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Reservoir Operation Techniques

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RESERVOIR OPERATION TECHNIQUES

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ABSTRACT

To meet the increasing demands of water due to urbanization, industrialization and modern agricultural practices, there is necessity to conserve the limited available water resources through scientific management strategies and achieve optimal utilisation of the conserved resources. The advancements made in modern technology in the field of system analysis techniques and the computer facilities available should be effectively utilised for planning and management of the basin as an unit instead of the present project oriented approach. The conventional methods must be replaced by the modern scientific approach and the easy availability of personal computers should be fully utilised as an useful tool in helping the decision makers to select the best out of the number of feasible alternatives. This paper describes the guidelines for the operation of reservoirs. System Engineering Techniques, which are used for integrated operation of multipurpose multireservoir have been explained in detail. Real Time Operation of Reservoirs, where decisions regarding releases are taken relatively quickly for deriving maximum benefits of conserved water, based on inflow forecasts have been included. Certain thrust areas, where further research is necessary have also been identified.

1.0 INTRODUCTION

Water is the most precious resource of nature, especially in countries like India, where the distribution of water resource with respect to space and time is quite uneven. The importance of optimal utilisation and conservation of available water resources can, therefore, not be under estimated. With the increase in population and overall economic development in the country, water demands for various basic and developmental purposes have increased considerably. The utilisable resources are finite in extent and can not be expanded to meet the growing needs of the population, agriculture, industry and domestic sectors. The various uses of water for irrigation, hydro electric power generation, industrial and municipal water supply with concurrent flood protection are not only competing but also conflicting sometimes. Due to this the water resources planners and managers are facing a challenging task of developing and managing the limited water resources of various river basins in the country.

The main source of water is the surface run-off in the form of rivers. The flow in the river changes seasonally and from year to year, due to temporal and spatial variation in precipitation. Thus, the water available abundantly during monsoon season, becomes scarce during non-monsoon season, when it is most needed. The flow may be exceedingly high during monsoon and may cause extensive damage in the form of floods. During floods, a lot of water flows unutilised. The traditional method followed for meeting water demands during the scarce period, is construction of storage reservoirs. The excess water during the monsoon season is stored in such reservoirs, for eventual use in lean period. Construction of storages also helps in controlling and mitigating flood damages as well as generation of hydel power. To meet the objectives setforth in planning a reservoir or a group of reservoirs and to achieve maximum benefits out of the storages created, it is imperative to evolve guidelines for operation of reservoirs.

Construction of storage reservoirs will have to be followed by the evolution of certain guidelines for their operation. Operation of reservoirs without a proper regulation schedule entails a considerable risk as the objectives of the project may not be fully realised apart from danger to the structure itself. If the reservoir is not filled up in the early stages to accommodate probable high floods, it may not be filled up adequately at a later stage, if the anticipated inflows do not occur. On the other hand, if the reservoir is filled upto FRL in the early stages of the monsoon to avoid the risk of reservoirs remaining unfilled at later stage, there may be problem of accommodating high floods occurring at later stage.

So far a project oriented approach was adopted in the country, but now the need for planning the basin as a whole is felt for the optimum utilisation of the Water resources Under the dictates of the National Water Policy, 1987, the river basin is considered as a hydrologic unit, within which water resources planning, development and management should take place. With the advent of high speed computers, there has been spectacular development in the field of water resources system engineering during the last two decades. The achievements made in the modern technology of systems analysis techniques and the computer facilities available can be used effectively for integrated and optimal planning and management of water resources, considering multiplicity of objectives.

The main purpose of this paper is to acquaint the water resource engineers about the general guidelines for the operation of resevoirs, to explain about the application of system engineering techniques and to identify the thrust areas in the field of reservoir operation to make the optimum utilisation of the limited available water resources to meet the increasing multipurpose demands.

2.0 GUIDELINES FOR OPERATION

Determination of an optimum mode of operation for the reservoir has always been a complex task because of the allocation to competing and conflicting uses. The efficient management and operation of reservoir system calls for complex engineering and mathematical technologies coupled with excellent managerial judgment. The main difficulties stem from the randomness and stochastic nature of the inputs, the multiobjective and conflicting nature of the needs of the number of decision variables of the problem to be solved both in temporal and spatial horizons. In reservoir operation analysis, the problem is to be optimised between the immediate use of available stored water and its preservance to meet future demands with the possibility of deriving maximum benefits. Reservoir operational decisions are generally based on rule curves and the judgment of the operator is responsible for day to day operations.

