THE DEVELOPMENT OF A HYDROLOGIC MODEL FOR WATER LEVEL FORECASTING IN THE PHILIPPINES' DEEPEST LAKE

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BACKGROUND

Lake Mainit is considered to be the Philippine's deepest lake with a maximum depth reaching about 223 m (Lewis, 1973). It is geographically located between the Provinces of Surigao del Norte and Agusan del Norte, in the Island of Mindanao. With a surface area of 149.86 km^2, it ranks fourth to Laguna Lake as one of the Philippine's largest lakes (Tumanda et al., 2003). The lake receives inflows from several major and minor tributaries located in the municipalities of Mainit and Alegria (Surigao del Norte) and Kitcharao and Jabonga (Agusan del Norte). During heavy rainfall events, inflows from these tributaries increase the lake's water level and causes flooding of barangays located near the shore. This scenario is exemplified recently during the January 2014 Typhoon *Agaton.* In this paper, we present the development of a hydrologic model of Lake Mainit in order to gain a better understanding of how the various tributaries contribute to the lake's water level during rainfall events. With the development of this model, the water level in the lake can be simulated or forecasted given the amount of rainfall measured by existing rainfall stations located in the lake's vicinity.

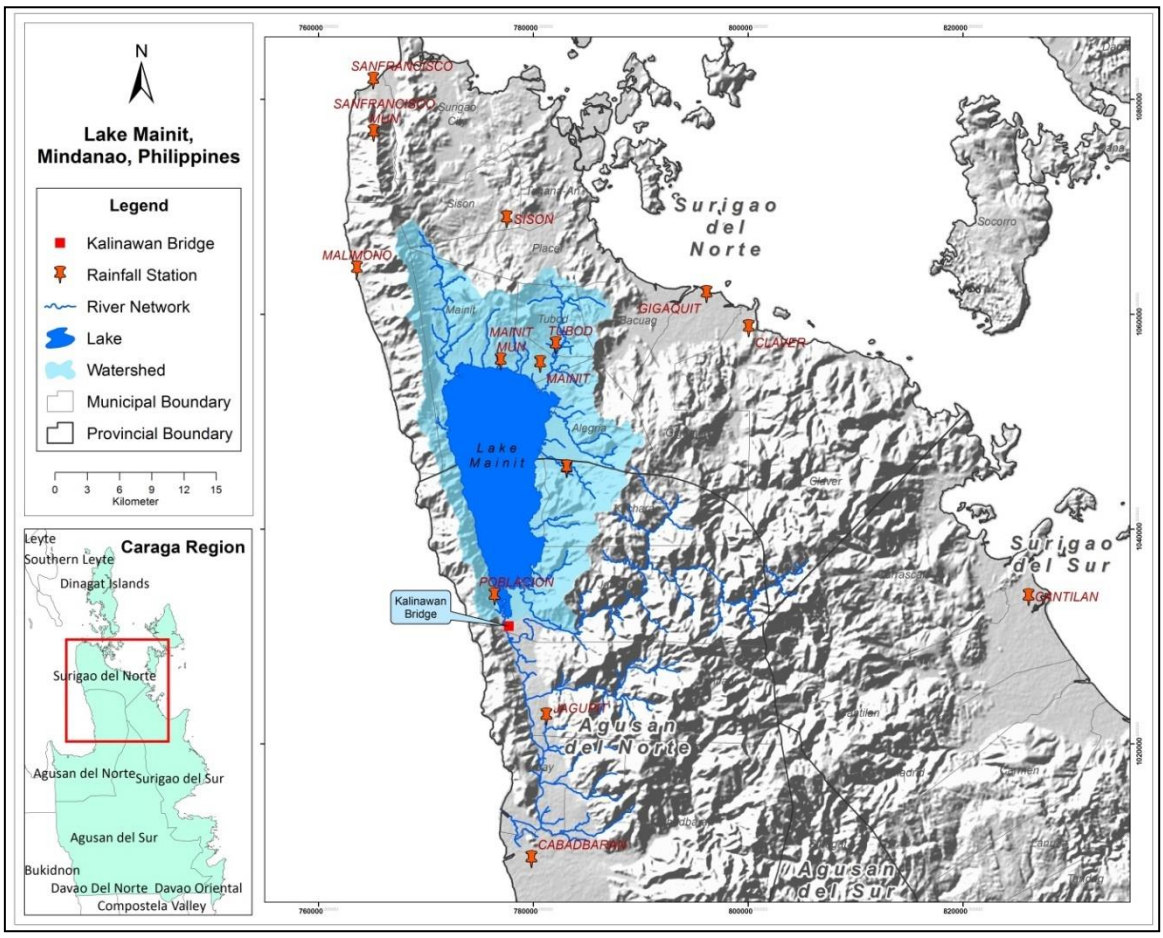

Figure 1.Map of Lake Mainit, Mindanao, Philippines.

