UNSTEADY FLOOD MODELING FOR KANDALERU AND PULICHINTALA DAM USING HEC-RAS

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OBJECTIVE

- Dam break analysis of Kandaleru and Pulichintala dam using HEC-RAS. The study includes the sensitivity analysis for dam breach parameters.
- Computation of flood hydrograph at different cross-sections.
- Assessment of flood inundation extent and water depth at different places in the downstream of dam and plotting of inundation map.

STUDY AREA

- **Kandaleru dam** is an irrigation project built on Kandaleru river in Nellore district of Andhra Pradesh. The project is a part of the Telugu Ganga project which supplies drinking water to Chennai city from the Srisailam reservoir on Krishna river. Kandaleru reservoir is mainly fed by a link canal from the Somasila dam. The Telugu Ganga project also provides irrigation water in Andhra Pradesh. It is an earthen dam of 10 km length and falls between latitude $14^0$16'57.26" N and longitude of $79^0$36'28.70" E. Dam has top elevation of 89.00m with 3 gates of size 12m x 10m.
- **Pulichintala Dam** is built on Krishna river and is a distinguished dam situated in Guntur district of Andhra Pradesh state. It is a Concrete dam constructed on Krishna river. The dam has a height of 42.24 metres and length of 2922 metres. The latitude and longitude of this dam are $16^0$46'14" N and $80^0$03'33" E respectively. Dam has top elevation of 58.24m with 24 radial gates of size 18.15m x 17m. It is a multipurpose dam and its water is used to irrigate the areas of Guntur District.

STUDY AREA 1- KANDALERU DAM

STUDY AREA 2- PULICHINTALA DAM

INTRODUCTION

- Dam failure can cause high level of flood to the nearby areas of dam and flood analysis is required for preparedness of the flood disaster.
- Now, it has become mandatory to conduct dam break analysis for all major dams.
- Dam break analysis is an important tool for flood analysis and it can be done by various models such as NWSBRK, HEC-RAS, MIKE11, MIKE21 etc..
- Hydrologic Engineering Centre River Analysis System (HEC-RAS) is developed by U. S. Army Corps of Engineers and it is capable of doing dam break analysis.
- HEC-RAS is capable of doing one dimensional, two dimensional modelling. The data requirement and modelling procedure is different for both the modelling.
- Kandaleru and Pulichintala dam break modelling is performed with the HEC-RAS one-dimensional model and the equations used for modeling are shown below.

1-D modelling gives the hydrograph at every previously plotted cross-sections on the river. In this modelling 1-D Saint Venant's Equation is used as described below.

The equation of Saint Venant's expressed in conservation form with additional terms for the effect of expansion/contraction, channel sinuosity and non-Newtonian flow consist of mass equations.

These equations are:

- **Conservation of mass equation**

$$\frac{\partial Q}{\partial X} + \frac{\partial S_c(A+A_0)}{\partial t} - q = 0$$

- **Conservation of momentum equation**

$$\frac{\partial(S_m Q)}{\partial t} + \frac{\partial(\beta Q^2/A)}{\partial X} + gA\left(\frac{\partial h}{\partial X} + S_f + S_e + S_i\right) = 0$$

DATA REQUIRED FOR ONE-DIMENSIONAL MODELLING USING HEC-RAS

- Digital Elevation Model of study area
- Probable Maximum Flood hydrograph
- Elevation-volume curve of reservoir
- Manning's roughness value of site
- Rating curve or Normal depth at downstream location of river reach
- Cross-section data of river reach
- Salient feature of dam hydraulic structure
- Breach parameters

BREACH CHARACTERISTICS

Breach parameters selection plays an important role in dam break modelling. There are various guidelines for breach parameters which are given by different agencies such as NWS, USACE, FERC etc.

In this project breach characteristics are generated with the help of guidelines given in report, “Guidelines for Mapping Flood Risks Associated with Dams, CWC, Ministry of Water Resources, River Development & Ganga Rejuvenation, GOI”.

- Breach parameters includes:

