SOME OF THE IMPORTANT RECOMMENDATIONS

(i) For the design flood estimation of a larger basin a network model may be developed and unit hydrograph technique together with flood routing through channel and reservoir may be used to estimate the design flood. However, for smaller basins (of size less than 5000 sq km) unit hydrograph technique may be used. Whenever adequate records of rainfall and runoff are available, the unit hydrograph and flood routing parameters may be calibrated and validated. In case limited or no data are available, the Geomorphological Instantaneous Unit Hydrograph (GIUH) based approach or regionalisation approach may be used for determining those parameters.

The GIUH based Clark model has been applied to simulate the flood hydrographs of some of the sub-basins of Narmada river basin. It was found that the velocity is one of the important parameters which determines the shape of the unit hydrograph. The advantage of GIUH based Clark model is that it provides a methodology for deriving the variable unit hydrograph for different storm events. **Two approaches for the velocity estimation have been suggested. The user may opt for one of these depending upon the availability of data.**

(ii) Based on the comparative flood frequency studies involving at-site, at-site and regional and regional methods using Extreme Value-1 (EV-1), General Extreme Value (GEV) and Wakeby distributions as well as the USGS method carried out for the Upper Narmada and Tapi subzone 3(c) and Lower Narmada and Tapi subzone 3(b) at site and regional GEV method is found to be robust. The conventional empirical flood formulae do not provide floods of desired return periods. However, the flood formulae developed in this study are capable of providing flood estimates for different return periods. Regional flood frequency relationships and flood formulae have been developed using the L-moment based GEV distribution. **The regional flood formulae for the subzones 3(b) and 3(c) are expressed as:**

Subzone 3(b), $$Q_T = [61.3(-\ln(1-\frac{1}{T}))^{-0.20}-46.9]A^{0.46}$$

Subzone 3(c), $$Q_T = [52.2(-\ln(1-\frac{1}{T}))^{-0.11}-44.3]A^{0.67}$$

(Here, Q_T is flood in cumec for T year return period, A is the catchment area in square kilometers).

(iii) The European Hydrological System Model (SHE) has been verified on Indian data, although not for research catchments with good data coverage. The present results indicate that SHE is able to reproduce the rainfall-runoff process and give a physically reasonable representation of the intermediate hydrological processes for the characteristic monsoon environment. However, experience from the Narmada studies indicates that the main part of the required data already exists with different agencies representing meteorological, irrigation, agricultural, geological, and other professional fields, many of which are not usually contacted in traditional hydrological and water resources studies. The SHE, owing to its generalized structure and process description, is in principle applicable to almost any hydrological regime in India and for most hydrological problems. For problems dealing with prediction of the effects of man's activities, for which the traditional models are not applicable, SHE is particularly well suited and models of the SHE type are technically the only feasible option. **The studies conclude that SHE Model can be successfully and efficiently applied in Indian catchments for various applications like: prediction of effects of land use change; simulation of interaction between surface water and ground water, e.g. conjunctive use; water management in irrigation command areas; prediction of effects of climate change.** SHE is also well suited as the hydrological basis for water quality and soil erosion modelling, for which a detailed and physically correct description of the water flow process is required.

(iv) **Different rule curves have been recommended for the Bargi reservoir for irrigation, power generation and water supply demands.** It is seen from the analysis that the upper rule levels, specified in the presently followed operation policy, are too low and the water is spilled at the cost of conservation demands. Simulation analysis also shows that the inflow in the reservoir during the period from October to February is critical for satisfying full conservation demands. Further, since the sill level of right bank canal is quite high, it seems difficult to meet its demands in the long run.

Rule curves based policy has been adopted for the conservation regulation of Tawa dam. Three rule curves have been recommended: upper rule curve, middle rule curve (critical for irrigation), and lower rule curve (critical for water supply and upstream use). From the analysis, it is observed that the presently followed policy gives higher reliability than the recommended policy for meeting the full as well as partial demands. However the presently followed policy gives more critical failures than the recommended policy. **The recommended policy tries to distribute the deficit equitably in all the months. As soon as shortage of water is anticipated, the supply is curtailed much in advance so that reduced supply can be maintained throughout the year. The recommended operating policy improves the volume reliability for irrigation and water supply by 1% over the current operating policy.**

(v) About 12 years water quality data observed at the Manot site of upper Narmada basin is used to carry out statistical analysis. The analysis has been carried out in three phases viz. (a) quality-quantity relationships have been developed relating the concentration of quality parameters to the magnitude of stream flow for various water quality determinants, (b) probability distributions have been plotted which give the information about the probability of violation of allowable limits of various water quality parameters and (c) multiple regression models have been developed for various water quality parameters which may be used for filling the missing data values. **The results of the statistical analysis could be used for computing hardness, chlorides, bicarbonate, pottasium, sodium, nitrate, total dissolved solids, conductivity and turbidity. However, these results are based on limited data available for the river.**

These multiple regression models may also be used for filling the missing data values which is an important step for further analyses like time series analysis, stream quality forecasting, pollutant concentration, frequency analysis, etc.

(vi) A rational approach is imperative to develop the water resources of canal command area in such a manner that the adverse effects of uncontrolled surface water irrigation can be avoided. **Proper conjunctive use of surface water and ground water is necessary to efficiently utilize the water resources without endangering the command area with waterlogging and salinity problems in future. Based on the limited studies taken up in Bargi Left Bank canal command area, it is recommended that regular determination of infiltration rates, and aquifer parameters is necessary.**

(vii) Land capability classification has been carried out for a part of Narmada Basin considering several soil characteristics and associated land features. The major soil characteristics considered are texture, depth, permeability and salinity of the soil. The importance associated with land characteristics are landuse, slope of the land, erosion, etc. **Results relating to soil type, texture, depth, permeability, and salinity would be useful for various government agencies and researchers working in this area.**