CAPACITY EXPANSION OF A WATER RESOURCES SYSTEM

A THESIS

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By

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Gratis

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled **CAPACITY EXPANSION OF A WATER RESOURCES SYSTEM** in fulfillment of the requirement for the award of the degree of **Doctor of Philosophy** and submitted in the **Department of Hydrology, University of Roorkee,** is an authentic record of my own research work carried out during a period from February 1995 to June 1998, under the supervision of **Professor D.K. Srivastava.**

The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other University.

Date: July, 07, 1998

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This is to certify that the above statements made by the candidate are correct to the best of my knowledge.

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ABSTRACT

Comprehensive river basin water resources planning is a complex and very difficult task posing numerous social, economic, environmental, and engineering problems. While planning for the development of a big river basin it is always necessary to take into account the various aspects of long-term river basin planning. One such implied aspect is the determination of sequence of development of various reservoirs. The sequencing of various reservoirs should be such that the decisions taken on grounds of exigency and expediency do not lead to infructuous and wasteful investments in the long-run. Nowadays it is very much possible to carry out such studies using modern systems analysis techniques and computing facilities.

The specific problem in question is of obtaining a sequence of development of the reservoirs for capacity expansion of a multipurpose, multifacility system on the Narmada river in Central India, to meet current and forecasting growth in demand of water for irrigation and hydropower. The system consists of 30 major reservoirs, out of which, 10 are situated on the main river, the remaining 20 on nineteen tributaries, which include 2 in series on a tributary, and the other 18 are independent of each other and are situated on eighteen tributaries. The development is proposed in two Phases spread over 45 years as

stipulated in the Master Plan. The various alternative configurations are to be analysed, based on the various proposals and engineering considerations for obtaining the optimal water use targets from reservoirs and subsequently the optimal sequencing of the reservoirs over alternative planning horizons is to be obtained.

The approach is to arrive at a suitable methodology to identify the minimum cost sequencing of reservoirs in the river basin for its development subjected to technological, economical and policy constraints. In view of the large number of reservoirs being involved and the planning nature of the present study, the neighbouring similar reservoirs have been suitably clubbed. A detailed flexible simulation model is effectively used for fixing the annual irrigation targets of reservoirs with irrigation and also for quantifying the effect of upstream reservoir(s) on annual firm hydropower targets of reservoirs with hydropower on the basis of water use dependability criteria. For this 22 years flow data is used. Further, a deterministic backward dynamic programming process for tackling the reservoir sequencing problem, has been evolved and used in both the Phases. For analysis a few system demand patterns and planning periods in both the Phases have been formulated on the basis of data available.

Suitable computer programs have been developed for simulation and for sequencing. These programs are efficient, flexible, convenient and useful tools for obtaining sequencing of multipurpose, multireservoir system.

Initially, assuming that all 30 reservoirs are existing in the system, the individual reservoir wise as well as combined simulation runs for all the 30 reservoirs were undertaken starting from upstream to downstream for fixing the final simulated irrigation targets of each of the irrigation reservoirs.

Secondly for 14 Phase I reservoirs the initial and the final simulated firm hydropower targets of hydropower reservoirs were determined. In each case, the irrigation targets were kept constant as obtained in the previous para. Further, sequencing of the Phase I reservoirs was done using the sequencing model.

Finally, 16 Phase II reservoirs were sequenced in similar fashion as in Phase I. Looking at the huge size of the problem due to the presence of a large number of reservoirs in both the Phases of development it was necessary to reduce the size of the problem by clubbing some of the small neighbouring reservoirs and calling the new system by projects.

In this study an attempt was made to blend the major advances of systems analysis by using simulation and sequencing models for capacity expansion. Dynamic programming has been used as an optimization technique for sequencing owing to obvious reasons of multistage sequential decisions involved in such problems. These models were effectively used for capacity expansion of the Narmada river water resources system. The large multipurpose reservoirs are found insensitive to sequencing parameters such as demand patterns, allowances for shortage and excess and corresponding penalties, etc. and tend assume almost a fixed position in sequencing over the recommended planning horizon of 14 periods. However, small and moderate size reservoirs are found sensitive to the sequencing parameters.

Three categories of targets have been considered, namely mixed, simulation and master plan for analysis and the simulation target sequencing is preferred and suggested for implementation amongst the recommended sequences. Trend of existing development is found to be matching with recommended sequences. Tradeoff between irrigation supply area fulfilled and hydropower supply for recommended as well as no penalty sequences is also studied. The agroclimatic zonewise distribution of the sequenced projects for the preferred simulation category sequence indicated evenly spread and balanced development of the system with respect to space (three zones) and time (planning horizon).

The use of proposed strategy of exhaustive analysis of all possible reservoir combinations by detailed simulation model and subsequently sequencing by optimization(DP) suggests a promising scheme for capacity expansion of a multipurpose, multireservoir system. Such a strategy is likely to guarantee an optimal capacity expansion path. The approach is feasible and efficient within a reasonable amount of computing time and efforts.

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INTRODUCTION

It is a no denying fact that water is an extremely important constituent of the geosystem. It is a vital natural resource essential for the very existence of the life on this planet. It has been closely related to the development of different civilizations and in future also it will continue to play the same role. The population of the world is exploding at an alarming rate and is estimated to reach 10 to 16 Billions by the year 2050 (U.N., 1973). Due to this, there is an acute pressure on water resources, and in coming years this will mount further. It has therefore become necessary to give more emphasis on careful planning for conservation and use of water resources.

Over the last few decades, water resources planning has evolved from a relatively straight forward methodology to a complex procedure. Planning is now more broadly based. Instead of stressing for a single project to meet a specific defined requirement, nowadays, all needs and opportunities for water resources development are considered in a region such as a river basin, as a large water resources system. The large scale water resources systems are usually consisting of multiple and multipurpose reservoirs and hence complex. Integrated planning for such systems is obviously a difficult task primarily due to the large number of possible development strategies which invariably require vast data handling and computational efforts for obtaining an optimal development plan. Despite these difficulties, it is being increasingly realised to have a comprehensive planning program that will determine an optimal development strategy because of the huge investment required in construction and operation of such large systems and also due to great potential for cost reduction through improved systems design. Systems analysis techniques can be effectively used to assist the planners and decision makers to accomplish these tasks.

Systems Analysis techniques have been well developed in theory as well as in practice. The tools of the systems analysis are therefore many but varied in their usefulness. Accordingly, it becomes necessary to first identify a set of the suitable techniques and then tailor them to suit a specific real life planning study.

1.1 PROBLEM IDENTIFICATION

The water resources planners usually aim at identification or development of possible water resources systems, designs or management plans and evaluation of their economic, ecological, environmental, and social impacts. In this, single or combined decisions are sought on selection, siting, sizing, target fixing, operation, capacity expansion, and financial planning etc. in respect of a water resources system.

Rapid economic growth and population growth have led to spiraling of water demands and eventually capacity expansion planning has gained significant importance in water resource development. It was therefore decided to focus attention on capacity expansion planning of water resources system, in the present study. It essentially involves the determination of sequencing of different projects in the system for meeting forecasting water demand over time.

Since the late 1950s, systems methodology has been successfully used to develop various techniques for solving classical water resources systems planning problems and their extensions. However, it has been generally accepted that real-life applications are required to validate the efficacy and worthwhileness of certain techniques. World over a considerable number of real-life casestudies on capacity expansion of water resources systems, have been reported in the literature. Some of the notable studies amongst them are Butcher et al.(1969), Kuiper and Ortolano(1973), Becker and Yeh(1974a,b), O'laoghaire(1978), Major and Lenton(1979), Helm et al.(1984), and Mazzola(1992). Neverthless, the following observations on these and other earlier studies are noteworthy:

(i) Mostly, either water supply system or hydropower system was analysed. The casestudies on multipurpose water resources systems are very rare.

(ii) Effect of interdependence of the reservoirs in the system on its expansion planning has been either ignored or grossly approximated.

(iii) Mostly, bulk simulation model was used for operating the system. Very few cases reported use of detailed simulation model. And also a limited number of configurations (states) of reservoirs were simulated after using screening criterion.

(iv) Generally sequencing of the reservoirs was tackled using forward dynamic programming process or mixed integer programming.

(v) Mostly, a reservoir was considered as a stage variable in case of dynamic programming. Very few cases considered time (period) as a stage.

(vi) Casestudies on the capacity expansion of a system consisting of a large number of reservoirs are rare.

Further, India is a vast country having many large and important inter-State river basins such as Ganga, Bramhaputra, Mahanadi, Narmada, Godavari, Krishna, Kaveri etc., to name a few. So far, the potential of these basins is not harnessed fully due to many reasons(inter-State water disputes, paucity of funds, etc.) and water resources development in these basins is still in its initial stages of development. The situation is more or less similar in many of the underdeveloped and developing countries in the world.

Keeping in mind the above mentioned considerations and recognizing the need of a suitable approach in the context of river basin developments in general and for India, in particular the present study is directed to evaluate the different developmental alternatives, and further the following objectives were set as the scope of this work.

1.2 OBJECTIVES OF THE PRESENT STUDY

The basic objectives in the present thesis can be broadly defined as under:

(i) To develop a backward dynamic programming process model for capacity expansion (sequencing) of reservoirs.

(ii) To test above developed model by applying it to a real life large scale river basin system consisting of multiple, multipurpose reservoirs and subsequently obtain the best possible sequence of development.

(iii) Before the sequencing model for capacity expansion is applied the following is to be investigated:

(a) To apply detailed simulation model for deciding the annual targets which could be supplied by a reservoir and also for investigating the effect of the interdependency of reservoirs in the system on these targets.

(b) To develop a methodology to simulate all the possible alternative configurations of reservoirs in the system in order to make use of this facility in the capacity expansion model also, in order to resemble and match it with the real life capacity expansion problem.

(iv) To develop suitable computer codes for detailed simulation and backward dynamic programming models.

(v) To draw suitable conclusions from the above results and the experience of applying the above simulation-optimization models for capacity expansion onto a large scale water resources system in order to use its full development potential in the best possible manner.

1.3 ASSUMPTIONS OF THE STUDY

(i) The central focus of the study is on the sequencing aspect of the capacity expansion planning of the system.

(ii) Models developed in the study are deterministic in nature.

(iii) The study does not address the capital budgeting as well as financial planning aspects.

(iv) As the real life system selected for application is still in the initial stages of development, it is considered to be a new system.

1.4 APPROACH

As proposed in the objectives, two models namely target fixing model and sequencing model are to be constructed. Both simulation and analytic models will be used to obtain best possible strategy of development of the Narmada river basin system, one of the important and largest water resources systems in India. The simulation model is to be used to obtain the annual targets that can be met by the various reservoirs and also to analyse the effect of hydrological dependence on these targets. All the possible reservoir combinations in the system would be simulated and each simulation run would be carried out by adding a downstream reservoir one by one from upstream to downstream. Subsequently, a suitable backward dynamic programming algorithm will be developed and utilized for obtaining the sequence of development of the reservoirs at the minimum total cost.

Thus, this thesis is an attempt to combine the major advances of both simulation and optimization models. The planning, formulation, and solution procedure of this analysis in this dissertation is described as below.

1.5 THE CHAPTERWISE PLANNING OF THE THESIS REPORT

With reference to the above said objectives, this research work is reported in seven chapters.

Chapter 2

In this chapter a literature review is presented related to topics of multireservoir simulation and sequencing using dynamic programming(DP), mixed integer programming(MIP), etc. Literature survey was carried out by referring to the prestigious international journals like Journal of Water Resources Research (A.G.U.), Journal of Water Resources Planning and Management

(A.S.C.E.), Journal of Hydraulics Division (A.S.C.E.), Water Resources Bulletin (U.S.A.), Journal of Operations Research (U.S.A.), Journal of Management Science (U.S.A.), Journal of Hydrology (The Netherlands), Journal of Advances in Water Resources (The Netherlands), Journal of Computers and Industrial Engineering (U.K.), and I.E.E.E., etc. Some text and reference books were also studied for this purpose. A brief description of the research works of different researchers is presented in this chapter in chronological order as far as possible.

Chapter 3

This chapter presents the formulation of Simulation Model in the context of fixing annual irrigation targets and quantification of effect of upstream reservoir(s) on firm hydropower targets of reservoirs in the multipurpose and multireservoir system by taking into account the hydrological interdependence of reservoirs.

Chapter 4

This chapter describes the development of a Sequencing Model using backward dynamic programming process. An illustrative example is also presented to explain the use of the proposed model.

Chapter 5

The Narmada river basin system in India has been briefly described in this chapter. Further, the problem statement is presented with respect to this system on which the proposed model(s) were applied.

Chapter 6

This chapter deals with the application of the above developed models to the Narmada river system keeping in mind the objectives as mentioned in Chapter 1. The results and discussions are also included in this chapter.

Chapter 7

Based on the results and experiences of the computations carried out, an analysis has been done and suitable conclusions have been drawn in this chapter. Lastly, some suggestions for future work are made.

LITERATURE REVIEW

2.1 INTRODUCTION

Modelling provides a way, perhaps the principal way, of predicting the future behaviour of existing or proposed water resource system. Over the past 40 years or so, we have witnessed advances in our abilities to model the engineering, economic, ecologic, hydrologic, and sometimes even the institutional or practical aspects of large complex multipurpose water resource systems. Applications of models to real systems have improved our understanding of such systems, and hence have often contributed to improved system design, management, and operation. Evaluation of the applications of numerous types of models has also taught us how limited our modelling skills remain (Loucks, 1992). Despite the many applications appearing in the literature, the mathematical programming techniques are not commonly applied in practice to complex environmental systems (Uber et al., 1992).

Water resources systems analysis has now been generally accepted to provide an efficient way of answering the numerous questions regarding planning of large scale water resources systems for which the conventional methods of analysis will be inadequate. The approach and appropriate technique will naturally vary from problem to problem as the configuration, state of development of the system, and stage of decision making is likely to vary over a vast range (Maass et al., 1962; Hufschmidt and Fiering, 1966; Hall and Dracup, 1970; Haimes, 1977; Loucks et al., 1981; Chartuvedi and Srivastava, 1981; Stedinger et al., 1983; Marino and Mohammadi, 1983a and 1983b; Mohammadi and Marino, 1984a and 1984b; Marino and Mohammadi, 1984; Goodman, 1984; Buras, 1985; Loaiciga and Marino, 1986; Srivastava, 1976 and 1987; Chavez-Morales et al., 1987; Chaturvedi, 1987; Flynn and Marino, 1988 and 1989; Afshar et al., 1991; Chavez-Morales et al., 1992; Simonovic, 1992; Srivastava and Patel, 1992; Wurbs, 1993; Boney, 1993; Sadeghian, 1995; Assadullah, 1995; Sunita Devi, 1997).

Since the late 1950s, operations research or systems methodology has been used to develop various methods to solve the classical capacity expansion problem and its extensions. Most of the works use dynamic programming, however, the use of other techniques such as Linear Programming(LP), Mixed Integer Programming(MIP), Simulation and Heuristic, etc. has also been reported in the literature. In this chapter some of the studies on capacity expansion planning and multireservoir operation problems using systems analysis and available in literature have been presented. At the end a few important studies have been presented alongwith the mathematical models. A critical review and present state of art related to the use of optimization and simulation models within the framework of multiple reservoir planning and management, available in literature of water resources planning and management have been presented in three parts as follows.

2.2 REVIEW OF ANALYTIC SEQUENCING MODELS

It is common in the field of water resources to build supply capacity beyond what is needed to satisfy current demand. Water demand is met by both surface and groundwater supplies. The size of groundwater projects can be changed in small increments by the addition of pumps. However, due to the indivisibility or lumpiness of increments to capacity, surface water facilities are usually built with long design periods, that is, with sufficient capacity to meet projections of demand increases for many years into the future. The optimum sizing and sequencing of capacity expansion of surface water supply projects have been the focus of much research and many models for capacity expansion have been suggested. More recently, optimum pricing and its relation to optimum capacity expansion has become an important issue. In general, capacity expansion models rely upon demand projections and estimates of costs and potential capacities of supply alternatives (economies of scale factors) which are exogenously determined. The assumptions on which the model are based vary, but the general progression over time has been towards less restrictive and more realistic models. Details of the various models are presented in the following sections, but a brief summary of the evolution of these models is thought to be worth mentioning and hence is given here (Haimes,1977 and Fallon, 1986).

The early capacity expansion models were based on equality of maximum capacity and economies for all alternatives, linearity of demand growth with respect to time, and zero price elasticity of demand. In some cases it was also assumed that supply must always be greater than or equal to demand. Thus, the problem reduced to that of estimating the optimum design period. In other cases initial supply deficits were allowed under the restriction of immediate alleviation by supply expansion at the beginning of the planning period. The problem then became that of estimating the optimum excess capacity of the initial project and the optimum design period of the subsequent projects. In other models supply deficits were allowed to be satisfied temporarily by importation from other supply sources so as to avoid occurrence of initial capacity expansion at the beginning of the planning period. The decision variables in these models were the optimum waiting period during which there is importation, the optimum excess capacity of the initial expansion, and the optimum design period for subsequent expansions. A slight variation of this type of model was the case where supply deficits were allowed to go unsatisfied by imposing a penalty cost for not meeting existing demand in the place of the cost of importing.

Two of the assumptions of the early capacity expansion models, namely, equality of maximum capacity and economies of scale for all alternatives, and linearity of demand growth with respect to time led directly to the optimal sequencing in order of increasing costs of the projects. Under the relaxation of either of these two, the optimum sequencing of the projects is more complicated and must be endogenously determined by the model as a function of the shape of the demand/time relationship, the interest rate, and the relative costs and capacities of the alternative projects.

Models have been suggested for sequencing of discrete projects with the sole objective of meeting water demand at a minimum present value of costs. An extension of this model was developed for the more general problem of scheduling, which involves selection and sequencing of alternative projects when only a subset of the alternative is needed to meet water demand. Models have also been developed to deal with project scheduling problem when projects must meet demands for multiple uses. In the early sequencing and scheduling models, the optimum sizing of alternative projects was determined exogenously.

Pricing traditionally has been ignored in capacity expansion models. The water demand forecasts used assume that water use will increase in some simple relation to the increase in population and economic activity. Pricing is an after-thought, and the only objective of which is to generate sufficient revenue to cover costs. Thus, capacity expansion planning and financial planning are entirely separate activities. Although a number of water demand studies suggest otherwise, the implicit assumption of the early capacity expansion models is that water price has no effect on water demand. A more recent development in capacity expansion modelling involves the relaxation of the assumption that the demand for water is price inelastic. In these models, the optimum pricing as well as optimum sizing and timing of capacity expansion are considered and the problem is one of the maximization the present value of net benefits rather than minimization of present value of costs.

The original capacity expansion model was proposed by Chenery in as early as 1952 (Fallon, 1986) which was concerned with effects of technology, specifically economies of scale and indivisibilities of added capacity, on investment behavior. Chenery asserted that, when economies of scale exist, there is an optimum overcapacity that is a function of scale of economies, planning period, discount rate, and the rate of demand increase. Manne(1961, 1967) gave an in-depth review of Chenery's model and presented his own generalized extension of the model which permitted accumulated backlogs of unsatisfied demand and a stochastic, rather than a deterministic , upward trend in demand. Manne(1967) and Erlenkotter(1967) analysed the situation where supply deficits within an area can be met by importation. Lauria et al.(1977) developed a similar model for capacity planning of water systems which considered the case where demand exceeds the capacity at t=0 and demand is allowed to go unsatisfied for an initial period before first expansion by imposing penalty cost. Scaroto(1969) was the first to apply the capacity expansion model to water resources in the analyses of optimum capacity of water pipelines and water treatment facilities.

Luss(1982) and Fallon(1986) reviewed the then existing literature on use of analytic models in capacity expansion planning and also highlighted the trends in modelling approach, solution strategy, and relevant application alongwith detailed listing of references covering a broad spectrum of capacity expansion problem.

2.2.1 Review of Dynamic Programming (DP) Based Models

Butcher et al.(1969) were the first to obtain optimum sequence of water supply projects using a DP technique which was further modified by Morin and Esogbue(1971) and Morin(1973a) as imbedded state approach for solving combined project selection and sequencing (i.e., scheduling) problem. Morin(1973b) also gave a theoretical overview of prior development relevant to multidimensional sequencing problem, which is mostly encountered in the capacity expansion of water resources systems and the proper operation of which involves the conjunctive use of individual facilities to provide required amounts of outputs such as power production, and water for domestic, industrial and agricultural uses. Erlenkotter(1973a, 1973b) developed a DP model for sequencing of expansion projects and extended it to sequencing of interdependent hydroelectric projects. Erlenkotter and Rogers(1977) tackled sequencing of the competitive expansion projects by a DP based technique. Erlenkotter et al.(1989) proposed a general DP model for water resource development under demand and supply uncertainty. Knudsen and Rosbjerg(1977) developed a general DP algorithm incorporating chance constraints or penalty functions for yielding least cost schedules. Bogardi et al.(1978) determined optimal sequence of a multipurpose water supply system by DP and then by using sensitivity analysis established that the optimal development and sequencing depend largely upon economic losses and the discount rate.

A set of twelve interdependent hydroelectric projects on Ganga river basin in the Northern India has been optimally sequenced minimizing the costs involved using dynamic programming (Chara, 1982). Rubinstein and Ortolano(1984) used a forward-stepping DP algorithm for scheduling of projects to be implemented from a given set of alternative supply augmentation and demand management projects. Two optimization criteria were considered (i) Minimization of the present value of the cost of implementing the projects, and (ii) Minimization of the expected value of the costs to cope with emergencies in supply of water. The tradeoffs between the two were examined by the Non-inferior Set Estimation Method. Fontane et al.(1989) used Objective Space DP (OSDP) with project costs as a state variable to develop multiple solutions for a range of funding levels and analyzed implementation strategies for salinity control projects in the Colorado river basin. Martin(1990) described a computational methodology based on DP algorithms for establishing the approximate minimum cost engineering design for a potential water conveyance pipe line in the San Antonio river basin in Texas.

2.2.2 Review of Models in Combination with DP

The DP approach was also used by Riordan(1971a, 1971b) alongwith the theory of welfare economics to solve joint sequencing-pricing problem. Kuiper and Ortolano(1973) analyzed the capacity expansion of a mixed hydrothermal power system by means of a DP-Simulation strategy in which a bulk simulation model was used. Nainis and Haimes(1974) formulated a capacity expansion planning model which used dynamic benefit-cost analysis to solve for a least cost schedule of projects that also maximizes the net benefits to the regional economy. A project-scheduling supply model first finds the minimum present value cost schedule to meet an initial fixed demand. A demand model then maximizes the value of possible outputs of various uses. Haimes and Nainis(1974) used a DP algorithm to schedule the projects and a Leontief input-output program to model the response to project supplies in the coordination of water supply and demand planning models.

Becker and Yeh(1974a) presented a model for optimal sizing as well as timing and sequencing of single-purpose water facilities based on firm water rather than reservoir capacity. Becker and Yeh(1974b) also handled combined sizing, capacity expansion and operation formulation of a multiple facility, multipurpose water resources system. The procedure incorporated an iterative LP technique for optimization of sizing and operation with a DP algorithm for optimal sequencing and timing determination. These models accounted for the fact that although it is firm water that is supplied, it is the reservoir capacity that is costed, and the relationship between the two is not simple nor is it independent of existing facilities in the same basin or recharge area. Kolo and Haimes(1977) presented an hierarchical approach aimed at coordinating several different models (incremental DP, NLP) in order to achieve optimal regional management of water resources and related land. The lower level of the model solved for the projected construction sequence which meets demands for both power and water at minimum cost. The higher level model examined resources allocation policies, which maximize return while subject to the constraint of meeting all demands. Moore and Yeh(1980) presented a dynamic programming model for water supply capacity expansion, the objective of which was to maximize net benefits. Benefits were calculated using a willingness-to-pay criterion and rationing by price was used as an alternative to project construction. Huges(1980) formulated the regional water supply planning problem as a generalized MIP to handle multiple sources and multiple service zones in which LP was used for screening and DP for investment timing.

Dandy et al.(1984, 1985) extended Riordan's work and used discrete dynamic programming for jointly determining the optimum annual price and capacity expansion schedule for a water supply system. They presented a general model for optimization of pricing and capacity expansion decisions constrained by the acceptable range of water price, the rate of price change, and financial cost recovery. The basic problem is to choose the water price and supply capacity for each planning period so as to maximize the net present value of benefits minus costs. The maximization is solved using a forward moving discrete dynamic programming algorithm. An application of the model to the twin cities of Kitcherner-Waterloo, Ontario is presented in Dandy et al.(1985). Braga et al.(1985) developed a capacity expansion model based on monthly simulation model and forward dynamic programming to facilitate the planning and the optimal timing and sizing of a system consisted of series of reservoirs and pumping stations. Kim and Yeh(1986) developed a two-step heuristic procedure in which the shortest path DP was used for sequence generation step and a univariate direct search algorithm for capacity refinement. Wan et al.(1989) applied combination of DP-MIP and flow regulation submodels for optimal sequencing of development for hydropower stations in cascade.

Ong and Adams(1990) presented a simple yet effective two level approach for solving regional wastewater treatment system capacity expansion problem. The lower level treats the subproblems related to separate facilities of a regional treatment system using DP whereas the upper level coordinates the lower level subproblems and also updates using a random polyhedron search algorithm that identifies progressively superior solutions. Bector and Goulter(1995) proposed an integration of Stochastic DP (SDP) and Fuzzy Integer Goal Programming (FIGP) modelling framework to handle problems of multiobjective-multicriteria sequential decision making under budgetary and socio-technical uncertainties inherent in water resources investment planning.

2.2.3 Review of Models Based on LP, MIP, etc.

O'Laoghaire(1978) formulated the capacity expansion problem of a water quality management system as 0-1 mixed integer programming and solved it by decomposing into a capital budgeting Little's branch and bound algorithm and a LP operational policy. Leighton and Shoemaker(1984) utilized MIP approach to identify attractive regionalisation plans for large wastewater and collection systems. Helm et al.(1984) presented a procedure based on mixed integer continuous linear programming with Benders' decomposition to select the reservoir sizing, timing of expansion and to establish operating policy for a multipurpose linked reservoir system receiving stochastic inflows. Moreau(1986) reported a LP based financial planning model for a publicly owned water and sewer utilities. Matsumoto et al.(1989) described a two level hierarchical MIP model to analyse longterm capacity expansion strategies for power generation systems consisting of hydrothermal plants and transmission lines and solved it by the Lagrangian relaxation. The objective was to determine the optimum capacity schedule that minimizes the present worth of capacity cost and operating cost, subject to meeting peak power demand and energy demand. Mazzola(1992) described the capacity expansion problem as a knapsack one and presented solution of the same by using iterative LP technique. Basagaoglar and Yazicigil(1994) developed and tested three MIP based models for the optimal capacity expansion planning in a hypothetical multiaquifer system. Multiobjective analysis and sensitivity study of the capacity expansion policies are the other main features of this study.

2.2.4 Review of Heuristic Models

Tsou et al.(1973) presented a shortcut method for solving a sequencing problem and making a sensitivity test of the results. Sniedovich and Nielsen(1983) solved a joint reservoir control-capacity problem using a heuristic and recommended that more emphasis should in water resources literature be given to the heuristic procedures developed for difficult water resources management problems. Nakasima et al.(1986) used a twophase heuristic optimization technique for designing regional water supply wherein the linearly constrained nonlinear phase-I model was solved by MLST (multilevel solution technique) based on out-of-kilter algorithm and phase-II model was a linear program.

Carlsen(1986) developed a method to identify the optimum form of development of hydropower projects taking into account the effects of one project on another. The model can also include thermal power in the generation system and the method has been applied for the master-plan for the Rufiji basin in Tanzania. Some examples of uprating and refurbishment schemes for expansion of existing hydropower stations on the Songhua and Yellow rivers in China are described by Xuemin(1992).

Goodman(1994) reported a detailed methodology for the integrated development of the Vardar/Axios international river basin which includes a system of projects scheduled to meet the needs and aspirations of Yugoslavia and Greece. The considerations that guided the detailed methodology for formulating the master plan included: economic sector development (principally agricultural, municipal and industrial, and electric power); balanced regional development; engineering and economic feasibility of facilities; and compatibility with existing power and hydraulic systems. Grigg(1997) discussed three versions of systems techniques and compared their concepts with those of other planning processes. The paper shows, through a retrospective view of a systems dynamic modeling project, how quantitative analysis can be applied to an urban water supply system and growth management and how other systems techniques are used in the decision process and it argues that comprehensive models could provide better decision information and inspire greater public confidence in the decision process. Systems and model techniques can enable civil engineers to provide more leadership by fathoming the complexity of issues and explaining options more closely during the decision process.

The Table 2.1 presents information on some of the important features such as aim(s) of model, purpose(s) of system, type of objective function, and systems analysis technique(s) employed etc. in respect of a few capacity expansion studies reported in earlier paragraphs.

2.3 REVIEW OF MULTIRESERVOIR SIMULATION MODELS

Simulation models are better suited to the modelling of a physical system for decision making as some of the approximations essential in an optimization model may not be necessary in a simulation model. However, simulation models are not able to directly generate optimal solutions except by exhaustive search of all possible alternatives scenario. As the computer developed in speed and capacity, it became possible to simulate the performance of large and complex river basin systems over extended periods of time (Sigvaldson, 1967). The application of systems analysis to water resources have increased rapidly since then.

Application of systems analysis techniques in the field of water resources planning and management can be considered to have begun in U.S.A. with Harvard Water Program in 1962. This program was the first to systematically present the modern, interdisciplinary systems analysis approach to water resources planning in which a simulation model was applied to the economic analysis of multipurpose multiproject system. Hufschmidt and Fiering(1966) presented a detailed analysis of their simulation model and discussed its use in the study of multipurpose planning of Lehigh river basin.

The Corps of Engineers have also developed the simulation packages, the Hydrologic Engineering Centre, HEC-3, HEC-5, and SSARR (Streamflow Synthesis and Reservoir Regulation) models which have found wide international use for river flow simulation. The HEC-3 (US Army Corps of Engineers, 1974) program simulates the operation of a reservoir system for conservation purposes like water supply, navigation, recreation, low flow augmentation, and hydroelectric power. The various demands are supplied from reservoirs so as to maintain balances of storage in the reservoir system. While flood control operation can be handled in some respects, a more complete simulation is possible using HEC-5. The program can accept any configuration of reservoirs, diversions, power plants, and stream control points. However, the program while accepting system power demands that override individual power plant requirements, does not provide for percolation losses or channel routings. The HEC-5 program is for simulation of flood events to assist in sizing the flood control and conservation requirements for each project recommended for the system. It can be used in studies to evaluate pre project condition and to show the effects of existing and/or proposed reservoirs on flows and damages in the system. It can also be used for indicating proper releases throughout the system during flood emergencies in order to minimize flooding while maintaining optimum balance of control storage among reservoirs. The above purposes are accomplished by simulating the sequential operation of a system of reservoirs of any configuration for short interval historical or synthetic floods or for long duration non-flood period or for combinations of the two (US Army Corps of Engineers, 1985).

The SSARR (US Army Corps of Engineers (USACE), 1986) model consists of the following three basic components:

(a) A generalised watershed model for synthesizing runoff from rainfall and/or snowmelt,

(b) A river system model for routing runoff downstream through channel and/or lake storage, and

(c) A reservoir regulation model for evaluating various modes of reservoir operation.

This model is particularly useful in flood forecasting with real-time precipitation.

The Department of Civil Engineering, MIT have developed a series of river basin simulation models (McBean et al., 1973; Strzepek and Lenton, 1978; and Lenton and Strzepek, 1979). MITSIM-1 was developed as a part of the UNDP sponsored study of Vardar/Axios river basins in Yugoslavia and Greece. The model provides for detailed simulation of both the physical and economic performance of river basin including multipurpose surface as well as ground water projects. It is claimed that this model is sufficient for planning purpose where standard rules for reservoir operation are used. Another version of MITSIM-1 was used by MIT to plan the Rio Colorado river basin in Argentina (Major and Lenton, 1979). The study consisted of screening, simulation and sequencing models. The number of issues like equity, shadow prices of inputs and outputs have been considered in this perhaps the most comprehensive planning study reported so far. There is however no information about the implementation of results by Government of Argentina. The MITSIM-1 has been updated by the International Institute for Applied Systems Analysis (IIASA), Austria to MITSIM-2 for water management studies of the South Western Skane Water Supply System in Sweden (Strzepek, 1981). This model has also undergone various revisions and a very versatile version of this was allowing simulation at variable time steps ranging from one week upward with an option to incorporate priorities for various releases.

Simulation models called MITTAMS and EXTG1 were used to evaluate the basin configuration in the integrated development of the 2400 sq. km. Vardar/Axios river basins in Yugoslavia and Greece (TAMS, 1978). These models accommodated a large number of projects and an enormous quantity of data and provided measures of performance in hydrologic and economic terms. They were also effective in accounting for the complementary purposes. The simulation models reproduced the interactions among the elements of the system and described the outcome of operating the system under a given set of inputs and operating assumptions. By successive and systematic runs of the models, the response to the variations in inputs or operating conditions or both were evaluated. When used in conjunction with engineering and economic criteria, the results of these runs allowed (i) the systematic comparison of alternative configurations of water resource projects in the basin, and (ii) the evaluation of the effect of the upstream development on the flows at the border and the consequent downstream development.

In the early 1970s a set of models named Dynamic Economic Simulation (DES) was developed as a part of research for Texas Water Development Board (now named as Texas Department of Water Resources). The computerised models for large scale multibasin surface water resources system have been developed to formulate the Texas Water Plan. The three principal models are SIMYLD-II (Texas Water Board, 1972), SIM-V (Martin, 1982), and AL-V (Martin, 1984).

The SIMYLD-II analysis water storage and water transfer within a multireservoir or multibasin system. It can simulate the movement of water through a system of river reaches, pump canals, reservoirs, and non-storage river junctions. Water demand to be made on the system can be applied to either the storage or non-storage junctions and the option is available to reckon these demands as monthly values or as total annual demand which can be reduced to monthly demand as per a set of user supplied demand distributing factors. It also offers the ability to set priorities for meeting demands and maintaining reservoir storage at each reservoir. Further it determines the firm yield of s single reservoir within a multireservoir system. It has been used by TWDB for adjudication of water rights in the Cypress Creek basin and for interbasin transfer connected with coastal canal and Nueces river basin.

SIM-V is a procedure designed to simulate the operation of a large complex surface water storage and transfer system. It allows individual network system elements to be introduced at any point of time in the simulation time span. It provides the option of investigating various pattern of construction schedules so that the least cost schedule can be selected for implementation. In this, capital costs are entered individually for each system (canal and reservoir) whereas system operating costs are computed by the model. In general, the movement of water via transfer links is done at a cost which is a known function of the quantity of water flowing and the pumping lift. It is the function of SIM-V to meet systems storage requirements, water demands and hydropower generation while minimizing cost of transportation within the system.

AL-V is a general hydrological optimization model to analyse the simulated multiperiod operation of any interconnected configuration of reservoirs, pump canals, and pipelines. It can be used (a) to find minimum cost operating plan for a system of reservoirs, river junctions, canals and river reaches, (b) to find minimum cost of sizing individual reservoirs, canals and closed conduits, (c) to determine the reservoir operating rules for use in related simulation models, and (d) to find the minimum cost of construction, sizing, and sequencing of a number of water storage and conveyance projects in a multipurpose river basin system.

TWDB is the first and perhaps the only agency to prepare a set of programs which are directed to all planning aspects of a river basin. However, it is understood that the models have been put to only limited use and Texas Water Plan could not make much headway. SIM-V and AL-V programs have been applied (Martin, 1983) to a large scale system comprising 27 reservoirs on the Arkansas-White-Red river system in the U.S.A.. The derived system operating policy computed a potential increase of approximately 8 percent in firm power production of the system over the previous study.

The model DWRSIM (Department of Water Resources Planning Simulation Model) is a generalised computer planning model for simulating monthly operation of the CVP-SWP (Central Valley Project and State Water Project) system consisting of surface reservoirs, groundwater reservoirs, conveyance facilities, pumping plants, and hydropower plants (Department of Water Resources, State of California, U.S.A., 1985 and 1986). Planning studies carried out involve determination of incremental yield resulting from the addition of each new reservoir into the existing system keeping in view the various constraints like the formula for sharing water between SWP and CVP. This can be effectively used for managing existing projects and to plan new facilities.

The Bureau of Reclamation studied Colorado River System, a very complex system in U.S.A. with numerous treaties and acts constraining its water use. The computer package called Colorado River Simulation System, (US Department of Interior, Bureau of Reclamation, 1981 and 1986) has the Colorado River Simulation Model (CRSM) as its main component. It has been used to study changes in operation policies and alternate development strategies for the river basin. After the unprecedented flood of 1983 the model was used to review the operation policies and formulate alternate operation strategies that will increase the beneficial use of the water in excess of the existing project uses (purposes).

Maji and Heady(1980) constructed a simulation model to estimate the physical and economic performance of alternative river basin development. The paper shows how the problems of large scale water resources development were confronted and solved. Also a set of general guidelines which may be helpful in other simulation studies have been derived.

A generalised reservoir-system simulation model routinely used in the USACE South Western Division (SWD) is described by Hula (1981). The SWD model simulated the daily sequential regulation of a multipurpose reservoir system, performing generally the same types of hydrologic and economic simulation computations as HEC-5. The SWD model uses a one day computation interval whereas the HEC-5 allows a variable time interval. MITSIM (Strzepek et al., 1989) provides the capability to evaluate the economic as well as hydrologic performance of a river basin system involving hydroelectric power, irrigation, municipal and industrial water supply, and other purposes. The Water Rights Analysis Program (TAMUWRAP) simulates surface water management and reservoir system operation under a prior appropriation water rights permit system (Wurbs et al., 1993). Unlike many simulation models in which computations usually proceed from upstream to downstream, the TAMUWRAP is based on meeting water demands in accordance to a user specified priority.

The distinctive feature of the IRIS (Interactive River System Simulation) program is extensive use of interactive computer graphics for information transfer between machine and user. IRIS simulates a water supply conveyance system of any normal configuration and also has a limited hydroelectric power simulation features (Loucks et al., 1989, 1990). Another interactive graphics oriented River Simulation System (RSS) developed at the Centre for Advanced Decision Support for Water and Environment Systems (CADWES) allows the user to develop a model for a particular river system using preprogrammed objects and functions. The object-oriented program structure also facilitates altering the RSS software by a programmer to include additional objects for functions as needed for particular applications.

A system of six reservoirs in Narmada river basin in India was simulated to study the Narmada River Water Dispute for finalising the reservoir sizes and the annual project targets

(Srivastava, 1976). Buras(1985) formulated a stochastic dynamic programming model to derive a schedule of seasonal optimal reservoir releases and their respective probabilities of occurence. The model was applied to Navagam reservoir site on Narmada river in India.

Rogers and Hurst(1993) reported a water resources planning methodology with primary objective of giving insights into the linking of water sector investments and macroeconomic policies. The model optimizes the present value of investments for water resources development, while embedding a macroeconomic model into the framework to allow for an examination of the interactions between water investments, the growth in the agricultural sector, and the performance of the overall economy. A case of Bangladesh is presented. Sule and Olu(1994) reported reservoir operation studies, based on present and future withdrawl rates, showing that the system will experience reduction in potential evaporation, reduction in active storage, loss of fishing zone, reduction in available flow to the downstream areas due to the Ilorin water supply expansion programme designed to raise plant output to nearly four times its existing capacity. A study was carried out to analyse the developmental plan of the Karun river basin system in Iran, which included multi-irrigation areas (Sadeghian, 1995). The basic issue was of siting and sizing of reservoirs in the basin to cater for the future water requirements.

2.4 BRIEF DESCRIPTION OF SOME CLASSICAL SEQUENCING AND CAPACITY EXPANSION MODELS

2.4.1 General

The capacity expansion and optimum sequencing of projects involve multistage decisions over the planning horizon.The dynamic programming is one of the techniques capable of handling such problem of making multistage decisions, and yields optimum solution, which is not always possible with the heuristic procedure. However, the conventional dynamic programming suffers from the curse of dimensionality. The core storage and time requirements increase exponentially with increase of problem size. Several versions of this technique like state incremental dynamic programming, differential dynamic programming, discrete differential dynamic programming, successive approximation, and so forth have been evolved and have, to some extent, been successful in overcoming these drawbacks. However, for capacity expansion and project sequencing problems these versions, barring successive approximation, are not very popular(Haimes,1977).

2.4.2 BHH Model

An important technique to solve the capacity expansion sequencing problem was proposed by Butcher et al.(1969) using dynamic programming.The number of projects considered was assumed to be the stage variable and state variable was the level of capacity, q, that the subset of n projects at stage n could cumulatively satisfy. The state at stage n includes not only the level of capacity , but also implicitly the optimal sequence of n existing projects to supply the level of capacity. These projects must be known so that no project is chosen more than once. The return function of the BHH formulation as a multistage process, is given by

$$v(q-q_n\ ;\ q_n) = \min \{\ g^i(q_n)(1+r)^{-\psi(q-q_n)}\ \}$$

subject to:

$i \in \{\ 1,\ .,\ .,\ \ldots,\ N\ \}$

$i \notin k_{n-1}(q-q_n)$ or $i = \emptyset$

Where,

r = Discount rate,

$\oplus$ = Represents addition to the project sequence,

$\emptyset$ = "Null" (not build) project,

$g^i(q)$=A function related to the construction cost of project i

= 0 for $q = 0$

= C_i for $0 < q \le Q_i$

= ∞ for $q > Q_i$,

$k_{n-1}(q)$ = A sequence of n-1 projects providing the capacity to satisfy the demand upto the level q, and

$\psi(q)$ = The inverse of $D(t)=D_t=q$, which implies that D_t must be strictly monotone increasing sequence.