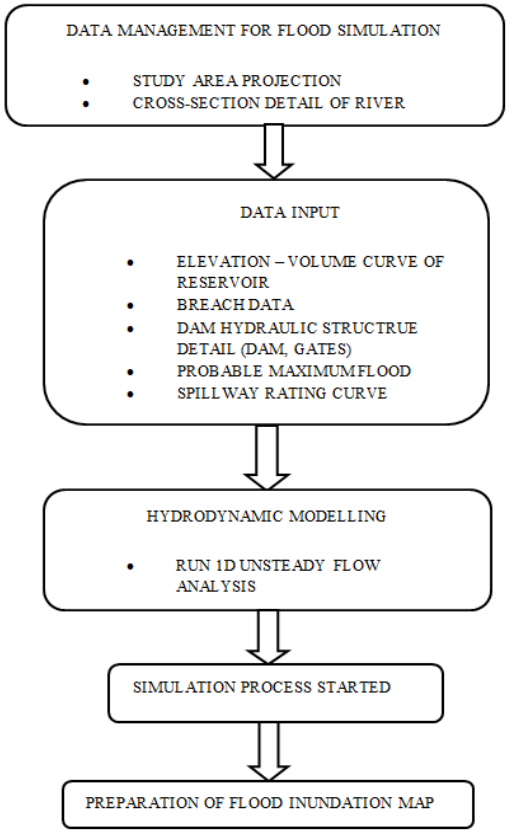
A) Geometric parameters

- Breach depth
- Breach width
- Breach side slope factor

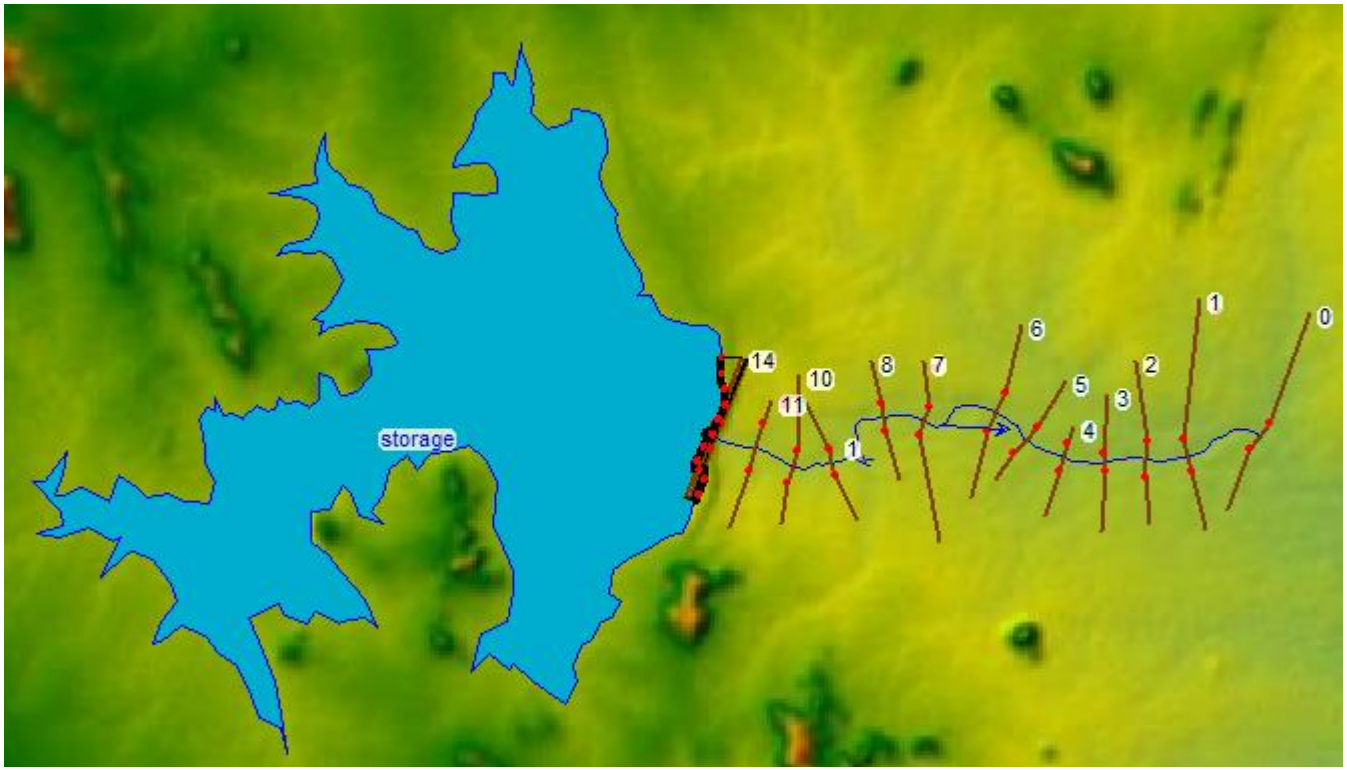
B) Time related parameters

- Breach initiation time
- Breach formation time