2.1 Rule Curves

Rule curves are often used as a guide in actual system operation and generally specify the storage or empty space to be maintained in a reservoir during different times of the year. Rule curves are generally derived by simulation of historical/generated flows. The implicit assumption in deriving the rule curves is that a reservoir can best satisfy its purposes, if the storage levels or the empty space specified by the rule curve are maintained in the reservoir at different times. The amount of water to be released from the reservoir, generally depends upon the demands, inflow to the reservoir and available storage. It does not give the amount of water to be released.

Sometimes due to certain conditions like low inflows, minimum requirements for demand etc., it may not be possible to stick to the rule curve levels. In such cases, it is desirable to have minimum variation from rule curve by curtailing the releases, if the actual levels are below the target rule curve levels or by releasing extra water upto the safe carrying capacity of the channel, in case the actual levels are above the rule curve levels. The rule curves implicitly reflect the established trade-off among various project objectives in the long run. For short term operations, they serve only as a guide and it may not always be possible to strictly follow the rule curves.

2.2 Classification of Reservoirs

For the purpose of reservoir regulation, reservoir can be classified into following types :

2.2.1 Single Purpose Reservoirs

These reservoirs are developed to serve only one purpose, which may be flood control or any of the conservation uses as irrigation, power generation, navigation, industrial use, domestic water supply etc.

2.2.2 Multipurpose Reservoir

These reservoirs are developed to serve more than one purpose, which may be a combination of any of the conservation uses with or without flood control.

2.2.3 System of Reservoirs

These consist of a group of single/multiple purpose reservoirs, which can be operated in an integrated manner for optimum utilisation of the water resources of the river system.

2.3 Preparation of Guide/Rule Curves

Some of the commonly adopted procedures for development of rule curves/guides for reservoir regulation are briefly described below :-

2.3.1 Single Purpose Reservoir

For conservation, the operational schedule of a conservation reservoir would usually consist of two parts one for filling period and the other for the depletion period. For each project it will be necessary to prepare guide curves separately for the filling period and for the depletion period. The guide curves for filling period can be developed from a study of the stream flow records over a long period. All water in excess of the requirements of filling period shall be impounded. No spilling of water over the spillway will be normally permitted until the FRL is reached. Should any flood occur, when the reservoir is at or near the FRL, release of flood waters shall be affected, so as not to exceed the discharge that would have occurred had there been no reservoir. In case the year happens to be dry, the draft for filling period shall be curtailed by applying suitable factors. These will show the limits in which reservoir levels are to be maintained during different times of the filling period, for meeting the conservation design commitments. When regulation is guided by such curves, it would be apparent, when restrictions are to be imposed on utilisation. However, in case the reservoir is planned with carry-over capacity, its regulation will provide the carry-over capacity to be ensured at the end of the depletion period.

Operation of flood control reservoirs is primarily governed by the available flood storage capacity, type of outlets, location and nature of areas, damage centers to be protected, flood characteristics, ability and accuracy of flood/storm rainfall forecast and size of the uncontrolled drainage area.

2.3.2 Multipurpose Reservoirs

In case of Multi-purpose reservoir operation shall be governed by the manner in which various uses of the reservoir have been combined.

When in a multi-purpose reservoir separate allocations of capacity have been made for each of the uses in addition to that required for flood control, operation for each of the function shall follow the principles of respective function. The storage available for flood control could also be utilised for generation of secondary power to the extent possible.

When in a multipurpose reservoir joint use of some of the storage space or stored water has been envisaged, operation becomes more complicated. While flood control requires low reservoir levels, conservation interests require as high a level as is attainable. Thus the requirements of these functions are not compatible and a compromise will have to be affected in flood control operations by sacrificing the requirements of these functions. Major floods occur in most rivers of India during the south-west monsoon season (July to October). Some portion of the conservation storage is utilised for flood moderation during the earlier stages of the monsoon. This space has to be filled up for conservation purposes towards the end of monsoon, progressively as it will not be possible to fill up this space during the post-monsoon periods, when the flows are insufficient even to meet the current requirements. This will naturally involve some sacrifice of the flood control interests towards the end of the monsoon.

Where joint use of some of the stored water is envisaged, operation shall be based on the priority of one use over the other and the compatibility among demands for different uses.

