TRAINING COURSE

ON

RESERVOIR OPERATION

(UNDER WORLD BANK AIDED HYDROLOGY PROJECT)

Module 7

Reservoir Operation

for

Flood Control

BY

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RESERVOIR OPERATION FOR FLOOD CONTROL

1.0 INTRODUCTION

Reservoirs are designed to hold excess flood waters temporarily in storage during the passage of floods and thereby reduce flooding at the affected down stream reach or reaches of the river. One of the essential features of reservoir operation for flood moderation is that storage space earmarked for flood storage is to be held empty throughout the flood season, except during passage of floods when all flood waters will be stored temporarily to prevent down stream flooding. To achieve this and also to prevent unnecessary storage in the flood control space of the reservoir for instance in the early part of a flood, it is important that sufficient discharging capacity at the bottom flood pool levels is available. Further, when flood storage space is occupied maximum possible releases subject down-stream constraints have to be allowed, as far as possible in order that this space can be vacated before the outset of the next flood.

In general, flood potential varies over the year or seasons due to seasonal variations in storm rainfall potential and catchment wetness conditions. Because of this seasonal variation in flood potential the requirements of flood control storage space may also vary seasonally.

Operation of flood control reservoirs can be made more effective if accurate forecasts of inflow are available for areas both above and below dam. Conceptually, if a perfect advanced knowledge can be assumed about the inflows over a time period and the time reservoir will take to fill and empty itself, the flood releases can be so planned as to make the most beneficial use of the available storage space in each and every flood event. Indeed such an ideal operation could even take advantage of depleting the reservoir in the early part of the flood thereby creating an additional space for flood storage, provided that was permissible.

For reasons of economy, multiple use of reservoir storage space is almost invariably restored to by combining flood control with other uses like hydropower and irrigation. In such cases effort is to strike maximum compromise between the conflicting requirements of flood control and consumption by restoring just of as much storage space as possible for both the objectives. Since space requirements for flood control may reduce towards the end of flood season, and since filling of storage for conservation takes place only progressively, some compatibility can always be achieved in that sacrificing too much.

1.1 FLOOD CONTROL RESERVOIR OPERATION

Reservoir Operation Questions

There are two basic reservoir operating questions regarding operation of flood reservoir:

1. Use of flood storage : Whether flood inflows should be stored to reduce current damage or released to provide additional storage space in case new rains produce even greater flows (i.e., release of flood waters during floods from the flood storage space).

2. Use of total storage : Whether storage space should be filled to save water for beneficial use or emptied to contain potential floods (i.e.,whether to use flood storage space temporarily for conservation during flood or vise versa).

Reservoir Operation with Zoning or Partitioning

In a multipurpose reservoir when the demands for water are competitive for the same time period, storage volumes in the reservoir must then be allocated to meet these competitive demands (Figure 1). This partitioning process involves both determination of required volumes, and establishing operating rules to specify how the reservoir is to be managed. The elevations of the various zones are used as guides for operation and can vary seasonally (Watershed Resources Management and Environmental Monitoring, 1981).

