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Comparative Study of Hydraulic River Models in Assessing Erosion Processes occuring over a series of Meanders along the Magdalena River, Colombia

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The Magdalena River located in Colombia is a large 1550 km long river basin draining the country over the mountains from South to North with an average width of 275m and an annual mean discharge of 7200 m3/s. La Dorada Township is located mid-way upstream along the west bank of the river. In this region the channel banks have been affected by severe erosion as a consequence of the flow dynamics across a series of meanders. The township has been affected over the years by serious flooding as the meander in this region is evolving at a steady pace endangering a great number of neighborhoods. This study strived to correctly model the flow characteristics of the river in order to evaluate various scenarios and mitigation measures related to erosion control and provide decision makers with a forecasting tool.
Two field campaigns were completed over the dry and rainy seasons including extensive topographical and channel survey using Topcon GR5 DGPS and Sontek River Surveyor ADCP. Also, in order to characterize the erosion process, extensive suspended and river bed samples were retrieved as well as soil perforation over the banks to evaluate maximum scour depth.
Using a digital elevation model of the channel and floodplain, the field data was incorporated in the HEC-RAS (1D), IBER (2DH) and FLOW (3D) Hydraulic River flow models assessing comparatively their ability and capabilities in characterizing dynamic flow processes and limitations in predicting scour occurring in the region. Model calibration was carried out comparing available historical data of a nearby hydrologic gauging station. Although the 3 models were able to effectively predict overall flow processes in the region, their spatial characteristics and limitations did not allow for an accurate representation of erosion processes occurring over the specific endangered bank areas and dwellings. Field data indicates that, as may be expected, a helical flow is occurring through the meander across the channel width. Results indicate that the HEC-RAS and FLOW models were generally in agreement and were able to correctly simulate historical events as they relate to waterline evolution and predicted maximum velocity. On the other hand the IBER model displayed significant discrepancies with the other 2 models generally underestimating maximum shear stress.
The study highlights how the validity of a hydraulic River Model in analyzing river sedimentation processes is highly dependent on its fundamental formulation and employed discretization methodology, and may provide flawed or inconsistent results if the underlying sedimentation mechanism is not well understood.