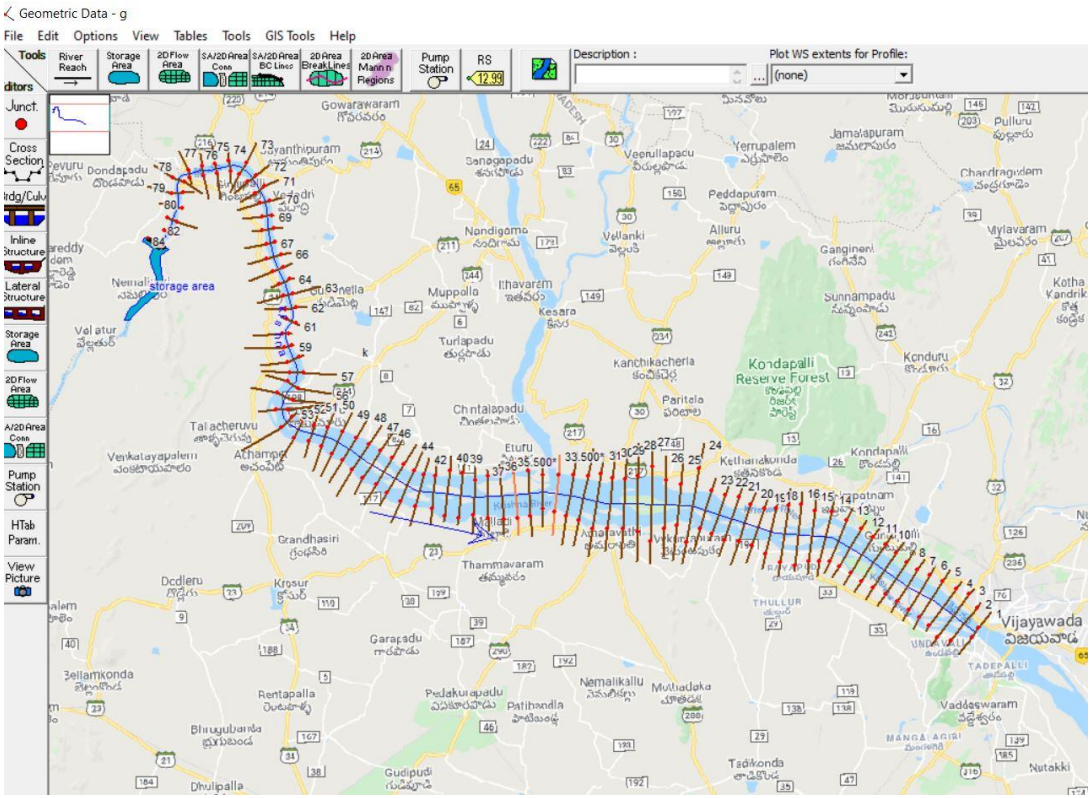
HEC-RAS ONE-DIMENSIONAL DAM BREAK METHODOLOGY



GEOMETRIC VIEW OF KANDALERU DAM BREAK ANALYSIS



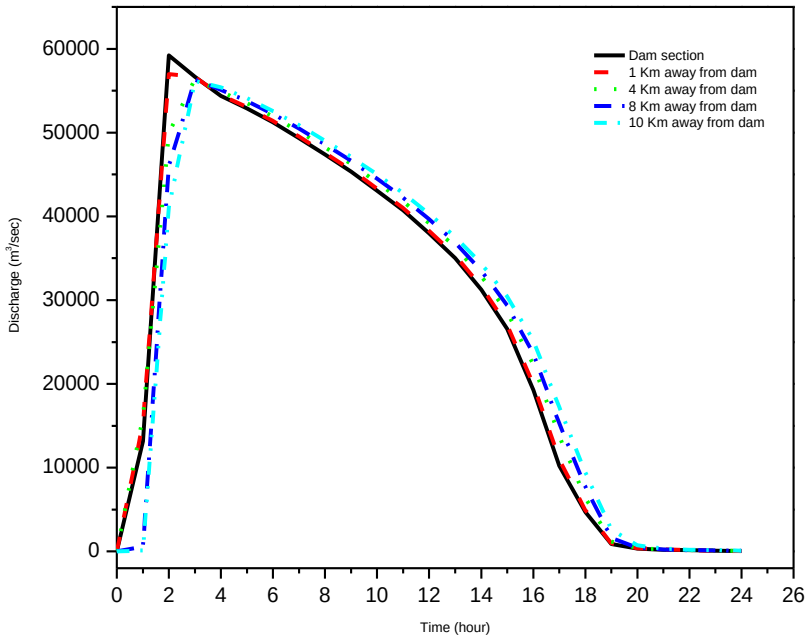
GEOMETRIC VIEW OF PULICHINTAL DAM BREAK ANALYSIS



