THE MATTHES ROLLING DIAMETER AS AN INDICATOR OF CHANNEL STABILITY

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INTRODUCTION

Gerard H. Matthes (1956) adapted the du Boys formula and showed that, in mature rivers, the rolling diameter of the largest stone on the deepest part of the bed, together with the bank-full depth, will give an indication of the river slope. "Rolling diameter" he defined as that diameter on which a stone rolls as if it were a barrel. These observations are easily made, and a high degree of accuracy is not necessary.

The author has applied the method to a number of New Zealand rivers, at the same time observing the slope. Most of the first observations made showed reasonable agreement with the Matthes diagram (Fig. 1) and encouraged further study, but there followed many which were misfits. Finally a pattern developed. Observations made on stable reaches, particularly after a flood, gave a good fit — almost invariably in the torrent part of the diagram. When the reach was unstable, or the bed was masked by smaller travelling shingle, there was no fit.

The method therefore provides a useful guide to the state of equilibrium of the reach. If there is no fit, then the bed is masked by sediments usually smaller than those required or the formation of a stable bed.

OBSERVATIONS

Some typical observations are plotted in Fig. 1. In the following comments the nomenclature used is:

d = rolling diameter,
D = water depth at bank-full stage.
S = water slope at bank-full stage.

1. 632000 Kowhai River, d 30 in., D 5 ft, S 128 ft/mile; observed after a major flood. For equilibrium d should be 24 in. The head-waters of this river are severely eroded, and during major floods an

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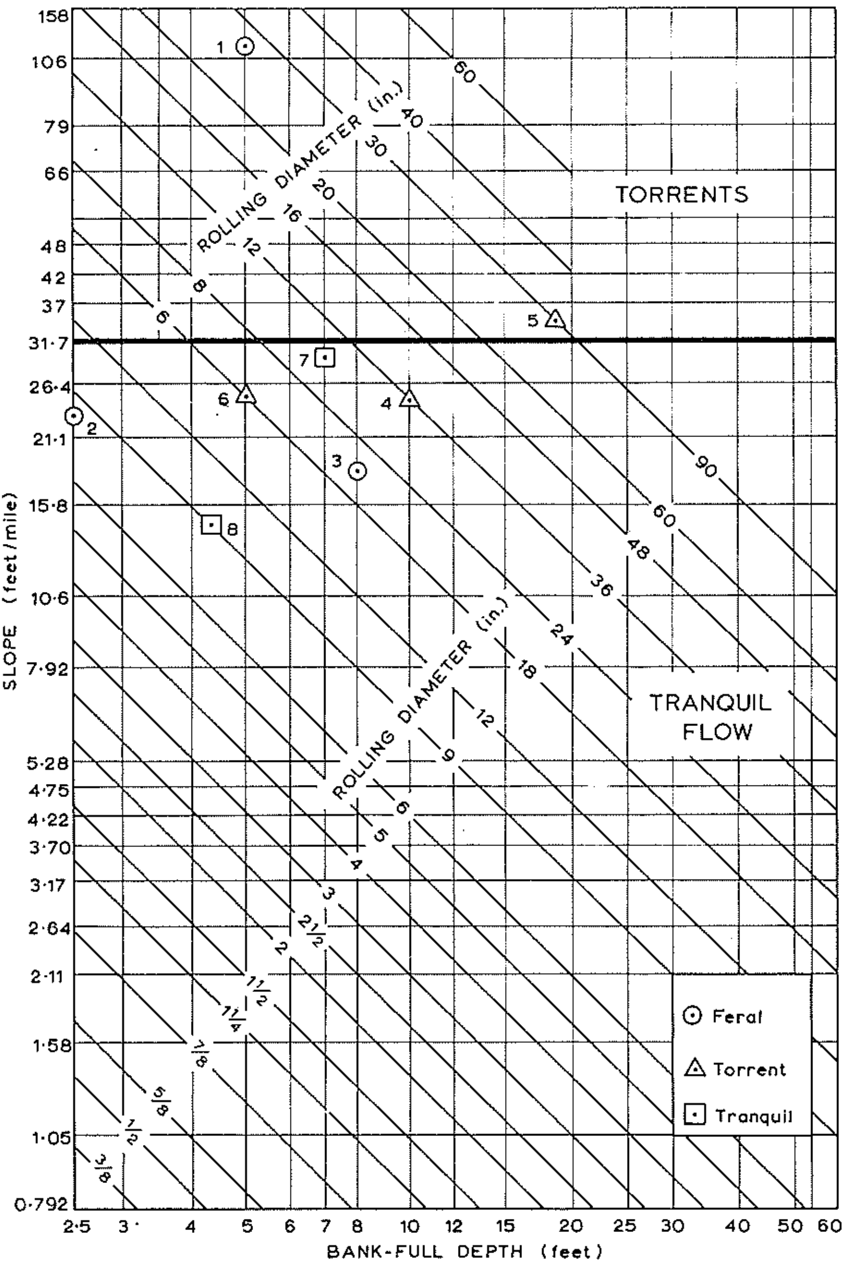

