

Stability of River-delta Bifurcations: An Integrated Field and Numerical Modeling Study

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INTRODUCTION

The creation and evolution of multi-channel fluvial networks in alluvial fans, braided streams, and deltas (Fig. 1) arises through channel bifurcation wherein a single channel splits into two bifurcate channels. Bifurcate channels are typically unequal in width and depth

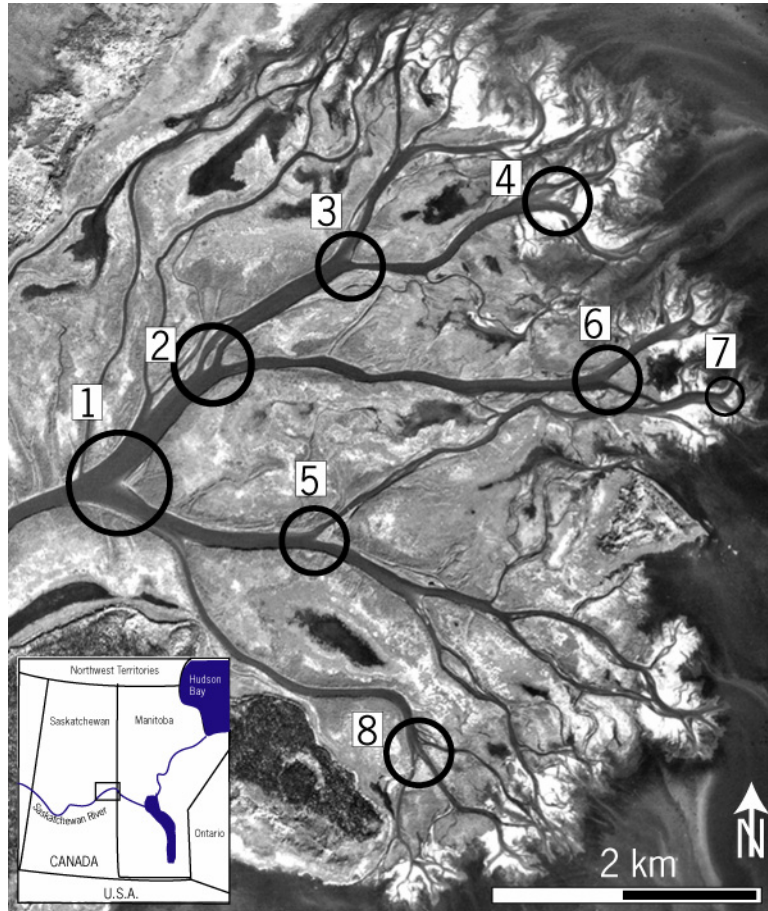


Figure 1: 1982 aerial photograph of Mossy delta showing the eight bifurcation studied in the field campaign.

(Edmonds & Slingerland, 2007) and are either stable (both channels receive water) or unstable (one channel receives water). Given flood hazards of unstable bifurcations, it is surprising we do not know why bifurcations are stable, or their response to perturbations. I hypothesize that bifurcations maintain stability by damping perturbations through local (within the bifurcation) feedbacks. Locally, an increase in discharge (Q) will scour the deeper bifurcate and create a step between bifurcate channels. This step redirects bedload to the scouring channel to stop the erosion. The alternative hypothesis is bifurcations maintain stability through global (within the delta) feedbacks. Globally, increasing Q increases the backwater effect that extends upstream from the delta front. The result will be a shallower water slope at the bifurcation that stops the scouring.

FIELD DATA COLLECTION AND RESULTS

To understand what local feedbacks are present in natural bifurcations I collected data on Mossy Delta in Saskatchewan, Canada (Fig. 1). On the Mossy Delta, eight bifurcations were selected for monitoring that cover the range of natural bifurcation morphologies. Detailed bathymetric maps and water surface surveys indicate that there are certain sedimentologic and hydrodynamic characteristics that are common to most bifurcations in the Mossy Delta.