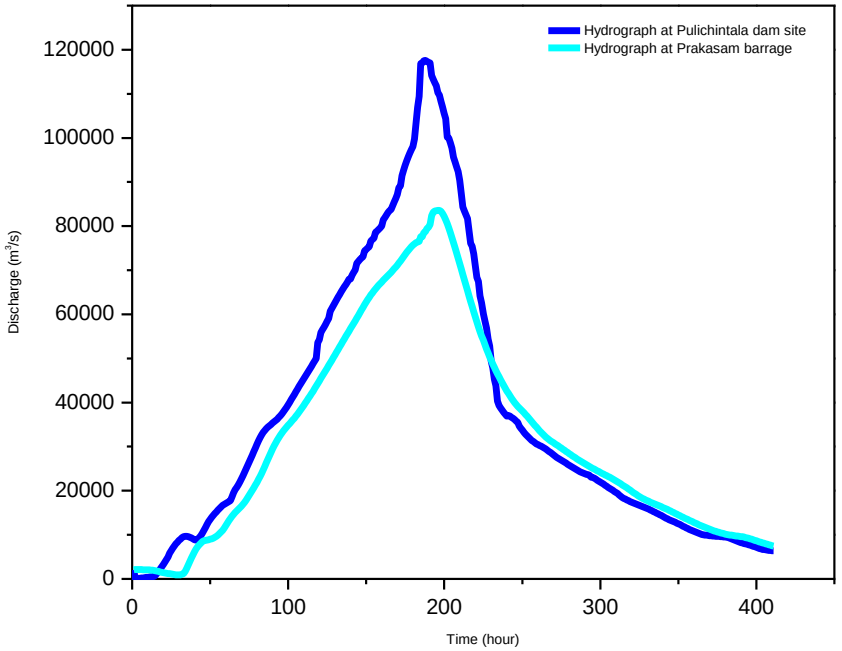
RESULTS

- **Kandaleru dam** break modelling is considered by overtopping failure. If the upstream water reach the TBL of dam ie 89.00m, then it will lead to the overtopping failure of dam.
- **Pulichintala dam** break modelling is considered by overtopping failure. If the upstream water reach the TBL of dam i.e 58.24m, then it will lead to the overtopping failure of dam.
- The hydrographs are shown for both the dam with different downstream cross-sections.

KANDALERU DAM



PULICHINTALA DAM



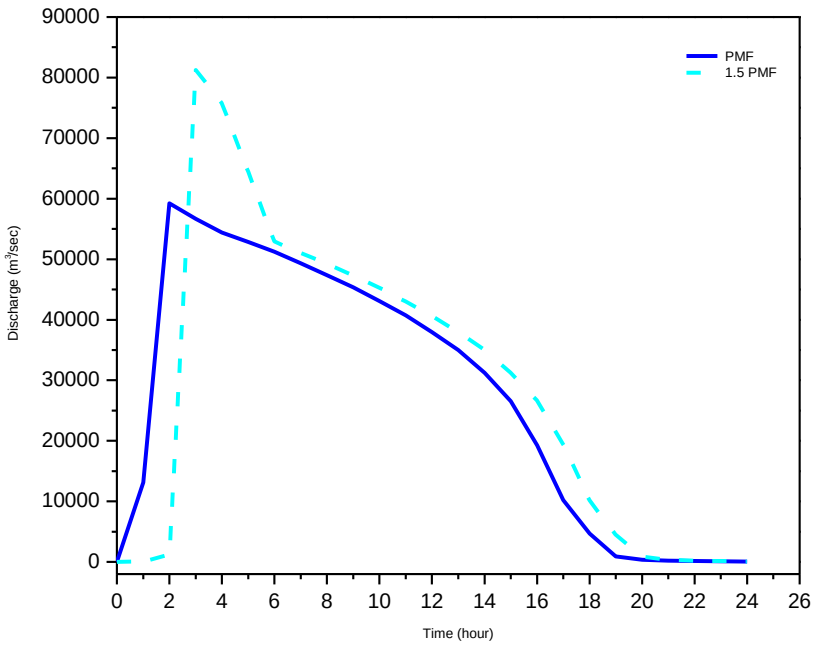
SENSITIVTY ANALYSIS

- Sensitivity analysis is also performed for the better visualization of results and after performing simulation inundation map is prepared for the worst scenario.
- For sensitivity analysis, PMF, breach width, breach formation time and manning's roughness changes were considered.
- For the Kandaleru dam the analysis is considered for about 10km downstream of dam, with the various cross-sections at 1km distance.
- For the Pulichintala dam the analysis is considered for about 85km downstream of dam till Prakasam barrage location, with the various cross-sections at 1km distance.