The following recursive equation can be used to link the adjacent stages in the DP formulation:

$$f_n^{k_n(q)}(q) = \min \{ f_{n-1}^{k_{n-1}(q-q_n)}(q-q_n) + g^{i*}(q_n)\ (1+r)^{-\psi(q-q_n)} \}$$

with

$0 \le q_n \le q \le \sum_1^N Q_i \qquad i^* \notin k_{n-1}(q-q_n)$

also

$k_n(q) = i^* \oplus k_{n-1}(q-q_n)$

$f_n^{k_n(q)}(q)$ = Minimum present value cost of supplying demand up to a quantity q with an optimal schedule k_n of n out of the N admissible projects from which to choose.

2.4.3 Kuiper and Ortolano Model

For a monotonically increasing demand function D(t), and N feasible projects having capacities Q_i and Cost of development C_i, $1<i<N$, the order and times at which the projects should be completed is determined with the objective of minimizing the discounted sum of project costs (Kuiper and Ortolano, 1973). The level of capacity is taken as state variable and number of years in planning horizon as stage variables. The constraint can be that at all times t, during the plan period, the cumulative capacity of projects already operative upto this time, must not be lesser than demand D(t). The objective may be to design the sequence of water resources developments that will satisfy the capacity requirements at the minimum total cost. The problem may

be solved by using dynamic programming to investigate all the alternative sequences of development that are feasible and to select optimum sequence among these alternative feasible solutions. The problem can be analyzed in stages, each representing one time period. In each stage a number of states are defined to represent the alternative combinations of plants that might exist in that stage.

The general dynamic programming algorithm, which involves an arbitrary number of states and stages, discounting of costs, and other constraints, is summarized in the following sections.

The states used in the dynamic programming algorithm correspond to alternative possible combinations of projects in each stage. Any possible combination can be represented by a state vector X defined as:

$$X = \{S_1, S_2, \ldots\ldots\ldots\ldots\ldots, S_n\}$$

Where S_k represents the capacity of project k and n represents the number of different projects. Each of the S_k can have only a limited number of discrete values.

The dynamic programming algorithm may be used to determine a feasible sequence of states X_i that minimizes the total discounted cost

$$\sum_{t=1}^{T} A_t (X_i)$$

Where T is the total number of time periods and $A_t(X_i)$ is the discounted annual cost of the water resources system X_i in time period t. This annual cost includes fixed annual capital costs and variable annual costs.

A feasible state X_t in time period t must satisfy the following constraints:
The capacity of $X_i(t)$ must be greater than or equal to demand in time period t.

A feasible solution to the problem is a sequence of feasible states satisfying the continuity constraint ,i.e.,

$$X_i (t) \geq X_j (t-1) \qquad \text{for all } t$$

Where the symbol $\geq$ is used to indicate that state i can be reached from state j. The following recursive equation may be used to determine the optimum sequence of expansion to each feasible state in every stage:

$$C_t(X_i) = A_t(X_i) + \min_{j \leq i} \{C_{t-1} (X_j)\}$$

Where $A_t(X_i)$ represents a discounted annual cost.

Table 2.1 - Capacity Expansion Planning Literature Review

AUTHOR (year)	AIM of MODEL							No. of FACILITY		PURPOSE of FACILITY					TYPE of MODEL		OBJECTIVE FUNCTION			TECHNIQUES EMPLOYED							REMARKS
	Selection	Siting	Sizing	Sequencing	Timing	Operation	Financial planning	Single	Multiple	Irrigation	Water supply	Hydro Power	Flood Control	Others	Deterministic	Stochastic	Minimization of cost	Maximization of Benefits	Others	LP	DP	MIP	NLP	Simulation	Heuristic	Others	
SCARATO (1969)			✓	✓	✓			✓			✓				✓		✓									✓	DIFFERENTIAL CALCULUS
BUTCHER et al. (1969)				✓	✓				✓		✓				✓		✓				✓						
RIORDAN (1971a)							✓		✓		✓				✓			✓			✓						PRICING
RIORDAN (1971b)			✓		✓				✓		✓				✓			✓			✓						
ERLEN-KOTTER (1973)				✓	✓				✓			✓			✓		✓				✓						INTERDEPENDENT PROJECTS
TSOU et al. (1973)	✓			✓					✓						✓				✓						✓	✓	R-INDEX
MORIN (1973)		✓		✓	✓				✓		✓	✓	✓	✓	✓		✓				✓						
KUIPER AND ORTOLANO (1973)				✓		✓			✓			✓			✓		✓				✓			✓			
BECKER & YEH (1974a)			✓	✓	✓				✓		✓				✓		✓				✓						
BECKER & YEH (1974b)			✓	✓	✓	✓			✓		✓	✓	✓	✓	✓		✓		✓		✓						POT. ENE LOSS MIN.

Table 2.1 Contd...

Table 2.1 - Capacity Expansion Planning Literature Review

AUTHOR (year)	AIM of MODEL							No. of FACILITY		PURPOSE of FACILITY					TYPE of MODEL		OBJECTIVE FUNCTION			TECHNIQUES EMPLOYED							REMARKS
	Selection	Siting	Sizing	Sequencing	Timing	Operation	Financial planning	Single	Multiple	Irrigation	Water supply	Hydro Power	Flood Control	Others	Deterministic	Stochastic	Minimization of cost	Maximization of Benefits	Others	LP	DP	MIP	NLP	Simulation	Heuristic	Others	
HAIMES & NAINIS (1974)				✔	✔						✔			✔	✔		✔	✔		✔	✔						
NAINIS & HAIMES (1975)		✔	✔		✔				✔		✔				✔		✔			✔	✔						DEMAND SUPPLY EQUILIBRIUM
HELM et al. (1977)			✔	✔	✔	✔			✔	✔						✔			✔			✔					
BOGARDI et al. (1977)				✔					✔	✔	✔			✔		✔	✔				✔		✔				
KOLO & HAIMES (1977)				✔		✔			✔	✔	✔	✔				✔	✔	✔			✔						COORDINATOR
O'LAOGHAIRE (1978)		✔	✔	✔	✔	✔	✔		✔		✔					✔	✔			✔		✔					
OCANAS & MAYS (1981)				✔	✔				✔		✔				✔		✔									✔	SUCCESSIVE LP
CHARA (1983)				✔		✔			✔	✔		✔			✔		✔								✔		
BRAGA et al. (1985)			✔	✔	✔				✔		✔				✔		✔				✔			✔			

Table 2.1 Contd...

Table 2.1 - Capacity Expansion Planning Literature Review

AUTHOR (year)	AIM of MODEL							No. of FACILITY		PURPOSE of FACILITY					TYPE of MODEL		OBJECTIVE FUNCTION			TECHNIQUES EMPLOYED							REMARKS
	Selection	Siting	Sizing	Sequencing	Timing	Operation	Financial planning	Single	Multiple	Irrigation	Water supply	Hydro Power	Flood Control	Others	Deterministic	Stochastic	Minimization of cost	Maximization of Benefits	Others	LP	DP	MIP	NLP	Simulation	Heuristic	Others	
KIM & YEH (1986)		✔	✔	✔	✔				✔		✔				✔		✔								✔		SHORTEST PATH DP & NLP
MOREAU (1987)			✔		✔		✔		✔		✔				✔		✔				✔						
MARTIN (1987)			✔	✔		✔			✔		✔				✔						✔					✔	NETWORK OPTIMIZATION
FONTANE (1989)	✔				✔		✔		✔					✔	✔		✔				✔						SALINITY CONTROL
WAN et al. (1989)	✔			✔	✔	✔			✔			✔	✔			✔	✔		✔		✔	✔				✔	FRM (FLOW REGULATION MODEL)
MAZZOLA (1992)				✔					✔		✔				✔				✔	✔		✔					KNAPSACK

Table 2.1 Concluded

SIMULATION MODEL

3.1 INTRODUCTION

Simulation can be defined as reproducing the essence of a system without reproducing the system itself in reality. The essential characteristics of the system are usually reproduced in the simulation model. Simulation is perhaps the most widely used method for evaluating alternative water resource systems. The reason for its popularity primarily lies in its mathematical simplicity and versatility.

Simulation is not an optimizing procedure. Rather, it merely provides a rapid means of evaluating the anticipated performance of the system for any set of design and operating policy parameter values. It is necessary for the analyst to specify the trial design (or, equivalently, allow the computer to do so in accordance with some algorithm), whereupon the simulation model yields estimates of the economic, environmental or/and any other responses associated with the trial. Simulation methods do not identify the optimal design and operating policy, nevertheless, they are indeed an excellent means of evaluating the expected performance resulting from any design and operating policy. Hence they are often used to assist the water resources planners in evaluating those designs and operating policies defined by simpler optimization models.

3.2 THEORY

The simulation problem considered for the present study can be stated as follows (Maass et al., 1962; Hufschmidt and Fiering, 1966; and Srivastava, 1976.)

Determine:

(i) the 75% dependable annual target level of irrigation, and firm annual target levels of water supply and energy outputs,

(ii) average annual deficits, average annual releases for various uses and average annual spill, and

(iii) extent of effect of presence of upstream reservoirs and irrigation on the firm annual energy outputs.

Given:

(i) a combination of reservoirs, their sizes, hydrological interdependence, etc.,

(ii) monthly runoff values at reservoir sites, and

(iii) an operating procedure for reservoirs for design purpose.

3.2.1 System Design Variables, and Parameters

In general, there are two classes of system components (i) design variables which are free to change from one simulation run to the next, and (ii) invariant physical functions and parameters of the water resources system under study.

3.2.1.1 Major design variables

A. Major physical design variables in terms of their assumed ranges and unit of measurements

(i) Target outputs: (a) annual firm target outputs for water supply, (b) annual 75% dependable target outputs for irrigation, and (c) annual firm target outputs for energy.

3.2.1.2 Physical functions, parameters and constants

A. Components of the system: (a) gross and dead storage capacities of reservoir, and (b) power plant capacity, if any.

B. Irrigation: (a) monthly irrigation requirements.

C. Water supply: (a) monthly water supply requirements.

D. Power Generation: (a) equation used for energy generation, (b) penstock capacities, (c) maximum head for power plants, (d) turbine and generator efficiencies, (e) tail water level and dead storage level, and (f) monthly hydropower requirements.

E. Functions for each reservoir: (a) reservoir capacity vs. reservoir elevation relationship, and (b) reservoir capacity vs. reservoir area relationship.

3.2.1.3 Streamflow data

Cumulative monthly river flows at each reservoir site.

3.2.1.4 Reservoir evaporation data

Monthly reservoir evaporation values at each reservoir site.

3.3 OPERATION OF SYSTEM

Since the performance of the river basin system in terms of physical outputs is being measured by simulating the behaviour of the system on a digital computer, it is necessary to construct an operating procedure (a set of rules for storing and releasing water in reservoir and among reservoirs in a given period) in a form suitable for computer (Srivastava, 1992).

3.3.1 Individual Reservoir Operation

The reservoir will operate under the following basic constraints:

1. The volume of water released during any period can not exceed the contents of the reservoir at the beginning plus the inflow into the reservoir during the period, i.e.,

$O_{i,t} \leq S_{i,t-1}+F_{i,t}+P_{i,t}+\bar{I}_{i,t}-El_{i,t}-Yd_i$ for all i and t (3.1)

2. The continuity constraint

$S_{i,t}=S_{i,t-1}+F_{i,t}+P_{i,t}+\bar{I}_{i,t}-O_{i,t}-El_{i,t}-Yd_i$ for all i and t (3.2)

3. The contents of the reservoir at any period cannot exceed the capacity of the reservoir as well as the dead storage of the

reservoir puts a lower limit on the reservoir storage, such that

$$Yd_i \le S_{i,t-1} \le Y_i \qquad \text{for all i and t} \quad (3.3)$$

Where

$El_{i,t}$= Reservoir evaporation for i^{th} reservoir in time t,

$F_{i,t}$ = Natural inflow from its own catchment plus contributions of all possible regulated flows from upstream reservoirs and return flows from upstream water uses at i^{th} reservoir in time t,

$\bar{I}_{i,t}$ = Local inflow into i^{th} reservoir from surrounding areas in time t,

$O_{i,t}$ = Total reservoir release from i^{th} reservoir in time t,

$P_{i,t}$= Precipitation effect directly upon i^{th} reservoir in time t,

$S_{i,t-1}$ = Initial reservoir storage or content of i^{th} reservoir in time t,

$S_{i,t}$ = Final reservoir storage or content of i^{th} reservoir at the end of time t,

Y_i = Gross storage capacity of the i^{th} reservoir, and

Yd_i = Dead storage capacity of the i^{th} reservoir.

3.3.2 Reservoir Operation among Reservoirs

In establishing an operating procedure among reservoirs for simulation the hydrological properties of the basin, the physical configuration of the basin, and the water use points are important. The relevant reservoir operation policy is discussed later in para 3.5.

3.4 RESULTS FROM SIMULATION

Each simulation run for monthly operation gives the following results and statistics for behaviour analysis of the system.

3.4.1 Reservoir Behaviour

(i) Number of times the reservoir was full in a calendar month (12 element vector),

(ii) Number of times the reservoir was empty in a calendar month (12 element vector),

(iii) Number of times the reservoir was full in a calendar year,

(iv) Number of times the reservoir was empty in a calendar year,

(v) Final reservoir content at the end of every year,

(vi) Average annual spill, and

(vii) Average annual releases water usewise.

3.4.2 Irrigation Analysis

(i) Monthly irrigation deficit in a calendar month (12 element vector),

(ii) Number of monthly irrigation deficits in a calendar month (12 element vector),

(iii) Average annual irrigation deficit,

(iv) Average annual irrigation release, and

(v) Number of deficit years.

3.4.3 Energy Analysis

(i) Monthly energy deficit in a calendar month (12 element vector),

(ii) Number of monthly energy deficits in a calendar month (12 element vector),

(iii) Average annual energy deficit,

(iv) Average annual hydropower release, and

(v) Number of deficit years.

3.5 OPERATION POLICY FOR RESERVOIRS IN MULTIRESERVOIR SYSTEM

The reservoir operation policy adopted for the operation of different reservoirs in combination (Islam, 1991; Rath, 1991; and Srivastava, 1992) is as follows:

(i) The reservoir operation begins from the upstream most reservoir and continues sequentially to the next reservoir in downstream and so on to the next, in a given time period unit (in this case a month). The starting month in a water year is July.

(ii) The individual reservoir operation policy is described in para 3.3.1.

(iii) All water demands shall be met by various shares of water. Two types of water shares are defined. The share-1 meets various upstream and downstream demands from the total monthly inflows reaching a reservoir. Share-2 then meets the deficits in various downstream water demands, if any, from the water available within the conservation storage.

(iv) Any number of water uses can be considered in any sequence. The water among various uses will be shared on the basis of predecided priority of uses.

(v) To meet the energy demand an option has been kept whether the nonhydropower releases, i.e., towards water supply and irrigation requirements can be put to power generation or not. Another option has also been put forth whether the spilled water can be put to power generation or not, in case power is generated at a canal power house.

(vi) In case of all reservoirs, the total monthly inflow to a reservoir includes the return flows from various water users upstream of the reservoir under consideration plus the reservoir spills, if any from the upstream reservoirs contributing to the flow of reservoir under consideration. In present study ,100% of hydropower release, 50% of water supply release, and 10% of irrigation release are taken as contribution towards return flows.

3.6 WORKING PRINCIPLE OF SIMULATION COMPUTER PROGRAM

The computer program for the simulation of multireservoir system is a huge model (Garudkar, 1992; Dayaratne, 1992; and Jain, 1993). It comprises of as many as 16 subroutine subprograms and 11 function subprograms alongwith the main program. The program works in accordance with the operation policy framed earlier (Appendix 3-I).

A general flowchart for simulation steps is presented in Fig.3.1. The functions of the various important subprograms are briefly enumerated below

1. SUBROUTINE NTFLO

This calculates the net monthly flow at the sites under consideration by deducting the flows at the immediate upstream sites.

2. SUBROUTINE STAT1

This instructs to make upstream subtractions and downstream releases from Share-1 and downstream releases from Share-2 as defined earlier.

3. SUBROUTINE WATER

This does the following

(i) Use of Share-1: Firstly, it makes the subtractions for upstream water uses from Share-1, then makes releases for downstream water uses from unutilized water of Share-1. Further, it calculates deficits in the upstream and downstream water demands, if any.

(ii) Use of Share-2: It makes releases for downstream water uses from Share-2, if there were any deficits as per previous calculations.

4. SUBROUTINE RELES

This calculates and defines the current net water available and deficits after every upstream subtractions and downstream releases.

5. SUBROUTINE POWER

This does the basic computations for energy generation.

6. SUBROUTINE CAL1

This subroutine calculates statistics for various upstream and downstream water demands (clubbed) for behaviour analysis.

7. SUBROUTINE CAL11

This subroutine calculates statistics for various upstream and downstream water demands (unclubbed) for behaviour analysis.

8. SUBROUTINE INTI1

This subroutine initialises the statistical variables for various upstream and downstream water demands (clubbed) under consideration to zero.

9. SUBROUTINE INIL1

This subroutine initialises the statistical variables for various upstream and downstream water demands (unclubbed) under consideration to zero.

10. SUBROUTINE WRT11

This subroutine writes the statistics for various upstream and downstream (unclubbed) water demands.

11. SUBROUTINE WRT12

This subroutine writes the data used.

12. SUBROUTINES WRTM and WRT

These write the intermediate calculations giving distribution of water shares among various upstream and downstream demands (clubbed) and their deficits for each time period.

13. SUBROUTINE WRRES

This writes the salient end results in required format.

14. SUBROUTINE RTNFL

This writes the return flow contributions at the site under consideration from the immediate upstream reservoirs.

15. FUNCTION AREA

This calculates the reservoir water spread area as a function of reservoir storage.

16. FUNCTION ELEVAT

This calculates the reservoir elevation as a function of reservoir storage.

LIST OF VARIABLES

$El_{i,t}$ = Reservoir evaporation for i^{th} reservoir in time t,

$F_{i,t}$ = Natural inflow from its own catchment plus contributions of all possible regulated flows from upstream reservoirs and return flows from upstream water uses at i^{th} reservoir in time t,

$\bar{I}_{i,t}$ = Local inflow into i^{th} reservoir from surrounding areas in time t,

$O_{i,t}$ = Total reservoir release from i^{th} reservoir in time t,

$P_{i,t}$ = Precipitation effect directly upon i^{th} reservoir in time t,

$S_{i,t-1}$ = Initial reservoir storage or content of i^{th} reservoir in time t,

$S_{i,t}$ = Final reservoir storage or content of i^{th} reservoir at the end of time t,

Y_i = Gross storage capacity of the i^{th} reservoir, and

Yd_i = Dead storage capacity of the i^{th} reservoir.

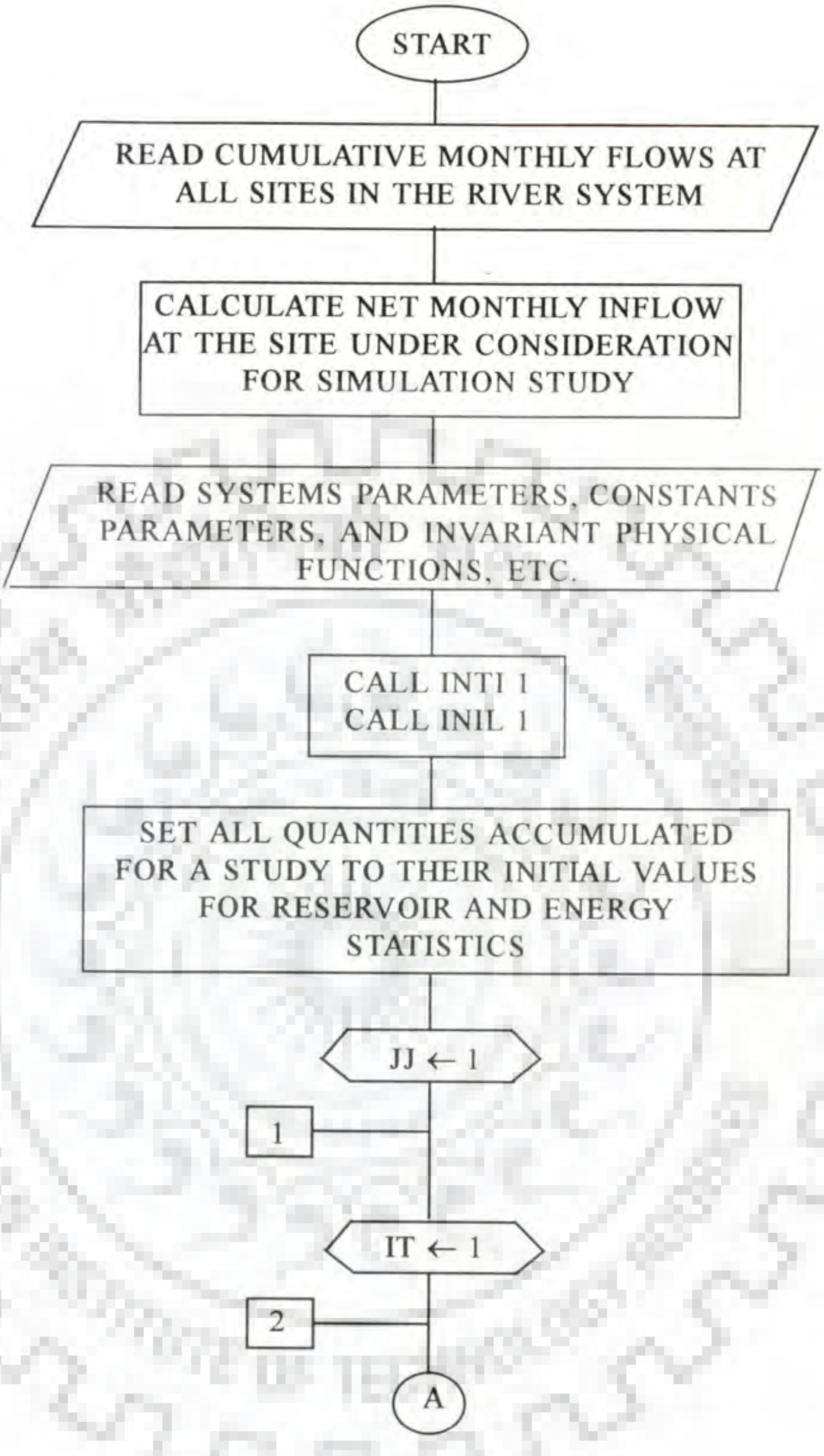
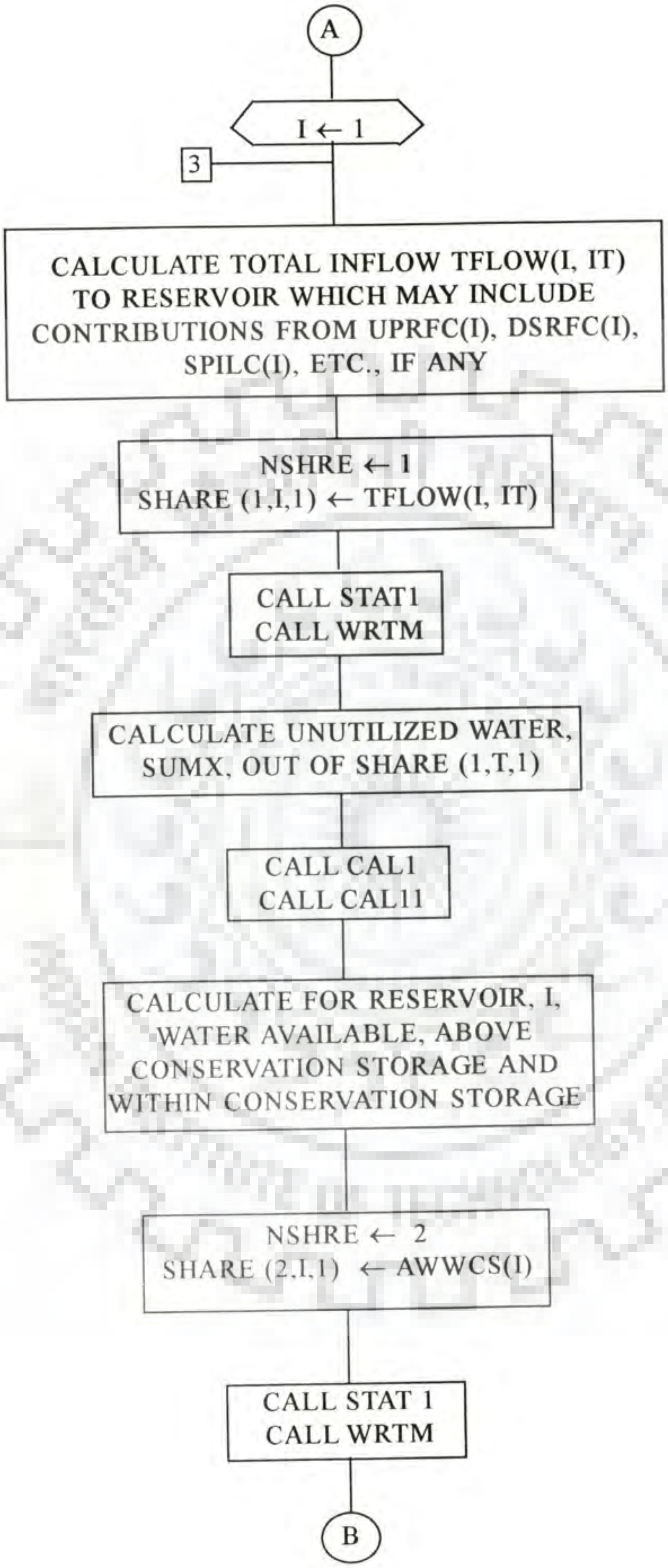


Fig. 3.1. General flowchart for simulation

Contd.


A
I ← 1
3
CALCULATE TOTAL INFLOW TFLOW(I, IT) TO RESERVOIR WHICH MAY INCLUDE CONTRIBUTIONS FROM UPRFC(I), DSRFC(I), SPILC(I), ETC., IF ANY
NSHRE ← 1
SHARE (1,I,1) ← TFLOW(I, IT)
CALL STAT1
CALL WRTM
CALCULATE UNUTILIZED WATER, SUMX, OUT OF SHARE (1,T,1)
CALL CAL1
CALL CAL11
CALCULATE FOR RESERVOIR, I, WATER AVAILABLE, ABOVE CONSERVATION STORAGE AND WITHIN CONSERVATION STORAGE
NSHRE ← 2
SHARE (2,I,1) ← AWWCS(I)
CALL STAT 1
CALL WRTM
B

Contd.

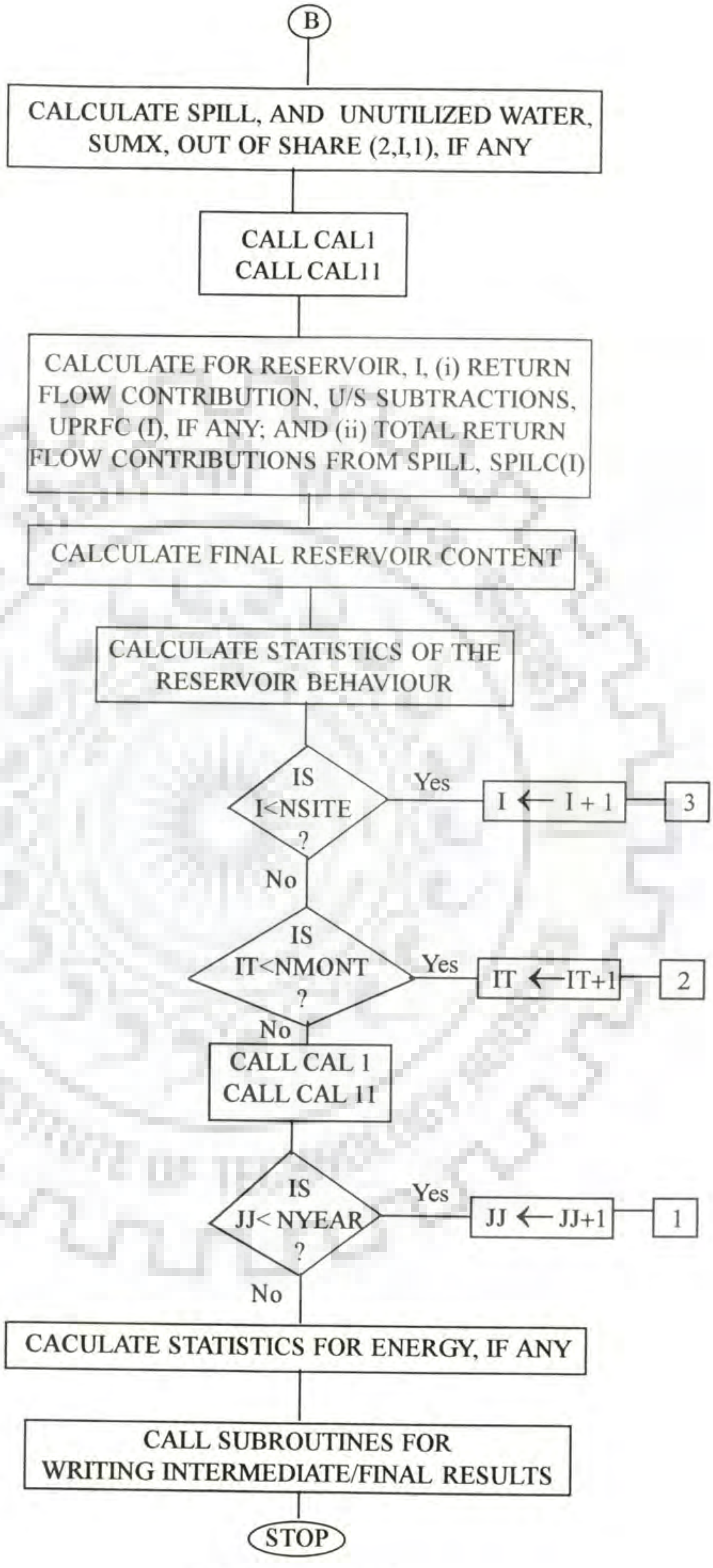


Fig.3.1. Concluded

DYNAMIC PROGRAMMING CAPACITY EXPANSION (SEQUENCING) MODEL

4.1 INTRODUCTION

4.1.1 General

Planning for the expansion of production capacity is of vital importance in water resources systems as it requires the commitment of substantial capital resources over long periods of time (Haimes, 1977). Rapid economic development and population growth have led to spiraling water demands for domestic, industrial, agriculture, hydropower, recreation and other purposes. As a consequence, optimal capacity expansion planning has become an extremely important concept in water resource development. It is however a complex and difficult task and, it is moreso when the system is multipurpose and multifacility. Task would undoubtedly become further intricate when the combined decisions on project selection, siting, sizing, target renewal, operation, financial planning etc. are sought alongwith capacity expansion.

4.1.2 Definition

The capacity expansion planning involves the selection of suitable projects, and the decision regarding sequential order and commissioning time of these projects over and above any existing system to meet the future growth in demand. Generally the immediate requirements of additions are effected and the planning process is repeated at every specified interval of time. Each time, depending upon the prevailing conditions, the optimum mode of expansion is decided. At any time the decisions regarding first few projects are taken to meet the immediate requirements with certain degree of reliability; but it is necessary to ascertain that these decisions are compatible with longterm expansion decisions. This makes it necessary to consider the problem in its totality taking all candidate projects, each time when the planning process is repeated. The capacity expansion of a system on ad-hoc basis considering different projects in isolation or at the most considering the interdependent projects only, with a few decision and state variables, is likely to lead to economically inefficient planning. If the effect of timing of project is not analysed in its due detail, then in the long run, the static decisions taken at different times may not yield an optimal solution.

4.1.3 Factors Affecting

For economically efficient expansion planning the projects are to be selected, sequenced, and timed in such a manner that the demand is fully satisfied at all the points of the planning horizon, and the present value of total costs of the set of selected projects is minimum. If the demand is a linear function of time and projects are of about same maximum capacity, then going by the effect of interest rate, the project with the lowest unit cost would be constructed first and projects with higher unit costs would be delayed as far as possible. But when the demand function is nonlinear, or when the capacities differ substantially, the sequence on the above criterion may not be the optimal.

An oversimplified example (Haimes, 1977) with a linear projected water demand function is useful to illustrate these effects. If the increase of water demand, D, is at the rate of 1/3 units per year, and a decision on the sequence of the construction of two water supply projects has to be made, and if the total supply under consideration is 10 units, the demand will reach this figure in 30 years. Let the annual discount rate, i, be 5%. Consider the following two cases:

Case-I: If the project 1 has the capacity, Q_1, of 4 units and a cost, C_1, of Rs.50,000, then unit cost is Rs.12,500 per unit. Similarly, if project 2 has a capacity , Q_2, of 6 units and a cost, C_2, of Rs.60,000, then its unit cost is Rs.10,000 per unit. The total present cost of building these two projects so as to always meet the water demand and when project 1 is constructed first is

$C_1 + C_2(1+i)^{-t_1} = 50000 + 60000(1.05)^{-12} =$ Rs. 83408.

Where $t_1=Q_1/D$. However, the total present cost when project 2 is constructed first is

$C_2 + C_1(1+i)^{-t_2} = 60000 + 50000(1.05)^{-18} = Rs.\ 80775.$

Where $t_2=Q_2/D$. Hence , in this case the decision would be, using a criterion of minimum present cost, to build the larger project first.

Case-II: Consider a similar example to the above but with some of the data changed. If project 1 is the same as in Case I above but if project 2 has a capacity, Q_2 of 6 units and a cost, C_2, of Rs.70,000, then the unit cost is Rs.11,667.

Under these circumstances the total project cost when project 1 is constructed first is

$C_1 + C_2(1+i)^{-t_1} = 50000 + 70000(1.05)^{-12} = Rs.\ 89076.$

In this case, the total present cost when project 2 is constructed first is

$C_2 + C_1(1+i)^{-t_2} = 70000 + 50000(1.05)^{-18} = Rs.\ 90775.$

Thus, in the second case, the optimal decision using the same criterion as above is to build the smaller project first, which, it might be noted, has the larger unit cost. In Case I, the project with smaller unit cost was the chosen project. Thus, unit cost is not a satisfactory criterion and it could be also shown that the choice of discount rate could also change the decisions in the above two cases.

Stated more generally, for a choice between the two possible sequences of constructions of two projects, the decision will be based on the relative magnitude of the two sides of the statement below

$$\{ C_1 + C_2(1+i)^{-t_1} \} \gtreqless \{ C_2 + C_1(1+i)^{-t_2} \}$$

The role that the slope of water demand curve plays in the decision making can also be illustrated as follows:

Consider now Case II with a different rate of increase in D2 of 1 unit per year.Under these circumstances, the total cost when project 1 is constructed first is

$C_1+C_2(1+i)^{-t_3}$=50000 + 70000(1.05)$^{-4}$=Rs.107589 where $t_3=Q_1/D_2$.

Whereas the total cost when project 2 is constructed first is

$C_2+C_1(1+i)^{-t_4}$=70,000+50,000(1.05)$^{-6}$=Rs.1,07,310 where $t_4=Q_2/D_2$.

Thus, the optimal decision would now be to construct the large project first.

The conclusion drawn is that the decision based on minimum present cost is influenced by the slope of the water demand curve, the discount rate applicable, and the relative costs and capacities of the facilities envisaged.

4.1.4 Classification

The capacity expansion can be handled as an independent problem or in combination with one or more of the other aspects of the water resource development such as project selection, siting, sizing, target renewal, operation, financial planning etc. Based on location the classes of sequencing models are single location and multilocation. The planning horizon may be singleperiod or multiperiod. The length of planning horizon may be finite or infinite. The time value of money as expressed in the discount factor makes the problem of project selection dynamic. The dynamic sequencing problems can be further classified as: (i)continuous project size and continuous time; (ii)continuous project size and discrete time; (iii)discrete project size and continuous time; (iv)discrete project size and discrete time (Haimes, 1977).

The projects under consideration may be interdependent or independent. The possible interdependencies include political, financial, and physical or hydrological, which can be portrayed by using two types of interactions namely, eliminative or precedence. When the project size is fixed, the problem is capacitated one, while if for every project are stated only inferior or superior capacity bounds, the problem is uncapacitated one. The problem may be of single facility expansion or multiple facility expansion. The projects may be serving single purpose or multiple purposes. The cost functions may be linear or nonlinear. The cost may be fixed or combined fixed and OMR cost. It may be expressed as annuity or unit cost.

Demand may be linear or nonlinear with respect to time. It may be inelastic or elastic to price. It may be required to be satisfied always or some deficit may be permitted. Supply may be required to be always greater than or equal to demand or initial supply deficits may be allowed under certain conditions such as immediate alleviation of deficits by supply expansion at the beginning of the planning period, or by importation from other sources of supply so that the initial capacity expansion need not occur at the beginning of planning period. Alternatively, the supply deficits may be allowed to go unsatisfied with a provision for a penalty cost for not meeting existing demand.

The objective function(s) may be the Minimization of present value of costs or the Maximization of present value of net benefits or otherwise.

4.2 PROPOSED SEQUENCING AND CAPACITY EXPANSION MODEL

4.2.1 General

The capacity expansion and optimum sequencing of projects involve multistage decisions over the planning horizon. The dynamic programming is one of the techniques capable of handling such problem of making multistage decisions, and yields optimum solution, which is not always possible with the heuristic procedure. However, the conventional dynamic programming suffers from the curse of dimensionality. The core storage and time requirements increase exponentially with increase of problem size. Several versions of this technique like state incremental dynamic programming, differential dynamic programming, discrete differential dynamic programming, successive approximation, and so forth have been evolved and have, to some extent, been successful in overcoming these drawbacks. However, for capacity expansion and project sequencing problems these versions, barring successive approximation, are not very popular (Haimes,1977).

4.2.2 Problem Statement

It is proposed to plan a river basin system consisting of a number of single/multipurpose reservoirs over the next few planning periods. Each reservoir is to be constructed only once and any combination of reservoirs may be built. The reservoirs are to be constructed to meet the increasing water demands. The usewise water demands in the basin are known and the minimum levels of cumulative demands should be met. However, some deficit in satisfying a demand may be permitted by incorporating suitable penalty in the relevant cost functions. Hydrological interaction among reservoirs may be taken into account by allowing a reservoir to be built and changing its target, if the interacting upstream reservoir(s) were built.

4.2.3 Formulation

The problem stated in the previous para, may be formulated as a dynamic programming problem since it involves sequential and multistage decision making. The use of backward process (initial value problem) of DP to examine alternative sequences of river basin development is considered in the following sections. First, the objective of the formulation is identified. Further, the recursive equation, which is the crux of a DP formulation, is explained alongwith associated terminology and constraints. An illustrative example is also presented to explain the proposed solution methodology.

4.2.3.1 Objective

The objective is to design the sequence of river basin reservoir developments that will satisfy the water capacity requirements at the minimum total cost. Thus, all the alternative sequences of development that are feasible are to be investigated and the optimum sequence among these alternative feasible solutions is to be selected.

4.2.3.2 Terminology and recursive equation

In this, time period is considered a stage variable. It is represented in terms of the stages to go for backward dynamic programming process. For each stage to go, a number of states are defined to represent the alternative combinations of reservoirs that might exist.

The total target of a state (target that can be supplied by a state) is the sum of the target of each reservoir included in that state with due consideration to the reservoir interactions amongst the reservoirs appearing in the state. Similarly, the total cost of a state is the sum of the cost of each reservoir included in the state. The total cost of a sequence is the sum of the total costs of the states included in that sequence. Generally these costs are taken as the annual cost of the reservoir.

The total number of possible states, N_k is given by equation

$$N_k = \prod_{j=1}^{np} L_j$$

Where,

Π = The Multiplication function,

N_k = Total number of possible states,

L_j = Total number of levels of target under consideration for reservoir j, for j = 1 to np, and

np = Total number of reservoirs.

e.g., if np=3 and each reservoir can be considered at its full capacity only, then it will have two levels, i.e., full or null. Thus $L_1=L_2=L_3=2$ and N_k = 2.2.2 = 8. Further, say $L_1=L_2=2$ and say reservoir 3 can be built in phases so that it will have three levels of capacity, namely, null capacity, half capacity and full capacity. Thus, $L_3=3$ and N_k = 2.2.3 =12.

The recursive equation which can be used to determine the optimum sequence of expansion to each feasible state for any r stages to go is as follows

$$f_r(S_r) = \min_{O_r} \{g_r(S_r,O_r)+[(1/(1+i)^r)*f_{r-1}(S_{r-1})]\} \text{ for all r} \quad (I)$$

Where,

$f_r(S_r)$ = The optimum minimum cost of the reservoir sequence stemming out from the initial feasible state, S_r, for r stages to go so as to attain the corresponding connected resulting state, S_{r-1},

N = Total number time periods,

t = Any time period, t = 1, 2 , ..., N,

r = Stages to go , r = 1, 2, ..., N,

r = N - t,

i = Discount rate,

S_r = Feasible state for r stages to go (a state variable)

O_r = State (reservoir combination) to be added for r stages to go into initial state, S_r, to attain the resulting (final) state, S_{r-1}, (a decision variable),

D_r = Cumulative demand for r stages to go,

$g_r(S_r, O_r)$ = Cost function for adding the state (reservoir combination), O_r, into the state, S_r, for r stages to go for attaining the state, $S_{r-1} = C(S_r) + C(O_r) = C(S_{r-1})$.

$C(S_r)$ = Cost of the initial feasible state, S_r, for r stages to go,

$C(O_r)$ = Cost of the state (reservoir combination), O_r, added, and

$C(S_{r-1})$ = Cost of the resulting state, S_{r-1}, for r stages to go.