2.3.3 System of Reservoirs

For the preparation of regulation plans for an integrated system of reservoirs, principles applicable to separate units are first applied to the individual reservoirs. Modification of the schedules so developed shall be then considered by working out several alternative plans based on the co-ordinated operation and the best plan selected. Principal factors considered are usually the following :

For flood control regulation - The basin-wise flood conditions, the occupancy of flood reserves in each of the reservoirs, distribution of releases among the reservoirs and bankful stages at critical locations shall be considered simultaneously. For instance, if a reduction in outflows is required, it shall be made from the reservoir, having the least capacity occupied or has the smaller flood run-off from its drainage area. If an increase in release is possible, it should be made from the reservoir where the percentage occupancy is the highest or relatively a higher flood run-off is occurring.

Higher releases from reservoirs receiving excessive flood run-off may be thus counterbalanced, particularly in cases of isolated storms, by reducing releases from reservoirs receiving relatively less run-off.

For conservation regulation, the current water demands for various purposes, the available conservation storage in individual reservoirs and the distribution of releases among the reservoirs, shall be considered to develop a co-ordinated plan to produce the optimum benefits and minimize water losses due to evaporation and transmission.

3.0 SYSTEM ENGINEERING TECHNIQUES

System engineering is a powerful tool, which can be used to achieve certain tangible and non-tangible objectives without much risk of loosing probability by examining and selecting the best among them. Most of the water resources problems are multiobjective. These objectives may be of benefit to some and may affect others. A planner, therefore, has to select a healthy and most acceptable set of objectives for which system engineering techniques like simulation and optimisation come handy. The achievements made in the field of systems analysis techniques and the computer facilities available are used effectively for integrated and optimum planning and management of water resources.

3.1 System Engineering Approach

Reservoir is a source of supply for irrigation, drinking water, hydro power, flood control etc. Reservoir operation thus assumes greater significance in view of its large potential for conservation of water resources. Reservoir operation is a complex process, as both water and storage have to be allocated for competing and conflicting uses over an extended period of time. Most of the reservoirs are now operated with conventional methods, resulting in inefficient utilisation of water.

A system engineering approach to the water resource system is a systematic analysis and design of the numerous choices and options to the planners, economists, policy and decision makers. Not only must a much larger number of alternatives be considered, but each alternative representing a complex problem of inter-related effects must be evaluated in respect of their effects at various locations. System engineering approach offers a dynamic facility for continuous evaluation and replanning to encounter the challenging scenarios. It can markedly improve the planning and operation of water resources systems, provided that both the managers and analysts are clear about the limitations of this approach.

There are a variety of mathematical modeling techniques viz. analytical, optimisation, probabilistic models, simulation models etc. The digital computers have the advantage of handling large amount of data, flexibility, efficiency and to analyse vast data for mathematical models. There is no general algorithm that covers all types of problems. The choice of techniques depends upon the characteristics of the system, the availability of data, objectives and constraints. The mathematical techniques, which have extensive application in the field of water resources are linear programming, dynamic programming, goal programming, integer programming, simulation techniques etc.

3.2 Need for System Engineering

In classical approach water resources planners and designers were familiar with consideration of projects in isolation and the projects were implemented to serve limited objectives. Since the projects were few, interactions between projects was absent and each project could be investigated and implemented independently. But now due to increased concern for economic efficiency in water resource investment, and pressure on water and financial resources, the need to exploit the complementarity between the various interacting, interrelated and interdependent components has come to the forefront. The following are some of the points necessitating the application of system engineering approach:

i) Water resource projects typically involve large scale integral, more or less permanent physical changes such as creation of reservoirs, protection of flood plains, canals for water supply etc.

ii) The expertise of many traditional disciplines like hydrologists, meteorologists, engineers, agronomists, environmentalists, economists, legal experts etc. are simultaneously called for.

iii) The large capital intensive characteristics of investment and the major effects on the economy of the region highlight the desirability of achieving even small improvement over the traditional design.

iv) Availability of high speed computers, capable of examining various feasible alternatives to arrive at the most economical and acceptable mode of development, which otherwise might have been ignored for want of time and manpower required for computation.

3.3 System Engineering Concepts

Water Resources system is very complex in nature because of multiplicity of goals and alternatives. Since there is only one chance of developing the system and the process is irretrievable, the planner has to adopt the best among the various alternatives. Because of this inherent nature of the water resources system, logical procedures are required which can rationally eliminate alternatives, reduce thousands of decisions to relatively few on the basis of rather formidable mass of information.