MATERIALS AND METHODS

Model Development

We combined various geomatics technologies (remote sensing, GIS, and numerical modeling) in developing the hydrologic model of Lake Mainit. A 10-m Synthetic Aperture Radar – Digital Elevation Model (SAR-DEM),andrivers and stream networks digitized from high resolution satellite images were utilized and processed in HEC-GeoHMS to delineate the sub-basin boundaries and the reach elements of the model. The land cover parameters derived from the analysis of year 2014 Landsat 8 OLI images, and the river roughness characteristics derived from high resolution satellite image interpretation,were integrated and imported to HEC HMS for the setup of the model. As a result of the delineation, the hydrologic model geometry consisted of 120 sub-basins (or watersheds) draining into the lake. The lake itself was represented as a reservoir in the model. Other elements present in the hydrologic model are 110 reaches, 120 junctions and 1 diversion.

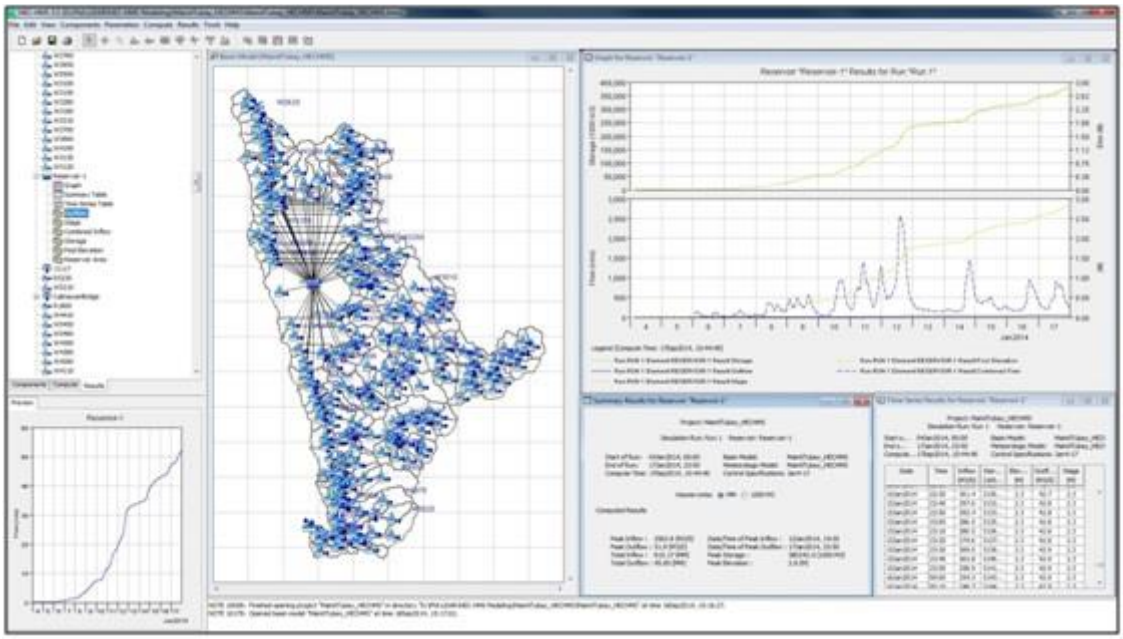

Figure 2. Interface of the HEC HMS model of Lake Mainit.

Reservoir Parameterization

The reservoir element of the HEC HMS model (Lake Mainit) uses the Outflow Curve Routing method which represents the lake with a user-provided relationship between storage and discharge. The Elevation-Area-Discharge method was implemented which utilizedElevation-Discharge (Figure 3) and Elevation-Area (Figure 4) functions as inputs. The elevation and discharge relationshipof Lake Mainit was derived using the data from the *"Master Plan and Feasibility Study of Flood Control and Drainage Projects of Selected River Basins Nationwide"* (DPWH, 2011), while the elevation and area relationshipwas obtained from the research study on the *"Limnological and Water Quality Assessment of Lake Mainit"* (Tumanda et al., 2003).

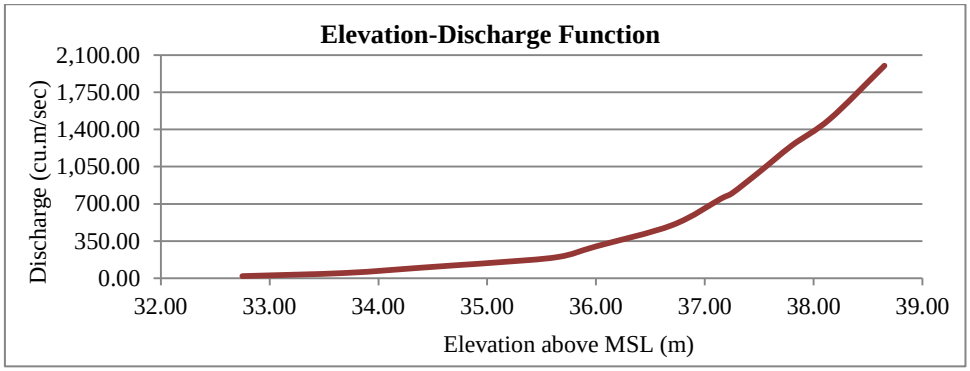

Figure 3. Graph of Elevation-Discharge function of Lake-Mainit.