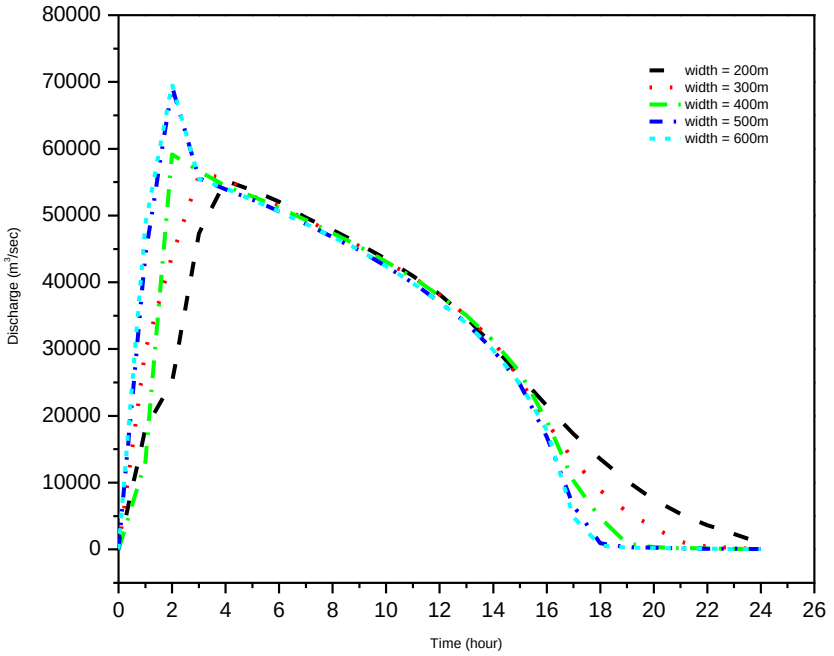
KANDALERU DAM: Sensitivity Analysis

- While analysing peak flow, it was found that peak flow is increasing when PMF is increasing by 1.5 times. As the PMF values increases by 1.5 times of initial values, the outflow discharge values increases by 27.18% and water surface elevation increases by 5.51% correspondingly at the dam section.
- When the breach time increases from 3.0 hour to 9.0 hour i.e of 66.66%, the discharge decreases by 56.19% . Also as the breach formation time increases the water surface elevation decreases.
- As the width increases from 200 to 600m i.e of 66.66%, the discharge value also increases with 20.75% and the maximum water surface elevation also increases.
- As the river roughness increases from 0.035, 0.040, 0.045, 0.050 the discharge value decreases. River channel roughness has more impact rather than floodplain roughness.