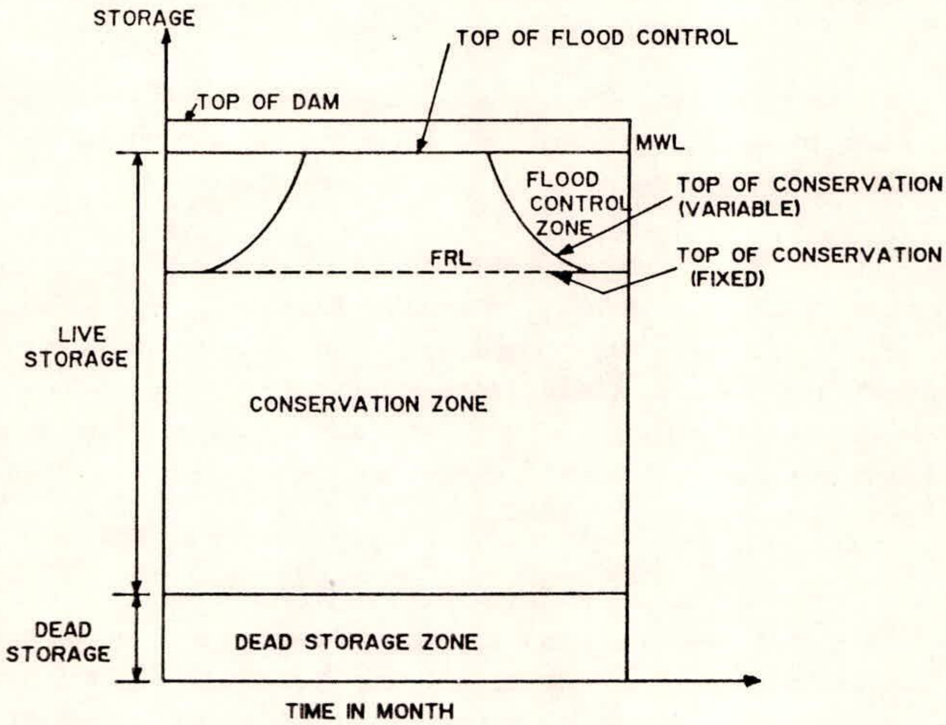

Fig. 1 Partitioning (Zoning) of Reservoir Storage

The following two zones might be considered for flood operation :

1. Surcharge zone: The storage above the flood control zone is associated with actual flood damage. The top of the flood control pool is used to maintain the integrity of the reservoir. Reservoir releases are usually at or near their maximum to prevent the dam from collapsing when the storage volume is within this zone.

2. Flood control zone: A reserve for storing large inflows during periods of abnormally high runoff. The flood control zone would be evacuated of water, at a time corresponding to the flood season.

The reservoir would then be kept at the top of conservation space (bottom of flood control space) to provide sufficient storage to control flooding. Once the pool elevation is in this zone, the reservoir is operated to release the maximum amount of water without causing flooding. Ideally, this would coincide with bankfull conditions downstream.

Reservoir Release Policy During Passage of Flood

Rules for deciding reservoir releases during the passage of floods keeping in view the release criteria discussed and the consideration of dam safety and where more than one reservoir are involved require additional rules for deciding the priorities of releases, between reservoirs. Conceptually, there is an optimal operation policy associated with any given system and system inputs and outputs. However, when choice is to be made by taking several alternative designs, it is usually not feasible to search and specify optimal policies for each design. On the other hand in management problems where the system is known, the optimization for operation policy can be attempted by simulation.

2.0 FLOOD ROUTING STUDY OF KANGSABATI RESERVOIR

The Kangsabati dam is situated on the river Kangsabati in the district of Bankura, West Bengal. The catchment area up to the dam site is 1400 sq. miles, leaving a catchment area of 900 sq. miles downstream. The river is purely a seasonal river originating from the hills of Chhotanagar range in the district of Purulia, West Bengal. The reservoir provides a total flood cushion of about 3.0 million acre ft., between the monsoon flood storage level of 434.0 feet and the maximum flood storage level of 445.0 feet. The design discharge of the spillway is 3.75 million cusecs corresponding to a flood of 1000 years frequency. The dam is provided with 11 numbers of gates with their sill levels fixed at R.L. 408 feet, each bay being 30 feet.

The flood volume for the spillway design flood hydrograph is 14 lacs ac-ft., with the peak inflow of 3.75 lacs cusecs spread over a base period of 10 days. Whereas, the reservoir design flood hydrograph of 100 years frequency has a volume of 9.6 lacs ac-ft., with the peak inflow of 2.68 lacs cusecs spread over a base period of 10 days, Figure 2.

The study has been carried out firstly, to moderate the floods of 100 and 1000 years return periods to utilize the minimum flood storage as far as possible and increasing conservation storage with the existing stipulation made for routing for the Kangsabati reservoir and secondly, to minimize the routed outflow as far as possible by the formulation of new flood operation policy, increasing simultaneously conservation storage (Roy, 1983; Srivastava and Roy, 1993). Various reservoir release policies during floods for 100 and 1000 years frequency floods are given in Tables 1 and 2 respectively. The reservoir flood routing was carried out with a routing period of 3 hours. The maximum rise in the water levels in the reservoir and maximum routed outflows are given in Table 3 and 4 for 100 and 1000 years frequency floods respectively. With the help of the modified stipulation in the flood operation policy it is possible to moderate the peak flood discharge of 1000 years frequency to 2.0 lacs cusecs from 3.75 lacs cusecs. The reservoir water elevation and the rate of its rise with the time are shown in Figure 3.

