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REPORT ON PROBABLE EFFECT OF INCREASING THE NATURAL DISCHARGE OF THE MILK RIVER IN ALBERTA

Summary

There can be no doubt that additions to the supply of a meandering river increase the meandering tendency, so result in bank erosion that would not occur otherwise. The releases from the St. Mary's River into the North Fork of the Milk River must have caused noticeably increased erosion of the banks of that Fork; some increased erosion must have resulted along the banks of the combined river also, but would be difficult to identify or prove.

There are several practical methods of attempting to establish that erosion must have occurred, or of estimating its probable amount.

1. Introduction

This report is preliminary and aims at clearing the ground for a formal investigation, if desired. It concerns the effect on river regime of releasing up to 600 cusecs of extra supply, over several years, into the North Fork of the Milk River.

The writer inspected records of flow with Mr. George Underhill in the Water Resources, Alberta, office on 20th October 1954, and was shown sites near Milk River Town on 22nd October by Mr. Frank Young. This site inspection was followed, on the same day, by a drive from the town to Del Bonita and then North to MacGrath, so that the South Fork of the Milk River was crossed and followed for several miles, and the North Fork was crossed.

2. Effect of Discharge on Meandering

Because of the variety of inexpert personal opinions that exist on river behaviour, this section outlines what has been established authoritatively and can be verified from publications. In the writer's opinion, expert knowledge may be condensed to the following:

" i. By comparing different rivers with each other, it has been found that channel width, meander length, and meander belt width increase in proportion to each other when a representative channel discharge is increased and all other factors remain unaltered.

ii. Channel width, meander belt width, and meander length vary as the square root of representative discharge -- all other factors remaining constant.

iii. The best representative discharge is not yet known."

Perhaps the best proof of item i. is that a river model is always made bigger according as the discharge used for it is bigger, and it is universal practice to give the meander dimensions the same scale as channel width; a river model is just a small river, when it is working properly. However, the subject has been treated from the viewpoint of river observations by Sir Claude Inglis (Ref. 1). In Chap. 4 of his book he plots meander belt width against channel width for streams in flood plains (Fig. 4-1) and for incised streams (Fig. 4-2) separately. He acknowledges the source of the data as a paper (Ref. 2) by Professor Mark Jefferson of the State Normal College, Ypsilanti, Michigan. The plots show that meander belt width is proportional to channel width, with some secondary laws superposed. Increase of meander dimensions with discharge has been observed on models by Friedkin (Ref. 5), who states, inter alia, on his page 8:

"These studies showed that for the same bank material and the same initiating angle of attack the size of bends becomes greater with increase in discharge and slope. The following tests show that an increase in discharge results in increasing the size of bends...."

Item ii. owes its origin to Sir Claude Inglis, vide Fig. 4-3 of his Ref. 3. However, it follows directly from regime theory (Ref. 4), and is used by those who use that theory for designing model scales. The part of it dealing with channel width has been demonstrated recently, from U.S. rivers, by Leopold (Ref. 5).

Item iii. is necessarily complex, and the definition of "representative discharge" probably needs to be framed to suit the problem in hand. Some aspects of the subject are discussed in Ref. 4. Leopold's Ref. 5 shows that arithmetic mean discharge is an excellent representative one for linking average behaviour with the theory of steady behaviour.

3. Opinion on effect of releases on North Fork

Figures inspected by the writer suggest that this channel has had its long-term mean discharge increased several times, and its peak flood (2,170 cusecs at International Boundary?) increased about 30%. Inspection of the road-crossing vicinity shows that the 600 cusecs of release water alone would be actively erosive. Even were peak flood the sole criterion -- which it is not -- the meander belt width and, with it, the width between earth cliffs bounding the narrow valley in which meandering occurs would increase some 15%.

If the river valley has been formed by a river not larger than one of the present size, then the writer would expect it to erode to not less than 50% wider on an average as a consequence of the releases. Further, he believes that very noticeable erosion must have occurred to date, but has not caused complaint because land along the river is of little value.