4.2.3.3 The Constraints

The stated recursive equation is subjected to the following constraints.

a. Feasibility constraint:

The target, $X(S_r)$, of a feasible state, S_r, for r stages to go must be greater than or equal to the cumulative demand on the system

$$X(S_r) \geq D_r \qquad \text{for all } r \qquad (4.1)$$

b. Transition feasibility / continuity constraint:

The feasible solution to the problem under consideration is a sequence of feasible states satisfying the constraint that

$$S_r \in S_{r-1} \qquad \text{for all } r \qquad (4.2)$$

and

$$S_{r-1} = S_r \oplus O_r \qquad \text{for all } r \qquad (4.3)$$

The symbol $\oplus$ indicates addition of state (reservoir combination). The symbol $\in$ indicates that the state, S_r, is included in the state, S_{r-1}, and hence the transition is feasible. For e.g., if the resulting state, S_{r-1}, contains the reservoirs A, B, and C and the corresponding initial state, S_r, contains the reservoirs B, and C then transition is feasible as state ABC can be reached from state BC. Whereas if state, S_{r-1}, is BC and state, S_r, is A then transition is infeasible since state BC cannot be reached from state A (A is not included in BC).

These constraints can be further generalized to accommodate (i) multipurpose reservoirs catering to more than one water use, and

(ii) allowable deficit in satisfying a water demand.

The modified constraints are

a. Feasibility constraint:

$$X_d(S_r) + A_d^r \geq D_d^r \qquad \text{for all } r \qquad (4.4)$$

Where

d = Water use or purpose number,

d = 1, 2, ...,N_d,

N_d = Total number of purposes/water uses,

$X_d(S_r)$ = Target of a feasible state, S_r, to satisfy d^{th} purpose/water use for r stages to go,

A_d^r = Allowable deficit in satisfying d^{th} purpose/water use for r stages to go, and

D_d^r = Cumulative demand for d^{th} purpose/water use for r stages to go.

b. Transition feasibility / continuity constraint:

It is same as stated earlier and is given by Eq.4.3.

The cost function in the recursive equation, in view of these modifications, will have the following form

$$g_r(S_r, O_r) = \sum_{d=1}^{N_d} [C_d(S_{r-1}) + \lambda_d(S_{r-1})] \qquad \text{for all } r$$

Where

$d=1, \ldots\ldots, N_d$,

N_d = Number of purposes/water uses.

$C_d(S_{r-1})+\lambda_d(S_{r-1})$ = The cost of resulting state, S_{r-1}, for d^{th} purpose/water use for r stages to go,

$$= [C_d(S_r)+\lambda_d(S_r)] + [C_d(O_r)+\lambda_d(O_r)]$$

$C_d(S_r)$ = Cost of the initial feasible state, S_r, for d^{th} purpose/water use for r stages to go,

$C_d(O_r)$ = Cost of the state (reservoir combination), O_r, added, for d^{th} purpose/water use for r stages to go,

$\lambda_d(S_r)$ = The penalty cost for allowing deficit for the initial feasible state, S_r, for d^{th} purpose/water use for r stages to go, and

$\lambda_d(O_r)$ = The penalty cost for allowing deficit for the added state (reservoir combination), O_r, for d^{th} purpose/water use for r stages to go.

4.3 WORKING PRINCIPLE OF SEQUENCING COMPUTER PROGRAM

The computer program for the sequencing of multipurpose, multireservoir system is a very complex program. It comprises of as many as 8 subroutine subprograms alongwith the main program. The program works according to the proposed mathematical model presented in earlier sections (Appendix 4-I).

A general flowchart for the steps in the sequencing is presented in Figs. 4.1(a), (b), and (c). The functions of the various important subprograms are briefly highlighted in the following sections.

1. SUBROUTINE CODE

This generates code in terms of 0 and 1 for representing the states (reservoir combinations). Two versions of this are developed. One operates at bit level which may not be supported by all compilers/computer machines whereas the other one makes use of bytes and hence can be used with all compilers/computer machines.

2. SUBROUTINE STYLD

This calculates the usewise target and cost of each state.

3. SUBROUTINE ARRANG

This arranges the states in either descending or ascending order using total cost and total target of the states. Further it finds out the state codes to be used in further calculations. This may be useful and effective only for sequencing of single purpose reservoirs due to the following reasons:

(a) Addition of reservoir(s) into a state results in increase in the capacity of a state facilitating the ordering of states.

(b) Equal capacity states can be screened thereby causing reduction in the number of states to be considered in every stage for sequencing.

(c) Sequencing can be considered beyond any initial state condition.

However, this subroutine may not be that useful and effective for sequencing of multipurpose reservoirs or also for reservoirs serving different purposes due to the following reasons:

(a) Addition of reservoir(s) into a state does not necessarily result in increase in the usewise capacity (target) of a state and hence not facilitating the ordering of states.

(This is moreso in case of hydropower reservoirs having irrigation or multipurpose reservoirs at the upstream).

(b) Sequencing can not be considered beyond any initial state condition as states can not be arranged in any order thus making it imperative to consider all the states in every stage for sequencing.

4. SUBROUTINE DPALG [Fig.4.1(b)]

This by making use of various subroutines finds the optimal paths of expansion of the given system for all feasible given initial states at every stages to go using the recursive equation.

5. SUBROUTINE FUNCT

This evaluates the total cost function of the feasible states at every stage.

6. SUBROUTINE CONNECT

This determines the feasibility as well as transition feasibility of a state.

7. SUBROUTINE OPTPA [Fig.4.1(c)]

This performs the forward tracing of the optimal path of expansion starting with time zero.

8. SUBROUTINE SERCH

This deciphers/retrieves the information about the optimal path of expansion in terms of actual reservoir name codes and writes the reservoir code name(s) as per states added in every stage (period) along the optimal path of expansion.

This computer program has been thoroughly tested for the four projects-four period sequencing problem and also for the numericals presented in the following sections.

4.4 ILLUSTRATIVE EXAMPLE

A simple example of hydropower capacity expansion (sequencing) problem earlier solved by Kuiper and Ortolano(1973) using forward process of dynamic programming is again solved here using the backward dynamic programming approach in order to explain the proposed methodology. Consider a power system involving three independent hydropower projects, labeled A, B, and C, that can be constructed to meet an increasing capacity demand. Assume that no deficits are allowed and therefore the penalty cost is 0(zero). The annual cost and capacity of each hydropower project are as follows

Project	**Capacity**	**Annual Cost**	**Penalty cost**
A	500	30	0
B	1000	50	0
C	1500	60	0

The increase in the capacity required over next three time periods is

Period	0	1	2	3
Capacity required	0	1000	2000	3000

The problem can be analyzed in three stages, each representing one time period, so N=3. As there are three projects, each of which may have two capacity levels namely, either built at full capacity or not built at all, there are eight possible combinations of the projects that represent the various possible states for any stage to go. Thus, N_k=2.2.2=8.

The recursive equation states that the minimum total cost of attaining the resulting state, S_{r-1}, for r stages to go is equal to the cost of this state plus the minimum total cost of attaining the least expensive connected resulting state for the previous r-1 stages to go. Only those states satisfying the capacity requirements may be included in any sequence of expansion.

By using the recursive equation the minimum total cost of all the states in a stage to go can be calculated using only data on the minimum total costs in the previous stage to go. Once each stage to go has been completed, the next stage to go is examined, until all the costs in all stages to go have been calculated. Then the state for last N stages to go with the lowest total cost is selected as the optimum starting state and the sequence of expansion stemming out from this state becomes the optimum sequence of expansion.

At the end of the one stage to go, only state ABC satisfy the capacity requirement and is therefore feasible. The total cost of state ABC for one stage to go is equal to the cost of that state, since the total cost of the resulting state in the previous 0(zero) stages to go is 0(zero). At the end of the two stages to go, the states AC, BC, and ABC are feasible because they have capacity either equal or more than the required 2000 units of capacity. These states are included in the state ABC of the one stage to go and hence this can be attained from all of the states of the two stages to go. Further, at the end of the three stages to go, the states B, C, AB, AC, BC, and ABC are feasible as they have capacity either equal to or more than the required 1000 units of capacity. The states B, C, AB, AC, BC, and ABC are included in the state ABC of two stages to go; the states B, C, BC are included in the state BC of the two stages to go; and the states C, and AC are included in the state AC of the two stages to go. Ultimately, the 'null' state is included in all feasible states at the end of the three stages to go.

Also, at the end of the one stage to go, the minimum cost of the sequences stemming out from the from the states AC, BC, and ABC of the two stages to go is (140+0) each with resulting state as ABC and added states as B, A, and 'null' respectively. At the end of the two stages to go, the costs of the sequences BC, AC, and ABC stemming out form the the state C are ((110+0)+140), ((90+0)+140) and ((140+0)+140). Out of these, the sequence AC is the minimum cost sequence and added state is A. The minimum cost sequences stemming out from the remaining feasible states for two stages to go can be derived in similar manner. In each case, the state, its resulting state, the minimum cost, and the decision regarding state to be added are also recorded in the computations.

Lastly, at the end of the three stages to go, it is assumed that the starting state, from which the feasible sequences towards the feasible states for two stages to go are stemming out, is the 'null' state. The optimum sequence of expansion stemming out from this 'null' state is shown in Table 4.1.

As per the data given in the example all the possible feasible states and their transition feasibilities (connections) for each r are shown in the Fig. 4.2.

Computation: Backward Dynamic Programming Process.

One Stage to go, r = 1:
Initial feasible states ($S_r = S_1$) are AC, BC, and ABC.
Resulting (final) feasible state ($S_{r-1} = S_0$) is ABC only.
Transition feasibility is as follows

Resulting feasible state, S_0	Included initial feasible state, S_1	Added state, O_1
ABC	AC	B
ABC	BC	A
ABC	ABC	NULL

The cost function $g_r(S_r, O_r) = g_1(S_1, O_1)$
$= C_1(S_0) + \lambda_1(S_0)$
$= [C_1(S_1) + \lambda_1(S_1)] + [C_1(O_1) + \lambda_1(O_1)]$

The recursive equation is
$f_1(S_1) = \text{Min}_{O_1} \{ [C_1(S_0) + \lambda_1(S_0)] + f_0(S_0) \}$

	$[C_1(S_0)+\lambda_1(S_0)]+f_0(S_0)$	$f_1(S_1)$	Resulting state	Added state, O_1
$S_0 \Rightarrow$	ABC			
S_1				
BC	(140+0)+0	140	ABC	A
AC	(140+0)+0	140	ABC	B
ABC	(140+0)+0	140	ABC	NULL

Two Stages to go, r = 2

Initial feasible states ($S_r = S_2$) are B, C, AB, AC, BC, and ABC.
Resulting (final) feasible states, ($S_{r-1} = S_1$) AC, BC ,and ABC.

Transition feasibility is as follows

Resulting feasible state, S_1	Included initial feasible state, S_2	Added state, O_2
AC	C	A
AC	AC	NULL
BC	B	C
BC	C	B
BC	BC	NULL
ABC	B	AC
ABC	C	AB
ABC	AC	B
ABC	AB	C
ABC	BC	A
ABC	ABC	NULL

The cost function $g_r(S_r, O_r) = g_2(S_2, O_2) = C_1(S_1) + \lambda_1(S_1)$
$= [C_1(S_2) + \lambda_1(S_2)] + [C_1(O_2) + \lambda_1(O_2)]$

The recursive equation is
$f_2(S_2) = \text{Min}_{O_2} \{ [C_1(S_1) + \lambda_1(S_1)] + f_1(S_1) \}$

	$[C_1(S_1)+\lambda_1(S_1)]+f_1(S_1)$			$f_2(S_2)$	Resulting state	Added state O_2
$S_1 \Rightarrow$	AC	BC	ABC			
S_2						
B	***	110+0+140	140+0+140	250	BC	C
C	90+0+140	110+0+140	140+0+140	230	AC	A
AC	90+0+140	***	140+0+140	230	AC	NULL
AB	***	***	140+0+140	280	ABC	C
BC	***	110+0+140	140+0+140	250	BC	NULL
ABC	***	***	140+0+140	280	ABC	NULL

Three stages to go, r = 3
Initial feasible state ($S_r = S_3$) is assumed to be NULL state.
Resulting (final) feasible states ($S_{r-1} = S_2$) are B, C, AB, AC, BC, and ABC.
Transition feasibility is as follows

Resulting feasible state, S_2	Included initial feasible state, S_3	Added state, O_3
B	NULL	B
C	NULL	C
AB	NULL	AB
AC	NULL	AC
BC	NULL	BC
ABC	NULL	ABC

The cost function $g_r(S_r, O_r) = g_3(S_3, O_3)$
$= C_1(S_2) + \lambda_1(S_2)$
$= [C_1(S_3) + \lambda_1(S_3)] + [C_1(O_3) + \lambda_1(O_3)]$

The recursive equation is

$f_3(S_3) = \text{Min}_{O_3} \{ [C_1(S_2) + \lambda_1(S_2)] + f_2(S_2) \}$

	$[C_1(S_2)+\lambda_1(S_2)]+f_2(S_2)$						$f_3(S_3)$	Resulting state	Added state, O_3
$S_2 \Rightarrow$	B	C	AC	BC	AB	ABC			
S_3 null (0)	(50+0 +250) =300	(60+0 +230) =290	(90+0 +230) =360	(110+0 +250) =320	(80+0 +280) =360	(140+0 +280) =420	290	C	C

Table 4.1 Optimal sequence of states (at the end of r stages to go) for illustrative example.

Time Period	Stages to go	Composition	Total capacity	Total cost
0	3	NULL	0	0
1	2	C	1500	60
2	1	AC	2000	150
3	0	ABC	3000	290

ADDITIONAL EXAMPLES

EXAMPLE 1

In the illustrative example given above, consider a project D with capacity 2000 and annual cost 80. Solution to this four project sequencing problem is given in Table 4.2.

As per the data given in the example all the possible feasible states and their transition feasibilities (connections) for each r are shown in the Fig. 4.3.

Table 4.2 Optimal sequence of states (at the end of r stages to go) for example 1.

Time Period	Stages to go	Composition	Total capacity	Total cost
0	3	NULL	0	0
1	2	D	2000	80
2	1	D	2000	160
3	0	BD	3000	290

Alternative optimal sequence of states (at the end of r stages to go) for example 1 is also given below.

Time Period	Stages to go	Composition	Total capacity	Total cost
0	3	NULL	0	0
1	2	C	1500	60
2	1	AC	2000	150
3	0	ABC	3000	290

EXAMPLE 2

In an another example consider the following data

Project	Capacity	Annual Cost	Penalty cost
A	500	30	0
B	1000	50	0
C	1500	60	0
D	2000	80	0

The increase in the capacity required over next four time periods is

Period	0	1	2	3	4
Capacity required	0	1000	2000	3000	4000

The solution to this problem is given in the Table 4.3.

As per the data given in the example all the possible feasible states and their transition feasibilities (connections) for each r are shown in the Fig. 4.4.

Table 4.3 Optimal sequence of states (at the end of r stages to go) for example 2.

Time Period	Stages to go	Composition	Total capacity	Total cost
0	4	NULL	0	0
1	3	D	2000	80
2	2	D	2000	160
3	1	CD	3500	300
4	0	ACD	4000	470

EXAMPLE 3

The increase in the capacity required over next four time periods is

Period	**0**	**1**	**2**	**3**	**4**
Capacity required	**0**	**1000**	**3000**	**4000**	**5000**

Solution to this problem is given in the Table 4.4.

Table 4.4 Optimal sequence of states (at the end of r stages to go) for example 3.

Time Period	Stages to go	Composition	Total capacity	Total cost
0	4	NULL	0	0
1	3	C	1500	60
2	2	CD	3500	200
3	1	ACD	4000	370
4	0	ABCD	5000	590

Alternative optimal sequence of states (at the end of r stages to go) for example 3 is also given below.

Time Period	Stages to go	Composition	Total capacity	Total cost
0	4	NULL	0	0
1	3	B	1000	50
2	2	BD	3000	180
3	1	BCD	4500	370
4	0	ABCD	5000	590

EXAMPLE 4

In the example given above, consider the increase in the capacity required over next four time periods as given below:

Period	**0**	**1**	**2**	**3**	**4**
Capacity required	**0**	**3000**	**4000**	**4500**	**5000**

Solution to this problem is given in the Table 4.5.

Table 4.5 Optimal sequence of states (at the end of r stages to go) for example 4.

Time Period	Stages to go	Composition	Total capacity	Total cost
0	4	NULL	0	0
1	3	BD	3000	130
2	2	BCD	4500	320
3	1	BCD	4500	510
4	0	ABCD	5000	730

As per the data given in the examples 3 and 4 all the possible feasible states and their transition feasibilities (connections) for each r and the optimal expansion paths for both the examples are shown in the Fig. 4.5.

LIST OF VARIABLES

Π = The Multiplication function,

N_k = Total number of possible states,

L_j = Total number of levels of target under consideration for reservoir j, for j = 1 to np,

np = Total number of reservoirs,

$f_r(S_r)$ = The optimum minimum cost of the reservoir sequence stemming out from the initial feasible state, S_r, for r stages to go so as to attain the corresponding connected resulting state, S_{r-1},

N = Total number time periods,

t = Any time period, $t = 1, 2, \ldots\ldots, N$,

r = Stages to go , $r = 1, 2, \ldots., N$,

$r = N - t$,

i = Discount rate,

S_r = Feasible state for r stages to go (a state variable),

O_r = State (reservoir combination) to be added for r stages to go into initial state, S_r, to attain the resulting (final) state, S_{r-1}, (a decision variable),

D_r = Cumulative demand for r stages to go,

$g_r(S_r, O_r)$ = Cost function for adding the state (reservoir combination), O_r, into the state, S_r, for r stages to go for attaining the state, S_{r-1},

$C(S_r)$ = Cost of the initial feasible state, S_r, for r stages to go,

$C(O_r)$ = Cost of the state (reservoir combination), O_r, added,

$C(S_{r-1})$ = Cost of the resulting state, S_{r-1}, for r stages to go.

$d = 1, \ldots\ldots, N_d$,

N_d = Number of purposes/water uses,

$C_d(S_{r-1}) + \lambda_d(S_{r-1})$ = The cost of resulting state, S_{r-1}, for d^{th} purpose/water use for r stages to go,

$$= [C_d(S_r) + \lambda_d(S_r)] + [C_d(O_r) + \lambda_d(O_r)]$$

$C_d(S_r)$ = Cost of the initial feasible state, S_r, for d^{th} purpose/water use for r stages to go,

$C_d(O_r)$ = Cost of the state (reservoir combination), O_r, added, for d^{th} purpose/water use for r stages to go,

$\lambda_d(S_r)$ = The penalty cost for allowing deficit for the initial feasible state, S_r, for d^{th} purpose/water use for r stages to go, and

$\lambda_d(O_r)$ = The penalty cost for allowing deficit for the added state (reservoir combination), O_r, for d^{th} purpose/water use for r stages to go.

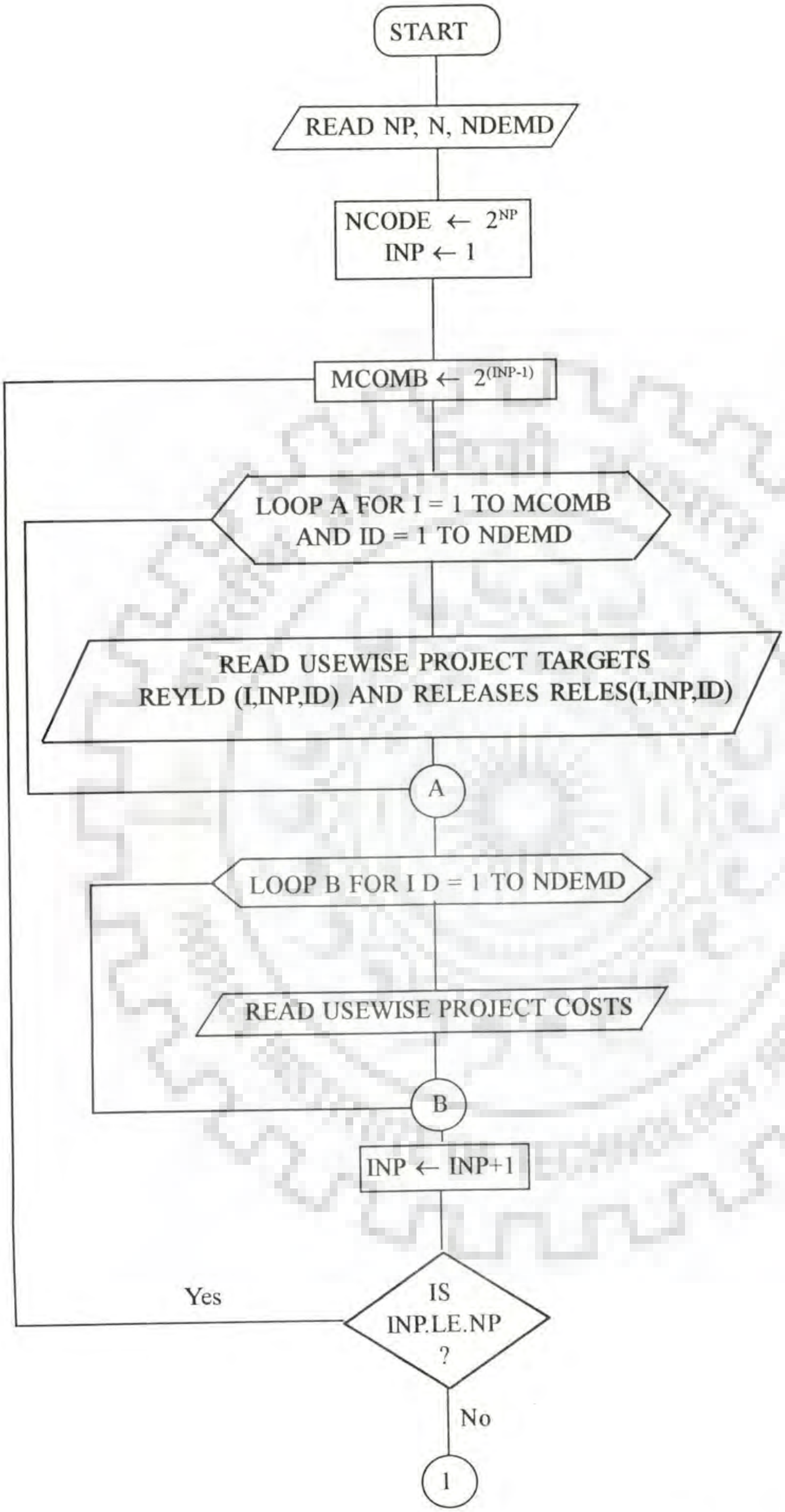


Fig. 4.1(a). General flowchart for DP sequencing algorithm

Contd.

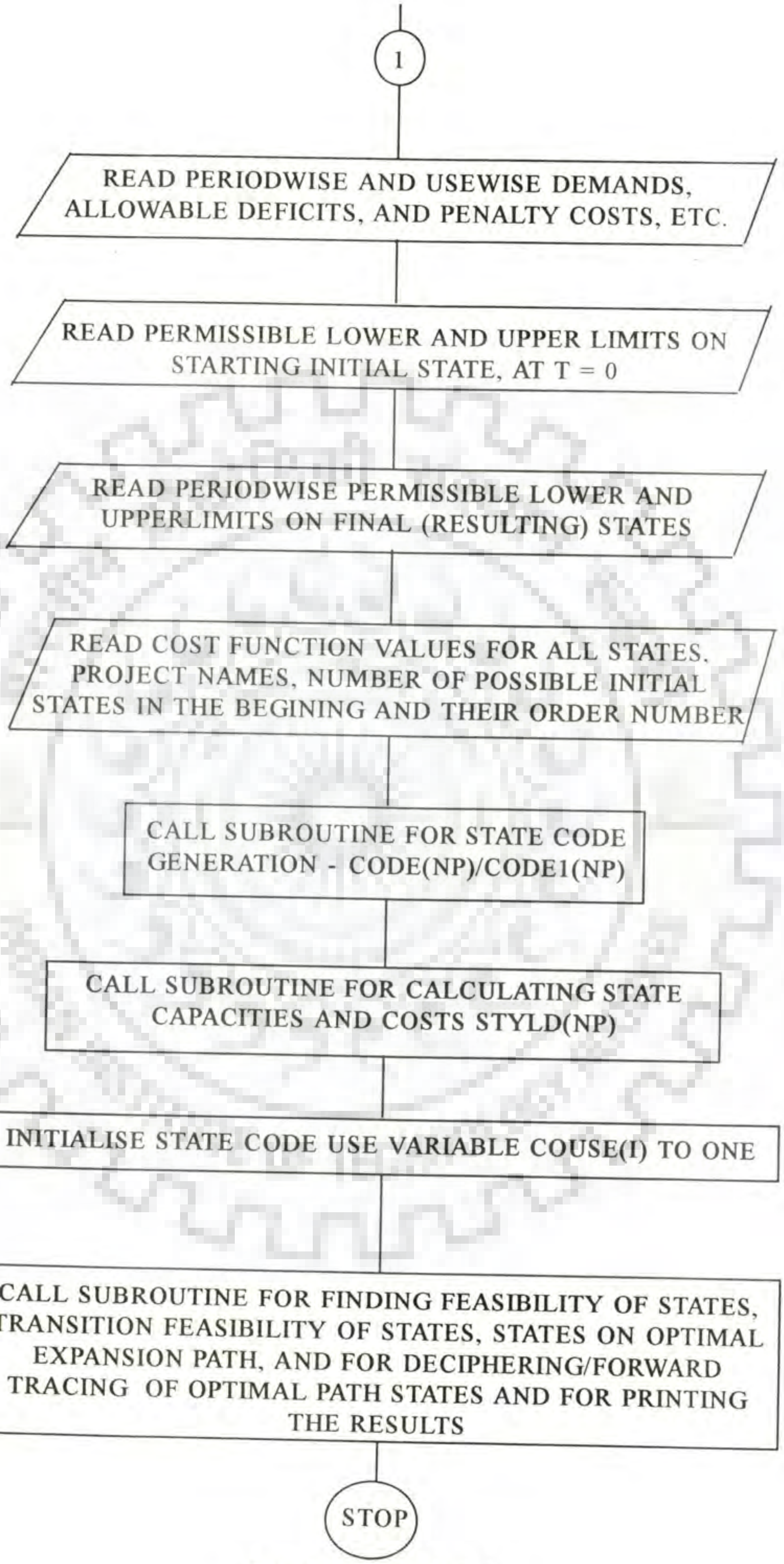


Fig. 4.1(a). Concluded

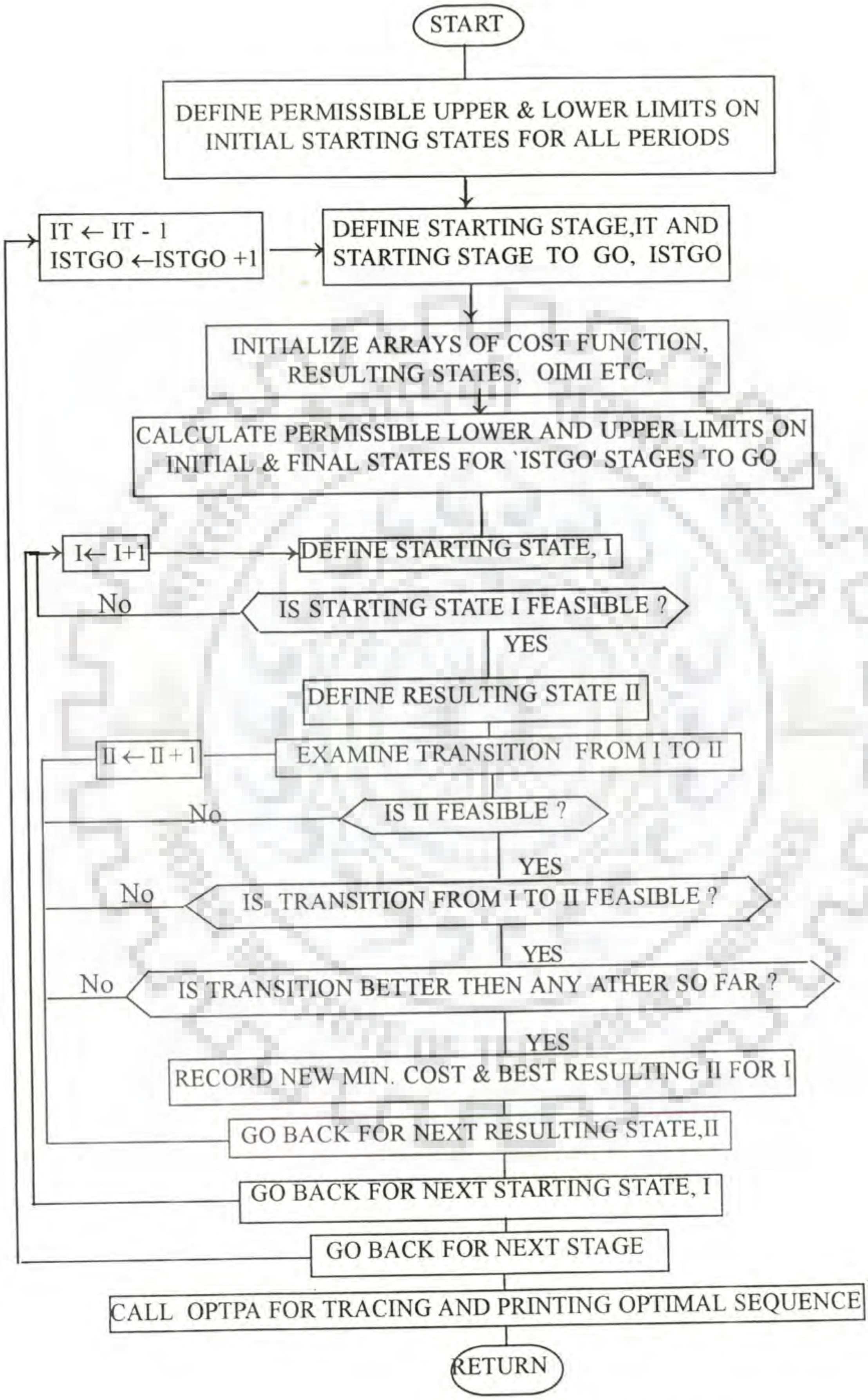


Fig. 4.1(b) Flowchart of subroutine DPALG

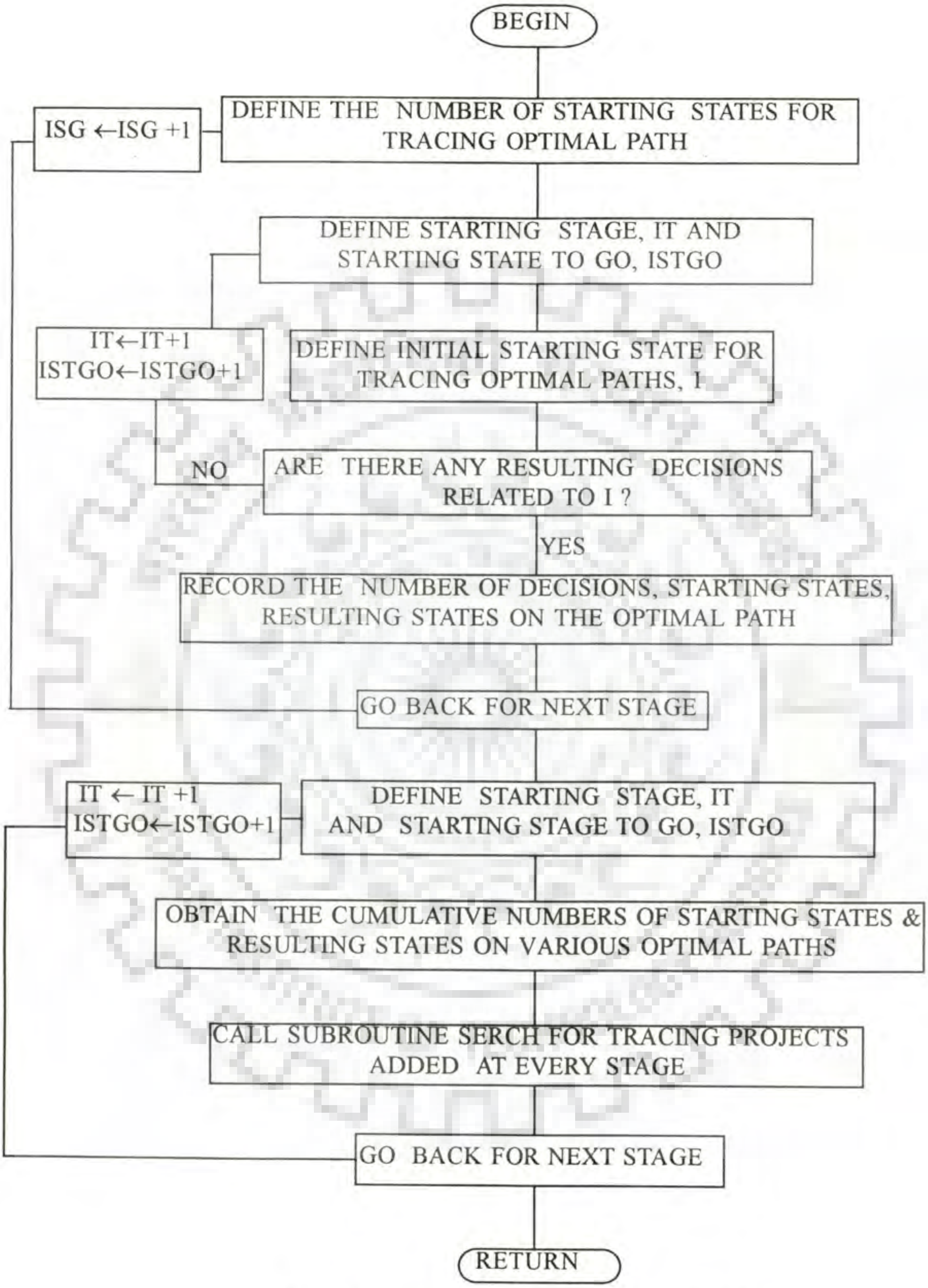


Fig.4.1(c) Flowchart of subroutine OPTPA

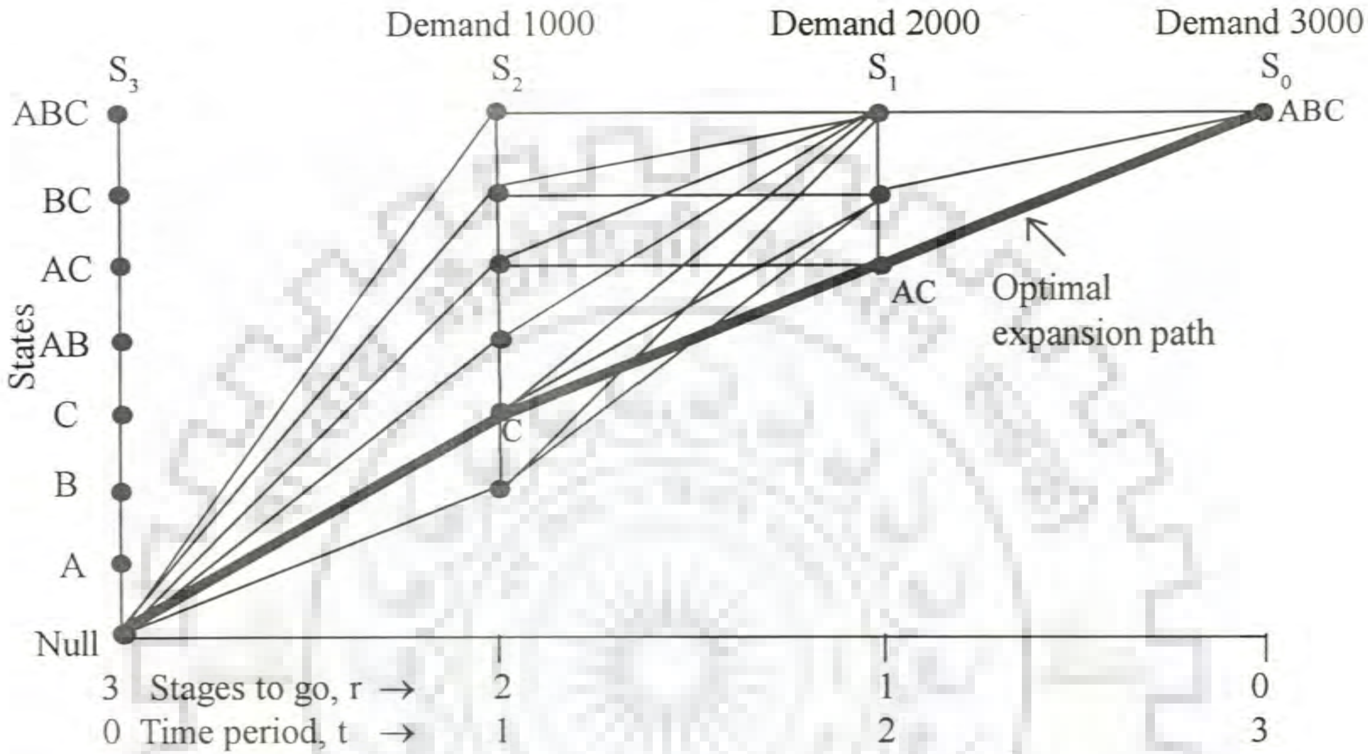


Fig. 4.2 Transition feasiblility of states for illustarative example

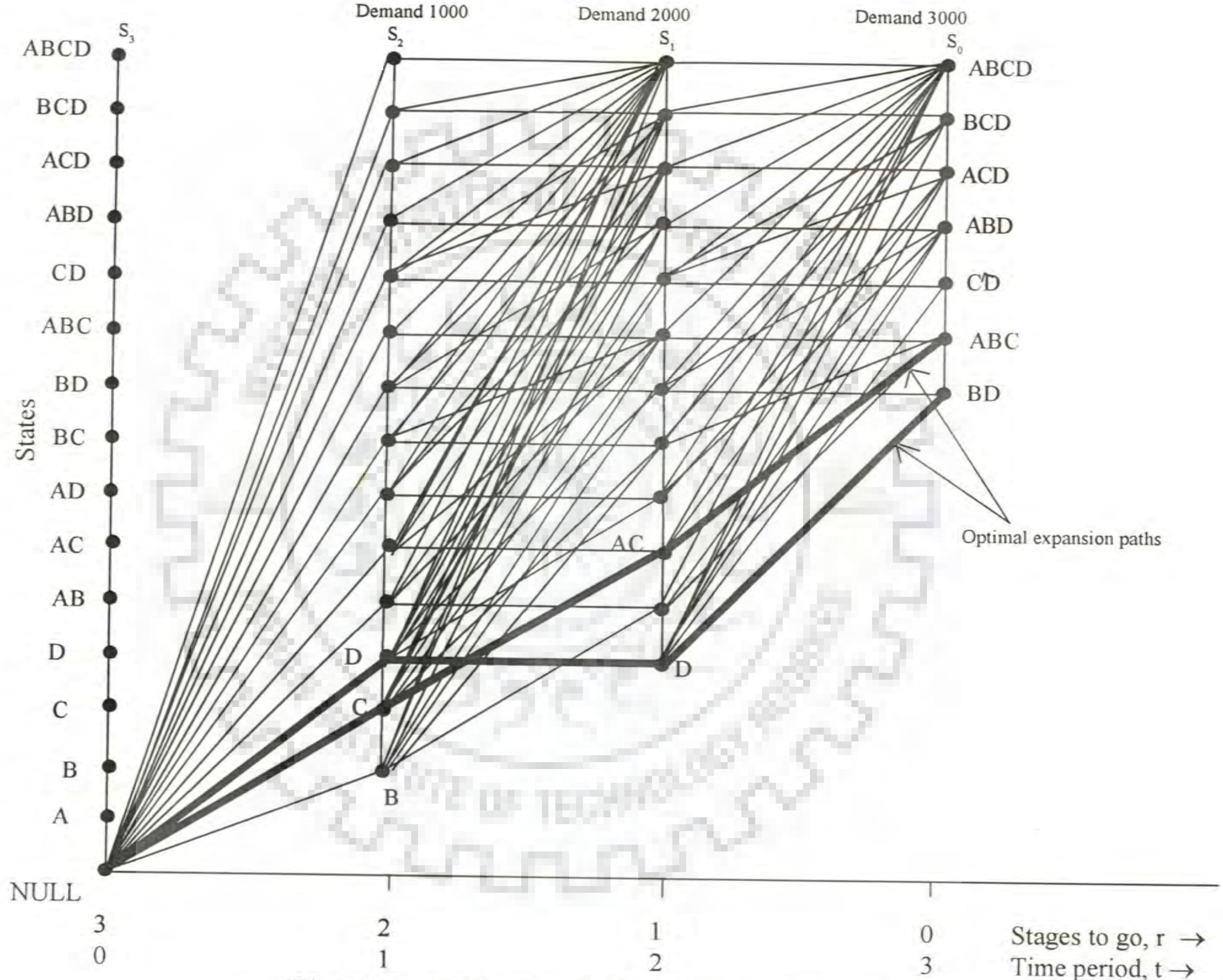


Fig.4.3 Transition feasibility of states for example 1.

