# Flood Modelling in the Mahaweli River Reach from Kotmale to Polgolla

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## ABSTRACT

The occurrence of floods and inundation of the low lands adjacent to the Mahaweli River reach from Gampola to Polgolla in Central Sri Lanka were very frequent prior to last two decades. It is with the completion of the Kotmale reservoir project in mid 1980s, the regulation of flow by the Kotmale reservoir has reduced the inundation risk of these lands which were vulnerable to frequent flooding. Since then, the lands are developed at an increasing rate and many people have started to live in the fertile river valley. This development accompanies an overlooked risk to the community and alarming signal to the authorities as the damages that might be caused due to an extreme flood event could be significant. It is therefore of paramount importance that flood modeling and inundation analysis of the Mahaweli River reach between Kotmale and Polgolla is carried out. This paper presents the flood modeling in the 42.2 km long Mahaweli river reach from the Kotmale dam to Polgolla barrage using the HECRAS model. The model is set up to estimate the water stages along the river reach for the floods of different return periods.

**Key words:** extreme flood, inundation modeling, Mahaweli River, HECRAS

## INTRODUCTION

The Mahaweli River; the longest river in Sri Lanka originates from the central hills of the country and flows over a length of about 335 km to discharge to the Indian Ocean at North-Eastern city of Trincomalee. It drains a basin area of 10,025 km$^2$ receiving rainfall from 1500 mm -5500 mm, elevations extending up to 2524 m. The Mahaweli River is the most important source for the water resources development in the country. There are several multi-purpose reservoirs impounded by the construction of dams, barrages and weirs in the river to facilitate the 6 major hydropower plants, and number of inter and transbasin diversions for irrigated agriculture and water supply.

Figure 1 shows the location of the Mahaweli River basin, and its upper basin of 1573 km$^2$ ranging from 434 m to 2524 m. elevation up to the Polgolla barrage of the river. The basin receives high rainfall during the monsoon and inter-monsoon seasons a large runoff is generated. Several major cities including Kandy which is the hill capital are located in the valleys of this sub basin of the river.

The occurrence of floods and inundation of the low lands adjacent to the Mahaweli River reach from Gampola to Polgolla were very frequent prior to mid 1980s. The Kotmale reservoir project was completed in 1985 as part of the massive water resources development project centering the Mahawelir River. The Kotmale dam is a rock fill dam of about 87 meters height constructed intercepting the flow of the Kotmale Oya which the uppermost major tributary of the Mahaweli River. The Kotmale reservoir with a capacity of 174 million m$^3$ was impounded with a 200 MW hydropower plant. During last two decades, the regulation of flow by the reservoir has reduced the inundation risk of these lands, which were vulnerable to frequent flooding. As a result, these lands are developed at an increasing rate with significant investment on housing and infrastructure development. Many people have started to live in the fertile valley with pleasant weather and close to major city of Kandy. This fact gives an alarming signal to the authorities, as the damage that might be caused due to an extreme flood event could be significant. The major flood experienced by the region in 1978 before the Kotmale project, which was estimated to carry about 3050 $m^3/s$ dam, inundated a large extent causing severe damages. Though the Kotmale reservoir acts as a flood control reservoir for floods of medium return periods, it becomes ineffective to reduce the flood levels in the downstream flood plains due to floods of high return periods. The Kotmale dam is equipped with a spillway which could release a discharge 5500 $m^3/s$. It would disastrous if a flood of similar magnitude occurs at present condition. Therefore, flood modeling and inundation analysis in region downstream of the Kotmale reservoir is extremely important to plan the flood mitigations measures.

Figure 1 shows the stream network and details of the catchments for Kotmale dam and Polgolla barrage. The Upper Mahaweli River joins the river at several kilometers downstream of the Kotmale dam. There are also several small tributaries joining the river as shown in Fig. 1 and the areas are given in Table 1.