Hall and Dracup has defined system engineering as an art and science of selecting from a large number of feasible alternatives, involving substantial engineering content that particular set of actions which will best accomplish the overall objectives of the decision makers, within the constraints of law, morality, economics, resources, political and social aspects and the laws governing the physical life and other natural sciences. The art consists of elimination of large number of alternatives based on the judgment without the necessity of a detailed analysis. However, even after applying the judgment, a number of potentially valuable alternatives are left. The science of system engineering is required to achieve the best feasible alternatives by evaluating these relatively small number of alternative combinations. System engineering aids a decision maker to arrive at better decisions than otherwise possible, by better understanding of the system and inter-linkages of various sub-system by predicting the consequences of several alternatives, course of action or by selecting a suitable course of action which will accomplish the desired results.

3.4 System Objectives

The basic motivation of Government planning and developing water resources is usually improvement in national or regional welfare. The delineation of a government's objective function is a problem of great importance to social, economic and political analysis, but it is an area involving conceptual difficulties. The following are some of the objectives:

i) Increasing national income
ii) Promoting national self-sufficiency
iii) Redistribution of consumption (diversion to backward regions, low income groups or sectors).
iv) Preservation of the quality of the environment

3.4.1 Objective Function

Ideally, the formulation of objective is an initial step of planning process. The system approach does demand a major explicit articulation of objectives. The objective function is any statement by which the consequences or the outputs of the system can be determined, given the policy, the initial values of the state variables and the system parameters. The usage is, however, generally limited to the term to the determination of those quantitative objectives, which are fully commensurate. Water resources systems are particularly troublesome in this regard because there are many non-commensurate and nonquantitative objectives. Another complicating factor is a very large number of decision variables which require a number of stages or rational decomposition to break the system down into manageable subsystem.

3.5 Tools Available

In order to evaluate the system performance, it is necessary to have a model, which is simplified representation of reality. The model conceptualises the real system and makes the actual situation in real world less complex. Using the models, various alternative systems and policies can be evaluated without interfering with the real system or actually having a prototype. The mathematical model provides a link between the description of the system and electronic computers by means of operational mathematical techniques. The best feasible alternative can be found using simulation or optimisation techniques, which are briefly described below :

3.5.1 Simulation

Simulation is a process of designing a computerised model of a system and using it for understanding the behavior of the system and for evaluating various strategies for its operation. In simulation, any arbitrary or judgementally selected decision set is evaluated directly for its objective and constraint responses. Simulation begins with a trial decision set, evaluates it and then uses mathematical logic to determine the second trial set. The trials are continued till the optimal results are obtained.

3.5.2 Optimisation

Optimisation is the science of choosing the best solution from a number of possible alternatives, without having to evaluate beyond all possible alternatives. Optimisation implies use of an appropriate optimisation model in conjunction with an optimisation algorithm. Optimisation methods find out a set of decision variables such that the objective function is optimised. The most common optimisation algorithm are calculus method, linear programming, dynamic programming, non-linear programming and goal programminng.

a) Calculus Method

If the optimisation problem consists of a continuous and differentiable objective function f (x , x .....x) to be maximised or minimised, their partial derivatives with respect to any x would change sign for any maxima or minima. If the x are all independent decisions, then the set of n algebraic equations representing $f/x_i = 0$ constitute a set of algebraic equations and n unknown x . these can be solved as a set of simultaneous equations to determine one or more x for which the results might be maximum or minimum.

Real life problems are always constrained either on availability of resource or system capacity or both. Solving constrained problems with inequality constraints is more difficult. Because of the mathematical complexities involved in formulating and solving water resource problems, calculus approach is rarely used.

b) Linear Programming

Linear programming (L.P.) is a very popular optimisation technique and finds applications in many disciplines and in the field of water resources systems, as a result of the readily available software packages of algorithm. The disadvantage of L.P. technique is primarily the limitation of its use for linear relationship only. Since most of the functions involved in water resources planning are non-linear, they are approximated by piecewise linearlisation for obtaining the optimal solution.

