The overall procedure of output updating of the physically-based model, as illustrated in Figure 1, is presented next. First, the physically-based model is run by using input variables to compute the flow values. Next, the neural network model, ANN1, is applied by using available hydrometeorological observation data to improve the output flow of the physically-based model for the selected gauged streamflow sites in a watershed. The improved flows of the gauged sites as well as the hydrometeorological data are then used by the second neural network model, ANN2, to update the computed flow values of the physically-based model for the corresponding ungauged sites. The steps in the proposed methodology based on the computational engine of the HEC-HMS (USACE, 2000) are summarised as follows:

1. Determine the computed streamflow at the gauged site of the HEC-HMS model, $Q_{gHMS}(t)$.

2. Estimate the improved streamflow(s) at the gauged site(s), $iQ_{gHMS}(t)$, using the neural network model (ANN1), as given by:

   \[
   iQ_{gHMS}(t) = Q_{gANN}(t)
   \]

   \[
   Q_{gANN}(t) = f \left( Q_{gHMS}(t-1); Q_{o}(t-1); \right) \text{ and other available meteorological data} \] (2)

   where in the training process the ANN1 model’s target output is the observed streamflow of the gauged site, $Q_{o}(t)$. The computed streamflow ($Q_{gHMS}(t)$) is improved with the assistance of the ANN approach. The simulated flow generated by the ANN model (ANN1), $Q_{gANN}(t)$ using equation (2), becomes the improved streamflow at the gauged site, $iQ_{gHMS}(t)$ according to equation (1). The previous and/or recent HEC-HMS computed streamflow of gauged site, observed streamflow, mean-area rainfall, and additional meteorological variables are used by the ANN model (ANN1) in the output updating procedure.

3. Improve the model calculated streamflow values at the corresponding ungauged sites, by using the neural network model (ANN2), as follows:

   \[
   iQ_{ugHMS}(t) = Q_{ugANN}(t)
   \] (3)

   \[
   Q_{ugANN}(t) = f \left( \sum_{i=1}^{G} Q_{gHMS,i}(t); Q_{ugHMS}(t-1); Q_{o}(t-1); \right) \text{ and other available meteorological data} \] (4)

   where $f$ is the ANN function of input-output datasets, $Q_{gHMS}(t)$ and $Q_{ugHMS}(t)$ are the HEC-HMS computed flows at the gauged and ungauged sites, respectively; $Q_{o}(t-1)$ is an average observed flow at the gauged site; $iQ_{gHMS}(t)$ is the improved streamflow(s) from the gauged site(s) for $G$ gauging sites; $iQ_{ugHMS}(t)$ is the improved streamflow at the ungauged site; and $t = 1$ to $N$ is the time step. The ANN2 model’s target output in the training process is $Q_{ugHMS}(t)$.

4. Test the ANN2 model with the improved streamflow of gauged site(s), $iQ_{gHMS}(t)$ obtained from equations (1) and (2), instead of using the $Q_{gHMS}(t)$ in equation (4).