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Developing an Integrated Water Management Model of the System of Hydropower Generating Stations Operated by Manitoba Hydro

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In Manitoba, most of the rivers traverse mid- to high-latitude regions that are vulnerable to climate change and therefore understanding and mitigating risks associated with uncertain future climate conditions, especially extreme flood and drought events, has become important for water resources decision makers. Decision makers must therefore be able to get a comprehensive and rapid understanding of the system operations and water balances at different levels in the river basins, which can be achieved by developing water management models. There are limitations associated with the current water management models in Manitoba's river-reservoir system in the representation of the complex interconnections and addressing the associated uncertainties with the data availability. In these models, different adjustments need to be made including numerical approximations, segmentation, aggregation, linearization, and other interpolations, for modeling non-linear interactions by linear functions, which enhance the system's errors and reduce the model accuracy. Considering the complex interconnections and relationships in the system are necessary for understanding and improving the system performance. It is also crucial for predicting the performance or behavior of the proposed system designs or mitigation approaches confidently and addressing the associated uncertainties. For this reason, this study seeks to develop an integrated water management model for the system of control points in one of the important river basins in the area, the Nelson-Churchill Rivers basin, operated by Manitoba Hydro. The MODSIM-DSS water management modeling tool is used for developing the model with the ability to define non-linear relationships for representing the complex interconnections in the system by using the custom code editor. As an example, operating reservoirs in the model are considered as a function of different factors such as forebay elevation, tailwater elevation, hydropower and water demands, ice formation, and back water effects instead of operating them solely based on water level and discharge relationships. The performance of the model is evaluated by summarizing the discrepancy between simulated data and observed data. For the model calibration and validation, both wet and dry periods are considered to evaluate the model performance confidently. Performance evaluation coefficients show an acceptable alignment between the simulation results and historical trends. The developed model allows the simulation and analysis of various water allocation, water demand, and climate change scenarios, adjusting the historical rule curves, and evaluating the performance of the system under different management and mitigation options. It can also be used to promote the understanding of key concerns and issues among the managers and decision makers.