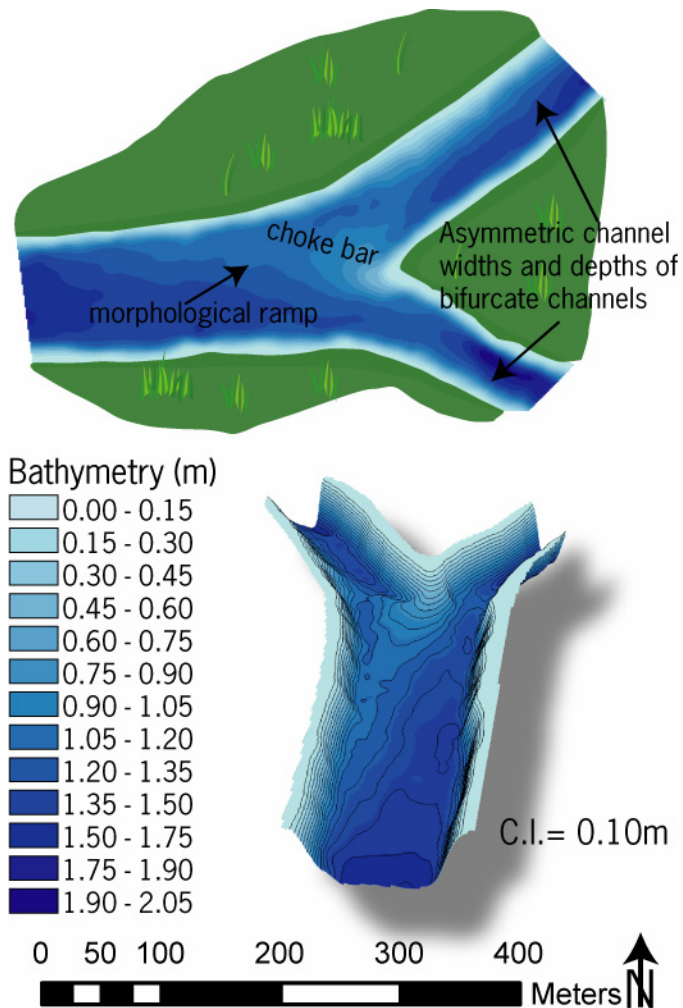


Figure 2. Sedimentologic elements of a bifurcation 3 from the Mossy Delta.

Doppler current profiler data were also collected at the bifurcations that were deep enough for the instrument. Those data show that flow vectors begin to bifurcate less than one channel width upstream of the bifurcation. This indicates that the influence of the bifurcation does not extend very far upstream.

FUTURE WORK

Future work includes conducting detailed numerical modeling. The modeling will have two functions. First, we hope to use numerical modeling to understand the field data collected during 2007. The modeling will help us understand the function of each element of the bifurcation (choke bar, morphological ramp, etc.) in maintain bifurcation stability. For example, is the choke bar a necessary condition for bifurcation stability? Secondly, the modeling will be used in a broader sense to define and understand how fine-grained cohesive sediment bifurcations maintain stability.

Sedimentologically, bifurcations possess a morphological ramp that modulates bedload delivery to bifurcate channels (Bolla Pittluga, et al. 2003), a choke bar in the throat of the shallower bifurcation, and a strong asymmetry in width and depth (Fig. 2). The exact role of the choke and the bifurcate channel asymmetry will be explored further with numerical modeling. Additionally, water surface data were collected with a digital global positioning system. In order to elucidate the microtopography of the water surface we used a floating survey technique. The GPS receiver was positioned in the boat and elevation data was continuously collected as the boat floated downstream through the delta network. Results show that in channel reaches upstream of the bifurcation point there is a relatively flat reach. Approaching the bifurcation the water surface slope steepens and reaches a maximum through the throat of the bifurcate channel. The role of the water surface topography variations in maintaining bifurcation stability is currently unknown, but preliminary modeling runs have reproduced the features observed in the field. Acoustic