4. Opinion on effect of releases on combined river

Figures inspected by the writer suggests that this channel (near Milk River Town) has had its mean discharge approximately doubled, but its peak discharge (7,460 cusecs in 1927?) enhanced only some 8%. The "concertina" meandering of the stream is consistent with the heterogeneous bank material found at site.

The writer's opinion is that the 600 cusec releases are likely to have more erosive effect than might be imagined from their ratio to peak flood, because they cause sub-meandering that can attack pockets of silty soil that would escape the effect of large floods. The Dobrocaine Ranch (Appx. 1) is a case in point. The ultimate enhancement of meander-belt width might be only 10 to 20%, and could take a century or two to occur. As some erosion has to occur anyway the difficulty of deciding what to attribute to releases is very great; to show that releases have had an effect may not be so difficult (see Sec. 5 below).

5. Methods of demonstrating existence and probable scope of erosion

The following conventional methods of investigation merit attention:

i. Specific gauge analysis. The river at Milk River town may have dropped progressively as a consequence of enhanced discharge. If it has, then enhanced undermining of cliffs must have occurred.

To test for a degradation of the river we need all the rating tables that have been made for the Milk River town discharge site. The curves on which they were based, along with the actual plotted data from which the curves were produced, should be presented; the gauges should be reduced to the ONE DATUM. Dominion Water Resources Division should do this work because only they know the true history of gauges and discharges. From what they present we can discover how gauges at various discharge levels have varied with time; any change of regime will then become apparent, and deductions can be made after Dominion Water Resources Division has certified that apparent changes of regime are not changes of discharge method, gauge zero, etc.

ii. Air photos. The amount of history, untraceable from the ground, that air photos can show is remarkable. In the present case we are looking for the obliteration of history, which may not be so easy to see. However, the writer feels optimistic about the possibilities of an air survey, particularly of North Fork. Stereo strips are required.

iii. Site inquiry. If there are landowners along North Fork an inquiry from them seems certain to produce evidence of severe erosion. The original owners of the farm at the crossing with the Del Bonita-MacGrath road seem to have had buildings endangered, and may have suffered financially.

The Provincial P.W.D.'s Road and Bridge branches may have information. The road crossing at the farm has had a new bridge recently, built away from the old site, perhaps in the hope of protecting the farm by diverting the river.

iv. A model. A model would have the advantage of demonstrating the kind of effect to expect from changing the water distribution in a river without changing its peak discharge -- a problem that cannot be solved from existing formulas because the exact effect of discharge distribution on "representative discharge" (Sec. 2, iii.) is not known. Of course it would show, very definitely, the effect of raising peak discharge as well as mean.

Such a model would have to be built out-of-doors, to contain sufficient meanders to represent a river reach. It would not be a copy of the prototype, for it could not reproduce the erodibility of the prototype's banks -- automatic reproduction of specified bank erodibility -- has never been achieved by any model. Most easily it could reproduce, with sand banks, a river having a hydrograph comparable with that of the Milk River in the absence of the 600 cusec releases, and show the meander pattern that would develop. The fact could be established that, when the model was "rubbed-out" and then re-run, it would produce the same degree of meandering again. Then the effect of changing the hydrograph to represent the sequence of 600 cusec releases imposed on the original hydrograph could be demonstrated. After that the whole sequence could be rerun with heterogeneous bank material that would cause the concertina type of meander pattern found at site.

If such a model were made at the University of Alberta, and if time were given to design and obtain the simple equipment during winter, results should be obtainable in one summer season. The limiting factor on time of running is that a model has a definite time scale fixed by dynamical laws. An engineer with model-making experience would have to be in charge, and would need a technician for routine running. The whole job would probably cost $20,000.00 including materials. Perhaps pump and tanks could be borrowed from Government sources and reduce the cost.

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