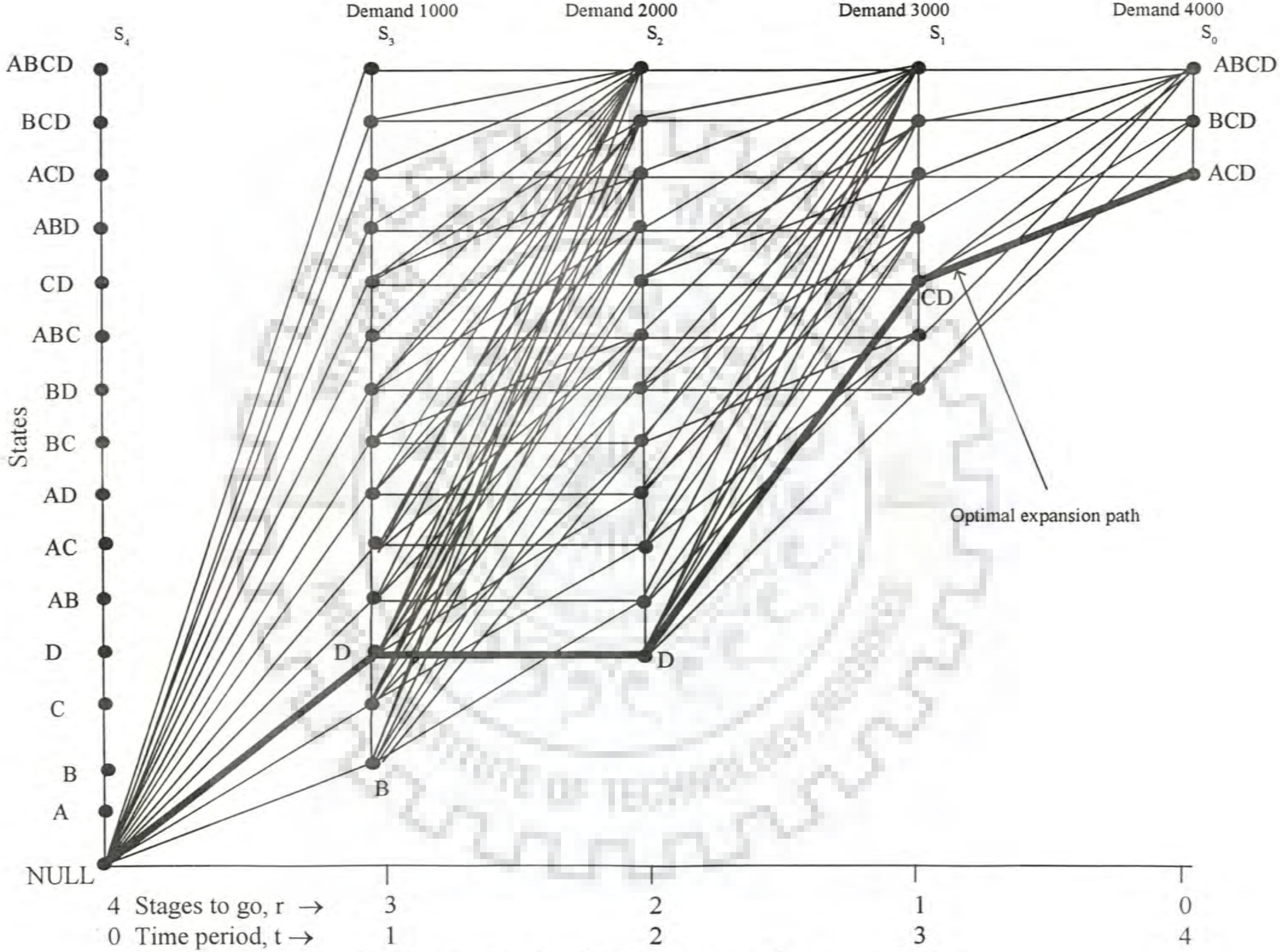


Fig.4.4 Transition feasibility of states for example 2.

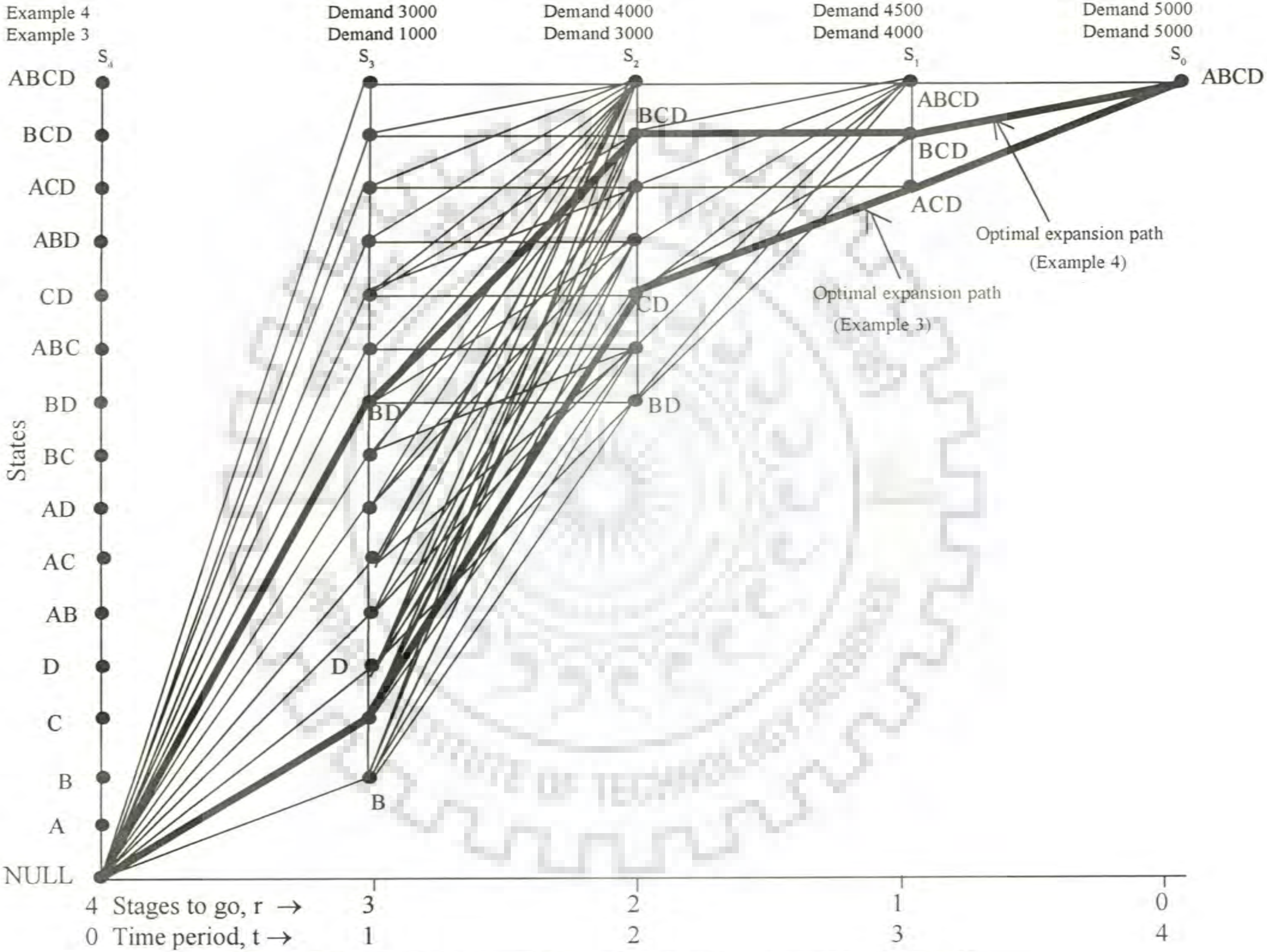


Fig.4.5 Transition feasibility of states for examples 3 and 4.

THE RIVER SYSTEM AND THE PROBLEM

5.1 BASIN DESCRIPTION

As stated in Chapter 1, there are many pending inter State river basin development issues in India due to river water disputes. However, it has been decided to consider the Narmada river basin for the present study owing to the following reasons:

(i) Tribunal awards for river water disputes for many inter State river basins are awaited, whereas the tribunal award for the Narmada river basin has already been given in 1979.

(ii) Master Plan for the Narmada river basin development and relevant data were generally available.

(iii) The river basin is large with multipurpose mega projects.

(iv) It is an internationally known basin.

(v) It is in the initial stages of development.

The Narmada basin (Master Plan, 1972) is located in central India. The Narmada is the largest west flowing and fifth largest river of India. It is an interstate river draining a large area in Madhya Pradesh besides some area in the States of Maharashtra and Gujarat. The Narmada basin lies between East longitudes $72^0 32'$ to $81^0 45'$ and North latitudes $21^0 20'$ to $23^0 45'$. The

Narmada rises from a spring at an elevation of 1057 m at Amarkantak in the Miakal hill in Shahdol district of Madhya Pradesh and flows through Madhya Pradesh, Maharashtra and Gujarat between Vindhya and Satpura ranges before falling into the Gulf of Cambay in the Arabian Sea about 10 km north of Bharuch. The total length of this west flowing river from its origin to its outfall into the sea is 1312 km. For the first 1079 km it runs in Madhya Pradesh and thereafter forms the common boundary between Madhya Pradesh and Maharashtra for 35 km, and Maharashtra and Gujarat for 39 km. In Gujarat State it stretches for 159 km.

There are 41 important tributaries to the Narmada river. Significant among them are Burhner, Banjar, Hiran, Tawa, Chhota Tawa, Orsang, and Kundi which are major tributaries having catchment area more than 3500 sq.km. The remaining tributaries are having catchment area ranging from 500 to 2500 sq. km. The catchment area, length, and elevation of the origin of the important tributaries are indicated in Table 5.1. The relative positions of the principal tributaries with respect to main Narmada river are shown in the line diagram Fig. 5.1.

5.2 CLIMATE AND RAINFALL

The climate in the basin is variable owing to topographic characteristics. However generally humid tropical conditions prevail in the basin as major part of the basin lies just below the Tropic of Cancer. In winter the minimum temperature varies from 1.5^{0}C to 9^{0}C. The maximum temperature varies from 40^{0}C to 49^{0}C with the month of May as the hottest month. Temperature rises from east to the west.

The average annual rainfall in the Narmada basin is 1250 mm. The south west monsoon sets in by the middle of June and withdraws by middle of October. About 90 percent of total rainfall is received during the monsoon months, of which nearly 50 percent is received during the months of July and August. Rainfall is more in the eastern hills and goes on decreasing towards low western hills.

The basin has been suitably subdivided into three zones namely upper, middle, and lower. The upper zone is from origin of the river to Bargi Reservoir. The middle zone is between Bargi and Narmada Sagar. The lower zone is below Narmada Sagar.

5.3 STREAMFLOW

The storage reservoirs on the Narmada would generally fill during July to October and would be depleted from November to the following June. The monthly flow data are therefore given from July to June of the next year (water year). Two sets of monthly data were prepared due to availability of raw data in both cases. These are explained below.

5.3.1 Twenty Two Year Monthly Flow Data (1948-1969)

Monthly flow data in million cubic meters (Mcm) at four important gauging sites in the basin namely Jamtara, Tawa, Mortakka and Garudeshwar were readily available in the Master Plan Vol. V. (Master Plan, 1972). These were transferred to reservoir sites using catchment area proportions. The monthly flow data at gauging sites are given in Table 5.2. The transferred monthly flow data at reservoir sites are reproduced in Table 5.3.

5.3.2 Sixteen Year Monthly Flow Data (1977-1993)

Daily discharge data in cumecs at 11 important gauging sites in the basin namely Manot, Mohgaon, Jamtara, Belkeri, Gadarwara, Tawa, Mortakka, Chiddgaon, Ginnore, Kogaon and Garudeshwar were available in the 77 column coded format. These huge data were decoded and converted to monthly flows in Mcm. These were further transferred to the reservoir sites using catchment area proportions. These transferred monthly flow data at reservoir sites are given in Table 5.4.

5.4 BASIN NEEDS (DEMANDS)

5.4.1 Irrigation Water Requirement

The irrigation water requirement of the basin has been assessed on the basis of water availability, annual irrigation intensity, cropping pattern, crop water requirement, and evaporation data etc. Most of the reservoirs in the Master Plan cater to the irrigation demand. It is stipulated to create irrigation facilities in an area of 2.755 Mha by constructing 29 major, 441 medium, and about 3000 minor schemes in Madhya Pradesh. Apart from the major, medium, and minor schemes referred to above, considerable irrigation development would also be expected from pumping schemes on streams all over the basin and on the numerous reservoirs to be created on the main river and tributaries.

5.4.1.1 Cropping pattern

Due to variations in climate, rainfall etc. various cropping patterns have been proposed for reservoirs in upper, middle and lower zones. The zonewise cropping patterns for major, medium, minor and pumping schemes are given in the Master Plan Vol. II (Master Plan, 1972). For some reservoirs the cropping patterns are given in their project reports. Some of the zonewise cropping patterns are given in Table 5.5.

5.4.1.2 Crop water requirement

Monthly crop water requirement depths for various crops in the upper, middle and lower zones are given in the Master Plan Vol. II (Master Plan, 1972). These are shown in the Table 5.5

alongwith the cropping pattern. Based on these, monthly irrigation water requirements (percentages) are obtained and the same are listed in Table 5.6.

5.4.2 Hydropower Requirement

The hydropower demand has been assessed on the basis of water availability and potential sites for hydropower generation. It is expected to augment the power supply from other sources such as thermal power stations etc..

The Narmada water provides a large scope for development of hydroelectric projects. The major reservoirs identified in the Narmada Valley, namely, Raghavpur, Rosra, Sitarewa, Maheshwar are purely hydel projects. Besides these, the multipurpose reservoirs Basania, Bargi, Narmada Sagar, Omkareshwar also have hydroelectric components. The aggregate total power potential of these projects is 1825 Mw. In addition, Madhya Pradesh has a share of 798 Mw (57%) in the installed capacity of 1400 Mw of Sardar Sarovar across the Narmada in Gujarat State. Thus, the total availability of hydel power in terms of the installed capacity will be about 2600 Mw which works out to be more than 30% of the total identified potential in the State of Madhya Pradesh.

The planwise demand pattern for Narmada basin as derived from Report of the Narmada Water Resources Development Committee

(1965) is given in Table 5.7.

5.5 RIVER DEVELOPMENT PLAN

The Narmada basin drains an area of 98800 sq. km. and has around 41 major tributaries feeding it. And on this river the State Governments of Madhya Pradesh and Gujarat have planned to build two mega reservoirs at Punasa (Narmada Sagar) and Navagam (Sardar Sarovar) respectively. Actually, these two form the focal point of a much larger development plan comprising of 30 major reservoirs, 441 medium schemes, and over 3000 minor schemes covering the entire basin. Out of these 30 major reservoirs (10 are on main river and 20 are on tributaries), 7 are multipurpose, 4 are purely hydel and 19 are purely irrigation reservoirs. This is really a gigantic and ambitious plan by any standards. The relative positions of the 30 major reservoirs with respect to main Narmada river are indicated in the line diagram Fig. 5.2. The locations of these 30 reservoirs are shown in the Plate I.

5.5.1 Phasing of Narmada Valley Development

In order to utilise its share of allocated surface water, Madhya Pradesh Government had prepared its Master Plan for development of Narmada water resources. It was proposed to develop the Narmada valley in two Phases over a span of 45 years between 1979 and 2024. In the Phase I (1979-2000) covering a period of 20 years it was planned

(i) To complete the then ongoing Bargi, Matiyari, and Kolar reservoirs.

(ii) To accelerate the then newly started reservoirs in the sixth plan under Narmada Sagar complex (comprising Narmada Sagar, Omkareshwar, and Maheshwar), Man and Jobat.

(iii) To take up Upper Narmada, Bargi diversion and Chhota Tawa reservoirs.

The line diagram in Fig. 5.3 shows the relative positions of these reservoirs.

In the Phase II of development (2000-2024), the remaining 16 reservoirs were to be taken up so as to complete the development of the Narmada Valley by 2024. The line diagram in Fig. 5.4 shows the relative positions of these reservoirs.

On the basis of these Master Plan documents, project reports, and other State and Central Government publications a lot of information on salient features of the major reservoirs was meticulously extracted. A schedule to present this information was carefully designed. This schedule is presented in the form of Table 5.6.

5.5.2 Existing Development

To-date very little development has taken place in the basin thus providing a major opportunity for harnessing of the large untapped water resources. The lack of development was mainly due to a water dispute that had arisen amongst the riparian States of Gujarat, Madhya Pradesh, and Maharashtra over the use, distribution, and control of the water of the interstate Narmada river. Rajasthan though not a co-riparian State became entitled to the share of the Narmada waters as a result of mutual agreement amongst the party States. The Government of India had set up the Narmada Water Disputes Tribunal (NWDT) in October 1969 to go into the various aspects of sharing of the Narmada waters amongst the riparian States. The Tribunal gave its award in August 1978. As per the stipulation of NWDT each State had to utilise its share within a period of 45 years commencing from the year of the final award in 1979.

In order to have a systematic development of Narmada basin various agencies such as Narmada Valley Development Authority, Narmada Control Authority, and Sardar Sarovar Narmada Nigam Limited have been constituted. However, out 14 reservoirs expected to be completed in ongoing Phase I, at present there is only one completed major multipurpose reservoir namely Bargi on main stem of Narmada river and four completed major irrigation reservoirs on different tributaries namely Matiyari, Barna, Tawa, and Sukta. Further, seven reservoirs namely, Kolar, Narmada Sagar, Omkareshwar, Maheshwar, Man, Jobat, and Sardar Sarovar are ongoing and many of them are still in initial stages of development. This implies slow pace of development. There are many reasons for this shortfall. The Narmada Sagar Complex reservoirs are financially supported by the World Bank. The information available todate reveals that the Bargi reservoir is completed in 1971(2nd period) but the infrastructure development is still ongoing, the reservoirs Barna, Tawa are completed in 1978(3rd period) and Sukta is completed in 1984(4th period).

The overall position (status), catchment area etc. of the 30 reservoirs in the basin are tabulated in the Table 5.8.

5.5.3 Development Potential

As per the Table 5.8 and as mentioned in earlier para, there appears to be a lot of scope for further water resources development in the Narmada basin. It is evident that whereas some irrigation potential has been developed but development of hydropower potential has not been commensurate with its demand. Phase I potential is yet not fully developed eventhough its stipulated period will be over soon. There is going to be a carry over of many Phase I reservoirs into Phase II. And as such at its present level of development, the Narmada river basin, in question, can be still considered to be in its initial stages of development for the purpose of analysis.

5.6 STATEMENT OF THE PROBLEM

While planning for the development of such a big river valley it is always necessary to take into account the various aspects of long-term river basin planning. One such implied aspect is the determination of sequence of development of various reservoirs. The sequencing of various reservoirs should be such that the decisions taken on grounds of exigency and expediency do not lead to infructuous and wasteful investments in the long-run.

Before the sequencing of reservoirs is done the alternative demand patterns may be developed from the available data to study various developmental strategies as the river system is still in the initial stages of development. This is due to the inter State river water dispute since long time, which has delayed the water resources development in the basin.

In view of this and as per the objectives set in the Chapter 1 it is proposed to follow the following steps in the combined use of simulation and sequencing models to analyse the problem of development of one of the most important and controversial Narmada river basin system.

Initially, assuming that all 30 reservoirs are existing in the system, the individual reservoir wise as well as combined simulation runs for all the 30 reservoirs would be undertaken starting from upstream to downstream for fixing the final simulated irrigation targets from each of the irrigation reservoirs.

Secondly, for 14 Phase I reservoirs the initial and the final simulated firm hydropower targets from hydropower reservoirs would be determined. In each case, the irrigation targets shall be kept constant as obtained in the previous para. Further, sequencing of the Phase I reservoirs would be done using the sequencing model.

Finally, 16 Phase II reservoirs would be sequenced in similar fashion as in Phase I. Looking at the huge size of the problem due to the presence of a large number of reservoirs in both the Phases of development it may be necessary to reduce the size of the problem by clubbing some of the small reservoirs.

The detailed discussion on the proposed procedure is an important part of the next chapter.

5.6.1 ASSUMPTIONS

The given statement of problem is derived on the basis of the following assumptions:

(i) The stream hydrologies are sufficiently well characterised by their historical monthly flow records, which quantify and contain the critical periods of subnormal streamflow.

(ii) The stream-site configuration may be any parallel-series arrangement.

(iii) The dimensions of the reservoir sites have been evaluated and total cost and annual cost at each site have been estimated exogenously.

(iv) Water demands are based on the potential of the system.

(v) The water demand function is deterministic, and monotonically increasing with time and has no other constraints on its form.

To avoid the inclusion of other factors that although important in their own right, are secondary to the purpose of this research work, the following assumptions are also made:

(i) The economic objective is the only one that needs to be investigated. Since a demand function is to be prescribed, the objective function will be to minimize the present worth of the total annual cost.

(ii) Project costs are incurred as lump sums at the time of construction. Individual reservoir costs are separable and the construction period is taken as being small (one or two planning periods).

(iii) The planning horizon is finite. (20, 30, 40 yrs for each Phase)

(iv) A project once constructed is operable over the finite planning horizon.

(v) Price elasticity of demand is zero.

(vi) Inflation effects are self-balancing and financial management considerations can be ignored.

(vii) The social discount rate is constant.

(viii) Each project is to be constructed only once and any combination of projects may be built.

(ix) Any project is constructed either to its full capacity or not constructed at all.

Further it is to be impressed here that

(i) Master Plan preparation in India, is based on social water needs and not on the basis of optimal utilisation.

(ii) Project cost estimates do not include environmental costs and social costs due to non-availability of reliable data.

(iii) The main aim here is to use the economic objective as a vehicle only in order to establish the sequencing model as a tool for satisfying system water demands.

Table 5.1 Information of principal tributaries of Narmada river

Sr.No.	Name of the Tributary	Elevation of Source MSL (m)	Catchment Area (Sq.km.)	Total Length from the Source (km)
1.	Kharmer (L)	-	557	64
2.	Silgi (R)	-	531	65
3.	Burhner (L)	900	4228	177
4.	Banjar (L)	600	3282	183
5.	Balai (R)	-	531	46
6.	Temur (L)	550	892	54
7.	Gaur (R)	690	1107	79.5
8.	Soner (L)	-	581	51
9.	Hiran (R)	500	4795	188
10.	Sher (L)	650	2903	129
11.	Biranjo (R)	-	1172	62
12.	Shakker (L)	900	2294	161
13.	Dudhi (L)	900	1542	129
14.	Sukhri (L)	-	609	39
15.	Tendoni (R)	500	1633	177
16.	Barna (R)	450	1789	105
17.	Tawa (L)	600	6338	172
18.	Hather (L)	-	645	37.5
19.	Kolar (R)	600	1348	101
20.	Ganjal (L)	700	1931	89
21.	Sip (R)	-	879	45
22.	Jamner (R)	470	671	30
23.	Chankeshar (R)	600	1249	30
24.	Anjal (L)	-	1203	62.5
25.	Machak (L)	550	1112	87.5
26.	Chhota Tawa (L)	400	5055	169
27.	Khari (R)	-	754	41
28.	Kenar (R)	-	1581	62.5
29.	Kaveri (L)	-	954	32.5
30.	Choral (R)	-	601	55
31.	Kharkia (L)	-	1099	24
32.	Kundi (L)	900	3973	120
33.	Karan (R)	-	858	45
34.	Board (L)	-	866	62.5
35.	Man (R)	550	1529	89
36.	Deb (L)	350	966	82.5
37.	Uri (R)	-	2004	74
38.	Goi (L)	800	1892	129
39.	Hatni (R)	350	1944	30
40.	Orsang (R)	300	3946	101
41.	Karjan (L)	200	1490	93

Table 5.2 Monthly flows at gauging sites (22 Years).

SITE NAME JAMTARA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	2249.0	4439.0	2837.0	410.0	260.0	105.0	68.0	63.0	41.0	12.0	4.0	30.0	10518.0	7	30.43
1949	738.0	4439.0	2837.0	759.0	169.0	57.0	49.0	51.0	64.0	27.0	7.0	26.0	9223.0	10	43.48
1950	2837.0	4484.0	1364.0	171.0	56.0	49.0	39.0	25.0	14.0	57.0	9.0	41.0	9146.0	11	47.83
1951	112.0	2622.0	1304.0	381.0	59.0	36.0	17.0	11.0	7.0	4.0	1.0	132.0	4686.0	20	86.96
1952	2299.0	4500.0	2351.0	255.0	73.0	39.0	39.0	25.0	9.0	2.0	1.0	.0	9593.0	8	34.78
1953	1842.0	2969.0	1225.0	243.0	74.0	41.0	25.0	11.0	5.0	4.0	1.0	21.0	6461.0	17	73.91
1954	1291.0	2194.0	2726.0	354.0	90.0	33.0	27.0	21.0	10.0	4.0	1.0	506.0	7257.0	16	69.57
1955	1395.0	3651.0	3919.0	1430.0	245.0	96.0	46.0	26.0	12.0	7.0	4.0	180.0	11011.0	6	26.09
1956	4368.0	6673.0	1642.0	782.0	322.0	106.0	111.0	41.0	59.0	36.0	9.0	16.0	14165.0	2	8.70
1957	1977.0	4022.0	1494.0	221.0	68.0	36.0	22.0	15.0	30.0	9.0	1.0	5.0	7900.0	14	60.87
1958	2298.0	2115.0	1847.0	1303.0	212.0	75.0	59.0	46.0	14.0	9.0	4.0	4.0	7986.0	13	56.52
1959	2991.0	4612.0	3255.0	611.0	141.0	70.0	78.0	36.0	23.0	21.0	7.0	97.0	11942.0	4	17.39
1960	1681.0	4316.0	994.0	862.0	147.0	74.0	56.0	52.0	21.0	6.0	1.0	274.0	8484.0	12	52.17
1961	5853.0	5227.0	5395.0	1068.0	248.0	149.0	83.0	48.0	36.0	21.0	9.0	88.0	18225.0	1	4.35
1962	868.0	2245.0	1861.0	294.0	96.0	343.0	63.0	25.0	17.0	10.0	10.0	134.0	5966.0	18	78.26
1963	1095.0	2985.0	3045.0	282.0	118.0	60.0	38.0	27.0	19.0	6.0	2.0	75.0	7752.0	15	65.22
1964	3084.0	5262.0	1797.0	550.0	130.0	70.0	46.0	28.0	17.0	28.0	4.0	118.0	11134.0	5	21.74
1965	486.0	641.0	1194.0	125.0	41.0	23.0	21.0	12.0	5.0	1.0	1.0	259.0	2809.0	22	95.65
1966	1233.0	2611.0	329.0	64.0	27.0	26.0	16.0	10.0	38.0	32.0	5.0	115.0	4506.0	21	91.30
1967	2968.0	5853.0	2963.0	400.0	104.0	152.0	217.0	80.0	48.0	12.0	7.0	63.0	12867.0	3	13.04
1968	1322.0	3502.0	693.0	228.0	74.0	44.0	37.0	12.0	7.0	4.0	1.0	2.0	5926.0	19	82.61
1969	1694.0	5422.0	1454.0	254.0	101.0	48.0	43.0	21.0	53.0	10.0	9.0	278.0	9387.0	9	39.13
Mean	2031.0	3853.8	2114.8	502.1	129.8	78.7	54.5	31.2	25.0	14.6	4.5	112.0	8952.0		

SITE NAME TAWA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	1449.0	2647.0	1801.0	247.0	222.0	51.0	33.0	12.0	9.0	6.0	4.0	27.0	6508.0	3	13.04
1949	565.0	649.0	2362.0	424.0	100.0	31.0	20.0	23.0	10.0	5.0	4.0	5.0	4198.0	7	30.43
1950	1435.0	475.0	644.0	22.0	19.0	16.0	17.0	7.0	5.0	4.0	4.0	83.0	2731.0	15	65.22
1951	213.0	1039.0	516.0	95.0	12.0	7.0	9.0	11.0	4.0	2.0	2.0	58.0	1968.0	21	91.30
1952	736.0	1088.0	155.0	19.0	7.0	6.0	5.0	5.0	4.0	2.0	2.0	22.0	2051.0	20	86.96
1953	549.0	1844.0	315.0	80.0	15.0	10.0	9.0	6.0	4.0	2.0	1.0	19.0	2854.0	14	60.87
1954	533.0	588.0	891.0	131.0	28.0	15.0	11.0	7.0	4.0	2.0	2.0	41.0	2253.0	18	78.26
1955	126.0	1125.0	1300.0	870.0	42.0	25.0	15.0	7.0	6.0	2.0	2.0	65.0	3585.0	10	43.48
1956	802.0	591.0	422.0	74.0	150.0	27.0	31.0	10.0	17.0	14.0	4.0	25.0	2167.0	19	82.61
1957	146.0	1151.0	479.0	35.0	11.0	7.0	5.0	4.0	4.0	2.0	2.0	26.0	1872.0	22	95.65
1958	422.0	1125.0	1586.0	242.0	102.0	27.0	9.0	6.0	4.0	2.0	2.0	73.0	3600.0	8	34.78
1959	2250.0	1807.0	3221.0	398.0	120.0	89.0	100.0	25.0	21.0	.0	.0	59.0	8090.0	2	8.70
1960	445.0	1875.0	233.0	275.0	60.0	46.0	20.0	10.0	.0	.0	.0	19.0	2983.0	13	56.52
1961	1064.0	2139.0	5442.0	540.0	95.0	72.0	56.0	28.0	19.0	20.0	4.0	28.0	9507.0	1	4.35
1962	523.0	1146.0	2299.0	131.0	12.0	47.0	10.0	9.0	33.0	4.0	4.0	33.0	4251.0	6	26.09
1963	164.0	1874.0	1763.0	131.0	86.0	81.0	63.0	52.0	37.0	23.0	19.0	97.0	4390.0	5	21.74
1964	897.0	3333.0	418.0	97.0	49.0	44.0	41.0	28.0	28.0	26.0	19.0	65.0	5045.0	4	17.39
1965	486.0	295.0	1426.0	91.0	38.0	30.0	17.0	10.0	10.0	5.0	4.0	2.0	2414.0	17	73.91
1966	1663.0	1173.0	218.0	26.0	6.0	6.0	5.0	4.0	5.0	2.0	2.0	111.0	3221.0	12	52.17
1967	1349.0	1010.0	1046.0	74.0	5.0	53.0	19.0	10.0	19.0	5.0	2.0	5.0	3597.0	9	39.13
1968	966.0	965.0	570.0	54.0	27.0	17.0	16.0	11.0	10.0	6.0	5.0	10.0	2657.0	16	69.57
1969	870.0	1615.0	860.0	44.0	19.0	11.0	9.0	5.0	12.0	5.0	4.0	69.0	3523.0	11	47.83
Mean	802.4	1343.4	1271.2	186.4	55.7	32.6	23.6	13.2	12.0	6.3	4.2	42.8	3793.9		

Table 5.2 Continued

SITE NAME MORTAKKA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	9464.0	14157.0	13928.0	2610.0	1643.0	801.0	472.0	331.0	268.0	164.0	111.0	301.0	44250.0	3	13.04
1949	4686.0	8384.0	13793.0	3978.0	1251.0	516.0	310.0	216.0	271.0	175.0	134.0	157.0	33871.0	7	30.43
1950	8911.0	11368.0	8343.0	1235.0	426.0	348.0	331.0	212.0	178.0	134.0	85.0	295.0	31866.0	9	39.13
1951	1866.0	7433.0	4643.0	1216.0	438.0	270.0	213.0	178.0	134.0	85.0	64.0	464.0	17004.0	20	86.96
1952	4649.0	13547.0	5045.0	872.0	364.0	253.0	218.0	186.0	136.0	86.0	59.0	76.0	25491.0	18	78.26
1953	5204.0	14368.0	4427.0	1020.0	400.0	266.0	210.0	147.0	96.0	73.0	58.0	138.0	26407.0	17	73.91
1954	3439.0	6322.0	15627.0	2800.0	877.0	438.0	280.0	191.0	110.0	74.0	57.0	593.0	30808.0	11	47.83
1955	2545.0	11183.0	19304.0	7345.0	1229.0	576.0	368.0	244.0	179.0	131.0	99.0	957.0	44160.0	4	17.39
1956	12469.0	15140.0	5701.0	3057.0	1906.0	702.0	606.0	360.0	324.0	308.0	153.0	521.0	41247.0	5	21.74
1957	3393.0	10061.0	5750.0	973.0	447.0	292.0	232.0	169.0	176.0	100.0	73.0	223.0	21889.0	19	82.61
1958	4582.0	8166.0	10206.0	4460.0	1270.0	513.0	322.0	232.0	170.0	105.0	75.0	173.0	30274.0	12	52.17
1959	11564.0	17211.0	16525.0	3530.0	1051.0	541.0	546.0	306.0	241.0	163.0	127.0	336.0	52141.0	2	8.70
1960	5287.0	17540.0	3270.0	2673.0	776.0	516.0	353.0	271.0	201.0	141.0	105.0	630.0	31763.0	10	43.48
1961	10816.0	12721.0	26589.0	7052.0	1485.0	794.0	559.0	376.0	308.0	237.0	148.0	111.0	61196.0	1	4.35
1962	3296.0	5805.0	12828.0	1729.0	691.0	804.0	386.0	243.0	210.0	130.0	89.0	263.0	26474.0	15	65.22
1963	1999.0	10380.0	10304.0	1597.0	569.0	375.0	259.0	190.0	170.0	111.0	85.0	418.0	26457.0	16	69.57
1964	6963.0	15686.0	6197.0	2360.0	662.0	381.0	279.0	170.0	136.0	121.0	73.0	176.0	33204.0	8	34.78
1965	3111.0	2235.0	3916.0	574.0	208.0	153.0	132.0	99.0	70.0	51.0	46.0	54.0	10649.0	22	95.65
1966	3776.0	8332.0	2775.0	376.0	199.0	171.0	121.0	84.0	69.0	111.0	44.0	355.0	16413.0	21	91.30
1967	4310.0	12088.0	10234.0	1442.0	426.0	545.0	440.0	222.0	207.0	100.0	65.0	78.0	30157.0	13	56.52
1968	4084.0	16077.0	4267.0	1336.0	407.0	271.0	213.0	132.0	105.0	70.0	48.0	58.0	27068.0	14	60.87
1969	5849.0	21111.0	8335.0	1581.0	578.0	342.0	306.0	210.0	215.0	113.0	79.0	1763.0	40482.0	6	26.09
Mean	5557.4	11787.0	9636.7	2446.2	786.5	448.5	325.3	216.8	180.6	126.5	85.3	370.0	31966.9		

SITE NAME GARUDESHWAR

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	10517.0	16958.0	18258.0	2885.0	1760.0	937.0	522.0	311.0	257.0	170.0	102.0	503.0	53180.0	4	17.39
1949	4881.0	9291.0	17455.0	6330.0	1634.0	669.0	317.0	318.0	282.0	185.0	125.0	148.0	41635.0	7	30.43
1950	8833.0	13441.0	13352.0	2307.0	792.0	492.0	456.0	232.0	191.0	181.0	128.0	278.0	40683.0	8	34.78
1951	3304.0	8872.0	4888.0	1237.0	453.0	338.0	245.0	183.0	141.0	83.0	44.0	484.0	20272.0	20	86.96
1952	4320.0	13879.0	5345.0	999.0	449.0	289.0	228.0	174.0	125.0	69.0	41.0	628.0	26546.0	18	78.26
1953	4626.0	15808.0	4965.0	1401.0	480.0	340.0	274.0	137.0	101.0	60.0	39.0	184.0	28415.0	17	73.91
1954	4628.0	6620.0	22410.0	1237.0	1441.0	698.0	455.0	294.0	107.0	73.0	52.0	818.0	38833.0	9	39.13
1955	3010.0	10889.0	22712.0	8761.0	1423.0	698.0	512.0	286.0	274.0	176.0	126.0	1084.0	49951.0	5	21.74
1956	12435.0	17610.0	5601.0	3079.0	1649.0	617.0	595.0	400.0	342.0	310.0	148.0	775.0	43561.0	6	26.09
1957	3209.0	11590.0	6254.0	1261.0	574.0	389.0	316.0	207.0	191.0	116.0	74.0	291.0	24472.0	19	82.61
1958	5182.0	8571.0	13180.0	5214.0	682.0	257.0	160.0	107.0	78.0	47.0	27.0	73.0	33578.0	13	56.52
1959	8739.0	21097.0	24695.0	5195.0	2170.0	1119.0	988.0	673.0	479.0	319.0	250.0	845.0	66569.0	2	8.70
1960	4772.0	18413.0	3768.0	6449.0	639.0	395.0	318.0	274.0	265.0	180.0	93.0	535.0	36101.0	11	47.83
1961	11682.0	14686.0	33555.0	11746.0	1748.0	709.0	445.0	316.0	241.0	173.0	121.0	105.0	75527.0	1	4.35
1962	3852.0	6297.0	15986.0	1908.0	671.0	719.0	326.0	195.0	171.0	117.0	86.0	588.0	30916.0	15	65.22
1963	1917.0	11608.0	11466.0	1415.0	599.0	311.0	328.0	264.0	148.0	126.0	93.0	431.0	28706.0	16	69.57
1964	6608.0	15877.0	6994.0	2833.0	646.0	419.0	406.0	216.0	149.0	109.0	91.0	169.0	34517.0	12	52.17
1965	3189.0	3138.0	4650.0	683.0	199.0	143.0	117.0	88.0	67.0	41.0	30.0	35.0	12380.0	22	95.65
1966	3248.0	9838.0	4301.0	498.0	217.0	171.0	133.0	95.0	78.0	107.0	49.0	664.0	19399.0	21	91.30
1967	6097.0	13867.0	13324.0	1702.0	634.0	685.0	508.0	261.0	250.0	112.0	69.0	95.0	37604.0	10	43.48
1968	2509.0	22025.0	5248.0	1764.0	657.0	413.0	249.0	159.0	143.0	104.0	56.0	122.0	33449.0	14	60.87
1969	6303.0	25738.0	13673.0	1617.0	690.0	376.0	333.0	265.0	213.0	150.0	76.0	4429.0	53863.0	3	13.04
Mean	5630.0	13459.7	12367.3	3205.5	918.5	508.4	374.1	248.0	195.1	136.7	87.3	603.8	37734.4		

Table 5.2 Concluded

Table 5.3 Monthly flow data at reservoir sites (22 years).