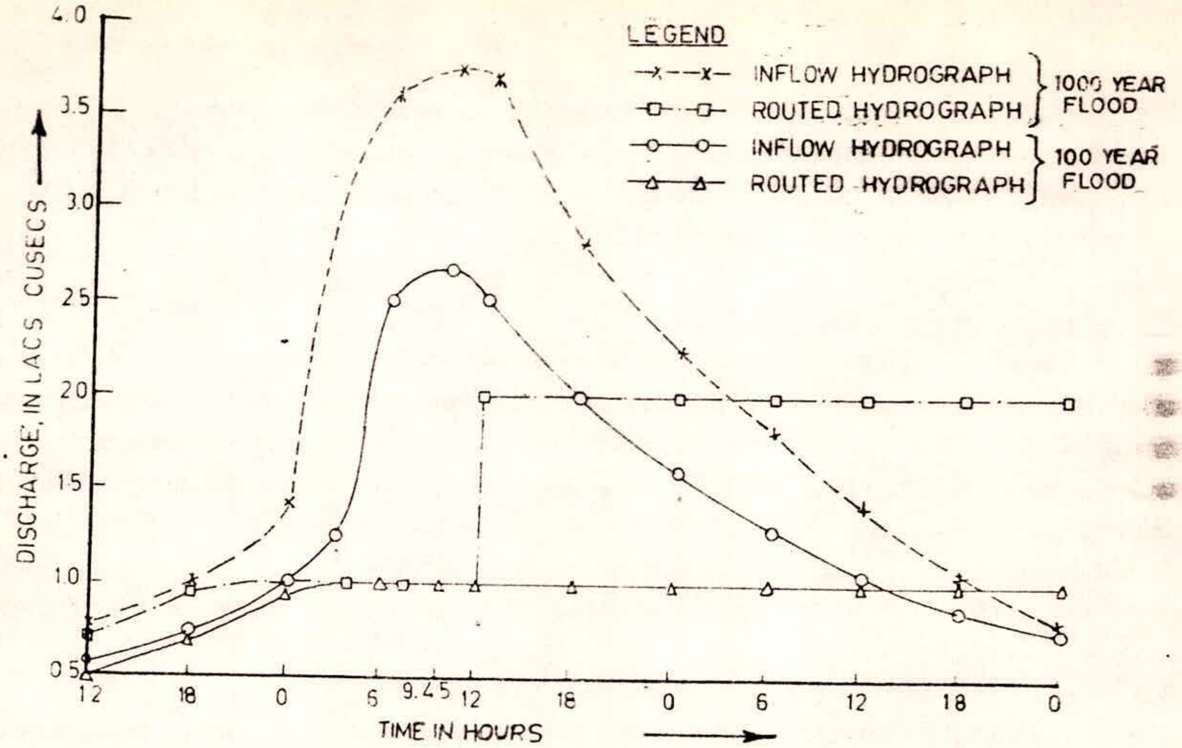

Fig. 2 Inflow and Routed Hydrographs

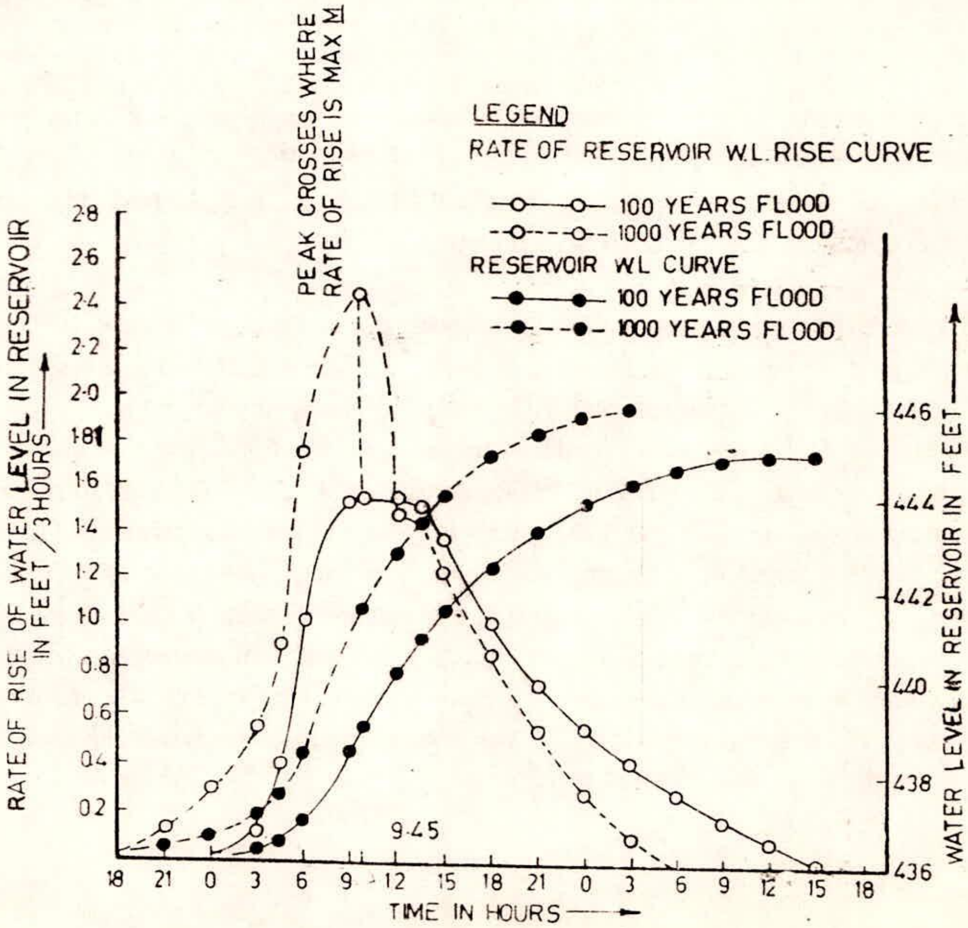

Fig. 3 Reservoir Water Level and its Rate of Rise

Table 1 - Reservoir Release Policy during Flood for 100 years Frequency Flood

Policy No.	Reservoir Water Level, in feet	Release Policy (Outflow), in cusecs
1.*	432-434**	Smaller of 50% of Inflow or 40,000
	434-436	Smaller of Inflow or 60,000
	436-440	90,000
	440-445	1,60,000
2.	436-438	Smaller of Inflow or 60,000
	438-440	90,000
	440-445	1,60,000
3.	438-440	Smaller of Inflow or 90,000
	440-445	1,60,000
4.	> 436	Smaller of Inflow or 1,00,000

* *Original stipulated reservoir flood operation policy as given in the project.*

** *In case heavy rainfalls are anticipated start routing from RL 432, otherwise, from RL 434.*

Table 2 - Reservoir Release Policy during Flood for 1000 years Frequency Flood

Policy No.	Reservoir Water Level, in feet	Release Policy (Outflow), in cusecs
1*	As per Original Stipulated Policy	As per Original Stipulated Policy
2.	436-440	Smaller of inflow or 1,00,000
	440-445	2,00,000

* Policy No. 1 of Table 7.

Table 3 - Flood routing Results for 100 years Frequency Flood

Policy No.	Maximum rise in Water Level in Reservoir, in ft.	Peak Outflow from Reservoir, in lacs cusecs	Reduction in Inflow Peak, in lacs cusecs
1.	443.110	1.6	1.08
2.	442.665	1.6	1.08
3.	443.890	1.6	1.08
4.	444.894	1.0	1.68

Table 4 - Flood Routing Results for 1000 years Frequency Flood

Policy No.	Maximum rise in Water Level in Reservoir, in ft.	Peak Outflow from Reservoir, in lacs cusecs	Reduction in Inflow Peak, in lacs cusecs
1.	447.111	1.6	2.15
2.	445.789	2.0	1.75

3.0 CONCLUSIONS