A typical linear model is

$$\text{Maximise } Z = b_i x_i$$

$$\text{Subject to } A > C$$
$$X > 0$$

Where b = benefit coefficient, n-dimensional
x = decision variables, n-dimensional
c = m - dimensional constants
A = m x n matrix

c) Dynamic programming

Dynamic programming (D.P.) is a powerful analytical optimisation technique, widely used in system analysis approach to water resources system designs, operations and allocation problems. The popularity and success of this technique can be attributed to the fact that the non-linear and stochastic features, which characterise a large number of water resource systems can be translated into a D.P. formulation. In addition, it has the advantage of effectively decomposing highly complex problems with a large number of variables into a series of subproblems, which are solved recursively.

The generalised recursion equation is:

$$f_t(Q_t) = \text{Max.}R_t\,[f_t(Q_t, R_t) + f_{t-1}(Q_{t-1}, R_{t-1})]$$

where $f_t(Q_t)$ represents optimal return

Q_t is the release quantity in stage t.

Major drawback of DP is its curse of dimensionality. When the number of stage variables increases, the computational load by this method increases exponentially.

d) Non-Linear Programming

Non-linear programming has not enjoyed the popularity that LP and DP have in water resources system analysis. This is particularly due to the fact that the optimisation process is usually slow and takes large amount of computer storage and time. The mathematics involved is much more complicated than linear programming. A major drawback is that the solution obtained by this technique does not ensure a global optimum and all possible local optimum solutions have to be exhausted.

e) Goal Programming

Goal Programming (G.P.) is a popular technique capable of considering multiple goals in the objective function. In contrast to the L.P. model, hierarchy of goals defines the operations objectives of the goal programming. In G.P., all the objectives are assigned target levels for achievement and a relative priority on achieving these levels. G.P. treats these targets as goal, but not as absolute constraints (mandatory) and attempts to find an optimal solution, as closely as possible, to the targets in the order of specific priority, whereas the real constraints are absolute restrictions on the decision variables. The method uses simplex algorithm for finding optimal solutions of a single or multi-dimensional objective function with a given set of constraints, which are expressed in linear form. It is based on the minimisation of weighted absolute deviations from targets of each objective. This technique is essentially a sequential optimisation process, in which successive optimisations are carried out as per priority. G.P. has been shown to be a very useful tool for multi-objective decision making and is computationally efficient.

4.0 REAL TIME OPERATION

The term "Real Time Operation" is used to denote that mode of operation for which the control decisions for a finite future time horizon are taken based on the conditions of the system at that instant of time, when the decision is to be taken and the forecast about the likely inputs over this time horizon. In real time operation, the decision regarding releases generally depends upon the state of reservoir at that instant, inflow forecast, penalties for deviation from target storage and the conditions downstream. The release decisions have to be made relatively quickly based on short term information. The definition of short term varies in accordance with the purpose of the reservoir. For flood control operations, it may be daily or even hourly, whereas for irrigation the short term may be a week, 10-day or a month.

The inflow forecasts are compared with the actual values and the forecasts updated at suitable intervals. Control decisions are modified in the light of updated forecasts.

Optimum real time operation of reservoirs require the best releases to specify various long term system purposes keeping in view the short term limitations on operation due to physical constraints, while using forecast formation. Real time operation is especially suitable during floods, where the system response changes very fast and the decision have to be taken rather quickly and adapted frequently. The operation incharge relies on information provided by water control data system for making decision necessary for daily scheduling.

4.1 Necessity of Real Time Operation

Generally the operation of reservoir system is based on certain operation rules, developed from historical or synthetic time series of hydrological variables and taking into account the demands of the past. But the probability of actual occurrence of an event in the same way as the prior event of the same type is very small. Also during daily water operations special situation or unanticipated condition may arise which require that a certain degree of flexibility be maintained to depart from normal operation criteria, if necessary. Unusual occurrence such as heavy rain in the command or areas downstream of dam may affect the water requirements for a particular period and accordingly the release decision. In addition, the regulation may have to be modified for special purposes such as maintaining water levels on a short term basis for construction/repair activities in downstream waterways, maintaining minimum flows, minimum reservoir levels for hydel generation or recreation etc.

All the above conditions require judgmental decisions to adopt the operating rules to real time management. A reservoir system can be operated efficiently, if the time interval between the occurrence of the event and the execution of the control adapted for this event is short. To react for the current situation, considering the variability of the inflows into the reservoir system, the real time operation models are developed.