SITE NAME **UPPER NARMADA**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	168.7	332.9	212.8	30.8	19.5	7.9	5.1	4.7	3.1	0.9	0.3	2.3	788.9	7	30.43
1949	55.3	332.9	212.8	56.9	12.7	4.3	3.7	3.8	4.8	2.0	0.5	2.0	691.8	10	43.48
1950	212.8	336.3	102.3	12.8	4.2	3.7	2.9	1.9	1.0	4.3	0.7	3.1	686.0	11	47.83
1951	8.4	196.6	97.8	28.6	4.4	2.7	1.3	0.8	0.5	0.3	0.1	9.9	351.5	20	86.96
1952	172.4	337.5	176.3	19.1	5.5	2.9	2.9	1.9	0.7	0.2	0.1	0.0	719.5	8	34.78
1953	138.1	222.7	91.9	18.2	5.6	3.1	1.9	0.8	0.4	0.3	0.1	1.6	484.6	17	73.91
1954	96.8	164.6	204.4	26.5	6.8	2.5	2.0	1.6	0.8	0.3	0.1	38.0	544.3	16	69.57
1955	104.6	273.8	293.9	107.3	18.4	7.2	3.5	2.0	0.9	0.5	0.3	13.5	825.9	6	26.09
1956	327.6	500.5	123.2	58.7	24.1	7.9	8.3	3.1	4.4	2.7	0.7	1.2	1062.4	2	8.70
1957	148.3	301.6	112.1	16.6	5.1	2.7	1.6	1.1	2.3	0.7	0.1	0.4	592.5	14	60.87
1958	172.4	158.6	138.5	97.7	15.9	5.6	4.4	3.5	1.0	0.7	0.3	0.3	599.0	13	56.52
1959	224.3	345.9	244.1	45.8	10.6	5.3	5.8	2.7	1.7	1.6	0.5	7.3	895.7	4	17.39
1960	126.1	323.7	74.6	64.7	11.0	5.6	4.2	3.9	1.6	0.4	0.1	20.5	636.3	12	52.17
1961	439.0	392.0	404.6	80.1	18.6	11.2	6.2	3.6	2.7	1.6	0.7	6.6	1366.9	1	4.35
1962	65.1	168.4	139.6	22.0	7.2	25.7	4.7	1.9	1.3	0.8	0.8	10.1	447.5	18	78.26
1963	82.1	223.9	228.4	21.1	8.9	4.5	2.8	2.0	1.4	0.4	0.2	5.6	581.4	15	65.22
1964	231.3	394.6	134.8	41.3	9.8	5.3	3.5	2.1	1.3	2.1	0.3	8.9	835.1	5	21.74
1965	36.5	48.1	89.6	9.4	3.1	1.7	1.6	0.9	0.4	0.1	0.1	19.4	210.7	22	95.65
1966	92.5	195.8	24.7	4.8	2.0	2.0	1.2	0.8	2.8	2.4	0.4	8.6	338.0	21	91.30
1967	222.6	439.0	222.2	30.0	7.8	11.4	16.3	6.0	3.6	0.9	0.5	4.7	965.1	3	13.04
1968	99.2	262.6	52.0	17.1	5.6	3.3	2.8	0.9	0.5	0.3	0.1	0.2	444.5	19	82.61
1969	127.1	406.6	109.1	19.0	7.6	3.6	3.2	1.6	4.0	0.8	0.7	20.9	704.0	9	39.13
Mean	152.3	289.0	158.6	37.7	9.7	5.9	4.1	2.3	1.9	1.1	0.3	8.4	671.4		

SITE NAME **RAGHAVPUR**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	428.7	846.1	540.7	78.2	49.6	20.0	13.0	12.0	7.8	2.3	0.8	5.7	2004.7	7	30.43
1949	140.7	846.1	540.7	144.7	32.2	10.9	9.3	9.7	12.2	5.2	1.3	5.0	1757.9	10	43.48
1950	540.7	854.7	260.0	32.6	10.7	9.3	7.4	4.8	2.7	10.9	1.7	7.8	1743.2	11	47.83
1951	21.4	499.8	248.5	72.6	11.3	6.9	3.2	2.1	1.3	0.8	0.2	25.2	893.1	20	86.96
1952	438.2	857.7	448.1	48.6	13.9	7.4	7.4	4.8	1.7	0.4	0.2	0.0	1828.4	8	34.78
1953	351.1	565.9	233.5	46.3	14.1	7.8	4.8	2.1	0.9	0.8	0.2	4.0	1231.4	17	73.91
1954	246.1	418.2	519.6	67.5	17.1	6.3	5.2	4.0	1.9	0.8	0.2	96.4	1383.2	16	69.57
1955	265.9	695.9	747.0	272.6	46.7	18.3	8.8	5.0	2.3	1.3	0.8	34.3	2098.7	6	26.09
1956	832.5	1271.9	313.0	149.1	61.4	20.2	21.2	7.8	11.3	6.9	1.7	3.0	2699.9	2	8.70
1957	376.8	766.6	284.8	42.1	13.0	6.9	4.2	2.9	5.7	1.7	0.2	0.9	1505.7	14	60.87
1958	438.0	403.1	352.0	248.4	40.4	14.3	11.3	8.8	2.7	1.7	0.8	0.8	1522.1	13	56.52
1959	570.1	879.0	620.4	116.5	26.9	13.3	14.9	6.9	4.4	4.0	1.3	18.5	2276.1	4	17.39
1960	320.4	822.6	189.5	164.3	28.0	14.1	10.7	9.9	4.0	1.1	0.2	52.2	1617.0	12	52.17
1961	1115.6	996.3	1028.3	203.6	47.3	28.4	15.8	9.1	6.9	4.0	1.7	16.8	3473.7	1	4.35
1962	165.4	427.9	354.7	56.0	18.3	65.4	12.0	4.8	3.2	1.9	1.9	25.5	1137.1	18	78.26
1963	208.7	568.9	580.4	53.8	22.5	11.4	7.2	5.2	3.6	1.1	0.4	14.3	1477.5	15	65.22
1964	587.8	1002.9	342.5	104.8	24.8	13.3	8.8	5.3	3.2	5.3	0.8	22.5	2122.2	5	21.74
1965	92.6	122.2	227.6	23.8	7.8	4.4	4.0	2.3	0.9	0.2	0.2	49.4	535.4	22	95.65
1966	235.0	497.7	62.7	12.2	5.2	5.0	3.0	1.9	7.2	6.1	0.9	21.9	858.9	21	91.30
1967	565.7	1115.6	564.8	76.2	19.8	29.0	41.4	15.3	9.1	2.3	1.3	12.0	2452.5	3	13.04
1968	252.0	667.5	132.1	43.5	14.1	8.4	7.1	2.3	1.3	0.8	0.2	0.4	1129.5	19	82.61
1969	322.9	1033.4	277.1	48.4	19.3	9.1	8.2	4.0	10.1	1.9	1.7	53.0	1789.2	9	39.13
Mean	387.1	734.5	403.1	95.7	24.7	15.0	10.4	5.9	4.8	2.8	0.8	21.3	1706.3		

Table 5.3 Continued

SITE NAME ROSRA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	585.0	1154.6	737.9	106.6	67.6	27.3	17.7	16.4	10.7	3.1	1.0	7.8	2735.7	7	30.43
1949	191.9	1154.6	737.9	197.4	44.0	14.8	12.7	13.3	16.6	7.0	1.8	6.8	2398.9	10	43.48
1950	737.9	1166.3	354.8	44.5	14.6	12.7	10.1	6.5	3.6	14.8	2.3	10.7	2378.9	11	47.83
1951	29.1	682.0	339.2	99.1	15.4	9.4	4.4	2.9	1.8	1.0	0.3	34.3	1218.8	20	86.96
1952	598.0	1170.4	611.5	66.3	19.0	10.1	10.1	6.5	2.3	0.5	0.3	0.0	2495.1	8	34.78
1953	479.1	772.2	318.6	63.2	19.3	10.7	6.5	2.9	1.3	1.0	0.3	5.5	1680.5	17	73.91
1954	335.8	570.7	709.0	92.1	23.4	8.6	7.0	5.5	2.6	1.0	0.3	131.6	1887.5	16	69.57
1955	362.8	949.6	1019.3	371.9	63.7	25.0	12.0	6.8	3.1	1.8	1.0	46.8	2864.0	6	26.09
1956	1136.1	1735.7	427.1	203.4	83.8	27.6	28.9	10.7	15.4	9.4	2.3	4.2	3684.3	2	8.70
1957	514.2	1046.1	388.6	57.5	17.7	9.4	5.7	3.9	7.8	2.3	0.3	1.3	2054.8	14	60.87
1958	597.7	550.1	480.4	338.9	55.1	19.5	15.4	12.0	3.6	2.3	1.0	1.0	2077.2	13	56.52
1959	778.0	1199.6	846.6	158.9	36.7	18.2	20.3	9.4	6.0	5.5	1.8	25.2	3106.1	4	17.39
1960	437.2	1122.6	258.5	224.2	38.2	19.3	14.6	13.5	5.5	1.6	0.3	71.3	2206.7	12	52.17
1961	1522.4	1359.5	1403.2	277.8	64.5	38.8	21.6	12.5	9.4	5.5	2.3	22.9	4740.3	1	4.35
1962	225.8	583.9	484.0	76.5	25.0	89.2	16.4	6.5	4.4	2.6	2.6	34.8	1551.7	18	78.26
1963	284.8	776.4	792.0	73.3	30.7	15.6	9.9	7.0	4.9	1.6	0.5	19.5	2016.3	15	65.22
1964	802.2	1368.7	467.4	143.1	33.8	18.2	12.0	7.3	4.4	7.3	1.0	30.7	2895.9	5	21.74
1965	126.4	166.7	310.6	32.5	10.7	6.0	5.5	3.1	1.3	0.3	0.3	67.4	730.6	22	95.65
1966	320.7	679.1	85.6	16.6	7.0	6.8	4.2	2.6	9.9	8.3	1.3	29.9	1172.0	21	91.30
1967	772.0	1522.4	770.7	104.0	27.0	39.5	56.4	20.8	12.5	3.1	1.8	16.4	3346.7	3	13.04
1968	343.9	910.9	180.3	59.3	19.3	11.4	9.6	3.1	1.8	1.0	0.3	0.5	1541.3	19	82.61
1969	440.6	1410.3	378.2	66.1	26.3	12.5	11.2	5.5	13.8	2.6	2.3	72.3	2441.6	9	39.13
Mean	528.3	1002.4	550.1	130.6	33.8	20.5	14.2	8.1	6.5	3.8	1.2	29.1	2328.4		

SITE NAME UPPER BURHNER

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	217.9	430.1	274.9	39.7	25.2	10.2	6.6	6.1	4.0	1.2	0.4	2.9	1019.2	7	30.43
1949	71.5	430.1	274.9	73.6	16.4	5.5	4.8	4.9	6.2	2.6	0.7	2.5	893.7	10	43.48
1950	274.9	434.5	132.2	16.6	5.4	4.8	3.8	2.4	1.4	5.5	0.9	4.0	886.3	11	47.83
1951	10.9	254.1	126.4	36.9	5.7	3.5	1.6	1.1	0.7	0.4	0.1	12.8	454.1	20	86.96
1952	222.8	436.0	227.8	24.7	7.1	3.8	3.8	2.4	0.9	0.2	0.1	0.0	929.6	8	34.78
1953	178.5	287.7	118.7	23.5	7.2	4.0	2.4	1.1	0.5	0.4	0.1	2.0	626.1	17	73.91
1954	125.1	212.6	264.1	34.3	8.7	3.2	2.6	2.0	1.0	0.4	0.1	49.0	703.2	16	69.57
1955	135.2	353.8	379.8	138.6	23.7	9.3	4.5	2.5	1.2	0.7	0.4	17.4	1067.0	6	26.09
1956	423.3	646.6	159.1	75.8	31.2	10.3	10.8	4.0	5.7	3.5	0.9	1.5	1372.6	2	8.70
1957	191.6	389.7	144.8	21.4	6.6	3.5	2.1	1.5	2.9	0.9	0.1	0.5	765.5	14	60.87
1958	222.7	204.9	179.0	126.3	20.5	7.3	5.7	4.5	1.4	0.9	0.4	0.4	773.8	13	56.52
1959	289.8	446.9	315.4	59.2	13.7	6.8	7.6	3.5	2.2	2.0	0.7	9.4	1157.2	4	17.39
1960	162.9	418.2	96.3	83.5	14.2	7.2	5.4	5.0	2.0	0.6	0.1	26.5	822.1	12	52.17
1961	567.2	506.5	522.8	103.5	24.0	14.4	8.0	4.7	3.5	2.0	0.9	8.5	1766.0	1	4.35
1962	84.1	217.5	180.3	28.5	9.3	33.2	6.1	2.4	1.6	1.0	1.0	13.0	578.1	18	78.26
1963	106.1	289.3	295.1	27.3	11.4	5.8	3.7	2.6	1.8	0.6	0.2	7.3	751.2	15	65.22
1964	298.8	509.9	174.1	53.3	12.6	6.8	4.5	2.7	1.6	2.7	0.4	11.4	1078.9	5	21.74
1965	47.1	62.1	115.7	12.1	4.0	2.2	2.0	1.2	0.5	0.1	0.1	25.1	272.2	22	95.65
1966	119.5	253.0	31.9	6.2	2.6	2.5	1.5	1.0	3.7	3.1	0.5	11.1	436.6	21	91.30
1967	287.6	567.2	287.1	38.8	10.1	14.7	21.0	7.8	4.7	1.2	0.7	6.1	1246.8	3	13.04
1968	128.1	339.3	67.2	22.1	7.2	4.3	3.6	1.2	0.7	0.4	0.1	0.2	574.2	19	82.61
1969	164.1	525.4	140.9	24.6	9.8	4.7	4.2	2.0	5.1	1.0	0.9	26.9	909.6	9	39.13
Mean	196.8	373.4	204.9	48.7	12.6	7.6	5.3	3.0	2.4	1.4	0.4	10.9	867.4		

Table 5.3 Continued

SITE NAME HALON

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	96.9	191.3	122.3	17.7	11.2	4.5	2.9	2.7	1.8	0.5	0.2	1.3	453.3	7	30.43
1949	31.8	191.3	122.3	32.7	7.3	2.5	2.1	2.2	2.8	1.2	0.3	1.1	397.5	10	43.48
1950	122.3	193.3	58.8	7.4	2.4	2.1	1.7	1.1	0.6	2.5	0.4	1.8	394.2	11	47.83
1951	4.8	113.0	56.2	16.4	2.5	1.5	0.7	0.5	0.3	0.2	0.0	5.7	201.9	20	86.96
1952	99.1	193.9	101.3	11.0	3.2	1.7	1.7	1.1	0.4	0.1	0.0	0.0	413.5	8	34.78
1953	79.4	128.0	52.8	10.5	3.2	1.8	1.1	0.5	0.2	0.2	0.0	0.9	278.5	17	73.91
1954	55.6	94.6	117.5	15.3	3.9	1.4	1.2	0.9	0.4	0.2	0.0	21.8	312.8	16	69.57
1955	60.1	157.4	168.9	61.6	10.6	4.1	2.0	1.1	0.5	0.3	0.2	7.8	474.6	6	26.09
1956	188.3	287.6	70.8	33.7	13.9	4.6	4.8	1.8	2.5	1.5	0.4	0.7	610.5	2	8.70
1957	85.2	173.4	64.4	9.5	2.9	1.5	0.9	0.6	1.3	0.4	0.0	0.2	340.5	14	60.87
1958	99.0	91.2	79.6	56.2	9.1	3.2	2.5	2.0	0.6	0.4	0.2	0.2	344.2	13	56.52
1959	128.9	198.8	140.3	26.3	6.1	3.0	3.4	1.5	1.0	0.9	0.3	4.2	514.7	4	17.39
1960	72.4	186.0	42.8	37.2	6.3	3.2	2.4	2.2	0.9	0.3	0.0	11.8	365.7	12	52.17
1961	252.3	225.3	232.5	46.0	10.7	6.4	3.6	2.1	1.5	0.9	0.4	3.8	785.5	1	4.35
1962	37.4	96.8	80.2	12.7	4.1	14.8	2.7	1.1	0.7	0.4	0.4	5.8	257.1	18	78.26
1963	47.2	128.6	131.2	12.1	5.1	2.6	1.6	1.2	0.8	0.3	0.1	3.2	334.1	15	65.22
1964	132.9	226.8	77.4	23.7	5.6	3.0	2.0	1.2	0.7	1.2	0.2	5.1	479.9	5	21.74
1965	21.0	27.6	51.5	5.4	1.8	1.0	0.9	0.5	0.2	0.0	0.0	11.2	121.1	22	95.65
1966	53.1	112.5	14.2	2.8	1.2	1.1	0.7	0.4	1.6	1.4	0.2	5.0	194.2	21	91.30
1967	127.9	252.3	127.7	17.2	4.5	6.6	9.4	3.5	2.1	0.5	0.3	2.7	554.6	3	13.04
1968	57.0	150.9	29.9	9.8	3.2	1.9	1.6	0.5	0.3	0.2	0.0	0.1	255.4	19	82.61
1969	73.0	233.7	62.7	10.9	4.3	2.1	1.9	0.9	2.3	0.4	0.4	12.0	404.6	9	39.13
Mean	87.5	166.1	91.1	21.6	5.6	3.4	2.4	1.3	1.1	0.6	0.2	4.8	385.8		

SITE NAME BASANIA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	1300.2	2566.2	1640.1	237.0	150.3	60.7	39.3	36.4	23.7	6.9	2.3	17.3	6080.5	7	30.43
1949	426.6	2566.2	1640.1	438.8	97.7	33.0	28.3	29.5	37.0	15.6	4.1	15.0	5331.8	10	43.48
1950	1640.1	2592.2	788.5	98.9	32.4	28.3	22.5	14.4	8.1	33.0	5.2	23.7	5287.3	11	47.83
1951	64.8	1515.8	753.8	220.3	34.1	20.8	9.8	6.4	4.1	2.3	0.6	76.3	2709.0	20	86.96
1952	1329.1	2601.4	1359.1	147.4	42.2	22.5	22.5	14.4	5.2	1.2	0.6	0.0	5545.7	8	34.78
1953	1064.9	1716.4	708.2	140.5	42.8	23.7	14.4	6.4	2.9	2.3	0.6	12.1	3735.1	17	73.91
1954	746.3	1268.3	1575.9	204.6	52.0	19.1	15.6	12.1	5.8	2.3	0.6	292.5	4195.3	16	69.57
1955	806.5	2110.6	2265.6	826.7	141.6	55.5	26.6	15.0	6.9	4.1	2.3	104.1	6365.4	6	26.09
1956	2525.1	3857.7	949.2	452.1	186.1	61.3	64.2	23.7	34.1	20.8	5.2	9.3	8188.8	2	8.70
1957	1142.9	2325.1	863.7	127.8	39.3	20.8	12.7	8.7	17.3	5.2	0.6	2.9	4567.0	14	60.87
1958	1328.5	1222.7	1067.8	753.3	122.6	43.4	34.1	26.6	8.1	5.2	2.3	2.3	4616.7	13	56.52
1959	1729.1	2666.2	1881.7	353.2	81.5	40.5	45.1	20.8	13.3	12.1	4.1	56.1	6903.7	4	17.39
1960	971.8	2495.1	574.6	498.3	85.0	42.8	32.4	30.1	12.1	3.5	0.6	158.4	4904.6	12	52.17
1961	3383.6	3021.7	3118.9	617.4	143.4	86.1	48.0	27.8	20.8	12.1	5.2	50.9	10535.9	1	4.35
1962	501.8	1297.8	1075.8	170.0	55.5	198.3	36.4	14.4	9.8	5.8	5.8	77.5	3448.9	18	78.26
1963	633.0	1725.6	1760.3	163.0	68.2	34.7	22.0	15.6	11.0	3.5	1.2	43.4	4481.4	15	65.22
1964	1782.9	3042.0	1038.8	318.0	75.2	40.5	26.6	16.2	9.8	16.2	2.3	68.2	6436.6	5	21.74
1965	281.0	370.6	690.3	72.3	23.7	13.3	12.1	6.9	2.9	0.6	0.6	149.7	1623.9	22	95.65
1966	712.8	1509.4	190.2	37.0	15.6	15.0	9.3	5.8	22.0	18.5	2.9	66.5	2604.9	21	91.30
1967	1715.8	3383.6	1712.9	231.2	60.1	87.9	125.4	46.3	27.8	6.9	4.1	36.4	7438.4	3	13.04
1968	764.3	2024.5	400.6	131.8	42.8	25.4	21.4	6.9	4.1	2.3	0.6	1.2	3425.8	19	82.61
1969	979.3	3134.5	840.6	146.8	58.4	27.8	24.9	12.1	30.6	5.8	5.2	160.7	5426.6	9	39.13
Mean	1174.1	2227.9	1222.6	290.3	75.0	45.5	31.5	18.0	14.4	8.5	2.6	64.7	5175.2		

Table 5.3 Continued

SITE NAME MATIYARI

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	21.6	42.6	27.2	3.9	2.5	1.0	0.6	0.6	0.4	0.1	0.0	0.3	101.0	7	30.43
1949	7.1	42.6	27.2	7.3	1.6	0.6	0.5	0.5	0.6	0.3	0.1	0.3	88.5	10	43.48
1950	27.2	43.0	13.1	1.6	0.5	0.5	0.4	0.2	0.1	0.6	0.1	0.4	87.8	11	47.83
1951	1.1	25.2	12.5	3.7	0.6	0.3	0.2	0.1	0.1	0.0	0.0	1.3	45.0	20	86.96
1952	22.1	43.2	22.6	2.5	0.7	0.4	0.4	0.2	0.1	0.0	0.0	0.0	92.1	8	34.78
1953	17.7	28.5	11.8	2.3	0.7	0.4	0.2	0.1	0.1	0.0	0.0	0.2	62.0	17	73.91
1954	12.4	21.1	26.2	3.4	0.9	0.3	0.3	0.2	0.1	0.0	0.0	4.9	69.7	16	69.57
1955	13.4	35.0	37.6	13.7	2.3	0.9	0.4	0.3	0.1	0.1	0.0	1.7	105.7	6	26.09
1956	41.9	64.1	15.8	7.5	3.1	1.0	1.1	0.4	0.6	0.3	0.1	0.2	136.0	2	8.70
1957	19.0	38.6	14.3	2.1	0.6	0.3	0.2	0.1	0.3	0.1	0.0	0.1	75.8	14	60.87
1958	22.1	20.3	17.7	12.5	2.0	0.7	0.6	0.4	0.1	0.1	0.0	0.0	76.7	13	56.52
1959	28.7	44.3	31.3	5.9	1.4	0.7	0.8	0.3	0.2	0.2	0.1	0.9	114.6	4	17.39
1960	16.1	41.4	9.5	8.3	1.4	0.7	0.5	0.5	0.2	0.1	0.0	2.6	81.4	12	52.17
1961	56.2	50.2	51.8	10.3	2.4	1.4	0.8	0.5	0.3	0.2	0.1	0.8	175.0	1	4.35
1962	8.3	21.5	17.9	2.8	0.9	3.3	0.6	0.2	0.2	0.1	0.1	1.3	57.3	18	78.26
1963	10.5	28.7	29.2	2.7	1.1	0.6	0.4	0.3	0.2	0.1	0.0	0.7	74.4	15	65.22
1964	29.6	50.5	17.3	5.3	1.3	0.7	0.4	0.3	0.2	0.3	0.0	1.1	106.9	5	21.74
1965	4.7	6.2	11.5	1.2	0.4	0.2	0.2	0.1	0.1	0.0	0.0	2.5	27.0	22	95.65
1966	11.8	25.1	3.2	0.6	0.3	0.3	0.2	0.1	0.4	0.3	0.1	1.1	43.3	21	91.30
1967	28.5	56.2	28.4	3.8	1.0	1.5	2.1	0.8	0.5	0.1	0.1	0.6	123.5	3	13.04
1968	12.7	33.6	6.7	2.2	0.7	0.4	0.4	0.1	0.1	0.0	0.0	0.0	56.9	19	82.61
1969	16.3	52.0	14.0	2.4	1.0	0.5	0.4	0.2	0.5	0.1	0.1	2.7	90.1	9	39.13
Mean	19.5	37.0	20.3	4.8	1.2	0.8	0.5	0.3	0.2	0.1	0.0	1.1	85.9		

SITE NAME BARGI

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	1974.8	3897.9	2491.2	360.0	228.3	92.2	59.7	55.3	36.0	10.5	3.5	26.3	9235.9	7	30.43
1949	648.0	3897.9	2491.2	666.5	148.4	50.0	43.0	44.8	56.2	23.7	6.2	22.8	8098.7	10	43.48
1950	2491.2	3937.4	1197.7	150.2	49.2	43.0	34.3	22.0	12.3	50.0	7.9	36.0	8031.1	11	47.83
1951	98.3	2302.4	1145.0	334.6	51.8	31.6	14.9	9.7	6.2	3.5	0.9	115.9	4114.8	20	86.96
1952	2018.8	3951.4	2064.4	223.9	64.1	34.3	34.3	22.0	7.9	1.8	0.9	0.0	8423.6	8	34.78
1953	1617.5	2607.1	1075.7	213.4	65.0	36.0	22.0	9.7	4.4	3.5	0.9	18.4	5673.4	17	73.91
1954	1133.6	1926.6	2393.7	310.9	79.0	29.0	23.7	18.4	8.8	3.5	0.9	444.3	6372.4	16	69.57
1955	1224.9	3205.9	3441.3	1255.7	215.1	84.3	40.4	22.8	10.5	6.2	3.5	158.1	9668.7	6	26.09
1956	3835.5	5859.6	1441.8	686.7	282.8	93.1	97.5	36.0	51.8	31.6	7.9	14.1	12438.3	2	8.70
1957	1736.0	3531.7	1311.9	194.1	59.7	31.6	19.3	13.2	26.3	7.9	0.9	4.4	6937.0	14	60.87
1958	2017.9	1857.2	1621.8	1144.2	186.2	65.9	51.8	40.4	12.3	7.9	3.5	3.5	7012.5	13	56.52
1959	2626.4	4049.8	2858.2	536.5	123.8	61.5	68.5	31.6	20.2	18.4	6.2	85.2	10486.3	4	17.39
1960	1476.1	3789.9	872.8	756.9	129.1	65.0	49.2	45.7	18.4	5.3	0.9	240.6	7449.8	12	52.17
1961	5139.5	4589.8	4737.4	937.8	217.8	130.8	72.9	42.2	31.6	18.4	7.9	77.3	16003.4	1	4.35
1962	762.2	1971.3	1634.1	258.2	84.3	301.2	55.3	22.0	14.9	8.8	8.8	117.7	5238.7	18	78.26
1963	961.5	2621.1	2673.8	247.6	103.6	52.7	33.4	23.7	16.7	5.3	1.8	65.9	6807.0	15	65.22
1964	2708.1	4620.6	1577.9	483.0	114.2	61.5	40.4	24.6	14.9	24.6	3.5	103.6	9776.8	5	21.74
1965	426.8	562.9	1048.4	109.8	36.0	20.2	18.4	10.5	4.4	0.9	0.9	227.4	2466.6	22	95.65
1966	1082.7	2292.7	288.9	56.2	23.7	22.8	14.1	8.8	33.4	28.1	4.4	101.0	3956.7	21	91.30
1967	2606.2	5139.5	2601.8	351.2	91.3	133.5	190.6	70.3	42.2	10.5	6.2	55.3	11298.5	3	13.04
1968	1160.8	3075.1	608.5	200.2	65.0	38.6	32.5	10.5	6.2	3.5	0.9	1.8	5203.6	19	82.61
1969	1487.5	4761.1	1276.8	223.0	88.7	42.2	37.8	18.4	46.5	8.8	7.9	244.1	8242.7	9	39.13
Mean	1783.4	3384.0	1857.0	440.9	114.0	69.1	47.9	27.4	21.9	12.9	3.9	98.3	7860.8		

Table 5.3 Continued

SITE NAME **ATARIA**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	78.6	117.5	115.6	21.7	13.6	6.7	3.9	2.8	2.2	1.4	0.9	2.5	367.3	3	13.04
1949	38.9	69.6	114.5	33.0	10.4	4.3	2.6	1.8	2.3	1.5	1.1	1.3	281.1	7	30.43
1950	74.0	94.3	69.3	10.3	3.5	2.9	2.8	1.8	1.5	1.1	0.7	2.5	264.5	9	39.13
1951	15.5	61.7	38.5	10.1	3.6	2.2	1.8	1.5	1.1	0.7	0.5	3.8	141.1	20	86.96
1952	38.6	112.4	41.9	7.2	3.0	2.1	1.8	1.5	1.1	0.7	0.5	0.6	211.6	18	78.26
1953	43.2	119.3	36.7	8.5	3.3	2.2	1.7	1.2	0.8	0.6	0.5	1.1	219.2	17	73.91
1954	28.5	52.5	129.7	23.2	7.3	3.6	2.3	1.6	0.9	0.6	0.5	4.9	255.7	11	47.83
1955	21.1	92.8	160.2	61.0	10.2	4.8	3.0	2.0	1.5	1.1	0.8	7.9	366.5	4	17.39
1956	103.5	125.7	47.3	25.4	15.8	5.8	5.0	3.0	2.7	2.6	1.3	4.3	342.3	5	21.74
1957	28.2	83.5	47.7	8.1	3.7	2.4	1.9	1.4	1.5	0.8	0.6	1.9	181.7	19	82.61
1958	38.0	67.8	84.7	37.0	10.5	4.3	2.7	1.9	1.4	0.9	0.6	1.4	251.3	12	52.17
1959	96.0	142.9	137.2	29.3	8.7	4.5	4.5	2.5	2.0	1.4	1.0	2.8	432.8	2	8.70
1960	43.9	145.6	27.1	22.2	6.4	4.3	2.9	2.3	1.7	1.2	0.9	5.2	263.6	10	43.48
1961	89.8	105.6	220.7	58.5	12.3	6.6	4.6	3.1	2.6	2.0	1.2	0.9	507.9	1	4.35
1962	27.4	48.2	106.5	14.4	5.7	6.7	3.2	2.0	1.7	1.1	0.7	2.2	219.7	15	65.22
1963	16.6	86.2	85.5	13.3	4.7	3.1	2.2	1.6	1.4	0.9	0.7	3.5	219.6	16	69.57
1964	57.8	130.2	51.4	19.6	5.5	3.2	2.3	1.4	1.1	1.0	0.6	1.5	275.6	8	34.78
1965	25.8	18.5	32.5	4.8	1.7	1.3	1.1	0.8	0.6	0.4	0.4	0.4	88.4	22	95.65
1966	31.3	69.2	23.0	3.1	1.6	1.4	1.0	0.7	0.6	0.9	0.4	3.0	136.2	21	91.30
1967	35.8	100.3	84.9	12.0	3.5	4.5	3.7	1.8	1.7	0.8	0.5	0.6	250.3	13	56.52
1968	33.9	133.4	35.4	11.1	3.4	2.3	1.8	1.1	0.9	0.6	0.4	0.5	224.7	14	60.87
1969	48.5	175.2	69.2	13.1	4.8	2.8	2.5	1.7	1.8	0.9	0.7	14.6	336.0	6	26.09
Mean	46.1	97.8	80.0	20.3	6.5	3.7	2.7	1.8	1.5	1.0	0.7	3.1	265.3		

SITE NAME **CHINKI**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	3157.2	4722.8	4646.4	870.7	548.1	267.2	157.5	110.4	89.4	54.7	37.0	100.4	14761.8	3	13.04
1949	1563.3	2796.9	4601.4	1327.1	417.3	172.1	103.4	72.1	90.4	58.4	44.7	52.4	11299.4	7	30.43
1950	2972.7	3792.4	2783.2	412.0	142.1	116.1	110.4	70.7	59.4	44.7	28.4	98.4	10630.5	9	39.13
1951	622.5	2479.6	1548.9	405.7	146.1	90.1	71.1	59.4	44.7	28.4	21.4	154.8	5672.5	20	86.96
1952	1550.9	4519.3	1683.0	290.9	121.4	84.4	72.7	62.0	45.4	28.7	19.7	25.4	8503.8	18	78.26
1953	1736.1	4793.2	1476.8	340.3	133.4	88.7	70.1	49.0	32.0	24.4	19.4	46.0	8809.4	17	73.91
1954	1147.3	2109.0	5213.2	934.1	292.6	146.1	93.4	63.7	36.7	24.7	19.0	197.8	10277.6	11	47.83
1955	849.0	3730.6	6439.8	2450.3	410.0	192.1	122.8	81.4	59.7	43.7	33.0	319.3	14731.8	4	17.39
1956	4159.7	5050.7	1901.8	1019.8	635.8	234.2	202.2	120.1	108.1	102.8	51.0	173.8	13760.0	5	21.74
1957	1131.9	3356.4	1918.2	324.6	149.1	97.4	77.4	56.4	58.7	33.4	24.4	74.4	7302.2	19	82.61
1958	1528.6	2724.2	3404.7	1487.9	423.7	171.1	107.4	77.4	56.7	35.0	25.0	57.7	10099.4	12	52.17
1959	3857.8	5741.6	5512.7	1177.6	350.6	180.5	182.1	102.1	80.4	54.4	42.4	112.1	17394.3	2	8.70
1960	1763.7	5851.3	1090.9	891.7	258.9	172.1	117.8	90.4	67.1	47.0	35.0	210.2	10596.1	10	43.48
1961	3608.2	4243.7	8870.1	2352.6	495.4	264.9	186.5	125.4	102.8	79.1	49.4	37.0	20415.0	1	4.35
1962	1099.6	1936.6	4279.4	576.8	230.5	268.2	128.8	81.1	70.1	43.4	29.7	87.7	8831.7	15	65.22
1963	666.9	3462.8	3437.4	532.8	189.8	125.1	86.4	63.4	56.7	37.0	28.4	139.4	8826.1	16	69.57
1964	2322.9	5232.9	2067.3	787.3	220.8	127.1	93.1	56.7	45.4	40.4	24.4	58.7	11076.8	8	34.78
1965	1037.8	745.6	1306.4	191.5	69.4	51.0	44.0	33.0	23.4	17.0	15.4	18.0	3552.5	22	95.65
1966	1259.7	2779.6	925.7	125.4	66.4	57.0	40.4	28.0	23.0	37.0	14.7	118.4	5475.4	21	91.30
1967	1437.8	4032.6	3414.1	481.0	142.1	181.8	146.8	74.1	69.1	33.4	21.7	26.0	10060.4	13	56.52
1968	1362.4	5363.3	1423.5	445.7	135.8	90.4	71.1	44.0	35.0	23.4	16.0	19.4	9029.9	14	60.87
1969	1951.2	7042.6	2780.6	527.4	192.8	114.1	102.1	70.1	71.7	37.7	26.4	588.1	13504.8	6	26.09
Mean	1854.0	3932.2	3214.8	816.0	262.4	149.6	108.5	72.3	60.3	42.2	28.5	123.4	10664.1		

Table 5.3 Continued

SITE NAME **SHER**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	122.1	182.6	179.7	33.7	21.2	10.3	6.1	4.3	3.5	2.1	1.4	3.9	570.8	3	13.04
1949	60.5	108.2	177.9	51.3	16.1	6.7	4.0	2.8	3.5	2.3	1.7	2.0	437.0	7	30.43
1950	114.9	146.6	107.6	15.9	5.5	4.5	4.3	2.7	2.3	1.7	1.1	3.8	411.1	9	39.13
1951	24.1	95.9	59.9	15.7	5.7	3.5	2.8	2.3	1.7	1.1	0.8	6.0	219.4	20	86.96
1952	60.0	174.8	65.1	11.3	4.7	3.3	2.8	2.4	1.8	1.1	0.8	1.0	328.8	18	78.26
1953	67.1	185.4	57.1	13.2	5.2	3.4	2.7	1.9	1.2	0.9	0.8	1.8	340.7	17	73.91
1954	44.4	81.6	201.6	36.1	11.3	5.7	3.6	2.5	1.4	0.9	0.7	7.7	397.4	11	47.83
1955	32.8	144.3	249.0	94.8	15.9	7.4	4.8	3.2	2.3	1.7	1.3	12.4	569.7	4	17.39
1956	160.9	195.3	73.5	39.4	24.6	9.1	7.8	4.6	4.2	4.0	2.0	6.7	532.1	5	21.74
1957	43.8	129.8	74.2	12.6	5.8	3.8	3.0	2.2	2.3	1.3	0.9	2.9	282.4	19	82.61
1958	59.1	105.3	131.7	57.5	16.4	6.6	4.2	3.0	2.2	1.4	1.0	2.2	390.5	12	52.17
1959	149.2	222.0	213.2	45.5	13.6	7.0	7.0	4.0	3.1	2.1	1.6	4.3	672.6	2	8.70
1960	68.2	226.3	42.2	34.5	10.0	6.7	4.6	3.5	2.6	1.8	1.4	8.1	409.7	10	43.48
1961	139.5	164.1	343.0	91.0	19.2	10.2	7.2	4.8	4.0	3.1	1.9	1.4	789.4	1	4.35
1962	42.5	74.9	165.5	22.3	8.9	10.4	5.0	3.1	2.7	1.7	1.1	3.4	341.5	15	65.22
1963	25.8	133.9	132.9	20.6	7.3	4.8	3.3	2.5	2.2	1.4	1.1	5.4	341.3	16	69.57
1964	89.8	202.4	79.9	30.4	8.5	4.9	3.6	2.2	1.8	1.6	0.9	2.3	428.3	8	34.78
1965	40.1	28.8	50.5	7.4	2.7	2.0	1.7	1.3	0.9	0.7	0.6	0.7	137.4	22	95.65
1966	48.7	107.5	35.8	4.8	2.6	2.2	1.6	1.1	0.9	1.4	0.6	4.6	211.7	21	91.30
1967	55.6	155.9	132.0	18.6	5.5	7.0	5.7	2.9	2.7	1.3	0.8	1.0	389.0	13	56.52
1968	52.7	207.4	55.0	17.2	5.3	3.5	2.8	1.7	1.4	0.9	0.6	0.8	349.2	14	60.87
1969	75.4	272.3	107.5	20.4	7.5	4.4	4.0	2.7	2.8	1.5	1.0	22.7	522.2	6	26.09
Mean	71.7	152.1	124.3	31.6	10.1	5.8	4.2	2.8	2.3	1.6	1.1	4.8	412.4		

SITE NAME **MACHREWA**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	65.7	98.3	96.7	18.1	11.4	5.6	3.3	2.3	1.9	1.1	0.8	2.1	307.1	3	13.04
1949	32.5	58.2	95.7	27.6	8.7	3.6	2.2	1.5	1.9	1.2	0.9	1.1	235.0	7	30.43
1950	61.8	78.9	57.9	8.6	3.0	2.4	2.3	1.5	1.2	0.9	0.6	2.0	221.2	9	39.13
1951	12.9	51.6	32.2	8.4	3.0	1.9	1.5	1.2	0.9	0.6	0.4	3.2	118.0	20	86.96
1952	32.3	94.0	35.0	6.1	2.5	1.8	1.5	1.3	0.9	0.6	0.4	0.5	176.9	18	78.26
1953	36.1	99.7	30.7	7.1	2.8	1.9	1.5	1.0	0.7	0.5	0.4	1.0	183.3	17	73.91
1954	23.9	43.9	108.4	19.4	6.1	3.0	1.9	1.3	0.8	0.5	0.4	4.1	213.8	11	47.83
1955	17.7	77.6	134.0	51.0	8.5	4.0	2.5	1.7	1.2	0.9	0.7	6.6	306.5	4	17.39
1956	86.5	105.1	39.6	21.2	13.2	4.9	4.2	2.5	2.3	2.1	1.1	3.6	286.3	5	21.74
1957	23.5	69.8	39.9	6.8	3.1	2.0	1.6	1.2	1.2	0.7	0.5	1.5	151.9	19	82.61
1958	31.8	56.7	70.8	31.0	8.8	3.6	2.2	1.6	1.2	0.7	0.5	1.2	210.1	12	52.17
1959	80.3	119.4	114.7	24.5	7.3	3.8	3.8	2.1	1.7	1.1	0.9	2.3	361.8	2	8.70
1960	36.7	121.7	22.7	18.5	5.4	3.6	2.5	1.9	1.4	1.0	0.7	4.4	220.4	10	43.48
1961	75.1	88.3	184.5	48.9	10.3	5.5	3.9	2.6	2.1	1.6	1.0	0.8	424.7	1	4.35
1962	22.9	40.3	89.0	12.0	4.8	5.6	2.7	1.7	1.5	0.9	0.6	1.8	183.8	15	65.22
1963	13.9	72.0	71.5	11.1	4.0	2.6	1.8	1.3	1.2	0.8	0.6	2.9	183.6	16	69.57
1964	48.3	108.9	43.0	16.4	4.6	2.6	1.9	1.2	0.9	0.8	0.5	1.2	230.4	8	34.78
1965	21.6	15.5	27.2	4.0	1.4	1.1	0.9	0.7	0.5	0.3	0.3	0.4	73.9	22	95.65
1966	26.2	57.8	19.3	2.6	1.4	1.2	0.8	0.6	0.5	0.8	0.3	2.5	113.9	21	91.30
1967	29.9	83.9	71.0	10.0	3.0	3.8	3.0	1.5	1.4	0.7	0.4	0.5	209.3	13	56.52
1968	28.3	111.6	29.6	9.3	2.8	1.9	1.5	0.9	0.7	0.5	0.3	0.4	187.8	14	60.87
1969	40.6	146.5	57.8	11.0	4.0	2.4	2.1	1.5	1.5	0.8	0.6	12.2	280.9	6	26.09
Mean	38.6	81.8	66.9	17.0	5.5	3.1	2.3	1.5	1.3	0.9	0.6	2.6	221.8		

Table 5.3 Continued

SITE NAME **SHAKKER**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	206.3	308.6	303.6	56.9	35.8	17.5	10.3	7.2	5.8	3.6	2.4	6.6	964.7	3	13.04
1949	102.2	182.8	300.7	86.7	27.3	11.3	6.8	4.7	5.9	3.8	2.9	3.4	738.4	7	30.43
1950	194.3	247.8	181.9	26.9	9.3	7.6	7.2	4.6	3.9	2.9	1.9	6.4	694.7	9	39.13
1951	40.7	162.0	101.2	26.5	9.6	5.9	4.6	3.9	2.9	1.9	1.4	10.1	370.7	20	86.96
1952	101.3	295.3	110.0	19.0	7.9	5.5	4.8	4.1	3.0	1.9	1.3	1.7	555.7	18	78.26
1953	113.4	313.2	96.5	22.2	8.7	5.8	4.6	3.2	2.1	1.6	1.3	3.0	575.7	17	73.91
1954	75.0	137.8	340.7	61.0	19.1	9.6	6.1	4.2	2.4	1.6	1.2	12.9	671.6	11	47.83
1955	55.5	243.8	420.8	160.1	26.8	12.6	8.0	5.3	3.9	2.9	2.2	20.9	962.7	4	17.39
1956	271.8	330.0	124.3	66.6	41.5	15.3	13.2	7.8	7.1	6.7	3.3	11.4	899.2	5	21.74
1957	74.0	219.3	125.3	21.2	9.7	6.4	5.1	3.7	3.8	2.2	1.6	4.9	477.2	19	82.61
1958	99.9	178.0	222.5	97.2	27.7	11.2	7.0	5.1	3.7	2.3	1.6	3.8	660.0	12	52.17
1959	252.1	375.2	360.2	76.9	22.9	11.8	11.9	6.7	5.3	3.5	2.8	7.3	1136.7	2	8.70
1960	115.3	382.4	71.3	58.3	16.9	11.3	7.7	5.9	4.4	3.1	2.3	13.7	692.4	10	43.48
1961	235.8	277.3	579.6	153.7	32.4	17.3	12.2	8.2	6.7	5.2	3.2	2.4	1334.1	1	4.35
1962	71.8	126.6	279.6	37.7	15.1	17.5	8.4	5.3	4.6	2.8	1.9	5.7	577.1	15	65.22
1963	43.6	226.3	224.6	34.8	12.4	8.2	5.7	4.1	3.7	2.4	1.9	9.1	576.8	16	69.57
1964	151.8	342.0	135.1	51.5	14.4	8.3	6.1	3.7	3.0	2.6	1.6	3.8	723.8	8	34.78
1965	67.8	48.7	85.4	12.5	4.5	3.3	2.9	2.2	1.5	1.1	1.0	1.2	232.1	22	95.65
1966	82.3	181.6	60.5	8.2	4.3	3.7	2.6	1.8	1.5	2.4	1.0	7.7	357.8	21	91.30
1967	94.0	263.5	223.1	31.4	9.3	11.9	9.6	4.8	4.5	2.2	1.4	1.7	657.4	13	56.52
1968	89.0	350.5	93.0	29.1	8.9	5.9	4.6	2.9	2.3	1.5	1.0	1.3	590.1	14	60.87
1969	127.5	460.2	181.7	34.5	12.6	7.5	6.7	4.6	4.7	2.5	1.7	38.4	882.5	6	26.09
Mean	121.2	257.0	210.1	53.3	17.1	9.8	7.1	4.7	3.9	2.8	1.9	8.1	696.9		