1. It has been seen that limiting the outflow to 1.6 lacs cusecs as per original flood operation policy, it is possible to increase the conservation storage to R.L. 438 in case of 100 years frequency flood. Increase in conservation storage results utilisation of flood storage for irrigation.
2. With the revised flood operation policy number 4, Tables 7 and 9, for the 100 year flood, a balance has been reached, i.e., maximum outflow has been further lowered by limiting it to 1.0 lacs cusecs and raising the maximum monsoon storage level to R.L. 436.
3. For 1000 years frequency flood, with the modified flood operation policy number 2. Tables 8 and 10, it may also be possible to moderate the flood peak to 2.0 lacs cusecs. This shows a reduction of 45 percent in the inflow flood peak of 3.75 lacs cusecs.
4. The time at which the flood peak has occurred can be known from the point at which, the maximum rate of rise of reservoir water elevation has taken place.
5. For the reservoir design flood (100 years frequency) and for the spillway design flood (1000 years frequency), the maximum reservoir routed outflow up to the R.L. 440 is 1.0 lacs cusecs. Beyond this level, the maximum routed outflow has to be increased to 2.0 lacs cusecs for the spillway design flood only.

This requires proper identification of the type of flood approaching the reservoir, in terms of its frequency well before the full utilization of the flood storage space is made in the reservoir.

4.0 REFERENCES

Roy, S.K., 1983. Flood Routing Study of Kangsabati Reservoir, M.E. Special Problem, International Hydrology Course, School of Hydrology, Univ. of Roorkee, Roorkee.

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