4.2 Components of Real Time Operation

Real time operation has great flexibility as compared to conventional methods of operation. It not only considers the current set of the system but also takes into account the meteorological and hydrological forecast. For successful application of real time operation techniques, it is essential to have the following :-

i) Suitable network for data collection & transmission

ii) Real time flow forecasting

iii) Scheduling Project Regulation based on (i) and (ii)

4.2.1 Data Collection and Transmission

For real time operation, it is necessary to collect data at short time intervals and have an efficient data transmission system. It is important to have a suitable network of hydrometeorological stations within the basin. A close coordination with meteorological department for the supply of various meteorological data and forecast is essential. Short duration rainfall, snow fall, temperature, humidity, wind speed and other meteorological data alongwith river and reservoir gauges, discharges at important points are to be collected and transmitted to the central station at the earliest.

The frequency at which the data is required depends mainly on the purpose of the reservoir. For flood control, the data may be required at short intervals or even hourly during critical periods; whereas for conservation purposes, the requirements may be daily, weekly or 10-daily depending upon the conditions of the reservoir.

Historically manual observations of water control parameters represented the backbone of hydrometeorological system. Even with more advanced systems, there may still be a need to incorporate manual observations into the networks. They may serve as a backup to the automated systems and may also be necessary for observing hydrometeorological parameters, that cannot be economically feasible or desirable to construct, operate and maintain an automatic system. Efforts may, however, be made to automate the network as quickly as resources will permit.

Manual observed data are usually transmitted to Incharge operations by telephone or by wireless. In recent years, full automation of field station reporting has replaced manual system. The installation of an automatic data handling system depends upon the time interval of transmission, time required for transmission, chances of errors in repeatedly handling the data, the ability to physically process the vast amount of data. Data transmission may be through one of the following media :

i) Ground based VHF radio
ii) Land line transmission
iii) Meteor - burst communication
iv) Satellite Communication

a) Ground Based VHF Radio

Very high frequency line of sight communication is used with wireless sets having repeater stations in between, if necessary. This is an efficient system, but costly and unsuitable for inaccessible areas. In this system, the station can be interrogated and voice communication is available.

b) Land Line Transmiss on

Data from field station is acquired by P&T land line channels and also over wireless transmission. The required data is inserted in the computer system interactively.

c) Meteor-Burst Communication

In this system, the data signal from the remote station is broadcast up and it gets reflected from a passing meteor to the receiving station. This is an intermittent, but effective communication system.

d) Satellite Communication

The system consists of data collection platforms (DCPs), sensors of various types, a 7 meter Direct Read-out Ground Station (DRGS) and associated decoding electronics and a central computer facility to serve as a network controller for communication and data processing. In this system DCP records data at every 15 minutes and it is transmitted every 3 to 4 hours to the central station. In this method, the station can not be interrogated, since the communication is one way from the remote station.

However, even after the installation of automated system, there may still be a need for manual interrogated equipment for backup and for users with less sophisticated needs to obtain river data.

4.2.2 Flow Forecasting

The success of Real time operation depends upon the flow forecast and the lead time of the forecast. Timely warning of an extreme flood event helps in taking prior action for making pre-releases to accommodate the floods and to warn the concerned authorities and affected people downstream to take timely preventive measures. The main component of inflow forecast are weather forecasting, if possible and rainfall-run-off or run-off-run-off modeling using various parameters. The forecasting could be long term or short term. The long term forecasting of monthly or seasonal flows etc. generally involves generation of random events, which preserve to a certain extent, the statistical behavior of the hydrological data. The short term forecasting is done in real time and the processing and analysis is done at the same time, when the events take place. The forecasts are continuously updated based on observed values. The inflow forecasts can be done using rainfall-run-off or run-off-run-off modeling in combination with channel routing. A number of models like HEC 1-F, SSAAR, Sacramento, Stanford, Watershed, NAM etc. are available for flow forecasting utilising the observed hydrometeorological data. One of these or any other model depending upon the site conditions can be used for Real Time forecasts.