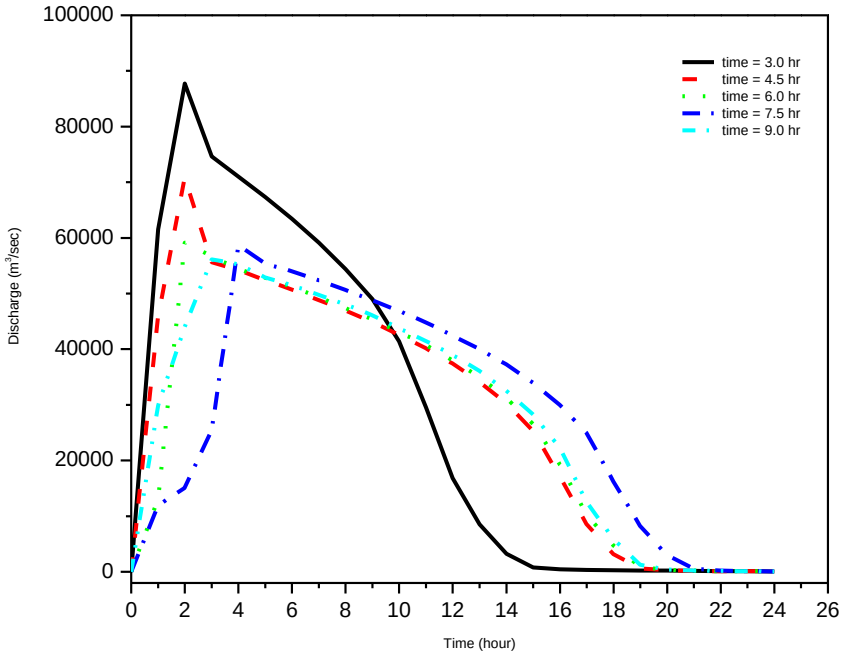
PMF



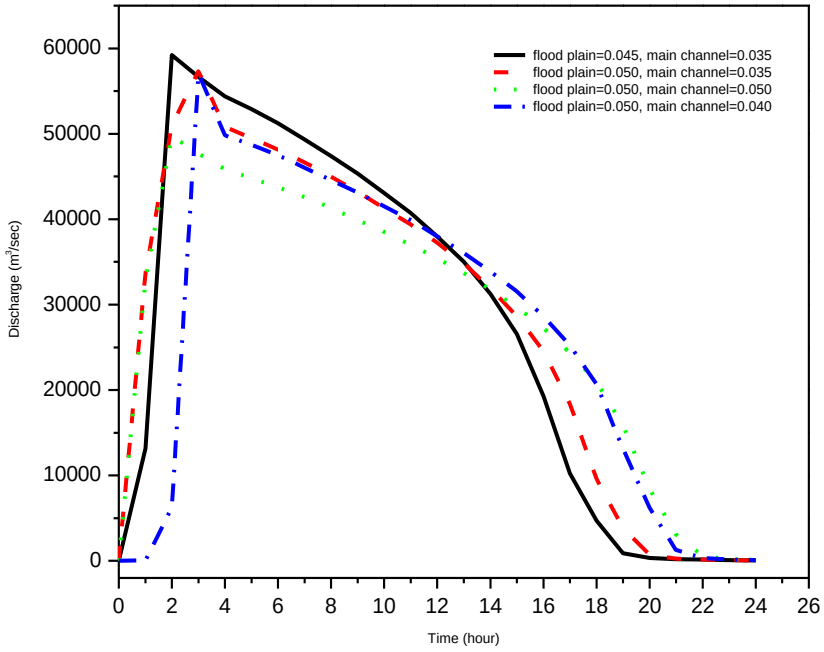
Breach width



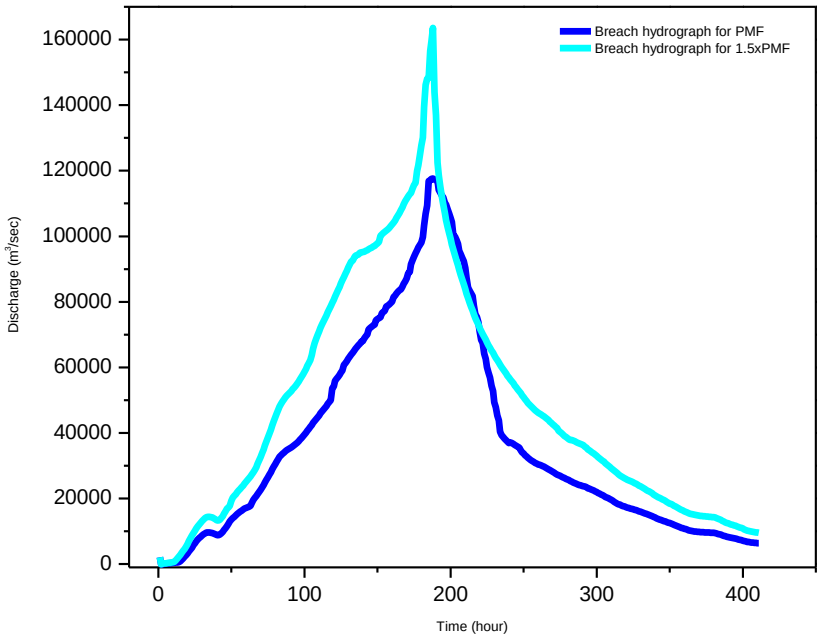
Breach formation time



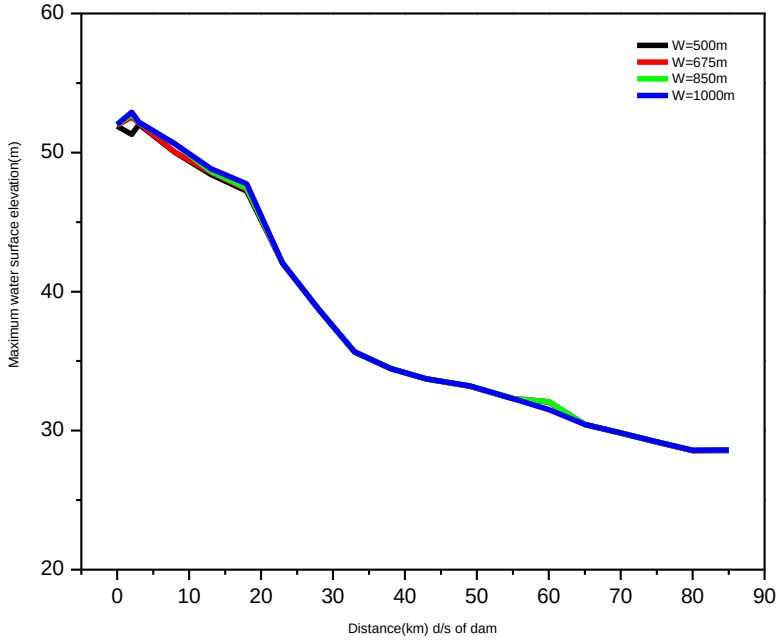
Manning's roughness