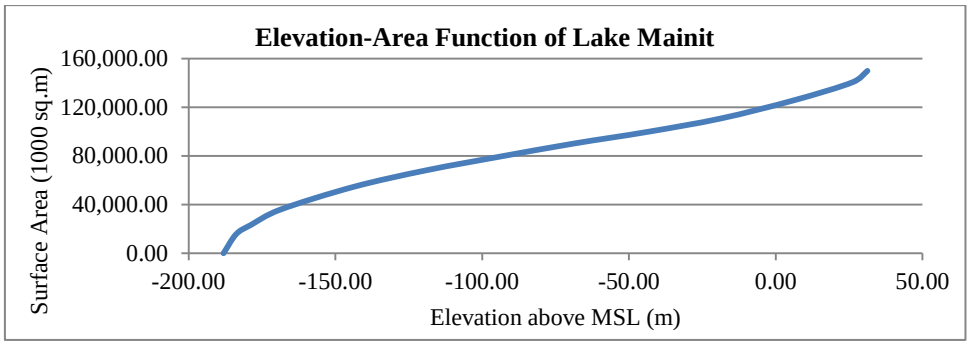

Figure 4. Graph of Elevation-Area function of Lake-Mainit.

Final Model Setup and Simulation

The meteorological model, time-series data of rainfall, and control specification indicating the simulation period were created in HEC HMS.The meteorological model, using the inverse distance method, utilizes the rainfall data recorded by fifteen (15) rainfall stations installed by ASTI DOST. These data were downloaded from the Predict server (http://repo.pscigrid.gov.ph/predict). The selected period for control specification is from January 4-17, 2014 (Typhoon *Agaton* event) in which notable rainfall values were recorded. During the simulation, HEC HMS utilizes the Elevation-Discharge Function to convert the simulated time series of total discharge flowing into the lake into a time series of water surface elevation or stage.

RESULTS

Shown in Figure 5 is the HEC HMS model simulated lake water levels for the Typhoon *Agaton* event. It can be observed that the hydrologic model was able to simulate the actual lake water level. The computed Nash-Sutcliffe Coefficient of Model Efficiency (E) was computed at 0.97 which indicates acceptable model simulated results. Despite of this good model performance, the calibration and validations of the model still needs to be done so that it can confidently utilized as a water level forecasting model during rainfall events. The forecasts provided by the calibrated and validated model can be useful as basis for early warning of communities around the lake. At present, hydrological data needed for calibration and validation of the model is still being gathered. The automation of the model input, simulation, and output generation is also being done as part of the development of a water level forecasting and flood inundation monitoring system for Lake Mainit. This system will not only provide water level forecasts but also flood inundation maps that can be used as basis in the determination adjacent areas to the lake that can be flooded when a certain rainfall event occurs.

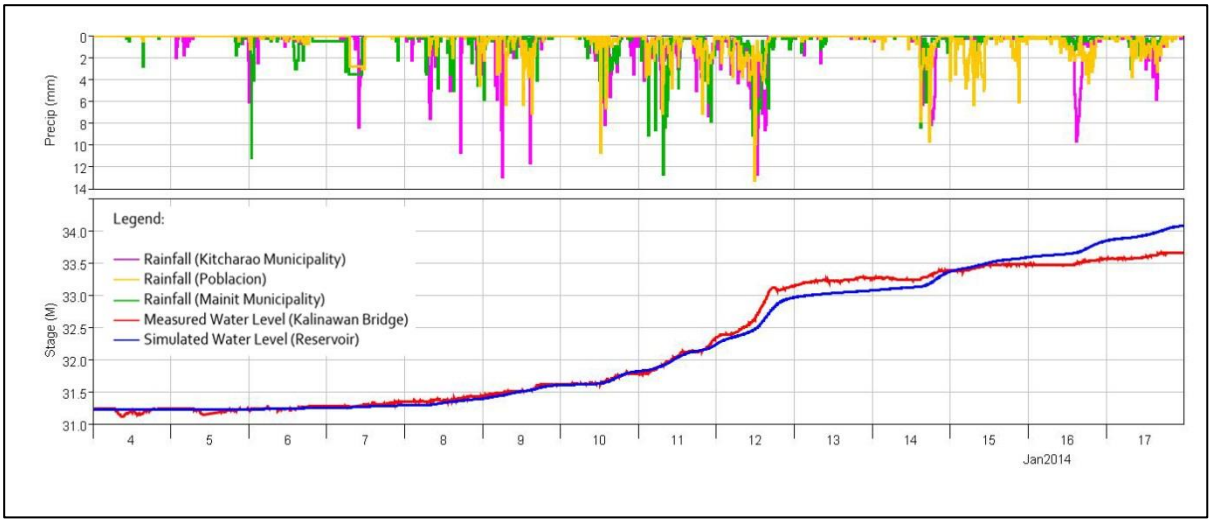

Figure 5. Comparison between the stage readings at Kalinawan water level station and the simulated stage readings at the reservoir given the rainfall data from three stations (Kitcharao Municipality, Poblacion and Mainit Municipality).

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