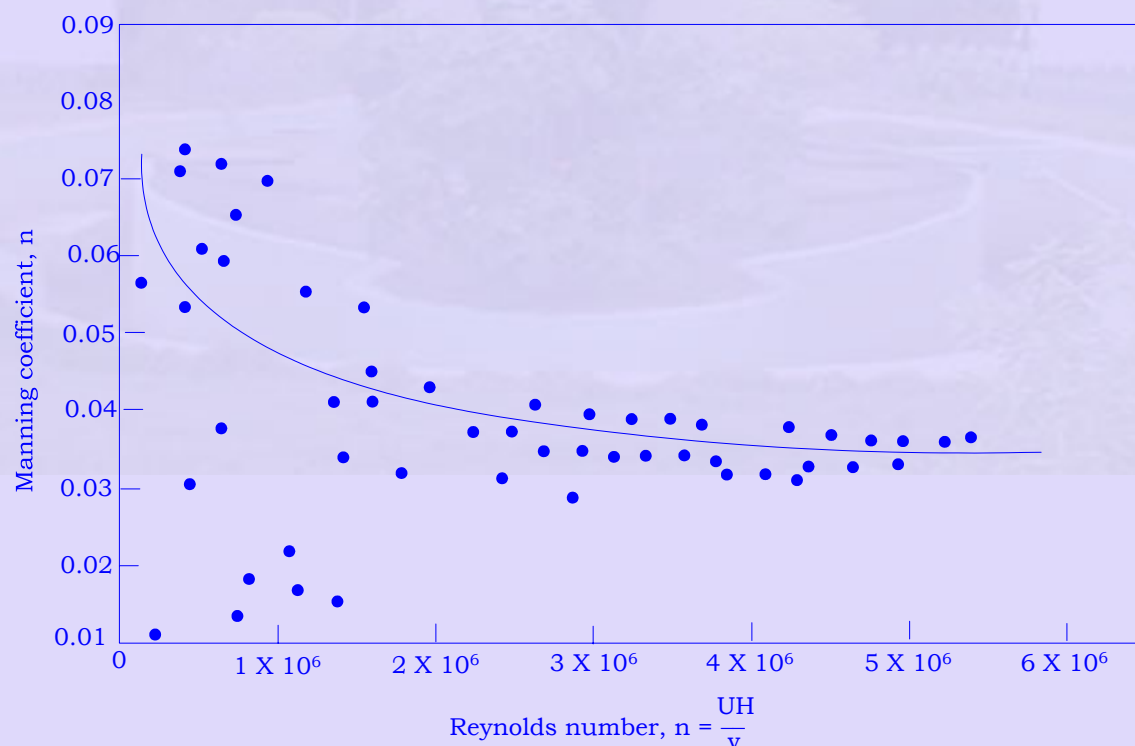
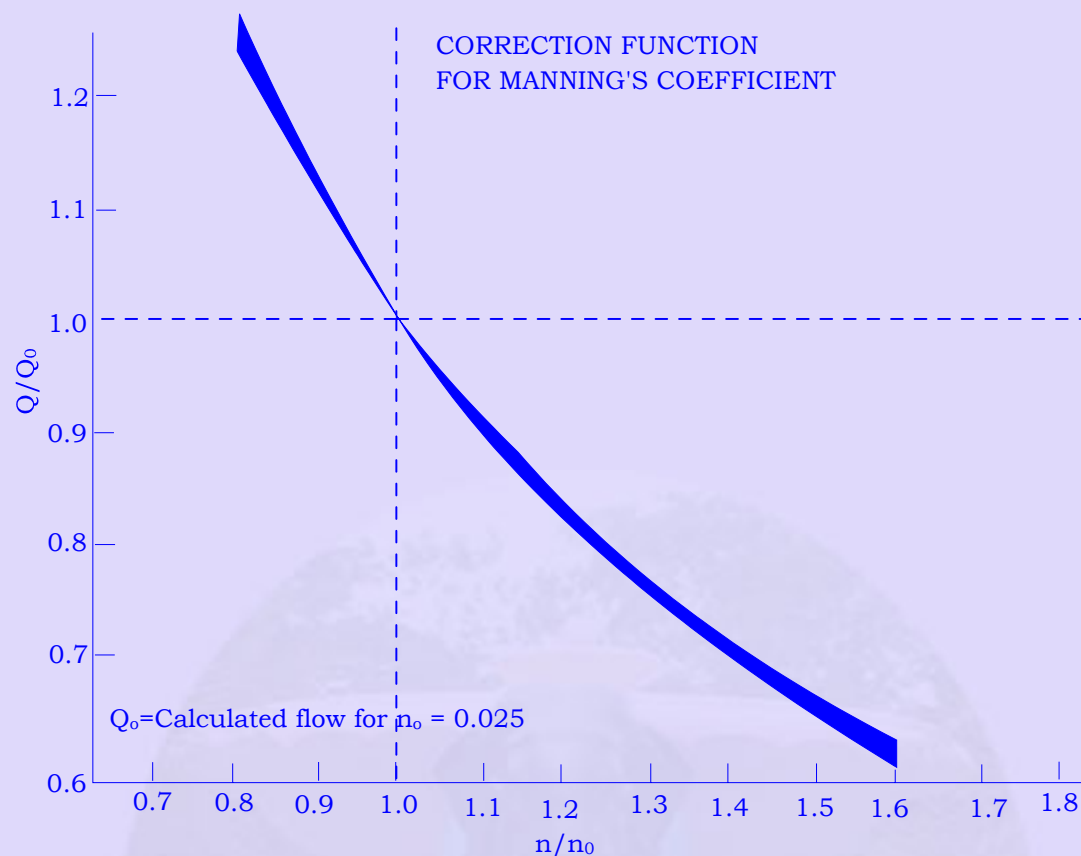


## 17.1 Friction

The Chezy and Manning equations have a long history in hydraulics. These empirical relationships are being used for more than two centuries since their development. Chezy equation was proposed by Antoine Chezy about 1769. Similarly, Gauckler in 1868 proposed the Manning formula. These equations do not account for turbulent processes. Both these equations require estimation of a resistance coefficient. The assumptions made while deriving the equations are steady uniform flow. However, these equations are being used in non-uniform as well for unsteady flows. Only a few attempts have made to investigate the validity of these assumptions for non-uniform flow. However, it is believed that these equations work for these cases also. The primary difficulty in predicting the frictional resistance still lies in estimating the resistance coefficient for a natural situation. Figure shows a variation of Manning  $n$  obtained by Baltzer and Lai for a natural channel. The large scatter at low Reynolds numbers is to be expected since the accuracy requirements on data become extremely high under this condition.



Manning  $n$  vs. Reynolds number for three-mile Slough near Rio Vista, California. (After Baltzer and Lai)



### Variation of flow rate with $n$ for the Detroit River

Reference Mahmood. K and Yevjevich. V (Ed) Unsteady flow in Open Channels,  
Volume - I Water Resources publications, Fort Collins, Colorado 1975,  
Page No. 47

One may note that, the relative error in the resistance coefficient leads to a relative error in velocity or flow of the same magnitude. The above figure shows the effect of over-estimating the value of  $n$  leading to under-estimating the flow rate and vice versa. This figure is based on computations made for the Detroit River. The width of the line indicates the variation of  $n$  with the normalizing flow  $Q_0$ . Situations such as a portion of the flow occupying a flood plain also complicate the assessment of frictional resistance. In general, the estimation of frictional resistance in natural channels is yet to be resolved.