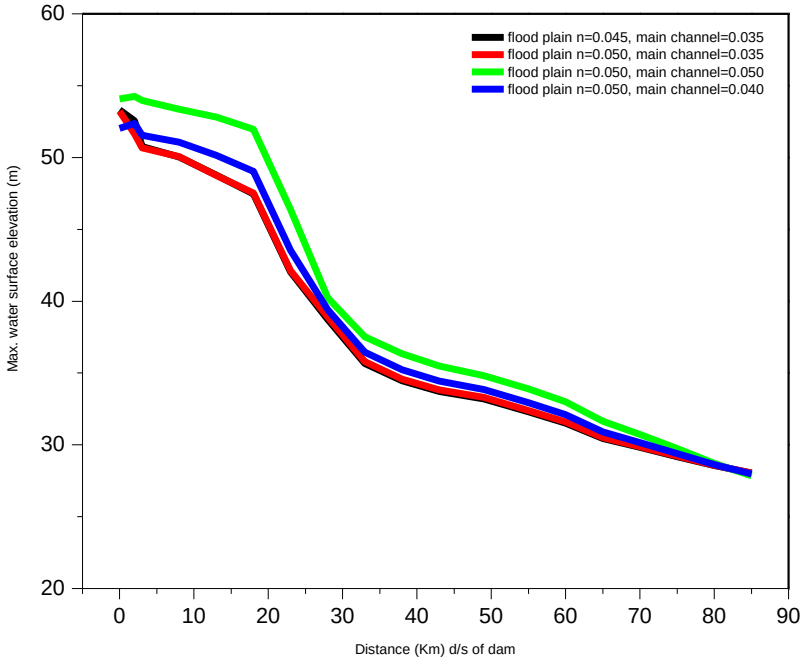
PMF



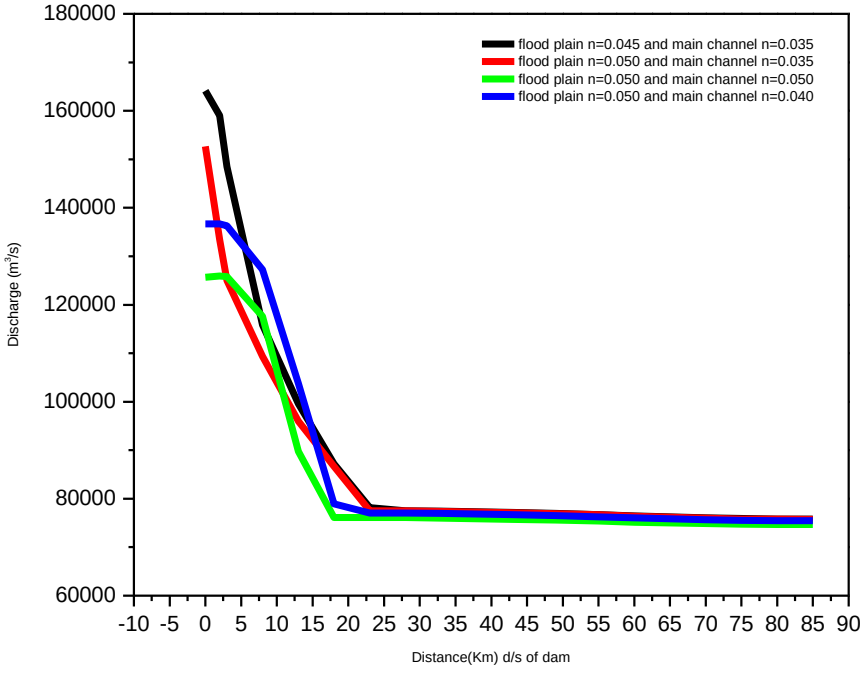
Breach width



Water surface with cross section for Changing Manning's roughness



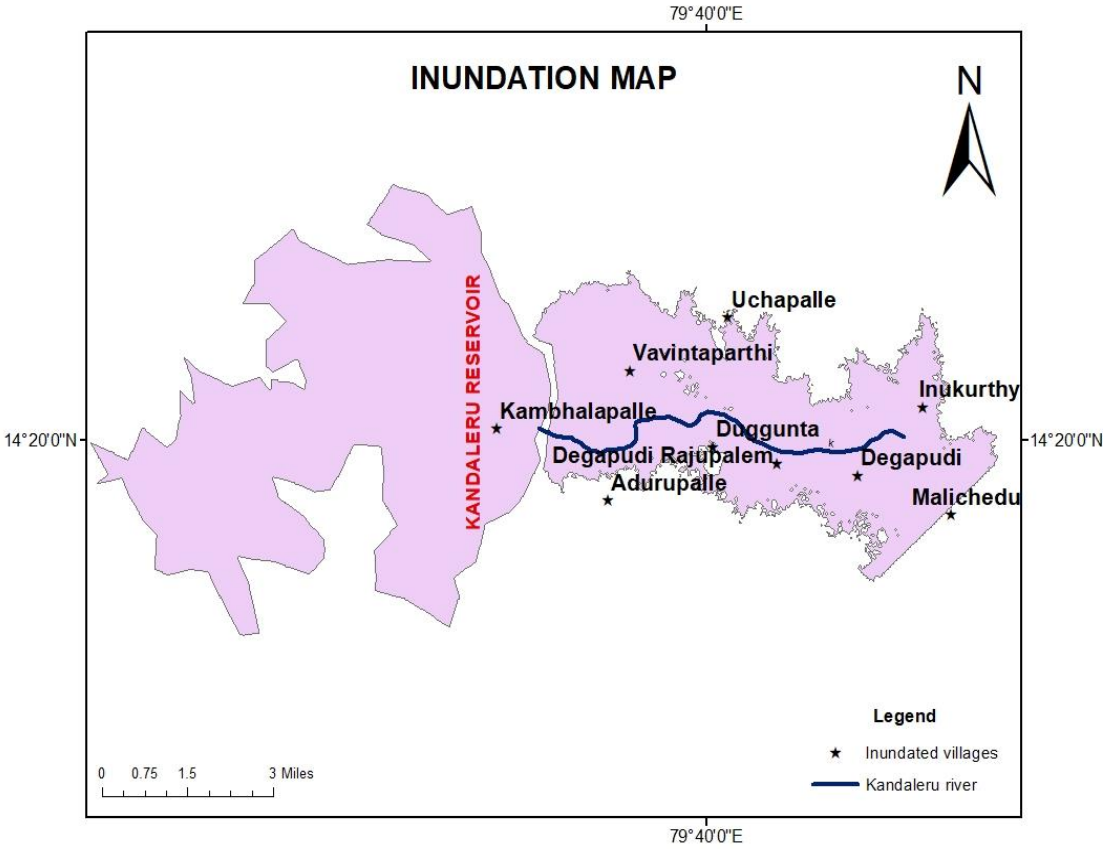
Discharge with Changing Manning's roughness