Fig. 1 — Tractive-force diagram for estimating slope in terms of bank-full depth and rolling diameter of largest stone. (Vertical scale has been converted from metric units.)

enormous quantity of unsorted debris is brought down. At a slope of 128 ft/mile the competence of the river during floods is insufficient to transport the sediments arriving from the mountain phase. Smaller floods, being less charged with headwater debris, do an appreciable amount of beneficial sorting. When a stable bed seems about to be achieved, however, the whole process begins again with another lahar type of flood depositing a three- to six-foot depth of debris over the developing bed. To such a channel condition as this Cotton has given the name "feral".

2. 789600 Hamilton Burn, d 6 in., D 2.5 ft, S 25 ft/mile; another feral observation, but this time falling into the tranquil zone. For equilibrium, stone size would be eight inches; obviously the bed is masked.

3. 786000 Oreti River, d 8 in., D 8 ft, S 20 ft/mile; the bed is slightly masked but, in common with other Southland observations (2,8), one would expect this to fall into the tranquil zone rather than where it does, in the torrent zone. Half a century ago tailings from gold mining overloaded this river and it has not yet recovered No comprehensive training has so far been undertaken, but when this is done the Oreti could be expected to trend towards the tranquil type.

4. 292240 Waiohine River, d 12 in., D 10 ft, S 26 ft/mile; observed after a major flood in a then partially trained river. The bed was not masked but was cleaned out to a regime condition, indicating a reasonable state of balance between channel condition, flood discharge and sediment transport.

5. 621000 Clarence River, d 30 in., D 19 ft, S 35 ft/mile; this was observed after a major flood which had rolled a 27-ton block of concrete some 30 chains down stream and had scoured the bed to a depth of eight feet, exposing a layer of large imbricated stones.

6. 695000 Orari River, d 6 in., D 5 ft, S 25 ft/mile; this reach had been trained to a stable single-threaded channel for about five years.

7. 701000 Pareora River, d 30 in., D 7 ft, S 30 ft/mile; a beautifully stable reach with sloping banks established at the correct width by old trees, in an otherwise feral greywacke river of the torrent type. It was a surprise to find that it fitted in the tranquil zone, although there is a similar length in the Tauanui (292050). Above and below this reach both the Pareora and the Tauanui are sub-region, with channels that change with each flood. All of the travelling shingle passes directly through the stable reach.

8. 789000 Aparima River, d 9 in., D 4.5 ft, S 13 ft/mile; the site was near the down-stream limit of the single phase. No training has been done but the river is reasonably stable. It falls into the

tranquil zone, an indication that the Southland landscape (as would be expected from the age of its rocks and its tectonic history) is reasonably mature, at least at the lower altitudes.

CONCLUSIONS

Feral rivers can be recognized at a glance, and rolling diameters are hardly worth observing as they will not fit the diagram (observations 1 and 2). As stability is approached, however, observations of the three criteria — d, D and S — and the resultant plot can help to focus attention on matters that might not otherwise be obvious. The plots are particularly helpful when tractive-force investigations are being undertaken. When the fit is poor it is difficult to define the size of stone that will indicate channel stability; probably the best that can be done is to assume that, with training, the existing materials will be sorted and the bed degraded. The commonest large size of stone should be taken, provided that there are enough of them in the mass. If the fit is very bad, even this may not be possible. When the fit is good, however, it will be found that the bed is usually paved with a dominant-sized stone and calculations of tractive force can then be made with some confidence.

ACKNOWLEDGMENT

Fig. 1 is reproduced by courtesy of the American Society of Civil Engineers.

REFERENCE

Matthes, G. H. 1956: River surveys in unmapped territory. *Trans. Am. Soc. Civil Engineers 121*: 739–758.