SITE NAME **SITAREWA**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	
1948	28.4	42.5	41.8	7.8	4.9	2.4	1.4	1.0	0.8	0.5	0.3	0.9	132.7	3	1
1949	14.1	25.1	41.4	11.9	3.8	1.5	0.9	0.6	0.8	0.5	0.4	0.5	101.6	7	30.
1950	26.7	34.1	25.0	3.7	1.3	1.0	1.0	0.6	0.5	0.4	0.3	0.9	95.6	9	39.1
1951	5.6	22.3	13.9	3.7	1.3	0.8	0.6	0.5	0.4	0.3	0.2	1.4	51.0	20	86.96
1952	13.9	40.6	15.1	2.6	1.1	0.8	0.6	0.6	0.4	0.3	0.2	0.2	76.5	18	78.26
1953	15.6	43.1	13.3	3.1	1.2	0.8	0.6	0.4	0.3	0.2	0.2	0.4	79.2	17	73.91
1954	10.3	19.0	46.9	8.4	2.6	1.3	0.8	0.6	0.3	0.2	0.2	1.8	92.4	11	47.83
1955	7.6	33.5	57.9	22.0	3.7	1.7	1.1	0.7	0.5	0.4	0.3	2.9	132.5	4	17.39
1956	37.4	45.4	17.1	9.2	5.7	2.1	1.8	1.1	1.0	0.9	0.5	1.6	123.7	5	21.74
1957	10.2	30.2	17.3	2.9	1.3	0.9	0.7	0.5	0.5	0.3	0.2	0.7	65.7	19	82.61
1958	13.8	24.5	30.6	13.4	3.8	1.5	1.0	0.7	0.5	0.3	0.2	0.5	90.8	12	52.17
1959	34.7	51.6	49.6	10.6	3.2	1.6	1.6	0.9	0.7	0.5	0.4	1.0	156.4	2	8.70
1960	15.9	52.6	9.8	8.0	2.3	1.5	1.1	0.8	0.6	0.4	0.3	1.9	95.3	10	43.48
1961	32.5	38.2	79.8	21.2	4.4	2.4	1.7	1.1	0.9	0.7	0.4	0.3	183.6	1	4.35
1962	9.9	17.4	38.5	5.2	2.1	2.4	1.2	0.7	0.6	0.4	0.3	0.8	79.4	15	65.22
1963	6.0	31.1	30.9	4.8	1.7	1.1	0.8	0.6	0.5	0.3	0.3	1.3	79.4	16	69.57
1964	20.9	47.1	18.6	7.1	2.0	1.1	0.8	0.5	0.4	0.4	0.2	0.5	99.6	8	34.78
1965	9.3	6.7	11.8	1.7	0.6	0.5	0.4	0.3	0.2	0.2	0.1	0.2	31.9	22	95.65
1966	11.3	25.0	8.3	1.1	0.6	0.5	0.4	0.3	0.2	0.3	0.1	1.1	49.2	21	91.30
1967	12.9	36.3	30.7	4.3	1.3	1.6	1.3	0.7	0.6	0.3	0.2	0.2	90.5	13	56.52
1968	12.3	48.2	12.8	4.0	1.2	0.8	0.6	0.4	0.3	0.2	0.1	0.2	81.2	14	60.87
1969	17.5	63.3	25.0	4.7	1.7	1.0	0.9	0.6	0.6	0.3	0.2	5.3	121.4	6	26.09
Mean	16.7	35.4	28.9	7.3	2.4	1.3	1.0	0.7	0.5	0.4	0.3	1.1	95.9		

Table 5.3 Continued

SITE NAME DUDHI

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	112.5	168.3	165.6	31.0	19.5	9.5	5.6	3.9	3.2	2.0	1.3	3.6	526.1	3	13.04
1949	55.7	99.7	164.0	47.3	14.9	6.1	3.7	2.6	3.2	2.1	1.6	1.9	402.7	7	30.43
1950	105.9	135.2	99.2	14.7	5.1	4.1	3.9	2.5	2.1	1.6	1.0	3.5	378.9	9	39.13
1951	22.2	88.4	55.2	14.5	5.2	3.2	2.5	2.1	1.6	1.0	0.8	5.5	202.2	20	86.96
1952	55.3	161.1	60.0	10.4	4.3	3.0	2.6	2.2	1.6	1.0	0.7	0.9	303.1	18	78.26
1953	61.9	170.8	52.6	12.1	4.8	3.2	2.5	1.8	1.1	0.9	0.7	1.6	314.0	17	73.91
1954	40.9	75.2	185.8	33.3	10.4	5.2	3.3	2.3	1.3	0.9	0.7	7.1	366.3	11	47.83
1955	30.3	133.0	229.5	87.3	14.6	6.8	4.4	2.9	2.1	1.6	1.2	11.4	525.1	4	17.39
1956	148.3	180.0	67.8	36.3	22.7	8.4	7.2	4.3	3.8	3.7	1.8	6.2	490.4	5	21.74
1957	40.3	119.6	68.4	11.6	5.3	3.5	2.8	2.0	2.1	1.2	0.9	2.7	260.3	19	82.61
1958	54.5	97.1	121.3	53.0	15.1	6.1	3.8	2.8	2.0	1.3	0.9	2.1	360.0	12	52.17
1959	137.5	204.6	196.5	42.0	12.5	6.4	6.5	3.6	2.9	1.9	1.5	4.0	620.0	2	8.70
1960	62.9	208.6	38.9	31.8	9.2	6.1	4.2	3.2	2.4	1.7	1.3	7.5	377.7	10	43.48
1961	128.6	151.3	316.1	83.8	17.7	9.4	6.7	4.5	3.7	2.8	1.8	1.3	727.6	1	4.35
1962	39.2	69.0	152.5	20.6	8.2	9.6	4.6	2.9	2.5	1.5	1.1	3.1	314.8	15	65.22
1963	23.8	123.4	122.5	19.0	6.8	4.5	3.1	2.3	2.0	1.3	1.0	5.0	314.6	16	69.57
1964	82.8	186.5	73.7	28.1	7.9	4.5	3.3	2.0	1.6	1.4	0.9	2.1	394.8	8	34.78
1965	37.0	26.6	46.6	6.8	2.5	1.8	1.6	1.2	0.8	0.6	0.6	0.6	126.6	22	95.65
1966	44.9	99.1	33.0	4.5	2.4	2.0	1.4	1.0	0.8	1.3	0.5	4.2	195.2	21	91.30
1967	51.3	143.7	121.7	17.1	5.1	6.5	5.2	2.6	2.5	1.2	0.8	0.9	358.6	13	56.52
1968	48.6	191.2	50.7	15.9	4.8	3.2	2.5	1.6	1.3	0.8	0.6	0.7	321.8	14	60.87
1969	69.5	251.0	99.1	18.8	6.9	4.1	3.6	2.5	2.6	1.3	0.9	21.0	481.3	6	26.09
Mean	66.1	140.1	114.6	29.1	9.4	5.3	3.9	2.6	2.1	1.5	1.0	4.4	380.1		

SITE NAME BARNA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	163.7	244.9	240.9	45.2	28.4	13.9	8.2	5.7	4.6	2.8	1.9	5.2	765.5	3	13.04
1949	81.1	145.0	238.6	68.8	21.6	8.9	5.4	3.7	4.7	3.0	2.3	2.7	586.0	7	30.43
1950	154.2	196.7	144.3	21.4	7.4	6.0	5.7	3.7	3.1	2.3	1.5	5.1	551.3	9	39.13
1951	32.3	128.6	80.3	21.0	7.6	4.7	3.7	3.1	2.3	1.5	1.1	8.0	294.2	20	86.96
1952	80.4	234.4	87.3	15.1	6.3	4.4	3.8	3.2	2.3	1.5	1.0	1.3	441.0	18	78.26
1953	90.0	248.6	76.6	17.6	6.9	4.6	3.6	2.5	1.7	1.3	1.0	2.4	456.8	17	73.91
1954	59.5	109.4	270.4	48.4	15.2	7.6	4.8	3.3	1.9	1.3	1.0	10.3	533.0	11	47.83
1955	44.0	193.5	334.0	127.1	21.3	10.0	6.4	4.2	3.1	2.3	1.7	16.6	764.0	4	17.39
1956	215.7	261.9	98.6	52.9	33.0	12.1	10.5	6.2	5.6	5.3	2.7	9.0	713.6	5	21.74
1957	58.7	174.1	99.5	16.8	7.7	5.1	4.0	2.9	3.0	1.7	1.3	3.9	378.7	19	82.61
1958	79.3	141.3	176.6	77.2	22.0	8.9	5.6	4.0	2.9	1.8	1.3	3.0	523.7	12	52.17
1959	200.1	297.8	285.9	61.1	18.2	9.4	9.4	5.3	4.2	2.8	2.2	5.8	902.0	2	8.70
1960	91.5	303.4	56.6	46.2	13.4	8.9	6.1	4.7	3.5	2.4	1.8	10.9	549.5	10	43.48
1961	187.1	220.1	460.0	122.0	25.7	13.7	9.7	6.5	5.3	4.1	2.6	1.9	1058.7	1	4.35
1962	57.0	100.4	221.9	29.9	11.9	13.9	6.7	4.2	3.6	2.3	1.5	4.6	458.0	15	65.22
1963	34.6	179.6	178.3	27.6	9.8	6.5	4.5	3.3	2.9	1.9	1.5	7.2	457.7	16	69.57
1964	120.5	271.4	107.2	40.8	11.4	6.6	4.8	2.9	2.3	2.1	1.3	3.0	574.4	8	34.78
1965	53.8	38.7	67.8	9.9	3.6	2.7	2.3	1.7	1.2	0.9	0.8	0.9	184.2	22	95.65
1966	65.3	144.1	48.0	6.5	3.4	3.0	2.1	1.5	1.2	1.9	0.8	6.1	283.9	21	91.30
1967	74.6	209.1	177.1	25.0	7.4	9.4	7.6	3.8	3.6	1.7	1.1	1.4	521.7	13	56.52
1968	70.7	278.1	73.8	23.1	7.0	4.7	3.7	2.3	1.8	1.2	0.8	1.0	468.3	14	60.87
1969	101.2	365.2	144.2	27.4	10.0	5.9	5.3	3.6	3.7	2.0	1.4	30.5	700.3	6	26.09
Mean	96.1	203.9	166.7	42.3	13.6	7.8	5.6	3.7	3.1	2.2	1.5	6.4	553.0		

Table 5.3 Continued

SITE NAME **TAWA PROJECT**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	1449.0	2647.0	1801.0	247.0	222.0	51.0	33.0	12.0	9.0	6.0	4.0	27.0	6508.0	3	13.04
1949	565.0	649.0	2362.0	424.0	100.0	31.0	20.0	23.0	10.0	5.0	4.0	5.0	4198.0	7	30.43
1950	1435.0	475.0	644.0	22.0	19.0	16.0	17.0	7.0	5.0	4.0	4.0	83.0	2731.0	15	65.22
1951	213.0	1039.0	516.0	95.0	12.0	7.0	9.0	11.0	4.0	2.0	2.0	58.0	1968.0	21	91.30
1952	736.0	1088.0	155.0	19.0	7.0	6.0	5.0	5.0	4.0	2.0	2.0	22.0	2051.0	20	86.96
1953	549.0	1844.0	315.0	80.0	15.0	10.0	9.0	6.0	4.0	2.0	1.0	19.0	2854.0	14	60.87
1954	533.0	588.0	891.0	131.0	28.0	15.0	11.0	7.0	4.0	2.0	2.0	41.0	2253.0	18	78.26
1955	126.0	1125.0	1300.0	870.0	42.0	25.0	15.0	7.0	6.0	2.0	2.0	65.0	3585.0	10	43.48
1956	802.0	591.0	422.0	74.0	150.0	27.0	31.0	10.0	17.0	14.0	4.0	25.0	2167.0	19	82.61
1957	146.0	1151.0	479.0	35.0	11.0	7.0	5.0	4.0	4.0	2.0	2.0	26.0	1872.0	22	95.65
1958	422.0	1125.0	1586.0	242.0	102.0	27.0	9.0	6.0	4.0	2.0	2.0	73.0	3600.0	8	34.78
1959	2250.0	1807.0	3221.0	398.0	120.0	89.0	100.0	25.0	21.0	0.0	0.0	59.0	8090.0	2	8.70
1960	445.0	1875.0	233.0	275.0	60.0	46.0	20.0	10.0	0.0	0.0	0.0	19.0	2983.0	13	56.52
1961	1064.0	2139.0	5442.0	540.0	95.0	72.0	56.0	28.0	19.0	20.0	4.0	28.0	9507.0	1	4.35
1962	523.0	1146.0	2299.0	131.0	12.0	47.0	10.0	9.0	33.0	4.0	4.0	33.0	4251.0	6	26.09
1963	164.0	1874.0	1763.0	131.0	86.0	81.0	63.0	52.0	37.0	23.0	19.0	97.0	4390.0	5	21.74
1964	897.0	3333.0	418.0	97.0	49.0	44.0	41.0	28.0	28.0	26.0	19.0	65.0	5045.0	4	17.39
1965	486.0	295.0	1426.0	91.0	38.0	30.0	17.0	10.0	10.0	5.0	4.0	2.0	2414.0	17	73.91
1966	1663.0	1173.0	218.0	26.0	6.0	6.0	5.0	4.0	5.0	2.0	2.0	111.0	3221.0	12	52.17
1967	1349.0	1010.0	1046.0	74.0	5.0	53.0	19.0	10.0	19.0	5.0	2.0	5.0	3597.0	9	39.13
1968	966.0	965.0	570.0	54.0	27.0	17.0	16.0	11.0	10.0	6.0	5.0	10.0	2657.0	16	69.57
1969	870.0	1615.0	860.0	44.0	19.0	11.0	9.0	5.0	12.0	5.0	4.0	69.0	3523.0	11	47.83
Mean	802.4	1343.4	1271.2	186.4	55.7	32.6	23.6	13.2	12.0	6.3	4.2	42.8	3793.9		

SITE NAME **KOLAR**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	71.0	106.2	104.5	19.6	12.3	6.0	3.5	2.5	2.0	1.2	0.8	2.3	331.9	3	13.04
1949	35.2	62.9	103.4	29.8	9.4	3.9	2.3	1.6	2.0	1.3	1.0	1.2	254.0	7	30.43
1950	66.8	85.3	62.6	9.3	3.2	2.6	2.5	1.6	1.3	1.0	0.6	2.2	239.0	9	39.13
1951	14.0	55.8	34.8	9.1	3.3	2.0	1.6	1.3	1.0	0.6	0.5	3.5	127.5	20	86.96
1952	34.9	101.6	37.8	6.5	2.7	1.9	1.6	1.4	1.0	0.6	0.4	0.6	191.2	18	78.26
1953	39.0	107.8	33.2	7.7	3.0	2.0	1.6	1.1	0.7	0.6	0.4	1.0	198.1	17	73.91
1954	25.8	47.4	117.2	21.0	6.6	3.3	2.1	1.4	0.8	0.6	0.4	4.4	231.0	11	47.83
1955	19.1	83.9	144.8	55.1	9.2	4.3	2.8	1.8	1.3	1.0	0.7	7.2	331.2	4	17.39
1956	93.5	113.6	42.8	22.9	14.3	5.3	4.6	2.7	2.4	2.3	1.1	3.9	309.4	5	21.74
1957	25.5	75.5	43.1	7.3	3.3	2.2	1.7	1.3	1.3	0.8	0.6	1.7	164.2	19	82.61
1958	34.4	61.2	76.5	33.5	9.5	3.8	2.4	1.7	1.3	0.8	0.6	1.3	227.0	12	52.17
1959	86.7	129.1	123.9	26.5	7.9	4.1	4.1	2.3	1.8	1.2	0.9	2.5	391.0	2	8.70
1960	39.7	131.6	24.5	20.0	5.8	3.9	2.7	2.0	1.5	1.1	0.8	4.7	238.2	10	43.48
1961	81.1	95.4	199.4	52.9	11.1	5.9	4.2	2.8	2.3	1.8	1.1	0.8	459.0	1	4.35
1962	24.7	43.5	96.2	13.0	5.2	6.0	2.9	1.8	1.6	1.0	0.7	2.0	198.5	15	65.22
1963	15.0	77.8	77.3	12.0	4.3	2.8	1.9	1.4	1.3	0.8	0.6	3.1	198.4	16	69.57
1964	52.2	117.6	46.5	17.7	5.0	2.9	2.1	1.3	1.0	0.9	0.6	1.3	249.0	8	34.78
1965	23.3	16.8	29.4	4.3	1.6	1.1	1.0	0.7	0.5	0.4	0.3	0.4	79.8	22	95.65
1966	28.3	62.5	20.8	2.8	1.5	1.3	0.9	0.6	0.5	0.8	0.3	2.7	123.1	21	91.30
1967	32.3	90.7	76.8	10.8	3.2	4.1	3.3	1.7	1.5	0.8	0.5	0.6	226.2	13	56.52
1968	30.6	120.6	32.0	10.0	3.0	2.0	1.6	1.0	0.8	0.5	0.4	0.4	203.0	14	60.87
1969	43.9	158.3	62.5	11.9	4.3	2.6	2.3	1.6	1.6	0.9	0.6	13.2	303.6	6	26.09
Mean	41.7	88.4	72.3	18.3	5.9	3.4	2.4	1.6	1.4	0.9	0.6	2.8	239.7		

Table 5.3 Continued

SITE NAME **MORAND**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	144.8	216.6	213.1	39.9	25.1	12.3	7.2	5.1	4.1	2.5	1.7	4.6	677.0	3	13.04
1949	71.7	128.3	211.0	60.9	19.1	7.9	4.7	3.3	4.2	2.7	2.0	2.4	518.2	7	30.43
1950	136.3	173.9	127.7	18.9	6.5	5.3	5.1	3.2	2.7	2.0	1.3	4.5	487.5	9	39.13
1951	28.5	113.7	71.0	18.6	6.7	4.1	3.3	2.7	2.0	1.3	1.0	7.1	260.1	20	86.96
1952	71.1	207.3	77.2	13.3	5.6	3.9	3.3	2.8	2.1	1.3	0.9	1.2	390.0	18	78.26
1953	79.6	219.8	67.7	15.6	6.1	4.1	3.2	2.3	1.5	1.1	0.9	2.1	404.0	17	73.91
1954	52.6	96.7	239.1	42.8	13.4	6.7	4.3	2.9	1.7	1.1	0.9	9.1	471.4	11	47.83
1955	38.9	171.1	295.4	112.4	18.8	8.8	5.6	3.7	2.7	2.0	1.5	14.6	675.6	4	17.39
1956	190.8	231.6	87.2	46.8	29.2	10.7	9.3	5.5	5.0	4.7	2.3	8.0	631.1	5	21.74
1957	51.9	153.9	88.0	14.9	6.8	4.5	3.5	2.6	2.7	1.5	1.1	3.4	334.9	19	82.61
1958	70.1	124.9	156.1	68.2	19.4	7.8	4.9	3.5	2.6	1.6	1.1	2.7	463.2	12	52.17
1959	176.9	263.3	252.8	54.0	16.1	8.3	8.4	4.7	3.7	2.5	1.9	5.1	797.8	2	8.70
1960	80.9	268.4	50.0	40.9	11.9	7.9	5.4	4.2	3.1	2.2	1.6	9.6	486.0	10	43.48
1961	165.5	194.6	406.8	107.9	22.7	12.1	8.6	5.8	4.7	3.6	2.3	1.7	936.3	1	4.35
1962	50.4	88.8	196.3	26.5	10.6	12.3	5.9	3.7	3.2	2.0	1.4	4.0	405.0	15	65.22
1963	30.6	158.8	157.6	24.4	8.7	5.7	4.0	2.9	2.6	1.7	1.3	6.4	404.8	16	69.57
1964	106.5	240.0	94.8	36.1	10.1	5.8	4.3	2.6	2.1	1.9	1.1	2.7	508.0	8	34.78
1965	47.6	34.2	59.9	8.8	3.2	2.3	2.0	1.5	1.1	0.8	0.7	0.8	162.9	22	95.65
1966	57.8	127.5	42.5	5.8	3.0	2.6	1.9	1.3	1.1	1.7	0.7	5.4	251.1	21	91.30
1967	65.9	184.9	156.6	22.1	6.5	8.3	6.7	3.4	3.2	1.5	1.0	1.2	461.4	13	56.52
1968	62.5	246.0	65.3	20.4	6.2	4.2	3.3	2.0	1.6	1.1	0.7	0.9	414.2	14	60.87
1969	89.5	323.0	127.5	24.2	8.8	5.2	4.7	3.2	3.3	1.7	1.2	27.0	619.4	6	26.09
Mean	85.0	180.3	147.4	37.4	12.0	6.9	5.0	3.3	2.8	1.9	1.3	5.7	489.1		

SITE NAME **GANJAL**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	60.6	90.6	89.1	16.7	10.5	5.1	3.0	2.1	1.7	1.0	0.7	1.9	283.2	3	13.04
1949	30.0	53.7	88.3	25.5	8.0	3.3	2.0	1.4	1.7	1.1	0.9	1.0	216.8	7	30.43
1950	57.0	72.8	53.4	7.9	2.7	2.2	2.1	1.4	1.1	0.9	0.5	1.9	204.0	9	39.13
1951	11.9	47.6	29.7	7.8	2.8	1.7	1.4	1.1	0.9	0.5	0.4	3.0	108.8	20	86.96
1952	29.8	86.7	32.3	5.6	2.3	1.6	1.4	1.2	0.9	0.6	0.4	0.5	163.1	18	78.26
1953	33.3	92.0	28.3	6.5	2.6	1.7	1.3	0.9	0.6	0.5	0.4	0.9	169.0	17	73.91
1954	22.0	40.5	100.0	17.9	5.6	2.8	1.8	1.2	0.7	0.5	0.4	3.8	197.2	11	47.83
1955	16.3	71.6	123.6	47.0	7.9	3.7	2.4	1.6	1.1	0.8	0.6	6.1	282.6	4	17.39
1956	79.8	96.9	36.5	19.6	12.2	4.5	3.9	2.3	2.1	2.0	1.0	3.3	264.0	5	21.74
1957	21.7	64.4	36.8	6.2	2.9	1.9	1.5	1.1	1.1	0.6	0.5	1.4	140.1	19	82.61
1958	29.3	52.3	65.3	28.5	8.1	3.3	2.1	1.5	1.1	0.7	0.5	1.1	193.7	12	52.17
1959	74.0	110.2	105.8	22.6	6.7	3.5	3.5	2.0	1.5	1.0	0.8	2.2	333.7	2	8.70
1960	33.8	112.3	20.9	17.1	5.0	3.3	2.3	1.7	1.3	0.9	0.7	4.0	203.3	10	43.48
1961	69.2	81.4	170.2	45.1	9.5	5.1	3.6	2.4	2.0	1.5	0.9	0.7	391.6	1	4.35
1962	21.1	37.2	82.1	11.1	4.4	5.2	2.5	1.6	1.3	0.8	0.6	1.7	169.4	15	65.22
1963	12.8	66.4	65.9	10.2	3.6	2.4	1.7	1.2	1.1	0.7	0.5	2.7	169.3	16	69.57
1964	44.6	100.4	39.7	15.1	4.2	2.4	1.8	1.1	0.9	0.8	0.5	1.1	212.5	8	34.78
1965	19.9	14.3	25.1	3.7	1.3	1.0	0.8	0.6	0.4	0.3	0.3	0.3	68.1	22	95.65
1966	24.2	53.3	17.8	2.4	1.3	1.1	0.8	0.5	0.4	0.7	0.3	2.3	105.0	21	91.30
1967	27.6	77.4	65.5	9.2	2.7	3.5	2.8	1.4	1.3	0.6	0.4	0.5	193.0	13	56.52
1968	26.1	102.9	27.3	8.6	2.6	1.7	1.4	0.8	0.7	0.4	0.3	0.4	173.2	14	60.87
1969	37.4	135.1	53.3	10.1	3.7	2.2	2.0	1.3	1.4	0.7	0.5	11.3	259.1	6	26.09
Mean	35.6	75.4	61.7	15.7	5.0	2.9	2.1	1.4	1.2	0.8	0.5	2.4	204.6		

Table 5.3 Continued

SITE NAME SUKTA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	65.3	97.7	96.1	18.0	11.3	5.5	3.3	2.3	1.9	1.1	0.8	2.1	305.3	3	13.04
1949	32.3	57.8	95.2	27.5	8.6	3.6	2.1	1.5	1.9	1.2	0.9	1.1	233.7	7	30.43
1950	61.5	78.4	57.6	8.5	2.9	2.4	2.3	1.5	1.2	0.9	0.6	2.0	219.9	9	39.13
1951	12.9	51.3	32.0	8.4	3.0	1.9	1.5	1.2	0.9	0.6	0.4	3.2	117.3	20	86.96
1952	32.1	93.5	34.8	6.0	2.5	1.8	1.5	1.3	0.9	0.6	0.4	0.5	175.9	18	78.26
1953	35.9	99.1	30.5	7.0	2.8	1.8	1.5	1.0	0.7	0.5	0.4	0.9	182.2	17	73.91
1954	23.7	43.6	107.8	19.3	6.1	3.0	1.9	1.3	0.8	0.5	0.4	4.1	212.6	11	47.83
1955	17.6	77.2	133.2	50.7	8.5	4.0	2.5	1.7	1.2	0.9	0.7	6.6	304.7	4	17.39
1956	86.0	104.5	39.3	21.1	13.1	4.8	4.2	2.5	2.2	2.1	1.1	3.6	284.6	5	21.74
1957	23.4	69.4	39.7	6.7	3.1	2.0	1.6	1.2	1.2	0.7	0.5	1.5	151.0	19	82.61
1958	31.6	56.3	70.4	30.8	8.8	3.5	2.2	1.6	1.2	0.7	0.5	1.2	208.9	12	52.17
1959	79.8	118.8	114.0	24.4	7.3	3.7	3.8	2.1	1.7	1.1	0.9	2.3	359.8	2	8.70
1960	36.5	121.0	22.6	18.4	5.3	3.6	2.4	1.9	1.4	1.0	0.7	4.3	219.2	10	43.48
1961	74.6	87.8	183.5	48.7	10.3	5.5	3.9	2.6	2.1	1.6	1.0	0.8	422.3	1	4.35
1962	22.7	40.0	88.5	11.9	4.8	5.6	2.7	1.7	1.5	0.9	0.6	1.8	182.7	15	65.22
1963	13.8	71.6	71.1	11.0	3.9	2.6	1.8	1.3	1.2	0.8	0.6	2.9	182.6	16	69.57
1964	48.0	108.2	42.8	16.3	4.6	2.6	1.9	1.2	0.9	0.8	0.5	1.2	229.1	8	34.78
1965	21.5	15.4	27.0	4.0	1.4	1.1	0.9	0.7	0.5	0.3	0.3	0.4	73.5	22	95.65
1966	26.0	57.5	19.1	2.6	1.4	1.2	0.8	0.6	0.5	0.8	0.3	2.5	113.2	21	91.30
1967	29.7	83.4	70.6	9.9	2.9	3.8	3.0	1.5	1.4	0.7	0.4	0.5	208.1	13	56.52
1968	28.2	110.9	29.4	9.2	2.8	1.9	1.5	0.9	0.7	0.5	0.3	0.4	186.8	14	60.87
1969	40.4	145.7	57.5	10.9	4.0	2.4	2.1	1.5	1.5	0.8	0.6	12.2	279.3	6	26.09
Mean	38.3	81.3	66.5	16.9	5.4	3.1	2.2	1.5	1.2	0.9	0.6	2.6	220.6		

SITE NAME CHOTTA TAWA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	211.1	315.7	310.6	58.2	36.6	17.9	10.5	7.4	6.0	3.7	2.5	6.7	986.8	3	13.04
1949	104.5	187.0	307.6	88.7	27.9	11.5	6.9	4.8	6.0	3.9	3.0	3.5	755.3	7	30.43
1950	198.7	253.5	186.1	27.5	9.5	7.8	7.4	4.7	4.0	3.0	1.9	6.6	710.6	9	39.13
1951	41.6	165.8	103.5	27.1	9.8	6.0	4.8	4.0	3.0	1.9	1.4	10.4	379.2	20	86.96
1952	103.7	302.1	112.5	19.5	8.1	5.6	4.9	4.2	3.0	1.9	1.3	1.7	568.5	18	78.26
1953	116.1	320.4	98.7	22.8	8.9	5.9	4.7	3.3	2.1	1.6	1.3	3.1	588.9	17	73.91
1954	76.7	141.0	348.5	62.4	19.6	9.8	6.2	4.3	2.5	1.6	1.3	13.2	687.0	11	47.83
1955	56.8	249.4	430.5	163.8	27.4	12.8	8.2	5.4	4.0	2.9	2.2	21.3	984.8	4	17.39
1956	278.1	337.6	127.1	68.2	42.5	15.6	13.5	8.0	7.2	6.9	3.4	11.6	919.8	5	21.74
1957	75.7	224.4	128.2	21.7	10.0	6.5	5.2	3.8	3.9	2.2	1.6	5.0	488.1	19	82.61
1958	102.2	182.1	227.6	99.5	28.3	11.4	7.2	5.2	3.8	2.3	1.7	3.9	675.1	12	52.17
1959	257.9	383.8	368.5	78.7	23.4	12.1	12.2	6.8	5.4	3.6	2.8	7.5	1162.7	2	8.70
1960	117.9	391.1	72.9	59.6	17.3	11.5	7.9	6.0	4.5	3.1	2.3	14.1	708.3	10	43.48
1961	241.2	283.7	592.9	157.3	33.1	17.7	12.5	8.4	6.9	5.3	3.3	2.5	1364.7	1	4.35
1962	73.5	129.4	286.1	38.6	15.4	17.9	8.6	5.4	4.7	2.9	2.0	5.9	590.4	15	65.22
1963	44.6	231.5	229.8	35.6	12.7	8.4	5.8	4.2	3.8	2.5	1.9	9.3	590.0	16	69.57
1964	155.3	349.8	138.2	52.6	14.8	8.5	6.2	3.8	3.0	2.7	1.6	3.9	740.4	8	34.78
1965	69.4	49.8	87.3	12.8	4.6	3.4	2.9	2.2	1.6	1.1	1.0	1.2	237.5	22	95.65
1966	84.2	185.8	61.9	8.4	4.4	3.8	2.7	1.9	1.5	2.5	1.0	7.9	366.0	21	91.30
1967	96.1	269.6	228.2	32.2	9.5	12.1	9.8	4.9	4.6	2.2	1.5	1.7	672.5	13	56.52
1968	91.1	358.5	95.2	29.8	9.1	6.0	4.8	2.9	2.3	1.6	1.1	1.3	603.6	14	60.87
1969	130.4	470.8	185.9	35.3	12.9	7.6	6.8	4.7	4.8	2.5	1.8	39.3	902.7	6	26.09
Mean	123.9	262.9	214.9	54.6	17.5	10.0	7.3	4.8	4.0	2.8	1.9	8.3	712.9		

Table 5.3 Continued

SITE NAME **NARMADA SAGAR**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	8682.3	12987.6	12777.5	2394.4	1507.3	734.8	433.0	303.7	245.9	150.4	101.8	276.1	40594.9	3	13.04
1949	4298.9	7691.5	12653.7	3649.4	1147.7	473.4	284.4	198.2	248.6	160.5	122.9	144.0	31073.3	7	30.43
1950	8175.0	10429.0	7653.9	1133.0	390.8	319.3	303.7	194.5	163.3	122.9	78.0	270.6	29233.9	9	39.13
1951	1711.9	6819.0	4259.5	1115.6	401.8	247.7	195.4	163.3	122.9	78.0	58.7	425.7	15599.5	20	86.96
1952	4265.0	12428.0	4628.3	800.0	333.9	232.1	200.0	170.6	124.8	78.9	54.1	69.7	23385.4	18	78.26
1953	4774.1	13181.2	4061.3	935.8	367.0	244.0	192.6	134.9	88.1	67.0	53.2	126.6	24225.8	17	73.91
1954	3154.9	5799.8	14336.2	2568.7	804.6	401.8	256.9	175.2	100.9	67.9	52.3	544.0	28263.3	11	47.83
1955	2334.8	10259.3	17709.5	6738.3	1127.5	528.4	337.6	223.9	164.2	120.2	90.8	878.0	40512.4	4	17.39
1956	11439.1	13889.4	5230.1	2804.5	1748.6	644.0	555.9	330.3	297.2	282.6	140.4	478.0	37840.0	5	21.74
1957	3112.7	9230.0	5275.0	892.6	410.1	267.9	212.8	155.0	161.5	91.7	67.0	204.6	20081.0	19	82.61
1958	4203.5	7491.5	9363.0	4091.6	1165.1	470.6	295.4	212.8	156.0	96.3	68.8	158.7	27773.4	12	52.17
1959	10608.8	15789.4	15160.0	3238.4	964.2	496.3	500.9	280.7	221.1	149.5	116.5	308.3	47834.1	2	8.70
1960	4850.3	16091.2	2999.9	2452.2	711.9	473.4	323.8	248.6	184.4	129.4	96.3	578.0	29139.4	10	43.48
1961	9922.6	11670.3	24392.8	6469.5	1362.3	728.4	512.8	344.9	282.6	217.4	135.8	101.8	56141.2	1	4.35
1962	3023.8	5325.5	11768.4	1586.2	633.9	737.6	354.1	222.9	192.6	119.3	81.7	241.3	24287.2	15	65.22
1963	1833.9	9522.6	9452.9	1465.1	522.0	344.0	237.6	174.3	156.0	101.8	78.0	383.5	24271.7	16	69.57
1964	6387.9	14390.3	5685.1	2165.1	607.3	349.5	255.9	156.0	124.8	111.0	67.0	161.5	30461.4	8	34.78
1965	2854.0	2050.4	3592.5	526.6	190.8	140.4	121.1	90.8	64.2	46.8	42.2	49.5	9769.4	22	95.65
1966	3464.1	7643.8	2545.8	344.9	182.6	156.9	111.0	77.1	63.3	101.8	40.4	325.7	15057.3	21	91.30
1967	3954.0	11089.5	9388.7	1322.9	390.8	500.0	403.7	203.7	189.9	91.7	59.6	71.6	27666.0	13	56.52
1968	3746.7	14749.0	3914.6	1225.7	373.4	248.6	195.4	121.1	96.3	64.2	44.0	53.2	24832.2	14	60.87
1969	5365.9	19367.2	7646.5	1450.4	530.3	313.8	280.7	192.6	197.2	103.7	72.5	1617.4	37138.2	6	26.09
Mean	5098.4	10813.4	8840.7	2244.1	721.5	411.5	298.4	198.9	165.7	116.1	78.3	339.4	29326.4		

SITE NAME **OMKARESHWAR**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	9138.4	13670.0	13448.9	2520.2	1586.5	773.5	455.8	319.6	258.8	158.4	107.2	290.6	42727.8	3	13.04
1949	4524.8	8095.6	13318.5	3841.2	1208.0	498.3	299.3	208.6	261.7	169.0	129.4	151.6	32705.9	7	30.43
1950	8604.5	10976.9	8056.0	1192.5	411.4	336.0	319.6	204.7	171.9	282.0	128.4	284.9	30968.7	9	39.13
1951	1801.8	7177.3	4483.3	1174.2	422.9	260.7	205.7	171.9	129.4	82.1	61.8	448.0	16419.1	20	86.96
1952	4489.1	12994.1	4871.5	842.0	351.5	244.3	210.5	179.6	131.3	83.0	57.0	73.4	24527.2	18	78.26
1953	5025.0	14134.5	4274.7	984.9	386.2	256.9	202.8	141.9	92.7	70.5	56.0	133.3	25759.3	15	65.22
1954	3320.7	6104.5	14741.8	2703.7	846.8	422.9	270.4	184.4	106.2	71.4	55.0	572.6	29400.6	11	47.83
1955	2457.4	10798.3	18639.9	7092.3	1186.7	556.2	355.3	235.6	172.8	126.5	95.6	924.1	42640.9	4	17.39
1956	12040.1	14619.2	5504.9	2951.8	1840.4	677.8	585.2	347.6	312.9	297.4	147.7	503.1	39828.1	5	21.74
1957	3276.3	9714.9	5552.2	939.5	431.6	282.0	224.0	163.2	169.9	96.6	70.5	215.3	21136.0	19	82.61
1958	4424.4	7885.1	9854.9	4306.6	1226.3	495.4	310.9	224.0	164.1	101.4	72.4	167.1	29232.6	12	52.17
1959	11166.2	16618.9	15956.5	3408.6	1014.8	522.4	527.2	295.5	232.7	157.4	122.6	324.4	50347.4	2	8.70
1960	5105.1	16936.6	3157.5	2581.1	749.3	498.3	340.9	261.7	194.1	136.1	101.4	608.3	30670.4	10	43.48
1961	10443.9	12293.0	25674.3	6809.4	1433.9	766.7	539.8	363.1	297.4	228.9	142.9	107.2	59100.5	1	4.35
1962	3182.6	5605.3	12386.7	1669.5	667.2	776.3	372.7	234.6	202.8	125.5	85.9	253.9	25563.3	16	69.57
1963	1930.2	10022.9	9949.5	1542.1	549.4	362.1	250.1	183.5	164.1	107.2	82.1	403.6	25546.9	17	73.91
1964	6723.5	15146.4	5983.8	2278.8	639.2	367.9	269.4	164.1	131.3	116.8	70.5	169.9	32061.8	8	34.78
1965	3004.0	2158.1	3781.3	554.3	200.8	147.7	127.5	95.6	67.6	49.3	44.4	52.1	10282.7	22	95.65
1966	3646.1	8045.4	2679.5	363.1	192.1	165.1	116.8	81.1	66.6	107.2	42.5	342.8	15848.4	21	91.30
1967	4161.7	11672.2	9882.0	1392.4	411.4	526.3	424.9	214.4	199.9	96.6	62.8	75.3	29119.6	13	56.52
1968	3943.5	15524.0	4120.2	1290.0	393.0	261.7	205.7	127.5	101.4	67.6	46.3	56.0	26136.9	14	60.87
1969	5647.8	20384.8	8048.3	1526.6	558.1	330.2	295.5	202.8	207.6	109.1	76.3	1702.3	39089.4	6	26.09
Mean	5366.2	11389.9	9289.4	2362.0	759.4	433.1	314.1	209.3	174.4	129.1	84.5	357.3	30868.8		

Table 5.3 Continued

SITE NAME **MAHESHWAR (MORTKKA)**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	9745.1	14577.5	14341.7	2687.5	1691.8	824.8	486.0	340.8	276.0	168.9	114.3	309.9	45564.2	3	13.04
1949	4825.2	8633.0	14202.7	4096.1	1288.2	531.3	319.2	222.4	279.0	180.2	138.0	161.7	34877.0	7	30.43
1950	9175.7	11705.6	8590.8	1271.7	438.6	358.3	340.8	218.3	183.3	300.7	136.9	303.8	33024.5	9	39.13
1951	1921.4	7653.8	4780.9	1252.1	451.0	278.0	219.3	183.3	138.0	87.5	65.9	477.8	17509.0	20	86.96
1952	4787.1	13856.7	5194.8	897.9	374.8	260.5	224.5	191.5	140.0	88.6	60.8	78.3	26155.4	18	78.26
1953	5358.6	15072.8	4558.5	1050.3	411.9	273.9	216.2	151.4	98.8	75.2	59.7	142.1	27469.3	15	65.22
1954	3541.1	6509.8	15720.4	2883.2	903.0	451.0	288.3	196.7	113.3	76.2	58.7	610.6	31352.3	11	47.83
1955	2620.6	11515.1	19877.3	7563.1	1265.5	593.1	378.9	251.3	184.3	134.9	101.9	985.4	45471.6	4	17.39
1956	12839.3	15589.7	5870.3	3147.8	1962.6	722.8	624.0	370.7	333.6	317.1	157.5	536.5	42472.0	5	21.74
1957	3493.8	10359.8	5920.8	1001.9	460.3	300.7	238.9	174.0	181.2	103.0	75.2	229.6	22539.1	19	82.61
1958	4718.1	8408.5	10509.1	4592.5	1307.7	528.2	331.6	238.9	175.1	108.1	77.2	178.1	31173.2	12	52.17
1959	11907.5	17722.2	17015.8	3634.8	1082.2	557.1	562.2	315.1	248.2	167.8	130.8	346.0	53689.6	2	8.70
1960	5444.0	18060.9	3367.1	2752.4	799.0	531.3	363.5	279.0	207.0	145.2	108.1	648.7	32706.4	10	43.48
1961	11137.2	13109.1	27378.7	7261.4	1529.1	817.6	575.6	387.2	317.1	244.0	152.4	114.3	63023.8	1	4.35
1962	3393.9	5977.4	13209.0	1780.3	711.5	827.9	397.5	250.2	216.2	133.9	91.6	270.8	27260.3	16	69.57
1963	2058.4	10688.3	10610.0	1644.4	585.9	386.1	266.7	195.6	175.1	114.3	87.5	430.4	27242.8	17	73.91
1964	7169.8	16151.9	6381.0	2430.1	681.7	392.3	287.3	175.1	140.0	124.6	75.2	181.2	34190.2	8	34.78
1965	3203.4	2301.4	4032.3	591.0	214.2	157.5	135.9	101.9	72.1	52.5	47.4	55.6	10965.3	22	95.65
1966	3888.1	8579.5	2857.4	387.2	204.9	176.1	124.6	86.5	71.1	114.3	45.3	365.5	16900.5	21	91.30
1967	4438.0	12447.0	10538.0	1484.8	438.6	561.2	453.1	228.6	213.1	103.0	66.9	80.3	31052.7	13	56.52
1968	4205.3	16554.5	4393.7	1375.7	419.1	279.0	219.3	135.9	108.1	72.1	49.4	59.7	27871.9	14	60.87
1969	6022.7	21738.0	8582.5	1628.0	595.2	352.2	315.1	216.2	221.4	116.4	81.3	1815.4	41684.4	6	26.09
Mean	5722.5	12146.0	9906.0	2518.8	809.9	461.9	334.9	223.2	186.0	137.7	90.1	381.0	32918.0		