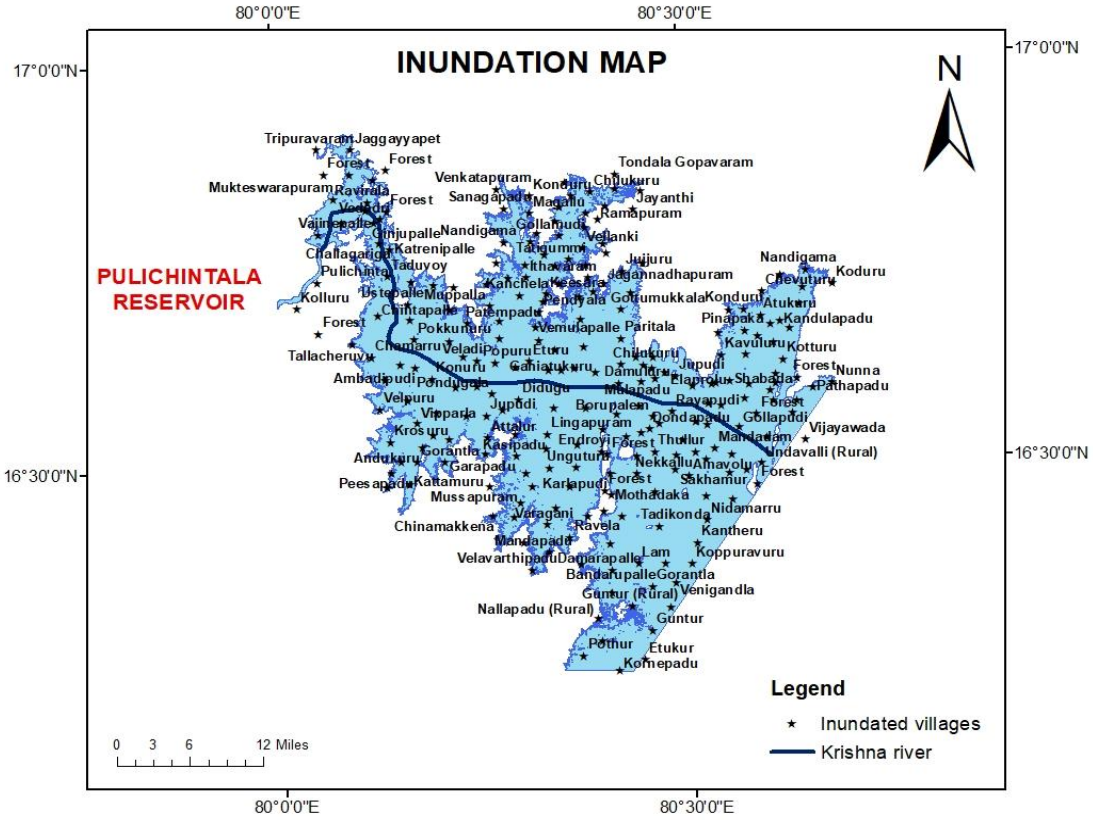
INUNDATION MAP OF KANDALERU AND PULICHINTALA DAM

- Inundation boundary corresponds to the maximum elevation reached by dam break flood at different location to the downstream of dam. For Kandaleru dam the inundated area is 45.68sq.km and for Pulichintala dam the inundated area is 1980.984sq.km.

KANDALERU DAM



PULICHINTAL DAM



CONCLUSION

- The HEC-RAS one-dimensional modeling gives better detail on dam break flood result at the cross-section location. Sensitivity analyses is helpful for the generation of better results in comparison to single value flood modeling. As the PMF changes discharges changes accordingly, as breach formation time increases, results changes according to dam type and cross-section position, as breach width increases, discharge increases, and for manning's roughness main channel has more impact comparison to flood plain roughness values. Inundation map gives better visualization of water depth for proper planning in any future flood condition.

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INCOLD
Indian National Committee on Large Dams

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