4.2.3 Scheduling Project Regulation

The main purpose of real-time system analysis studies to provide the Incharge Regulation with the ability to simulate the proposed regulation and thereby anticipate the effects of operating decisions on future regulation. The simulations are based on knowledge of the present and future conditions, in order to analyse the effects of various alternatives of regulations and expected weather conditions. Each day the Incharge Regulation must appraise the current regulation by comparing actual and guide curve reservoir levels, together with the system demands for various uses. The scheduling of project regulations may be based on the conditions of streamflow and water levels either at the downstream control points or at the project. After evaluating current conditions, it is necessary to consider the input from others, which affect project schedule e.g. immediate water requirement for various purposes, the current meteorological conditions and the latest weather forecasts. Thus a continuous interaction with various data collection, flow forecasting and user agencies is necessary. Appropriate computer model may be used to account for the effect of each of the hydrologic and project regulation elements in order to analyse the system response to various alternative project reschedules on hydrologic events. Daily schedules and operating instructions must be transmitted in time from the water control centre to each project office. The information allows the project operators to be aware of scheduled operations of upstream projects, which may affect the operation of their projects and provide complete understanding of the total system regulation.

5.0 DATA REQUIREMENTS

Most system analysis techniques are data intensive. Data requirements for system studies depend on the objectives of the study. The data generally required for multi-disciplinary water resources planning using system analysis techniques may include the following:

a) Water Supply and Requirements

Water supply, rainfall, run-off, short duration flood and rainfall data, evaporation, sedimentation, groundwater, water demand; present, proposed and projected irrigation, municipal and industrial, power and ecological requirements.

b) Engineering

Identification of new projects, Land use features, topography, construction material availability, design and costing of new dams, data on power potential generation etc.

c) Agronomy

Agrometeorology, agriculture, soils etc.

d) Environment

Watershed features, forest, wild life, other flora, archaeological monument, mineral deposits, waterlogging, salinity, water quality, low flow set.

e) Economics

Population, socio economic condition, food grain production, consumption, off-farm income, flood damage statistics etc.

6.0 CONCLUSIONS

The water resources scenario of the country is not very encouraging, with the vagaries of monsoon and wide variation in spatial and temporal distribution of rainfall. Necessity has risen now for conservation of the available water resources and their effective management using scientific approach, so as to meet the increasing demands. The situation calls for an optimum utilisation of the limited water resources through integrated operation at river basin level for the projects already developed and for integrated planning for the new projects, so as to utilise the limited water resources in most efficient and optimal manner. The following points about the system engineering may be considered while applying the techniques:-

i) System analysis is not a means of making decisions. Rather it is a means of helping responsible officials to make decisions. It is not a mechanical or mathematical substitute for the good judgment, wisdom and leadership of the official. System analysis cannot replace experience, it augments it.

ii) System analysis techniques have the potential of significantly improving water resources planning and management. The use of these techniques will increase rapidly with increasing complexities of water resources development problems, as no other present technique can provide the objectivity and flexibility required for solution.

iii) Improvement in hardware and software capabilities will further assist this development. This will always remain an adjunct to the managers in the field and not a replacement for professional experience. It will always be necessary to recognise the limitations of the techniques in planning and managing water resources systems.

iv) System analysis can markedly improve the planning and operation of water resource systems, provided that both the managers and system analysts are clear about the limitations of the techniques for the problem.

v) Benefits from such planning studies not only exceed the cost but in fact can make substantial projects saving over time.

The usefulness of the adoption of system analysis will be accelerated if some of the following points are kept in mind:-

i) The communication and understanding of the system analysis should be aided by less mathematically oriented discussions' emphasizing the links between system approach and more traditional techniques and utilisation of discussions that emphasize the strength and limitation of the approach rather than mathematics.

ii) More participation by operational personnel should be encouraged so as to have their practical difficulties and limitations in view.

iii) Balance should be maintained in system studies between temptations to model in extreme detail or to model with assumptions so gross as to eliminate the usefulness of the analysis. The methodology needs to be adapted to suit particular situations to achieve the desired objective and to assist the decision maker.

In view of the above, some of the thrust areas can be as below :-

i) Although a number of models for system studies have been developed/obtained from various countries, yet they may not be applicable to Indian conditions. It would be desirable to modify these models or develop new models to suit Indian conditions.

ii) With the easy availability of PCs, it is essential to make the models operational on PCs and to develop PC based models.

iii) Most of the reservoirs are being presently operated with conventional techniques using personal judgment, it would be desirable to inculcate the habit of using computers and system engineering techniques as a tool for assisting the operation decisions.

iv) Since the irrigation in India is based on 10-daily periods, the model should be able to accommodate regular 10-day periods and varying annual irrigation demands.

v) Since most of the reservoirs are developed and used to meet multi purpose competing and conflicting requirements, it would be worthwhile to examine the possibility of storing water in flood control zone during the exceeding monsoon period for conservation purposes.

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