SITE NAME **UPPER BEDA**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	64.2	103.4	111.4	17.6	10.7	5.7	3.2	1.9	1.6	1.0	0.6	3.1	324.4	4	17.39
1949	29.8	56.7	106.5	38.6	10.0	4.1	1.9	1.9	1.7	1.1	0.8	0.9	254.0	7	30.43
1950	53.9	82.0	81.4	14.1	4.8	3.0	2.8	1.4	1.2	1.1	0.8	1.7	248.2	8	34.78
1951	20.1	54.1	29.8	7.6	2.8	2.1	1.5	1.1	0.9	0.5	0.3	3.0	123.7	20	86.96
1952	26.4	84.7	32.6	6.1	2.7	1.8	1.4	1.1	0.8	0.4	0.3	3.8	161.9	18	78.26
1953	28.2	96.4	30.3	8.6	2.9	2.1	1.7	0.8	0.6	0.4	0.2	1.1	173.3	17	73.91
1954	28.2	40.4	136.7	7.6	8.8	4.3	2.8	1.8	0.6	0.4	0.3	5.0	236.9	9	39.13
1955	18.4	66.4	138.5	53.4	8.7	4.3	3.1	1.7	1.7	1.1	0.8	6.6	304.7	5	21.74
1956	75.8	107.4	34.2	18.8	10.1	3.8	3.6	2.4	2.1	1.9	0.9	4.7	265.7	6	26.09
1957	19.6	70.7	38.2	7.7	3.5	2.4	1.9	1.3	1.2	0.7	0.4	1.8	149.3	19	82.61
1958	31.6	52.3	80.4	31.8	4.2	1.6	1.0	0.6	0.5	0.3	0.2	0.4	204.8	13	56.52
1959	53.3	128.7	150.6	31.7	13.2	6.8	6.0	4.1	2.9	2.0	1.5	5.2	406.1	2	8.70
1960	29.1	112.3	23.0	39.3	3.9	2.4	1.9	1.7	1.6	1.1	0.6	3.3	220.2	11	47.83
1961	71.3	89.6	204.7	71.7	10.7	4.3	2.7	1.9	1.5	1.1	0.7	0.6	460.7	1	4.35
1962	23.5	38.4	97.5	11.6	4.1	4.4	2.0	1.2	1.0	0.7	0.5	3.6	188.6	15	65.22
1963	11.7	70.8	69.9	8.6	3.7	1.9	2.0	1.6	0.9	0.8	0.6	2.6	175.1	16	69.57
1964	40.3	96.8	42.7	17.3	3.9	2.6	2.5	1.3	0.9	0.7	0.6	1.0	210.6	12	52.17
1965	19.5	19.1	28.4	4.2	1.2	0.9	0.7	0.5	0.4	0.3	0.2	0.2	75.5	22	95.65
1966	19.8	60.0	26.2	3.0	1.3	1.0	0.8	0.6	0.5	0.6	0.3	4.1	118.3	21	91.30
1967	37.2	84.6	81.3	10.4	3.9	4.2	3.1	1.6	1.5	0.7	0.4	0.6	229.4	10	43.48
1968	15.3	134.4	32.0	10.8	4.0	2.5	1.5	1.0	0.9	0.6	0.3	0.7	204.0	14	60.87
1969	38.5	157.0	83.4	9.9	4.2	2.3	2.0	1.6	1.3	0.9	0.5	27.0	328.6	3	13.04
Mean	34.3	82.1	75.4	19.6	5.6	3.1	2.3	1.5	1.2	0.8	0.5	3.7	230.2		

Table 5.3 Continued

SITE NAME **MAN**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	102.0	164.5	177.1	28.0	17.1	9.1	5.1	3.0	2.5	1.6	1.0	4.9	515.8	4	17.39
1949	47.3	90.1	169.3	61.4	15.9	6.5	3.1	3.1	2.7	1.8	1.2	1.4	403.8	7	30.43
1950	85.7	130.4	129.5	22.4	7.7	4.8	4.4	2.3	1.9	1.8	1.2	2.7	394.6	8	34.78
1951	32.0	86.1	47.4	12.0	4.4	3.3	2.4	1.8	1.4	0.8	0.4	4.7	196.6	20	86.96
1952	41.9	134.6	51.8	9.7	4.4	2.8	2.2	1.7	1.2	0.7	0.4	6.1	257.5	18	78.26
1953	44.9	153.3	48.2	13.6	4.7	3.3	2.7	1.3	1.0	0.6	0.4	1.8	275.6	17	73.91
1954	44.9	64.2	217.4	12.0	14.0	6.8	4.4	2.8	1.0	0.7	0.5	7.9	376.7	9	39.13
1955	29.2	105.6	220.3	85.0	13.8	6.8	5.0	2.8	2.7	1.7	1.2	10.5	484.5	5	21.74
1956	120.6	170.8	54.3	29.9	16.0	6.0	5.8	3.9	3.3	3.0	1.4	7.5	422.6	6	26.09
1957	31.1	112.4	60.7	12.2	5.6	3.8	3.1	2.0	1.9	1.1	0.7	2.8	237.4	19	82.61
1958	50.3	83.1	127.8	50.6	6.6	2.5	1.5	1.0	0.8	0.5	0.3	0.7	325.7	13	56.52
1959	84.8	204.6	239.5	50.4	21.0	10.9	9.6	6.5	4.7	3.1	2.4	8.2	645.7	2	8.70
1960	46.3	178.6	36.5	62.6	6.2	3.8	3.1	2.7	2.6	1.8	0.9	5.2	350.2	11	47.83
1961	113.3	142.4	325.5	113.9	17.0	6.9	4.3	3.1	2.3	1.7	1.2	1.0	732.6	1	4.35
1962	37.4	61.1	155.1	18.5	6.5	7.0	3.2	1.9	1.7	1.1	0.8	5.7	299.9	15	65.22
1963	18.6	112.6	111.2	13.7	5.8	3.0	3.2	2.6	1.4	1.2	0.9	4.2	278.4	16	69.57
1964	64.1	154.0	67.8	27.5	6.3	4.1	3.9	2.1	1.5	1.1	0.9	1.6	334.8	12	52.17
1965	30.9	30.4	45.1	6.6	1.9	1.4	1.1	0.9	0.6	0.4	0.3	0.3	120.1	22	95.65
1966	31.5	95.4	41.7	4.8	2.1	1.7	1.3	0.9	0.8	1.0	0.5	6.4	188.2	21	91.30
1967	59.1	134.5	129.2	16.5	6.2	6.6	4.9	2.5	2.4	1.1	0.7	0.9	364.8	10	43.48
1968	24.3	213.6	50.9	17.1	6.4	4.0	2.4	1.5	1.4	1.0	0.5	1.2	324.5	14	60.87
1969	61.1	249.7	132.6	15.7	6.7	3.7	3.2	2.6	2.1	1.5	0.7	43.0	522.5	3	13.04
Mean	54.6	130.6	120.0	31.1	8.9	4.9	3.6	2.4	1.9	1.3	0.8	5.9	366.0		

SITE NAME LOWER GOI

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	131.5	212.0	228.2	36.1	22.0	11.7	6.5	3.9	3.2	2.1	1.3	6.3	664.8	4	17.39
1949	61.0	116.1	218.2	79.1	20.4	8.4	4.0	4.0	3.5	2.3	1.6	1.9	520.4	7	30.43
1950	110.4	168.0	166.9	28.8	9.9	6.2	5.7	2.9	2.4	2.3	1.6	3.5	508.5	8	34.78
1951	41.3	110.9	61.1	15.5	5.7	4.2	3.1	2.3	1.8	1.0	0.6	6.1	253.4	20	86.96
1952	54.0	173.5	66.8	12.5	5.6	3.6	2.8	2.2	1.6	0.9	0.5	7.8	331.8	18	78.26
1953	57.8	197.6	62.1	17.5	6.0	4.3	3.4	1.7	1.3	0.8	0.5	2.3	355.2	17	73.91
1954	57.8	82.8	280.1	15.5	18.0	8.7	5.7	3.7	1.3	0.9	0.6	10.2	485.4	9	39.13
1955	37.6	136.1	283.9	109.5	17.8	8.7	6.4	3.6	3.4	2.2	1.6	13.6	624.4	5	21.74
1956	155.4	220.1	70.0	38.5	20.6	7.7	7.4	5.0	4.3	3.9	1.9	9.7	544.5	6	26.09
1957	40.1	144.9	78.2	15.8	7.2	4.9	4.0	2.6	2.4	1.5	0.9	3.6	305.9	19	82.61
1958	64.8	107.1	164.8	65.2	8.5	3.2	2.0	1.3	1.0	0.6	0.3	0.9	419.7	13	56.52
1959	109.2	263.7	308.7	64.9	27.1	14.0	12.4	8.4	6.0	4.0	3.1	10.6	832.1	2	8.70
1960	59.7	230.2	47.1	80.6	8.0	4.9	4.0	3.4	3.3	2.3	1.2	6.7	451.3	11	47.83
1961	146.0	183.6	419.4	146.8	21.9	8.9	5.6	4.0	3.0	2.2	1.5	1.3	944.1	1	4.35
1962	48.2	78.7	199.8	23.9	8.4	9.0	4.1	2.4	2.1	1.5	1.1	7.3	386.5	15	65.22
1963	24.0	145.1	143.3	17.7	7.5	3.9	4.1	3.3	1.9	1.6	1.2	5.4	358.8	16	69.57
1964	82.6	198.5	87.4	35.4	8.1	5.2	5.1	2.7	1.9	1.4	1.1	2.1	431.5	12	52.17
1965	39.9	39.2	58.1	8.5	2.5	1.8	1.5	1.1	0.8	0.5	0.4	0.4	154.8	22	95.65
1966	40.6	123.0	53.8	6.2	2.7	2.1	1.7	1.2	1.0	1.3	0.6	8.3	242.5	21	91.30
1967	76.2	173.3	166.6	21.3	7.9	8.6	6.3	3.3	3.1	1.4	0.9	1.2	470.0	10	43.48
1968	31.4	275.3	65.6	22.0	8.2	5.2	3.1	2.0	1.8	1.3	0.7	1.5	418.1	14	60.87
1969	78.8	321.7	170.9	20.2	8.6	4.7	4.2	3.3	2.7	1.9	0.9	55.4	673.3	3	13.04
Mean	70.4	168.2	154.6	40.1	11.5	6.4	4.7	3.1	2.4	1.7	1.1	7.5	471.7		

Table 5.3 Continued

SITE NAME **JOBAT**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	88.3	142.4	153.4	26.2	14.8	7.9	4.4	2.6	2.2	1.4	0.9	4.2	446.7	4	17.39
1949	41.0	78.0	146.6	53.2	13.7	5.6	2.7	2.7	2.4	1.5	1.0	1.2	349.7	7	30.43
1950	74.2	112.9	112.2	19.4	6.7	4.1	3.8	2.0	1.6	1.5	1.1	2.3	341.7	8	34.78
1951	27.8	74.5	41.1	10.4	3.8	2.8	2.1	1.5	1.2	0.7	0.4	4.1	170.3	20	86.96
1952	36.3	116.6	44.9	8.4	3.8	2.4	1.9	1.5	1.0	0.6	0.3	5.3	223.0	18	78.26
1953	38.9	132.8	41.7	11.8	4.0	2.9	2.3	1.1	0.9	0.5	0.3	1.5	238.7	17	73.91
1954	38.9	55.6	188.2	10.4	12.1	5.9	3.8	2.5	0.9	0.6	0.4	6.9	326.2	9	39.13
1955	25.3	91.5	190.8	73.6	11.9	5.9	4.3	2.4	2.3	1.5	1.1	9.1	419.6	5	21.74
1956	104.4	147.9	47.0	25.9	13.9	5.2	5.0	3.4	2.9	2.6	1.2	6.5	365.9	6	26.09
1957	27.0	97.4	52.5	10.6	4.8	3.3	2.7	1.7	1.6	1.0	0.6	2.4	205.6	19	82.61
1958	43.5	72.0	110.7	43.8	5.7	2.2	1.3	0.9	0.7	0.4	0.2	0.6	282.1	13	56.52
1959	73.4	177.2	207.4	43.6	18.2	9.4	8.3	5.7	4.0	2.7	2.1	7.1	559.2	2	8.70
1960	40.1	154.7	31.6	54.2	5.4	3.3	2.7	2.3	2.2	1.5	0.8	4.5	303.2	11	47.83
1961	98.1	123.4	281.9	98.7	14.7	6.0	3.7	2.7	2.0	1.5	1.0	0.9	634.4	1	4.35
1962	32.4	52.9	134.3	16.0	5.6	6.0	2.7	1.6	1.4	1.0	0.7	4.9	259.7	15	65.22
1963	16.1	97.5	96.3	11.9	5.0	2.6	2.8	2.2	1.2	1.1	0.8	3.6	241.1	16	69.57
1964	55.5	133.4	58.8	23.8	5.4	3.5	3.4	1.8	1.3	0.9	0.8	1.4	290.0	12	52.17
1965	26.8	26.4	39.1	5.7	1.7	1.2	1.0	0.7	0.6	0.3	0.3	0.3	104.0	22	95.65
1966	27.3	82.6	36.1	4.2	1.8	1.4	1.1	0.8	0.7	0.9	0.4	5.6	163.0	21	91.30
1967	51.2	116.5	111.9	14.3	5.3	5.8	4.3	2.2	2.1	0.9	0.6	0.8	315.9	10	43.48
1968	21.1	185.0	44.1	14.8	5.5	3.5	2.1	1.3	1.2	0.9	0.5	1.0	281.0	14	60.87
1969	53.0	216.2	114.8	13.6	5.8	3.2	2.8	2.2	1.8	1.3	0.6	37.2	452.5	3	13.04
Mean	47.3	113.1	103.9	26.9	7.7	4.3	3.1	2.1	1.6	1.1	0.7	5.1	317.0		

SITE NAME **SARDAR SAROVAR**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1948	10358.2	16701.9	17982.3	2841.4	1733.4	922.8	514.1	306.3	253.1	167.4	100.5	495.4	52377.0	4	17.39
1949	4807.3	9150.7	17191.4	6234.4	1609.3	658.9	312.2	313.2	277.7	182.2	123.1	145.8	41006.3	7	30.43
1950	8699.6	13238.0	13150.4	2272.2	780.0	484.6	449.1	228.5	188.1	178.3	126.1	273.8	40068.7	8	34.78
1951	3254.1	8738.0	4814.2	1218.3	446.2	332.9	241.3	180.2	138.9	81.8	43.3	476.7	19965.9	20	86.96
1952	4254.8	13669.4	5264.3	983.9	442.2	284.6	224.6	171.4	123.1	68.0	40.4	618.5	26145.2	18	78.26
1953	4556.1	15569.3	4890.0	1379.8	472.8	334.9	269.9	134.9	99.5	59.1	38.4	181.2	27985.9	17	73.91
1954	4558.1	6520.0	22071.6	1218.3	1419.2	687.5	448.1	289.6	105.4	71.9	51.2	805.7	38246.6	9	39.13
1955	2964.6	10724.6	22369.1	8628.7	1401.5	687.5	504.3	281.7	269.9	173.3	124.1	1067.6	49196.7	5	21.74
1956	12247.2	17344.1	5516.4	3032.5	1624.1	607.7	586.0	394.0	336.8	305.3	145.8	763.3	42903.2	6	26.09
1957	3160.5	11415.0	6159.6	1242.0	565.3	383.1	311.2	203.9	188.1	114.3	72.9	286.6	24102.5	19	82.61
1958	5103.8	8441.6	12981.0	5135.3	671.7	253.1	157.6	105.4	76.8	46.3	26.6	71.9	33071.0	13	56.52
1959	8607.0	20778.4	24322.1	5116.6	2137.2	1102.1	973.1	662.8	471.8	314.2	246.2	832.2	65563.8	2	8.70
1960	4699.9	18135.0	3711.1	6351.6	629.3	389.0	313.2	269.9	261.0	177.3	91.6	526.9	35555.9	11	47.83
1961	11505.6	14464.2	33048.3	11568.6	1721.6	698.3	438.3	311.2	237.4	170.4	119.2	103.4	74386.5	1	4.35
1962	3793.8	6201.9	15744.6	1879.2	660.9	708.1	321.1	192.1	168.4	115.2	84.7	579.1	30449.2	15	65.22
1963	1888.1	11432.7	11292.9	1393.6	590.0	306.3	323.0	260.0	145.8	124.1	91.6	424.5	28272.5	16	69.57
1964	6508.2	15637.3	6888.4	2790.2	636.3	412.7	399.9	212.7	146.8	107.3	89.6	166.4	33995.8	12	52.17
1965	3140.9	3090.6	4579.8	672.7	196.0	140.8	115.2	86.7	66.0	40.4	29.5	34.5	12193.1	22	95.65
1966	3199.0	9689.5	4236.0	490.5	213.7	168.4	131.0	93.6	76.8	105.4	48.3	654.0	19106.1	21	91.30
1967	6004.9	13657.6	13122.8	1676.3	624.4	674.7	500.3	257.1	246.2	110.3	68.0	93.6	37036.2	10	43.48
1968	2471.1	21692.4	5168.8	1737.4	647.1	406.8	245.2	156.6	140.8	102.4	55.2	120.2	32943.9	14	60.87
1969	6207.8	25349.4	13466.5	1592.6	679.6	370.3	328.0	261.0	209.8	147.7	74.8	4362.1	53049.7	3	13.04
Mean	5545.0	13256.4	12180.5	3157.1	904.6	500.7	368.5	244.2	192.2	134.7	86.0	594.7	37164.6		

Table 5.3 Concluded

Table 5.4 Monthly flow data at reservoir sites (16 years)

SITE NAME UPPER NARMADA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	226.0	423.7	194.1	47.3	24.4	11.5	7.1	12.1	7.4	1.6	.3	62.8	1018.1	4	23.53
1978	217.1	269.8	104.5	23.1	12.6	17.2	8.0	10.2	4.1	1.1	.4	5.3	673.3	12	70.59
1979	58.8	141.4	24.7	9.8	3.8	2.3	2.2	1.0	.5	.5	.0	32.4	277.4	16	94.12
1980	292.8	375.8	407.0	41.5	20.9	6.3	5.8	2.9	1.9	.6	.6	13.2	1169.3	1	5.88
1981	173.9	194.8	79.8	32.0	7.3	5.1	4.7	4.8	1.5	.6	.9	6.2	511.6	13	76.47
1982	29.8	287.5	136.2	22.1	9.6	4.3	2.4	2.5	1.2	.4	.2	4.8	501.0	14	82.35
1983	119.7	237.5	263.2	69.3	14.9	9.0	30.6	12.5	4.3	1.7	.7	4.7	768.1	11	64.71
1984	82.8	556.8	132.9	21.8	6.9	4.9	9.9	10.8	1.9	1.0	.3	3.2	833.1	7	41.18
1985	258.5	533.5	104.0	30.2	10.3	6.5	4.2	9.0	4.7	1.0	.5	47.8	1010.1	5	29.41
1986	527.7	220.4	93.3	28.5	8.8	9.0	8.7	6.9	5.6	1.5	.7	9.5	920.5	6	35.29
1987	119.9	251.3	527.1	75.2	24.9	11.3	9.1	5.3	3.9	1.3	.7	57.4	1087.3	2	11.76
1988	160.1	489.6	90.7	29.0	10.9	6.5	4.6	2.2	2.2	1.1	.2	13.4	810.4	9	52.94
1989	53.5	174.2	88.3	19.7	6.7	6.2	4.0	3.6	1.7	.5	3.1	130.4	491.8	15	88.24
1990	223.8	166.7	467.6	109.2	23.1	12.3	9.1	4.6	3.5	1.8	.7	2.8	1025.2	3	17.65
1991	196.5	460.0	99.6	18.1	7.7	5.9	4.6	2.6	1.7	1.4	1.0	.8	799.8	10	58.82
1992	81.8	322.7	220.2	18.8	7.9	5.8	4.0	2.1	2.5	.9	.2	144.4	811.4	8	47.06
Mean	176.4	319.1	189.6	37.2	12.5	7.8	7.4	5.8	3.0	1.1	.7	33.7	794.3		

SITE NAME RAGHAVPUR

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	574.0	1076.3	493.0	120.2	61.9	29.1	17.9	30.7	18.9	4.0	.8	159.6	2586.4	4	23.53
1978	551.4	685.3	265.5	58.6	32.2	43.6	20.2	25.9	10.5	2.8	1.1	13.4	1710.4	12	70.59
1979	149.3	359.3	62.7	24.9	9.6	5.9	5.6	2.7	1.3	1.2	.1	82.4	704.8	16	94.12
1980	743.9	954.5	1033.9	105.5	53.1	16.0	14.6	7.5	4.8	1.5	1.6	33.6	2970.5	1	5.88
1981	441.6	494.8	202.8	81.3	18.6	13.1	11.9	12.1	3.8	1.5	2.3	15.9	1299.7	13	76.47
1982	75.7	730.5	345.9	56.1	24.4	10.8	6.1	6.3	3.1	1.1	.5	12.3	1272.8	14	82.35
1983	304.2	603.3	668.7	175.9	38.0	22.9	77.7	31.7	10.8	4.3	1.8	12.0	1951.2	11	64.71
1984	210.2	1414.6	337.5	55.3	17.6	12.5	25.1	27.5	4.8	2.7	.7	8.0	2116.4	7	41.18
1985	656.8	1355.3	264.3	76.7	26.0	16.4	10.6	22.8	12.0	2.6	1.2	121.3	2565.9	5	29.41
1986	1340.6	559.8	236.9	72.4	22.5	22.8	22.0	17.5	14.1	3.8	1.7	24.2	2338.3	6	35.29
1987	304.7	638.3	1338.9	191.0	63.2	28.6	23.0	13.5	9.9	3.3	1.8	145.8	2762.0	2	11.76
1988	406.8	1243.8	230.3	73.6	27.7	16.5	11.6	5.5	5.5	2.7	.5	34.0	2058.7	9	52.94
1989	135.9	442.5	224.2	50.0	16.9	15.7	10.2	9.1	4.3	1.3	7.9	331.4	1249.3	15	88.24
1990	568.6	423.5	1187.9	277.3	58.6	31.3	23.1	11.7	8.9	4.6	1.8	7.0	2604.2	3	17.65
1991	499.1	1168.5	253.0	46.0	19.5	15.0	11.6	6.6	4.3	3.4	2.6	2.1	2031.8	10	58.82
1992	207.8	819.8	559.4	47.8	20.0	14.8	10.3	5.3	6.4	2.2	.5	366.8	2061.2	8	47.06
Mean	448.2	810.6	481.6	94.5	31.9	19.7	18.9	14.8	7.7	2.7	1.7	85.6	2017.7		

SITE NAME ROSRA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	783.3	1468.9	672.9	164.1	84.4	39.7	24.5	41.9	25.7	5.5	1.0	217.8	3529.7	4	23.53
1978	752.5	935.2	362.3	79.9	43.9	59.5	27.6	35.4	14.3	3.8	1.5	18.2	2334.2	12	70.59
1979	203.8	490.3	85.6	33.9	13.0	8.1	7.7	3.7	1.7	1.6	.1	112.4	961.8	16	94.12
1980	1015.2	1302.6	1410.9	144.0	72.5	21.9	19.9	10.2	6.5	2.0	2.2	45.9	4053.9	1	5.88
1981	602.7	675.3	276.8	111.0	25.4	17.8	16.3	16.6	5.2	2.0	3.1	21.6	1773.8	13	76.47
1982	103.3	996.8	472.1	76.6	33.3	14.7	8.3	8.6	4.3	1.5	.7	16.7	1737.0	14	82.35
1983	415.1	823.3	912.5	240.1	51.8	31.3	106.0	43.2	14.7	5.8	2.5	16.4	2662.8	11	64.71
1984	286.9	1930.5	460.6	75.5	24.0	17.0	34.3	37.5	6.5	3.6	1.0	10.9	2888.3	7	41.18
1985	896.3	1849.6	360.6	104.7	35.5	22.4	14.5	31.1	16.3	3.5	1.6	165.5	3501.7	5	29.41
1986	1829.5	764.0	323.3	98.8	30.6	31.0	30.1	24.0	19.3	5.2	2.3	33.0	3191.1	6	35.29
1987	415.8	871.0	1827.2	260.6	86.3	39.0	31.4	18.5	13.5	4.5	2.5	199.0	3769.3	2	11.76
1988	555.2	1697.4	314.3	100.4	37.8	22.6	15.8	7.6	7.5	3.7	.7	46.4	2809.4	9	52.94
1989	185.4	603.9	306.0	68.2	23.1	21.4	13.9	12.4	5.8	1.7	10.9	452.2	1705.0	15	88.24
1990	775.9	578.0	1621.1	378.4	80.0	42.8	31.5	15.9	12.1	6.3	2.4	9.6	3554.0	3	17.65
1991	681.1	1594.7	345.3	62.7	26.7	20.5	15.9	9.0	5.8	4.7	3.5	2.9	2772.8	10	58.82
1992	283.5	1118.8	763.4	65.3	27.3	20.2	14.0	7.2	8.8	3.0	.7	500.6	2812.9	8	47.06
Mean	611.6	1106.3	657.2	129.0	43.5	26.9	25.7	20.2	10.5	3.7	2.3	116.8	2753.6		

Table 5.4 continued

SITE NAME UPPER BURHNER

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	227.1	344.6	153.5	42.4	10.7	10.8	5.8	6.7	3.2	1.3	.3	56.5	862.9	7	41.18
1978	227.1	344.6	153.5	42.4	10.7	28.0	15.0	22.9	2.8	.4	.1	7.0	854.4	9	52.94
1979	48.7	122.3	21.2	8.8	1.8	.9	1.1	.3	.0	.0	.0	71.7	276.9	16	94.12
1980	353.1	438.5	353.1	36.2	11.0	3.7	5.2	2.6	2.1	.3	.1	29.2	1235.3	2	11.76
1981	198.5	208.4	108.1	34.9	7.3	5.4	5.8	5.2	1.4	.2	.0	4.8	580.0	14	82.35
1982	41.4	385.3	136.8	15.4	7.1	4.6	2.5	5.8	.7	.1	.1	11.1	610.8	13	76.47
1983	157.9	294.9	252.9	90.4	11.8	7.3	20.3	9.2	2.1	1.2	.3	6.7	855.0	8	47.06
1984	71.1	661.0	126.3	22.3	8.2	3.9	19.4	17.9	1.2	.5	.2	7.5	939.3	5	29.41
1985	268.6	507.9	153.0	54.4	10.0	5.7	3.6	30.0	6.5	.9	.2	55.7	1096.5	3	17.65
1986	479.2	204.8	60.2	24.2	34.8	6.8	6.6	3.9	2.8	.2	.2	2.3	825.9	10	58.82
1987	129.9	92.1	329.1	88.7	16.8	7.6	5.9	3.5	7.3	.3	.2	42.0	723.5	12	70.59
1988	197.4	584.7	114.8	36.2	9.9	5.6	3.2	1.5	1.0	.7	.1	12.2	967.2	4	23.53
1989	48.5	196.5	123.6	14.7	4.9	3.8	2.5	1.9	.7	.2	2.0	162.4	561.6	15	88.24
1990	380.1	158.3	559.5	135.8	22.4	12.3	7.3	3.7	3.2	1.3	.3	1.3	1285.4	1	5.88
1991	189.4	466.1	81.2	15.1	8.0	4.5	2.7	1.1	.5	.4	.2	2.6	771.8	11	64.71
1992	92.9	399.1	285.6	37.9	6.3	3.8	2.2	1.1	1.1	.3	.1	56.5	886.9	6	35.29
Mean	194.4	338.1	188.3	43.7	11.3	7.2	6.8	7.3	2.3	.5	.3	33.1	833.3		

SITE NAME HALON

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	101.1	153.4	68.3	18.9	4.8	4.8	2.6	3.0	1.4	.6	.1	25.2	384.0	7	41.18
1978	101.1	153.4	68.3	18.9	4.8	12.4	6.7	10.2	1.2	.2	.0	3.1	380.3	9	52.94
1979	21.7	54.5	9.4	3.9	.8	.4	.5	.1	.0	.0	.0	31.9	123.2	16	94.12
1980	157.1	195.2	157.2	16.1	4.9	1.7	2.3	1.2	.9	.2	.1	13.0	549.8	2	11.76
1981	88.3	92.8	48.1	15.5	3.3	2.4	2.6	2.3	.6	.1	.0	2.1	258.1	14	82.35
1982	18.4	171.5	60.9	6.8	3.2	2.0	1.1	2.6	.3	.1	.1	4.9	271.8	13	76.47
1983	70.3	131.2	112.6	40.3	5.3	3.3	9.0	4.1	.9	.5	.1	3.0	380.5	8	47.06
1984	31.6	294.2	56.2	9.9	3.6	1.8	8.6	8.0	.5	.2	.1	3.3	418.1	5	29.41
1985	119.6	226.1	68.1	24.2	4.4	2.5	1.6	13.4	2.9	.4	.1	24.8	488.1	3	17.65
1986	213.3	91.1	26.8	10.8	15.5	3.0	2.9	1.7	1.2	.1	.1	1.0	367.6	10	58.82
1987	57.8	41.0	146.5	39.5	7.5	3.4	2.6	1.6	3.3	.2	.1	18.7	322.0	12	70.59
1988	87.9	260.2	51.1	16.1	4.4	2.5	1.4	.6	.4	.3	.0	5.4	430.5	4	23.53
1989	21.6	87.5	55.0	6.6	2.2	1.7	1.1	.9	.3	.1	.9	72.3	250.0	15	88.24
1990	169.2	70.5	249.0	60.5	9.9	5.5	3.2	1.7	1.4	.6	.1	.6	572.1	1	5.88
1991	84.3	207.4	36.2	6.7	3.6	2.0	1.2	.5	.2	.2	.1	1.1	343.5	11	64.71
1992	41.3	177.6	127.1	16.9	2.8	1.7	1.0	.5	.5	.1	.0	25.2	394.7	6	35.29
Mean	86.5	150.5	83.8	19.5	5.0	3.2	3.0	3.3	1.0	.2	.1	14.7	370.9		

SITE NAME BASANIA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	1745.2	3272.4	1499.0	365.5	188.1	88.5	54.5	93.3	57.3	12.2	2.3	485.2	7863.6	4	23.53
1978	1676.5	2083.5	807.2	178.1	97.7	132.6	61.5	78.8	31.9	8.4	3.4	40.6	5200.3	12	70.59
1979	454.0	1092.3	190.6	75.6	29.1	18.1	17.1	8.1	3.8	3.7	.3	250.4	2142.8	16	94.12
1980	2261.7	2902.1	3143.3	320.8	161.4	48.7	44.4	22.8	14.6	4.5	4.9	102.3	9031.4	1	5.88
1981	1342.8	1504.4	616.6	247.3	56.6	39.7	36.2	36.9	11.6	4.5	6.8	48.2	3951.7	13	76.47
1982	230.1	2220.8	1051.7	170.6	74.2	32.8	18.5	19.2	9.5	3.3	1.6	37.3	3869.7	14	82.35
1983	924.7	1834.2	2032.9	534.9	115.4	69.7	236.2	96.3	32.8	13.0	5.6	36.5	5932.2	11	64.71
1984	639.1	4300.8	1026.1	168.2	53.4	38.0	76.4	83.5	14.4	8.1	2.2	24.4	6434.6	8	47.06
1985	1996.8	4120.5	803.4	233.3	79.1	49.9	32.3	69.2	36.4	7.9	3.6	368.8	7801.3	5	29.41
1986	4075.8	1702.0	720.3	220.2	68.3	69.2	67.0	53.4	42.9	11.6	5.1	73.5	7109.2	6	35.29
1987	926.3	1940.5	4070.7	580.7	192.2	86.9	70.0	41.2	30.0	9.9	5.5	443.4	8397.3	2	11.76
1988	1236.8	3781.6	700.2	223.7	84.3	50.3	35.2	16.9	16.8	8.3	1.6	103.4	6259.0	9	52.94
1989	413.1	1345.3	681.7	152.0	51.5	47.7	31.0	27.7	13.0	3.8	24.2	1007.4	3798.4	15	88.24
1990	1728.6	1287.6	3611.6	843.1	178.1	95.3	70.1	35.5	27.0	14.0	5.4	21.4	7917.7	3	17.65
1991	1517.3	3552.6	769.3	139.7	59.4	45.6	35.4	20.1	13.0	10.4	7.8	6.5	6177.3	10	58.82
1992	631.7	2492.5	1700.8	145.4	60.7	45.1	231.2	16.1	19.6	6.8	1.6	1115.2	6466.7	7	41.18
Mean	1362.5	2464.6	1464.1	287.4	96.9	59.9	69.8	44.9	23.4	8.2	5.1	260.3	6147.1		

Table 5.4 continued

SITE NAME MATIYARI

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	31.7	39.0	25.7	5.2	3.8	.9	.4	.6	.1	.0	.0	2.1	109.5	2	11.76
1978	13.9	25.2	6.7	1.2	.5	1.0	.8	1.1	.2	.0	.0	.1	50.6	9	52.94
1979	1.6	17.7	1.8	.5	.1	.1	.1	.0	.0	.0	.0	5.3	27.1	16	94.12
1980	23.3	42.0	22.1	2.8	.9	.3	.2	.1	.0	.0	.0	.4	92.3	3	17.65
1981	19.6	14.2	6.8	3.4	.9	.4	.3	.2	.0	.0	.0	.2	46.0	11	64.71
1982	1.4	33.6	7.2	2.0	.6	.2	.1	.1	.0	.0	.0	.5	45.8	12	70.59
1983	3.5	20.2	19.6	7.0	1.3	.5	.6	.4	.1	.0	.0	.1	53.2	8	47.06
1984	1.9	34.6	4.3	1.1	.3	.1	.6	.3	.1	.0	.0	.1	43.4	14	82.35
1985	5.5	16.9	8.1	3.7	.6	.2	.1	1.4	.8	.1	.0	5.9	43.4	13	76.47
1986	44.4	29.2	4.6	1.6	.3	.5	.5	.1	.1	.0	.0	.1	81.6	4	23.53
1987	3.4	8.5	9.9	2.8	.8	.3	.2	.2	.3	.0	.0	1.6	28.1	15	88.24
1988	27.5	35.3	12.4	4.4	.7	.3	.1	.1	.0	.0	.0	.2	81.1	5	29.41
1989	3.0	21.6	14.6	1.5	.4	.3	.3	.2	.0	.0	.0	7.2	49.0	10	58.82
1990	38.8	21.8	41.6	14.4	1.8	.6	.6	.3	.5	.1	.0	.0	120.3	1	5.88
1991	12.2	40.9	7.7	2.0	.3	.2	.1	.1	.1	.0	.0	.0	63.6	6	35.29
1992	6.2	25.1	16.0	1.1	.2	.1	.0	.0	.0	.0	.0	14.0	62.7	7	41.18
Mean	14.9	26.6	13.1	3.4	.9	.4	.3	.3	.1	.0	.0	2.4	62.4		

SITE NAME BARGI

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	2219.9	4137.7	1711.8	492.0	229.2	106.8	61.9	102.2	60.4	17.9	6.6	285.8	9432.4	4	23.53
1978	2097.2	3546.7	921.1	203.9	106.1	159.7	76.8	113.1	30.9	10.1	4.9	26.3	7296.7	10	58.82
1979	474.4	1751.2	202.8	57.0	23.6	18.4	15.1	7.8	3.2	1.2	.4	486.1	3041.3	15	88.24
1980	2792.9	4325.9	2885.0	306.4	102.6	54.4	45.8	23.9	17.4	6.6	2.1	139.3	10702.1	2	11.76
1981	1308.4	1494.3	582.0	327.7	83.8	46.3	42.5	43.0	16.4	4.5	3.4	26.6	3979.2	14	82.35
1982	261.8	3795.9	1595.2	157.6	91.6	43.0	26.5	30.9	10.7	3.8	1.1	19.9	6037.9	12	70.59
1983	1120.4	3111.3	3524.2	1135.5	141.4	69.6	116.6	96.9	30.2	11.4	9.2	30.6	9397.3	5	29.41
1984	577.1	6495.9	1685.0	296.9	78.8	48.6	106.6	135.2	20.3	8.6	4.7	11.4	9469.0	3	17.65
1985	1247.0	4096.8	1366.0	993.5	355.5	51.1	28.8	106.9	58.5	12.4	5.1	252.7	8574.2	6	35.29
1986	3023.0	2344.3	1018.3	655.7	169.9	77.1	75.8	47.6	53.8	10.0	2.8	1.8	7480.1	9	52.94
1987	45.0	944.3	3117.3	466.0	146.8	62.7	50.3	25.0	28.5	2.9	3.3	322.5	5214.6	13	76.47
1988	1898.6	4934.3	877.9	203.3	221.8	170.5	47.9	38.8	29.8	16.6	3.5	67.3	8510.4	7	41.18
1989	306.7	568.8	226.5	294.3	220.7	191.2	127.3	50.0	68.7	73.2	79.8	283.9	2491.0	16	94.12
1990	2203.8	1896.3	3282.0	886.1	373.7	340.4	188.3	209.6	475.8	400.7	218.0	346.9	10821.5	1	5.88
1991	718.0	3850.5	1186.9	592.2	571.3	390.6	76.8	197.4	125.6	129.2	107.9	129.7	8075.9	8	47.06
1992	235.9	1280.2	1660.5	318.6	339.9	387.1	200.8	203.2	108.9	286.4	2.0	1125.2	6148.8	11	64.71
Mean	1283.1	3035.9	1615.2	461.7	203.5	138.6	80.5	89.5	71.2	62.2	28.4	222.2	7292.0		

SITE NAME ATARIA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	25.6	25.2	6.2	3.8	2.2	1.5	3.5	3.6	1.5	1.1	.7	1.2	76.1	13	76.47
1978	25.6	25.2	6.2	3.8	2.2	1.5	3.5	3.6	1.5	1.1	.7	1.2	76.1	14	82.35
1979	25.6	.3	2.8	1.5	1.2	1.5	.8	.6	.5	.3	.2	10.1	45.3	16	94.12
1980	57.7	144.3	102.7	16.3	5.9	3.8	3.0	2.0	2.0	1.8	.9	2.8	343.3	2	11.76
1981	25.6	25.2	6.2	3.8	2.2	1.5	3.5	3.6	1.5	1.1	.7	1.2	76.1	15	88.24
1982	4.1	90.0	65.3	11.7	4.8	3.1	2.3	1.9	1.3	1.0	.7	1.5	187.8	8	47.06
1983	22.7	44.9	135.9	63.2	12.0	4.3	4.0	2.9	2.0	1.2	.9	4.0	298.0	3	17.65
1984	5.2	84.7	60.1	11.0	4.7	2.5	2.8	2.1	1.6	1.1	.7	.9	177.4	10	58.82
1985	22.1	113.3	25.8	23.3	12.9	3.7	2.5	5.2	3.5	1.3	1.0	6.7	221.4	7	41.18
1986	19.5	35.5	10.9	4.8	2.3	1.8	2.3	1.5	1.5	.8	.7	.6	82.2	12	70.59
1987	7.3	59.7	104.5	26.3	9.3	3.6	2.8	2.0	1.8	1.2	1.0	6.3	225.8	6	35.29
1988	17.9	123.1	19.0	10.0	4.9	2.8	1.9	1.2	1.1	.9	.6	1.9	185.3	9	52.94
1989	9.6	28.2	16.3	5.5	1.6	1.0	.8	.8	.6	.3	.6	36.0	101.5	11	64.71
1990	87.9	93.4	158.1	43.5	7.6	3.5	2.8	1.8	2.2	1.5	1.0	2.2	405.5	1	5.88
1991	28.3	171.9	42.1	7.1	4.0	2.4	1.6	.9	.7	.9	1.1	.8	261.7	4	23.53
1992	12.9	82.6	129.3	18.1	8.9	2.0	1.3	.8	1.2	.8	.6	.0	258.5	5	29.41
Mean	24.8	71.7	55.7	15.8	5.4	2.5	2.5	2.2	1.5	1.0	.8	4.8	188.9		

Table 5.4 continued

SITE NAME	CHINKI													
Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	3139.0	6639.9	2539.0	1561.2	450.5	252.5	121.3	173.9	91.4	46.2	29.8	294.4	15339.0	1	5.88
1978	2527.4	5227.5	1684.8	398.4	179.6	257.3	124.3	169.2	71.4	54.4	49.5	70.5	10814.1	5	29.41
1979	508.0	2338.6	201.9	81.3	39.7	38.5	27.1	21.7	19.5	14.7	11.3	579.6	3882.0	16	94.12
1980	3077.5	5927.3	3795.2	445.2	145.1	89.4	84.7	45.4	35.7	26.9	23.1	316.8	14012.3	3	17.65
1981	1736.3	2353.8	701.8	458.6	121.1	78.4	82.6	76.5	38.4	22.0	15.9	42.5	5728.0	14	82.35
1982	261.3	3891.5	2221.8	300.0	145.0	74.2	48.5	54.5	37.0	23.2	19.6	29.5	7106.0	12	70.59
1983	965.3	2955.1	5525.4	1537.8	248.5	104.5	137.4	114.2	39.6	18.4	11.6	40.0	11697.8	4	23.53
1984	447.5	6972.7	1979.2	322.7	116.5	68.5	127.4	142.6	34.0	26.6	17.0	69.9	10324.4	8	47.06
1985	1254.4	5227.0	1463.3	980.8	336.7	107.3	78.2	188.2	112.2	39.8	29.5	216.5	10034.0	9	52.94
1986	2575.8	2561.9	827.8	643.3	214.3	97.8	104.2	69.4	70.3	25.3	17.0	17.9	7225.1	11	64.71
1987	135.6	1146.0	3615.5	612.9	218.4	100.0	79.7	43.3	37.6	16.6	15.5	370.7	6391.9	13	76.47
1988	2241.3	6149.6	1037.7	328.2	271.2	221.8	80.8	91.5	47.6	26.7	11.8	168.0	10676.3	6	35.29
1989	429.0	1145.5	451.7	372.8	309.7	298.4	263.9	111.7	155.6	108.7	.0	715.9	4363.0	15	88.24
1990	3189.3	2883.8	4615.5	1487.5	411.1	367.1	206.9	197.8	419.6	348.7	201.6	338.7	14667.6	2	11.76
1991	891.3	5701.2	1836.7	563.3	473.4	359.9	122.5	224.0	158.0	130.4	131.5	82.4	10674.7	7	41.18
1992	552.3	2513.5	2935.9	437.4	367.0	375.8	217.1	208.8	117.8	279.0	14.9	1646.8	9666.1	10	58.82
Mean	1495.7	3977.2	2214.6	658.2	253.0	180.7	119.2	120.8	92.9	75.5	37.5	312.5	9537.6		