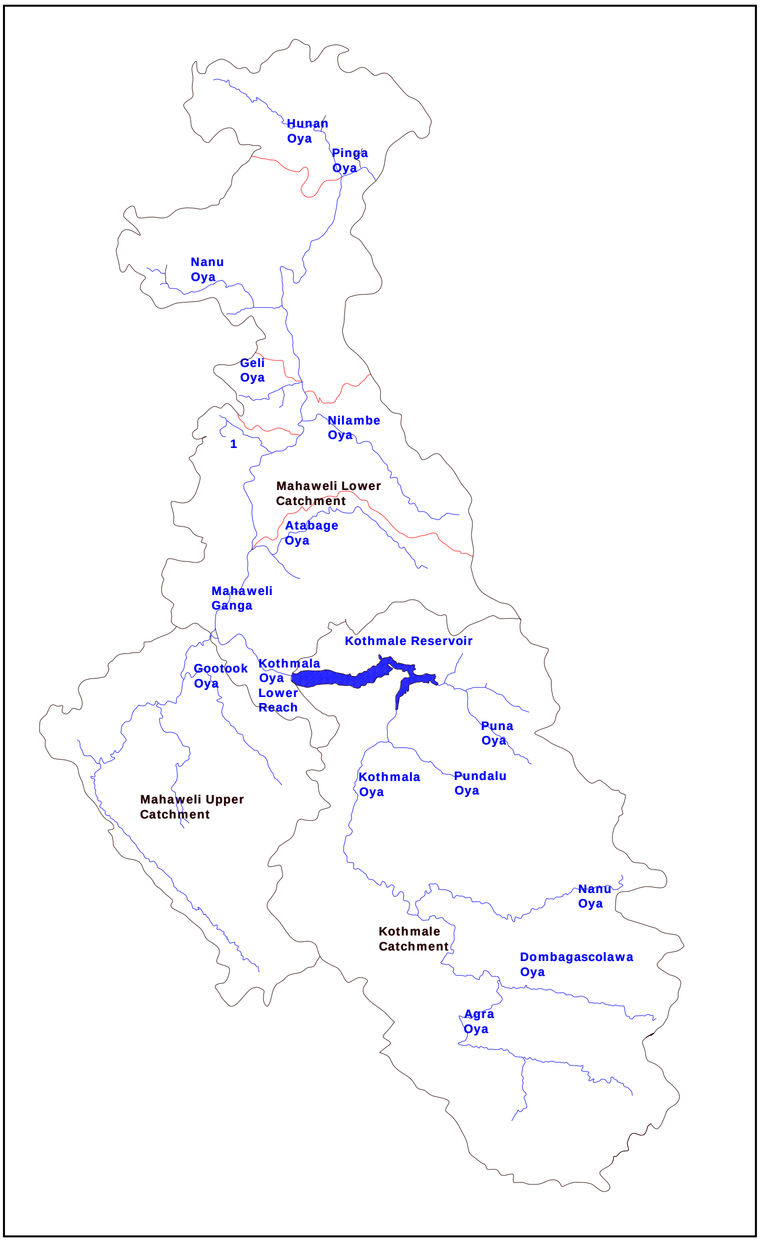


**Fig. 1** The Mahaweli River basin above Polgolla barrage

## MODEL APPLICATION

The HEC-RAS model of US-Army Corps Engineers was set up to estimate the water surface elevation levels in the 42.2 km reach of the Mahaweli River from the downstream of the Kotmale dam up to the Polgolla barrage. Steady, one-dimensional water surface profile computation in the HEC-RAS (Release 4.0) model is based on the solution of one-dimensional energy equation. Energy losses due to friction and changes

**Table 1**. Details of the sub basins

| No | Sub basin name | Area / ($km^2$) |
|---|---|---|
| 1 | Atabage Oya | 94.4 |
| 2 | Nilambe Oya | 71.3 |
| 3 | Geli oya | 15.9 |
| 4 | Nanu Oya | 81.7 |
| 5 | Hunan/Pinga Oya | 75.2 |
| 6 | Mahaweli Lower | 434.6 |
| 7 | Mahaweli Upper | 215.0 |
| 8 | Kothmala Oya | 535.2 |
| 9 | Other | 49.6 |

in cross sections are taken into account by distributed roughness coefficients and expansion /contraction coefficients. Momentum equation is used at the locations where the water surface profile is rapidly varied such as at hydraulic jumps, stream junctions and controls.

River cross sections at every 200 m intervals along the 42.2 km river reach were taken from the 1:10000 scale maps of the Survey Department of Sri Lanka as the first step. A reach length of 1.2 km was used for the Mahaweli Upper tributary (Fig. 2). The upstream boundary conditions were set up as the normal slope conditions and the downstream boundary condition was the specified water surface elevation at the Polgolla barrage using the weir formula.

For the calibration of the model, the only available data for extreme flows which is the flood discharge of 3050 $m^3$/s with a water depth of 15 m at Peradeniya Railway Bridge was used. It was in 1978 before the Kotmale reservoir. Peradeniya Railway Bridge is located at about 14 km upstream of the Polgolla barrage. The daily rainfalls recorded at the gauging stations in the basin vary from 60 mm to 143 mm. Simulation was carried out under an approximated rainstorm of 3 hour duration with an intensity of 29 mm/hr in the basin except for the sub basin above the upstream boundary of the Kotmale Oya. To match the flood discharge of 3050 $m^3$/s at Peradeniya Railway Bridge, an inflow of 1338 $m^3$/s at the upstream boundary of the Kotmale Oya was used. The corresponding total discharge at Polgolla was 3305 $m^3$/s with the contributions from the sub basins at the downstream of Peradeniya. The water depth at Peradeniya Railway Bridge due to 1978 flood was computed as 14.6 m which compares satisfactorily with the observation. The roughness coefficients used in the HECRAS model are given in Table 2. The computed water surface profiles is given Figs 2.

