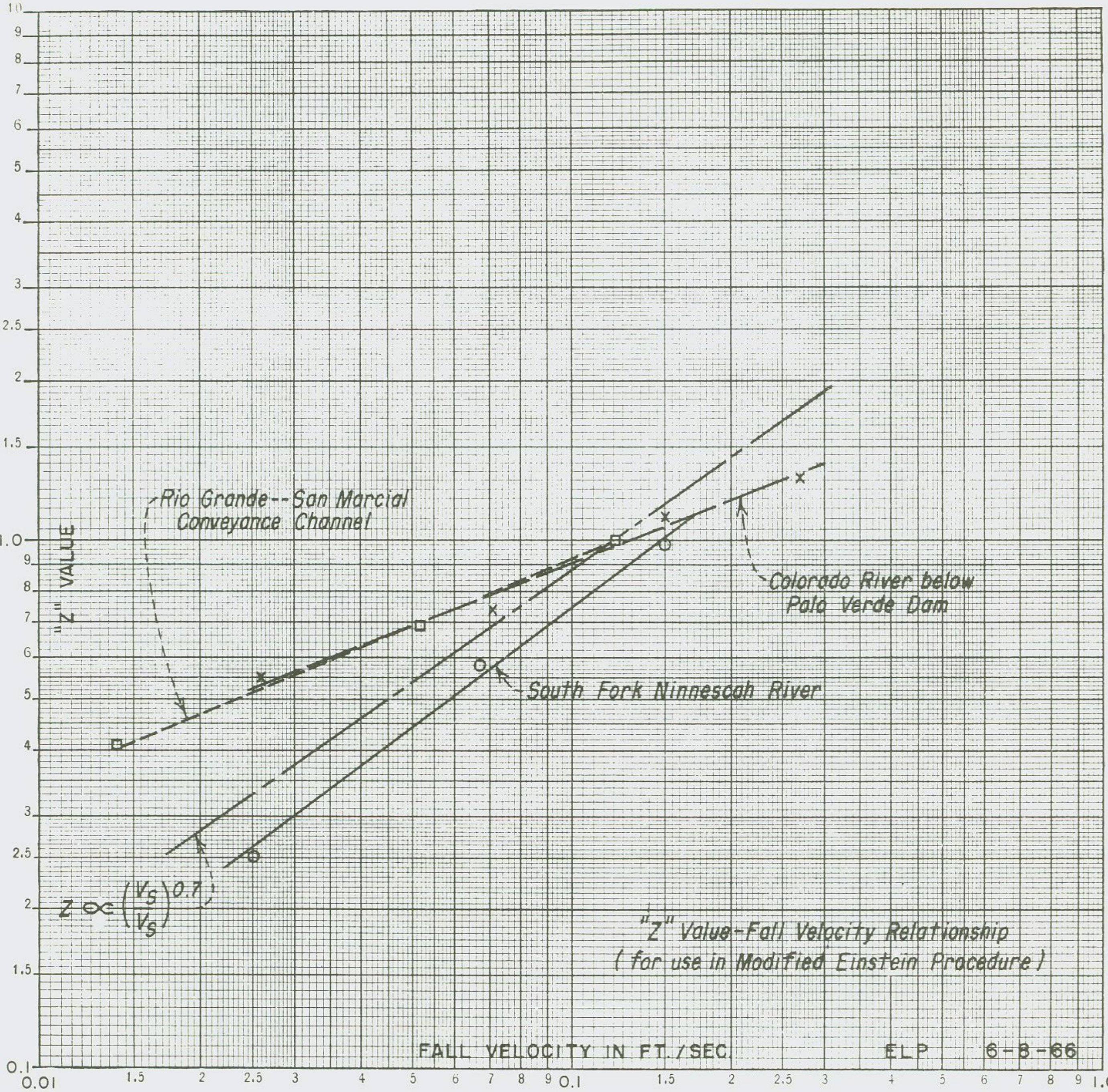
Colby, B. R. and Hembree, C. H., 1955, Computations of Total Sediment Discharge, Niobrara River near Cody, Nebraska: U.S. Geological Survey Water-Supply Paper 1357, 187 p.

Sheppard, J. R., 1961, Total Sediment Transport in the Lower Colorado River: Journal of the Hydr. Div., Proc. of the Am. Soc. of Civ. Engrs., v. 87, HY-6, pt. 1, p. 139-153

Table 1.--Stream Discharge and Sediment Data to Determine the "Z" Value

Stream	Date of measurement	Discharge in cfs	Size range in millimeters											
			0.0625-0.125			0.125-0.250			0.250-0.500			0.500-1.000		
				Z			Z			Z			Z	
			V_s[1/]	Comp.	Fitted	V_s	Comp.	Fitted	V_s	Comp.	Fitted	V_s	Comp.	Fitted
South Fork Ninnescah River near Murdock, Kansas	9- 2-63	6,480	0.025	0.25	0.26	0.067	0.58	0.55	0.15	0.98	1.00	–	–	–
Colorado River below Palo Verde Dam	8-24-65	12,370	0.026	0.55	0.53	0.071	0.74	0.79	0.15	1.11	1.05	0.27	1.31	1.33
Rio Grande--San Marcial Conveyance Channel, Sec. D	12-21-65	1,860	0.014	0.41	0.40	0.052	0.69	0.69	0.122	1.00	0.99	–	–	–

1/Fall velocity in feet per second



Rio Grande--San Marcial Conveyance Channel
Colorado River below Palo Verde Dam
South Fork Ninnescah River
$Z \propto \left(\frac{V_S}{V_S}\right)^{0.7}$
"Z" Value-Fall Velocity Relationship
(for use in Modified Einstein Procedure)
"Z" VALUE
FALL VELOCITY IN FT./SEC.
ELP 6-8-66

FIGURE 1