**Table 2** Roughness coefficients in different reaches

| | | Manning's n (SI Units) | | |
|---|---|---|---|---|
| Reach | Length from D/S (km) | LOB | Channel | ROB |
| Kothmale | 34.8 - 42.2 | 0.12 | 0.07 | 0.12 |
| Mahaweli Upper Tributary | 0-1.2 | 0.05 | 0.03 | 0.05 |
| Mahaweli | 10.0 - 34.8 | 0.05 | 0.03 | 0.05 |
| Mahaweli | 7.0 - 10.0 | 0.17 | 0.1 | 0.17 |
| Mahaweli | 0 - 7.0 | 0.05 | 0.03 | 0.05 |

LOB:Left over bank; ROB: Right over bank

The available hydrological data for the basin are the daily rainfall at 15 stations and daily flow data at three locations in the river. The maximum rainfalls of different return periods in the basin were estimated by Gumbel distribution fitted to the maximum annual basin rainfalls. Daily rainfall with 200-year return period was estimated as 175 mm. In the absence frequency-duration-intensity curves, rainstorms with estimated total rainfall but with different durations are considered for extreme flood analysis. Then, runoff from each sub basin is estimated using SCS Dimensionless Triangular Unit Hydrograph Method for each of the events. The release from the Kotmale reservoir defines the inflow to the reach. The Kotmale dam has a spillway equipped with radial gates to release a design discharge of 5500 $m^3$/s . Different spillway discharge scenarios are considered as upstream inflow boundary conditions to the reach.

The resulting large discharges in the river reach accompany larger depths. Thus, computation essentially require wide river cross sections extending to high elevations.. The trial simulations carried out showed the need for establishment of wide river cross sections as the inundations become excessive under large discharges that 4000 $m^3$/s in the reach with mild slope present below Gampola. It is with the acquisition geometric data by field surveying, which is ongoing, the computations of water stage and inundation extents due to estimated floods of high return periods are carried out.

## CONCLUDING REMARKS

The HECRAS model was set up to compute the water surface elevations along the Mahaweli River reach of 42.2 km from the Kotmale reservoir to the Polgolla Barrage under extreme flood events. The model is useful to estimate inundation extents under extreme floods of different return periods once the refine geometrical data covering wider river cross sections are made available. The model would be a useful tool for forecasting flood levels and inundation extents and thereby for planning disaster reduction strategies.

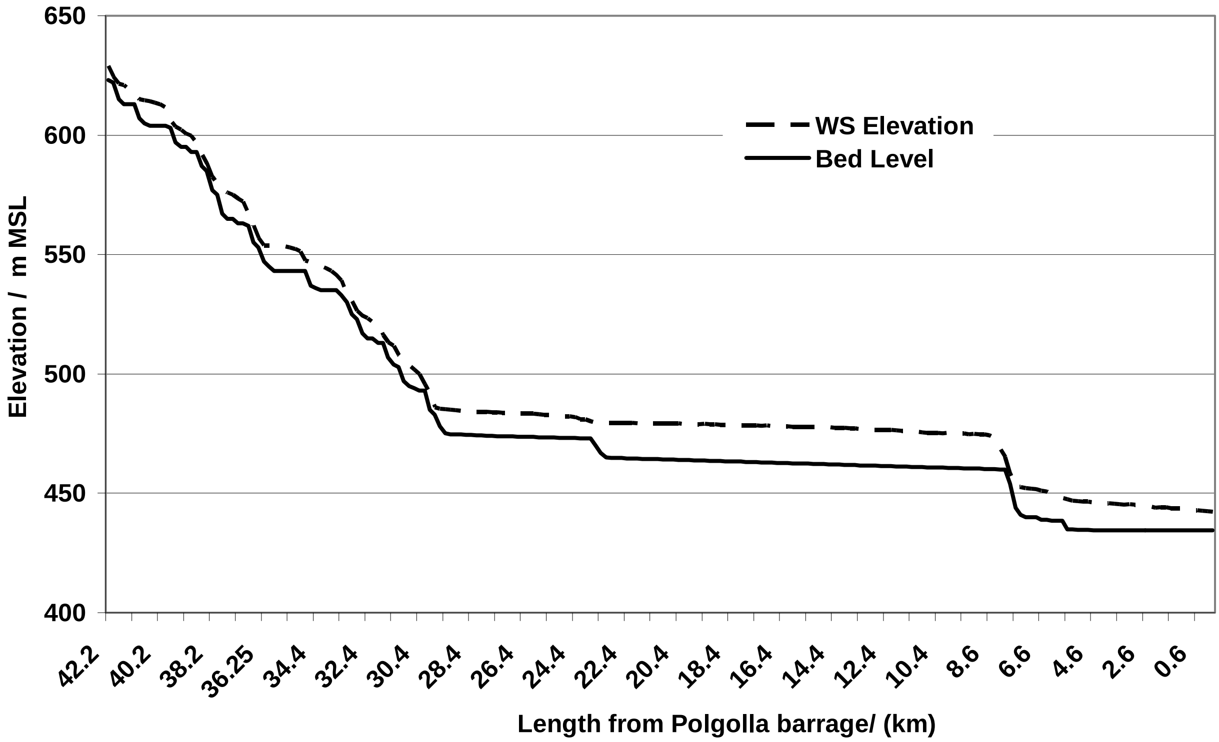


**Fig 2**. Water surface elevations along the river reach

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