SITE NAME	SHER													
1977	184.9	331.2	67.5	57.4	38.2	10.1	3.8	5.1	1.9	1.3	1.2	9.5	712.1	2	11.76
1978	126.9	251.1	36.9	8.8	3.9	5.6	3.6	5.4	2.6	2.0	1.8	12.3	460.8	4	23.53
1979	43.5	180.1	12.1	3.3	2.4	1.7	1.7	1.5	1.6	1.3	.7	24.6	274.4	14	82.35
1980	33.8	230.0	74.4	7.9	3.2	1.5	1.9	.7	.9	.9	.8	34.9	390.9	8	47.06
1981	101.1	175.5	57.4	14.1	2.8	1.6	1.7	1.9	1.4	1.0	1.0	11.3	370.6	9	52.94
1982	16.4	132.8	258.7	16.1	7.1	2.4	1.6	1.2	.8	.6	.6	2.7	440.9	5	29.41
1983	37.7	111.8	188.6	52.3	12.6	1.7	2.3	1.5	1.2	.9	.8	2.9	414.4	7	41.18
1984	17.5	755.3	37.5	6.1	2.0	1.4	4.0	2.0	1.0	.8	.8	10.2	838.6	1	5.88
1985	59.0	193.9	32.5	35.2	5.9	2.8	2.0	8.5	6.4	.9	.6	16.7	364.4	10	58.82
1986	141.3	188.7	12.2	4.0	5.8	1.1	1.4	1.5	2.0	1.7	1.3	2.3	363.3	11	64.71
1987	20.7	22.4	53.3	10.7	4.3	1.7	2.9	1.2	.8	.6	.5	20.7	139.9	16	94.12
1988	125.3	132.5	35.5	11.1	2.3	1.0	.8	.6	.7	.6	.5	26.6	337.7	12	70.59
1989	15.2	160.7	57.7	5.9	1.8	2.2	1.5	.8	.8	.6	.6	75.9	323.7	13	76.47
1990	212.0	178.6	138.6	41.0	5.0	3.9	2.9	2.1	2.5	1.3	.9	8.3	597.2	3	17.65
1991	24.2	176.4	40.0	5.3	2.2	1.0	.9	.8	.8	.7	.7	9.7	262.8	15	88.24
1992	76.2	243.1	9.1	9.2	4.3	1.4	.9	.7	.8	.6	.6	67.6	414.6	6	35.29
Mean	77.2	216.5	69.5	18.0	6.5	2.6	2.1	2.2	1.6	1.0	.8	21.0	419.1		

SITE NAME	MACHREWA													
1977	98.8	177.1	36.1	30.7	20.4	5.4	2.0	2.7	1.0	.7	.6	5.1	380.7	2	11.76
1978	67.8	134.2	19.7	4.7	2.1	3.0	1.9	2.9	1.4	1.0	1.0	6.6	246.3	4	23.53
1979	23.2	96.3	6.5	1.8	1.3	.9	.9	.8	.8	.7	.4	13.2	146.7	14	82.35
1980	18.1	122.9	39.8	4.2	1.7	.8	1.0	.4	.5	.5	.4	18.6	209.0	8	47.06
1981	54.0	93.8	30.7	7.5	1.5	.9	.9	1.0	.8	.6	.5	6.1	198.1	9	52.94
1982	8.8	71.0	138.3	8.6	3.8	1.3	.8	.6	.4	.3	.3	1.5	235.7	5	29.41
1983	20.1	59.8	100.8	28.0	6.7	.9	1.2	.8	.6	.5	.4	1.5	221.5	7	41.18
1984	9.4	403.8	20.0	3.3	1.1	.8	2.1	1.1	.5	.4	.4	5.5	448.3	1	5.88
1985	31.5	103.7	17.4	18.8	3.2	1.5	1.1	4.6	3.4	.5	.3	8.9	194.8	10	58.82
1986	75.5	100.9	6.5	2.1	3.1	.6	.7	.8	1.1	.9	.7	1.2	194.2	11	64.71
1987	11.1	12.0	28.5	5.7	2.3	.9	1.6	.6	.4	.3	.3	11.1	74.8	16	94.12
1988	67.0	70.8	19.0	5.9	1.3	.5	.4	.3	.4	.3	.3	14.2	180.5	12	70.59
1989	8.1	85.9	30.9	3.2	1.0	1.1	.8	.4	.4	.3	.3	40.6	173.1	13	76.47
1990	113.3	95.5	74.1	21.9	2.7	2.1	1.5	1.1	1.3	.7	.5	4.4	319.2	3	17.65
1991	12.9	94.3	21.4	2.8	1.2	.5	.5	.4	.4	.3	.4	5.2	140.5	15	88.24
1992	40.7	130.0	4.9	4.9	2.3	.8	.5	.4	.4	.3	.3	36.1	221.6	6	35.29
Mean	41.3	115.7	37.1	9.6	3.5	1.4	1.1	1.2	.9	.5	.5	11.2	224.1		

Table 5.4 continued

SITE NAME SHAKKER

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	245.7	734.1	310.3	208.0	74.7	27.9	13.5	17.6	8.5	5.0	4.0	21.1	1670.4	1	5.88
1978	328.7	712.2	106.0	20.5	11.3	12.8	14.1	13.3	6.2	5.0	4.8	29.0	1264.0	3	17.65
1979	43.4	230.0	23.1	7.0	5.4	6.2	4.8	3.7	3.6	3.2	2.7	52.1	385.0	15	88.24
1980	75.4	353.0	119.7	17.0	7.5	7.7	6.9	4.3	4.3	3.1	3.0	72.3	674.2	11	64.71
1981	142.8	166.0	117.7	36.0	10.5	8.5	8.6	7.4	3.7	2.9	2.5	11.8	518.5	13	76.47
1982	32.0	543.5	250.9	23.9	15.0	8.5	6.0	4.4	4.3	3.2	3.1	18.8	913.5	6	35.29
1983	51.1	326.8	577.9	105.2	25.5	14.8	12.5	10.0	7.8	5.2	4.3	5.1	1146.1	4	23.53
1984	40.8	844.0	61.0	15.9	7.8	6.9	9.5	5.2	4.2	4.1	3.1	17.4	1019.9	5	29.41
1985	62.7	245.1	101.5	54.3	15.4	7.5	5.8	14.3	10.9	5.3	5.2	11.9	539.9	12	70.59
1986	416.7	374.8	57.4	15.6	8.8	5.6	6.8	8.7	5.6	4.2	3.7	5.1	912.9	8	47.06
1987	19.8	86.4	120.3	26.0	7.3	5.4	5.5	3.6	2.8	2.2	2.1	38.3	319.6	16	94.12
1988	153.7	525.3	106.8	44.3	11.9	9.0	6.5	3.8	3.4	2.7	2.0	44.2	913.5	7	41.18
1989	58.6	401.3	83.5	13.7	5.8	5.3	4.8	3.6	3.1	2.7	2.5	96.6	681.5	10	58.82
1990	257.9	365.6	526.7	108.5	19.5	14.4	10.8	6.7	5.9	3.3	2.5	20.9	1342.7	2	11.76
1991	63.0	283.7	51.5	10.5	5.7	4.1	4.0	4.3	3.4	2.3	2.2	11.3	446.0	14	82.35
1992	111.1	420.5	118.2	31.3	6.8	5.4	4.7	3.6	3.8	3.0	2.5	99.2	810.2	9	52.94
Mean	131.5	413.3	170.8	46.1	14.9	9.4	7.8	7.2	5.1	3.6	3.1	34.7	847.4		

SITE NAME SITAREWA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	33.5	100.1	42.3	28.4	10.2	3.8	1.9	2.4	1.2	.7	.6	2.9	227.7	1	5.88
1978	44.8	97.1	14.4	2.8	1.5	1.7	1.9	1.8	.9	.7	.7	4.0	172.3	3	17.65
1979	5.9	31.4	3.1	.9	.7	.8	.6	.5	.5	.4	.4	7.1	52.5	15	88.24
1980	10.3	48.1	16.3	2.3	1.0	1.0	.9	.6	.6	.4	.4	9.9	91.9	11	64.71
1981	19.5	22.6	16.0	4.9	1.4	1.2	1.2	1.0	.5	.4	.3	1.6	70.7	13	76.47
1982	4.4	74.1	34.2	3.3	2.0	1.1	.8	.6	.6	.4	.4	2.6	124.5	7	41.18
1983	7.0	44.5	78.8	14.3	3.5	2.0	1.7	1.4	1.1	.7	.6	.7	156.2	4	23.53
1984	5.6	115.0	8.3	2.2	1.1	.9	1.3	.7	.6	.6	.4	2.4	139.0	5	29.41
1985	8.5	33.4	13.8	7.4	2.1	1.0	.8	2.0	1.5	.7	.7	1.6	73.6	12	70.59
1986	56.8	51.1	7.8	2.1	1.2	.8	.9	1.2	.8	.6	.5	.7	124.4	8	47.06
1987	2.7	11.8	16.4	3.5	1.0	.7	.8	.5	.4	.3	.3	5.2	43.6	16	94.12
1988	21.0	71.6	14.6	6.0	1.6	1.2	.9	.5	.5	.4	.3	6.0	124.5	6	35.29
1989	8.0	54.7	11.4	1.9	.8	.7	.6	.5	.4	.4	.3	13.2	92.9	10	58.82
1990	35.2	49.8	71.8	14.8	2.7	2.0	1.5	.9	.8	.4	.3	2.8	183.0	2	11.76
1991	8.6	38.7	7.0	1.4	.8	.6	.5	.6	.5	.3	.3	1.5	60.8	14	82.35
1992	15.1	57.3	16.1	4.3	.9	.7	.6	.5	.5	.4	.3	13.5	110.4	9	52.94
Mean	17.9	56.3	23.3	6.3	2.0	1.3	1.1	1.0	.7	.5	.4	4.7	115.5		

SITE NAME DUDHI

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	134.2	401.0	169.5	113.6	40.8	15.2	7.4	9.6	4.7	2.7	2.2	11.5	912.5	1	5.88
1978	179.6	389.0	57.9	11.2	6.2	7.0	7.7	7.3	3.4	2.7	2.6	15.9	690.5	3	17.65
1979	23.7	125.7	12.6	3.8	2.9	3.4	2.6	2.0	2.0	1.7	1.5	28.4	210.3	15	88.24
1980	41.2	192.8	65.4	9.3	4.1	4.2	3.8	2.4	2.4	1.7	1.6	39.5	368.3	11	64.71
1981	78.0	90.7	64.3	19.7	5.7	4.7	4.7	4.1	2.0	1.6	1.4	6.5	283.3	13	76.47
1982	17.5	296.9	137.0	13.0	8.2	4.6	3.3	2.4	2.4	1.8	1.7	10.3	499.0	7	41.18
1983	27.9	178.5	315.7	57.5	13.9	8.1	6.8	5.4	4.3	2.8	2.3	2.8	626.1	4	23.53
1984	22.3	461.1	33.3	8.7	4.3	3.8	5.2	2.8	2.3	2.2	1.7	9.5	557.2	5	29.41
1985	34.3	133.9	55.4	29.6	8.4	4.1	3.2	7.8	6.0	2.9	2.9	6.5	294.9	12	70.59
1986	227.6	204.7	31.4	8.6	4.8	3.1	3.7	4.7	3.1	2.3	2.0	2.8	498.7	8	47.06
1987	10.8	47.2	65.7	14.2	4.0	2.9	3.0	1.9	1.5	1.2	1.1	20.9	174.6	16	94.12
1988	83.9	287.0	58.3	24.2	6.5	4.9	3.6	2.1	1.9	1.5	1.1	24.1	499.0	6	35.29
1989	32.0	219.2	45.6	7.5	3.2	2.9	2.6	2.0	1.7	1.5	1.4	52.8	372.3	10	58.82
1990	140.9	199.7	287.8	59.3	10.6	7.8	5.9	3.7	3.2	1.8	1.4	11.4	733.5	2	11.76
1991	34.4	155.0	28.1	5.7	3.1	2.2	2.2	2.3	1.8	1.3	1.2	6.2	243.6	14	82.35
1992	60.7	229.7	64.6	17.1	3.7	3.0	2.5	2.0	2.1	1.7	1.3	54.2	442.6	9	52.94
Mean	71.8	225.8	93.3	25.2	8.1	5.1	4.3	3.9	2.8	2.0	1.7	19.0	462.9		

Table 5.4 continued

SITE NAME **BARNA**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	104.6	202.0	326.8	47.7	11.8	34.9	2.3	3.8	1.3	1.3	.9	45.3	782.6	2	11.76
1978	247.6	516.7	113.7	54.4	.6	.7	.5	2.7	.3	.2	.2	2.9	940.6	1	5.88
1979	21.1	102.3	4.7	.3	.5	2.1	.2	.2	.1	.1	.1	44.8	176.5	12	70.59
1980	34.4	111.2	59.9	.3	.2	.3	.3	.3	.3	.1	.2	3.4	210.8	11	64.71
1981	108.3	82.4	1.1	1.1	1.8	1.5	.8	4.1	.2	.1	.1	65.7	267.3	9	52.94
1982	4.0	132.1	22.8	2.8	2.3	.6	.3	.2	.2	.2	.1	.1	165.7	13	76.47
1983	5.3	115.8	198.4	23.0	27.0	.5	6.4	.9	.5	.3	.1	.2	378.5	7	41.18
1984	.6	366.2	1.6	.5	.5	.5	.5	.4	.5	.2	.2	.3	371.9	8	47.06
1985	.4	1.1	.6	73.4	.6	.5	.6	.4	.6	.3	.2	.5	79.2	15	88.24
1986	296.4	183.8	.6	.5	.6	.8	5.7	1.3	.4	.3	.3	.3	491.0	5	29.41
1987	.5	.6	1.0	.5	.3	.3	.4	.4	.3	.3	.2	.3	5.0	16	94.12
1988	.6	143.5	1.7	14.2	.3	.4	.3	.2	.2	.2	.1	.1	161.8	14	82.35
1989	.3	180.4	57.8	.4	.4	.4	.3	.4	.4	.2	.3	1.2	242.4	10	58.82
1990	3.9	272.2	193.9	52.4	.4	.4	.4	.4	.3	.2	.1	.6	525.2	4	23.53
1991	.5	44.1	326.8	47.7	11.8	34.9	.3	.4	.4	.2	.3	1.2	468.5	6	35.29
1992	3.9	272.2	193.9	52.4	.4	.4	.3	.4	.6	.5	.4	33.0	558.4	3	17.65
Mean	52.0	170.4	94.1	23.2	3.7	4.9	1.2	1.0	.4	.3	.2	12.5	364.1		

SITE NAME **TAWA**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	532.4	1027.7	1662.9	242.6	60.0	177.6	11.8	19.4	6.6	6.5	4.5	230.5	3982.4	2	11.76
1978	1260.0	2628.9	578.6	276.9	3.2	3.8	2.6	13.6	1.3	1.2	1.2	15.0	4786.0	1	5.88
1979	107.2	520.5	23.8	1.3	2.5	10.6	1.1	1.0	.7	.6	.7	228.1	898.0	12	70.59
1980	175.1	565.8	304.8	1.3	1.1	1.3	1.4	1.4	1.4	.7	.8	17.5	1072.6	11	64.71
1981	550.8	419.4	5.7	5.8	9.2	7.4	4.1	20.7	1.0	.7	.6	334.5	1359.9	9	52.94
1982	20.4	672.4	115.8	14.0	11.7	2.9	1.5	1.1	1.2	.8	.5	.5	842.9	13	76.47
1983	27.1	589.5	1009.4	117.2	137.2	2.5	32.7	4.6	2.4	1.7	.7	.9	1925.9	7	41.18
1984	2.8	1863.3	8.4	2.4	2.5	2.6	2.5	2.2	2.4	1.1	.9	1.4	1892.4	8	47.06
1985	2.3	5.5	3.0	373.6	3.2	2.7	2.8	2.0	2.8	1.5	1.2	2.3	402.9	15	88.24
1986	1508.3	935.4	3.0	2.8	3.1	3.8	29.2	6.6	2.0	1.6	1.4	1.5	2498.6	5	29.41
1987	2.3	3.3	4.9	2.3	1.5	1.7	2.1	2.1	1.4	1.3	.9	1.6	25.5	16	94.12
1988	2.8	730.3	8.7	72.2	1.3	2.0	1.3	1.2	1.2	1.0	.6	.7	823.2	14	82.35
1989	1.8	917.8	294.0	2.0	1.9	2.0	1.8	1.8	1.8	1.0	1.4	6.2	1233.5	10	58.82
1990	20.0	1385.1	986.6	266.5	2.1	2.1	2.1	1.9	1.8	.9	.6	2.9	2672.6	4	23.53
1991	2.5	224.2	1662.9	242.6	60.0	177.6	1.8	1.8	1.8	1.0	1.4	6.2	2383.8	6	35.29
1992	20.0	1385.1	986.6	266.5	2.1	2.1	1.8	1.8	3.3	2.5	1.9	167.9	2841.6	3	17.65
Mean	264.7	867.1	478.7	118.1	18.9	25.2	6.3	5.2	2.1	1.5	1.2	63.6	1852.6		

SITE NAME **KOLAR**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	21.6	104.3	252.8	15.8	6.5	5.0	3.7	3.6	2.8	2.2	2.1	8.8	429.1	6	35.29
1978	107.8	148.1	66.5	20.5	14.7	15.3	14.2	15.1	13.2	12.8	12.6	12.9	453.6	3	17.65
1979	37.9	132.3	20.3	14.8	13.4	14.6	13.1	12.7	12.6	12.5	12.5	18.5	315.3	9	52.94
1980	39.5	121.4	50.9	16.1	13.7	13.4	13.8	13.2	13.1	12.9	12.7	17.9	338.4	7	41.18
1981	53.2	112.0	30.0	18.9	14.7	13.8	13.5	14.0	13.0	12.8	12.8	13.6	322.3	8	47.06
1982	18.0	117.1	44.6	16.6	14.8	13.6	13.3	13.0	12.9	12.8	12.7	12.6	301.8	10	58.82
1983	17.0	103.8	263.3	29.8	14.8	14.2	16.4	13.7	13.1	12.9	12.7	14.6	526.4	2	11.76
1984	15.5	394.3	30.7	17.5	14.0	13.4	13.4	13.3	13.1	12.7	12.6	2.2	552.6	1	5.88
1985	4.6	64.3	16.7	16.0	3.6	1.6	1.1	1.9	1.2	.4	.3	3.6	115.4	13	76.47
1986	251.5	154.0	18.4	4.1	1.6	1.0	3.2	1.9	1.1	.5	.5	2.5	440.3	5	29.41
1987	4.8	27.3	24.5	4.6	1.5	1.1	.9	.7	.6	.4	.3	12.2	78.8	16	94.12
988	46.3	114.2	38.8	20.3	2.2	1.5	1.0	.7	.6	.4	.4	28.3	254.8	11	64.71
1989	13.1	123.6	32.4	3.4	1.3	1.0	1.0	.7	.7	.4	.4	32.7	210.7	12	70.59
1990	82.8	236.2	83.9	26.4	6.3	3.1	2.4	2.2	1.0	.7	.4	2.8	448.2	4	23.53
1991	35.2	50.8	13.5	5.5	1.1	.9	.4	.3	.3	.2	.1	3.1	111.2	15	88.24
1992	9.8	75.5	18.5	2.7	1.1	.6	.5	.4	.5	.3	.2	3.1	113.1	14	82.35
Mean	47.4	129.9	62.8	14.6	7.8	7.1	7.0	6.7	6.2	5.9	5.8	11.8	313.2		

Table 5.4 continued

SITE NAME **MORAND**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	44.3	213.7	518.0	32.3	13.4	10.3	7.5	7.3	5.8	4.5	4.3	18.1	879.4	6	35.29
1978	220.9	303.5	136.3	42.0	30.1	31.3	29.0	31.0	27.0	26.2	25.8	26.5	929.6	3	17.65
1979	77.7	271.1	41.6	30.3	27.5	29.9	26.8	26.1	25.9	25.7	25.6	38.0	646.2	9	52.94
1980	80.9	248.7	104.2	33.0	28.1	27.4	28.3	27.0	26.9	26.4	26.1	36.6	693.5	7	41.18
1981	109.0	229.5	61.5	38.7	30.2	28.3	27.8	28.7	26.6	26.3	26.3	27.8	660.5	8	47.06
1982	36.8	239.9	91.5	34.0	30.4	27.8	27.1	26.6	26.3	26.1	26.0	25.9	618.6	10	58.82
1983	34.9	212.6	539.6	61.0	30.4	29.2	33.6	28.1	26.9	26.3	26.1	30.0	1078.8	2	11.76
1984	31.7	808.0	62.8	35.8	28.7	27.4	27.4	27.2	26.9	26.1	25.8	4.4	1132.3	1	5.88
1985	9.3	131.8	34.2	32.8	7.5	3.4	2.2	4.0	2.4	.9	.7	7.4	236.4	13	76.47
1986	515.3	315.6	37.6	8.4	3.4	2.2	6.5	4.0	2.2	1.1	1.0	5.1	902.3	5	29.41
1987	9.8	56.0	50.1	9.4	3.0	2.3	1.8	1.4	1.1	.8	.7	25.1	161.6	16	94.12
1988	95.0	234.1	79.4	41.6	4.5	3.2	2.0	1.4	1.2	.9	.8	58.0	522.1	11	64.71
1989	26.8	253.3	66.4	7.0	2.6	2.0	2.0	1.5	1.4	.9	.9	66.9	431.7	12	70.59
1990	169.6	484.0	172.0	54.1	13.0	6.3	4.9	4.5	2.0	1.4	.8	5.8	918.5	4	23.53
1991	72.2	104.0	27.6	11.3	2.2	1.9	.9	.5	.5	.3	.2	6.3	227.9	15	88.24
1992	20.1	154.7	37.8	5.5	2.2	1.2	1.0	.8	1.1	.6	.3	6.4	231.7	14	82.35
Mean	97.2	266.3	128.8	29.8	16.1	14.6	14.3	13.8	12.8	12.2	12.0	24.3	641.9		

SITE NAME **GANJAL**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	18.5	89.3	216.5	13.5	5.6	4.3	3.1	3.0	2.4	1.9	1.8	7.6	367.5	6	35.29
1978	92.3	126.8	57.0	17.6	12.6	13.1	12.1	13.0	11.3	10.9	10.8	11.1	388.5	3	17.65
1979	32.5	113.3	17.4	12.7	11.5	12.5	11.2	10.9	10.8	10.7	10.7	15.9	270.0	9	52.94
1980	33.8	103.9	43.5	13.8	11.8	11.4	11.8	11.3	11.2	11.0	10.9	15.3	289.8	7	41.18
1981	45.5	95.9	25.7	16.2	12.6	11.8	11.6	12.0	11.1	11.0	11.0	11.6	276.0	8	47.06
1982	15.4	100.3	38.2	14.2	12.7	11.6	11.4	11.1	11.0	10.9	10.9	10.8	258.5	10	58.82
1983	14.6	88.8	225.5	25.5	12.7	12.2	14.0	11.7	11.2	11.0	10.9	12.5	450.8	2	11.76
1984	13.3	337.7	26.3	15.0	12.0	11.4	11.5	11.4	11.2	10.9	10.8	1.9	473.2	1	5.88
1985	3.9	55.1	14.3	13.7	3.1	1.4	.9	1.6	1.0	.4	.3	3.1	98.8	13	76.47
1986	215.4	131.9	15.7	3.5	1.4	.9	2.7	1.6	.9	.4	.4	2.1	377.0	5	29.41
1987	4.1	23.4	21.0	3.9	1.3	1.0	.8	.6	.5	.3	.3	10.5	67.5	16	94.12
1988	39.7	97.8	33.2	17.4	1.9	1.3	.9	.6	.5	.4	.3	24.2	218.1	11	64.71
1989	11.2	105.8	27.8	2.9	1.1	.9	.8	.6	.6	.4	.4	28.0	180.4	12	70.59
1990	70.9	202.3	71.9	22.6	5.4	2.6	2.1	1.9	.8	.6	.3	2.4	383.8	4	23.53
1991	30.2	43.5	11.6	4.7	.9	.8	.4	.2	.2	.2	.1	2.6	95.2	15	88.24
1992	8.4	64.7	15.8	2.3	.9	.5	.4	.3	.5	.2	.2	2.7	96.8	14	82.35
Mean	40.6	111.3	53.8	12.5	6.7	6.1	6.0	5.7	5.3	5.1	5.0	10.1	268.3		

SITE NAME SUKTA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	7.0	75.8	132.8	6.1	1.9	1.3	.6	.5	.2	.0	.0	2.4	228.4	6	35.29
1978	34.1	213.2	25.8	5.1	1.7	1.6	1.0	.8	.3	.0	.0	40.7	324.5	1	5.88
1979	38.7	102.8	12.3	4.1	6.1	4.5	1.2	.5	.1	.0	.0	35.2	205.6	8	47.06
1980	19.5	101.9	39.1	2.8	1.3	2.4	1.2	.2	.2	.0	.0	2.8	171.3	10	58.82
1981	35.5	99.6	34.0	9.8	4.8	1.4	2.3	3.5	.4	.0	.0	.0	191.2	9	52.94
1982	18.0	16.3	10.6	2.6	1.4	.3	.1	.0	.0	.0	.0	6.4	55.6	16	94.12
1983	48.8	106.1	107.2	18.8	2.8	1.7	1.8	.6	.3	.0	.0	.4	288.4	2	11.76
1984	2.8	199.1	8.8	4.7	1.7	.7	.6	.2	.0	.0	.0	1.5	220.0	7	41.18
1985	22.8	29.3	8.5	6.1	1.4	.4	.2	.2	.2	.0	.0	3.0	72.0	14	82.35
1986	92.4	121.4	8.5	1.8	.5	.3	.4	.2	.1	.0	.0	9.1	234.7	5	29.41
1987	22.2	23.4	12.6	1.8	2.4	.5	.2	.1	.0	.0	.0	10.7	73.9	13	76.47
1988	117.0	53.6	46.7	30.3	3.7	1.6	.9	.4	.3	.2	.0	27.9	282.5	3	17.65
1989	22.2	54.2	28.8	2.8	.5	.4	.4	.2	.1	.0	.0	8.4	117.9	11	64.71
1990	24.5	132.6	46.6	21.9	3.7	1.6	.9	.5	.5	.3	.2	10.4	243.6	4	23.53
1991	39.5	37.7	4.9	.6	.1	.1	.0	.0	.0	.0	.0	.8	83.7	12	70.59
1992	1.6	33.0	16.9	1.6	.1	.0	.0	.0	.0	.0	.0	3.9	57.1	15	88.24
Mean	34.2	87.5	34.0	7.6	2.1	1.2	.7	.5	.2	.0	.0	10.2	178.2		

Table 5.4 continued

SITE NAME CHOTTA TAWA

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	22.8	244.8	428.9	19.7	6.0	4.1	1.9	1.5	.6	.0	.0	7.7	737.8	6	35.29
1978	110.2	688.6	83.4	16.6	5.6	5.0	3.3	2.7	1.1	.1	.0	131.4	1048.1	1	5.88
1979	125.1	332.2	39.6	13.2	19.6	14.4	4.0	1.7	.4	.0	.0	113.8	664.0	8	47.06
1980	63.0	329.1	126.3	9.0	4.0	7.8	4.0	.7	.5	.0	.0	9.0	553.3	10	58.82
1981	114.6	321.7	109.8	31.7	15.4	4.6	7.3	11.1	1.2	.1	.0	.0	617.5	9	52.94
1982	58.2	52.6	34.3	8.3	4.7	.8	.3	.0	.0	.0	.0	20.7	179.7	16	94.12
1983	157.6	342.8	346.1	60.7	8.9	5.6	5.8	2.1	1.0	.0	.0	1.2	931.6	2	11.76
1984	8.9	643.0	28.5	15.1	5.4	2.2	1.8	.7	.1	.0	.0	4.8	710.6	7	41.18
1985	73.6	94.5	27.5	19.6	4.6	1.2	.7	.8	.5	.0	.0	9.6	232.6	14	82.35
1986	298.4	392.3	27.5	5.9	1.7	1.0	1.2	.6	.3	.0	.0	29.3	758.2	5	29.41
1987	71.6	75.5	40.8	5.9	7.9	1.5	.7	.2	.0	.0	.0	34.7	238.8	13	76.47
1988	377.8	173.0	150.9	97.9	11.9	5.2	2.8	1.4	1.0	.5	.0	90.0	912.5	3	17.65
1989	71.8	175.0	93.0	9.1	1.5	1.4	1.2	.6	.2	.0	.0	27.1	380.8	11	64.71
1990	79.1	428.3	150.5	70.7	12.0	5.2	2.8	1.6	1.5	1.1	.5	33.5	786.8	4	23.53
1991	127.7	121.9	15.8	2.0	.3	.2	.0	.0	.0	.0	.0	2.5	270.4	12	70.59
1992	5.1	106.6	54.6	5.1	.3	.0	.0	.0	.0	.0	.0	12.6	184.3	15	88.24
Mean	110.3	282.6	109.8	24.4	6.9	3.8	2.4	1.6	.5	.1	.0	33.0	575.4		

SITE NAME NARAMADA SAGAR

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	5328.1	14251.1	13382.2	2750.0	810.1	909.0	356.5	377.8	277.9	194.2	156.0	591.5	39384.4	2	11.76
1978	9381.3	17538.2	4851.0	1369.4	451.2	535.3	288.3	423.9	297.8	220.1	192.2	1097.6	36646.3	3	17.65
1979	1695.4	9608.5	786.8	364.0	285.1	341.5	174.5	148.5	136.9	113.4	91.1	2572.4	16318.1	15	88.24
1980	5467.7	12794.3	9665.8	1002.6	419.5	295.6	264.3	170.0	353.5	167.3	141.4	564.2	31306.2	7	41.18
1981	4754.2	9971.5	2180.1	1299.1	522.5	302.2	296.9	405.5	191.7	119.5	102.5	728.4	20874.1	9	52.94
1982	1287.3	9829.0	4989.5	801.4	607.3	288.5	244.6	182.3	145.8	101.4	85.4	169.9	18732.4	12	70.59
1983	1662.1	9094.9	14825.0	3509.8	802.1	404.0	455.9	328.1	222.7	170.1	112.0	202.6	31789.1	5	29.41
1984	801.2	25396.7	3565.4	802.9	394.3	292.3	310.2	324.0	208.2	117.2	83.7	156.7	32452.8	4	23.53
1985	1627.4	9615.9	3365.7	2958.2	747.0	331.6	253.6	349.8	309.6	133.9	90.3	506.2	20289.2	11	64.71
1986	13065.8	13300.7	1843.3	1120.9	568.5	281.0	399.8	247.4	276.0	117.9	92.6	388.8	31702.6	6	35.29
1987	906.0	4640.8	5713.6	2742.9	968.2	330.2	226.1	183.1	162.3	77.1	50.6	287.3	16288.2	16	94.12
1988	6155.9	11368.1	3774.4	2056.2	538.8	486.9	229.2	234.2	198.1	121.8	49.4	519.5	25732.6	8	47.06
1989	2279.3	8000.5	2340.1	612.9	424.4	476.4	520.5	275.5	331.0	180.0	239.8	1465.5	17145.8	14	82.35
1990	6983.1	12459.8	11559.2	3845.4	841.5	720.1	482.6	424.6	614.5	536.9	336.8	989.0	39793.7	1	5.88
1991	2810.2	9792.9	3857.1	876.4	676.8	652.6	309.3	382.0	323.9	206.6	199.7	265.2	20352.7	10	58.82
1992	815.3	7464.6	4549.3	798.0	467.7	560.8	404.6	354.7	280.5	324.1	306.9	2385.3	18711.9	13	76.47
Mean	4063.8	11570.5	5703.0	1681.9	595.3	450.5	326.0	300.7	270.6	181.4	145.6	805.6	26095.0		

SITE NAME OMKARESHWAR

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	5607.5	14998.5	14084.0	2894.2	852.6	956.7	375.2	397.6	292.5	204.4	164.2	622.6	41449.9	2	11.76
1978	9873.3	18457.9	5105.4	1441.3	474.8	563.4	303.4	446.1	313.4	231.7	202.3	1155.1	38568.3	3	17.65
1979	1784.3	10112.4	828.0	383.1	300.1	359.4	183.6	156.3	144.1	119.4	95.8	2707.3	17173.9	15	88.24
1980	5754.5	13465.3	10172.7	1055.2	441.5	311.1	278.2	178.9	372.0	176.1	148.8	593.8	32948.0	7	41.18
1981	5003.6	10494.4	2294.5	1367.2	549.9	318.1	312.4	426.8	201.8	125.8	107.9	766.6	21968.8	9	52.94
1982	1354.8	10344.5	5251.2	843.4	639.1	303.7	257.4	191.8	153.4	106.7	89.9	178.8	19714.8	12	70.59
1983	1749.3	9571.9	15602.4	3693.9	844.1	425.2	479.8	345.3	234.4	179.0	117.9	213.2	33456.3	5	29.41
1984	843.2	26728.7	3752.4	845.0	415.0	307.6	326.5	341.0	219.1	123.4	88.1	164.9	34154.8	4	23.53
1985	1712.7	10120.2	3542.2	3113.3	786.2	349.0	266.9	368.1	325.9	141.0	95.0	532.8	21353.2	11	64.71
1986	13751.0	13998.3	1940.0	1179.7	598.3	295.7	420.8	260.3	290.4	124.1	97.5	409.1	33365.3	6	35.29
1987	953.5	4884.2	6013.2	2886.7	1018.9	347.5	238.0	192.7	170.8	81.2	53.3	302.4	17142.4	16	94.12
1988	6478.7	11964.3	3972.4	2164.1	567.1	512.5	241.3	246.5	208.5	128.2	52.0	546.8	27082.2	8	47.06
1989	2398.9	8420.0	2462.8	645.1	446.6	501.4	547.8	289.9	348.4	189.4	252.4	1542.4	18045.1	14	82.35
1990	7349.3	13113.3	12165.5	4047.1	885.7	757.9	507.9	446.9	646.8	565.1	354.5	1040.9	41880.6	1	5.88
1991	2957.6	10306.5	4059.4	922.3	712.2	686.8	325.5	402.0	340.9	217.4	210.2	279.1	21420.1	10	58.82
1992	858.0	7856.1	4787.9	839.8	492.2	590.2	425.8	373.3	295.2	341.1	323.0	2510.4	19693.2	13	76.47
Mean	4276.9	12177.3	6002.1	1770.1	626.5	474.1	343.2	316.5	284.8	190.9	153.3	847.9	27463.6		

Table 5.4 continued

SITE NAME **MAHESHWAR**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	5980.1	15995.0	15019.8	3086.5	909.3	1020.3	400.1	424.0	311.9	217.9	175.1	663.9	44203.9	2	11.76
1978	10529.3	19684.3	5444.7	1537.0	506.4	600.8	323.6	475.8	334.2	247.1	215.7	1231.9	41130.8	3	17.65
1979	1902.9	10784.3	883.0	408.5	320.0	383.3	195.8	166.7	153.7	127.3	102.2	2887.2	18315.0	15	88.24
1980	6136.8	14360.0	10848.6	1125.3	470.8	331.8	296.7	190.8	396.7	187.8	158.7	633.3	35137.2	7	41.18
1981	5336.0	11191.7	2446.9	1458.1	586.4	339.2	333.2	455.1	215.1	134.1	115.0	817.6	23428.5	9	52.94
1982	1444.9	11031.8	5600.1	899.5	681.6	323.9	274.5	204.6	163.6	113.8	95.8	190.6	21024.7	12	70.59
1983	1865.5	10207.9	16639.1	3939.3	900.2	453.4	511.6	368.3	249.9	190.9	125.7	227.4	35679.3	5	29.41
1984	899.2	28504.6	4001.8	901.1	442.5	328.0	348.2	363.7	233.7	131.6	93.9	175.9	36424.1	4	23.53
1985	1826.5	10792.6	3777.5	3320.2	838.4	372.2	284.6	392.6	347.5	150.3	101.3	568.2	22772.0	11	64.71
1986	14664.7	14928.3	2068.9	1258.1	638.0	315.4	448.8	277.6	309.7	132.4	103.9	436.3	35582.1	6	35.29
1987	1016.8	5208.7	6412.8	3078.5	1086.6	370.6	253.8	205.5	182.1	86.6	56.8	322.5	18281.4	16	94.12
1988	6909.2	12759.2	4236.3	2307.9	604.8	546.5	257.3	262.9	222.3	136.8	55.4	583.1	28881.5	8	47.06
1989	2558.3	8979.5	2626.5	687.9	476.3	534.7	584.2	309.2	371.5	202.0	269.1	1644.8	19244.0	14	82.35
1990	7837.6	13984.5	12973.8	4316.0	944.5	808.3	541.6	476.6	689.7	602.6	378.0	1110.0	44663.3	1	5.88
1991	3154.1	10991.3	4329.1	983.6	759.6	732.5	347.1	428.8	363.6	231.9	224.1	297.6	22843.3	10	58.82
1992	915.0	8378.1	5106.0	895.7	524.9	629.4	454.1	398.1	314.9	363.8	344.5	2677.2	21001.7	13	76.47
Mean	4561.1	12986.4	6400.9	1887.7	668.1	505.6	366.0	337.5	303.8	203.6	163.5	904.2	29288.3		

SITE NAME **UPPER BEDA**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	43.7	83.1	66.7	7.3	4.3	2.1	.8	.6	.5	.2	.1	42.1	251.4	3	17.65
1978	43.7	83.1	66.7	7.3	4.3	2.1	.8	.6	.5	.2	.1	42.1	251.4	4	23.53
1979	17.2	53.6	8.9	3.8	2.4	1.7	.8	.5	.4	.2	.1	31.3	120.7	8	47.06
1980	13.4	29.1	11.2	2.3	1.0	1.1	.9	.3	.2	.1	.1	1.5	61.2	12	70.59
1981	15.1	124.6	22.0	11.3	21.2	2.0	1.8	1.6	.6	.4	.3	.3	201.1	6	35.29
1982	12.9	15.4	5.6	1.8	1.9	.4	.1	.0	.0	.0	.0	3.7	41.8	14	82.35
1983	23.1	28.5	34.2	25.3	6.4	2.3	1.5	.6	.3	.2	.1	2.0	124.4	7	41.18
1984	10.4	43.2	13.3	7.4	1.6	.8	.5	.3	.2	.3	.1	2.7	80.9	10	58.82
1985	11.3	19.9	2.5	9.1	.9	.2	.1	.0	.0	.0	.0	9.9	53.9	13	76.47
1986	13.9	64.1	8.8	1.7	.3	.1	.1	.0	.0	.0	.0	4.2	93.2	9	52.94
1987	5.6	11.0	1.3	.5	.1	.0	.0	.0	.0	.0	.0	7.2	25.8	16	94.12
1988	44.4	41.3	95.7	80.1	6.2	1.8	.5	.1	.4	.2	.0	17.3	288.0	2	11.76
1989	18.0	145.3	63.7	6.7	1.6	.5	.3	.0	.0	.0	.6	5.6	242.4	5	29.41
1990	32.3	142.3	76.8	42.0	6.0	2.5	1.5	.6	.3	.2	.2	13.7	318.2	1	5.88
1991	30.0	30.3	4.3	.6	.3	.2	.1	.0	.0	.0	.1	12.8	78.7	11	64.71
1992	2.5	4.7	5.8	4.6	.1	.0	.3	.0	.0	.0	.0	12.8	30.8	15	88.24
Mean	21.1	57.5	30.5	13.2	3.7	1.1	.6	.3	.2	.1	.1	13.1	141.5		

SITE NAME **MAN**

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	69.5	132.1	106.1	11.5	6.8	3.4	1.3	.9	.8	.3	.1	67.0	399.8	3	17.65
1978	69.5	132.1	106.1	11.5	6.8	3.4	1.3	.9	.8	.3	.1	67.0	399.8	4	23.53
1979	27.4	85.2	14.1	6.0	3.8	2.7	1.3	.8	.6	.3	.2	49.7	192.0	8	47.06
1980	21.3	46.3	17.8	3.7	1.5	1.8	1.4	.4	.4	.1	.1	2.3	97.2	12	70.59
1981	24.1	198.1	34.9	17.9	33.7	3.2	2.9	2.5	.9	.6	.4	.5	319.8	6	35.29
1982	20.5	24.6	8.9	2.8	2.9	.6	.2	.0	.0	.0	.0	5.9	66.3	14	82.35
1983	36.7	45.3	54.4	40.3	10.2	3.6	2.4	.9	.6	.4	.1	3.1	197.8	7	41.18
1984	16.6	68.7	21.2	11.7	2.6	1.2	.9	.4	.3	.6	.2	4.3	128.6	10	58.82
1985	17.9	31.6	4.0	14.4	1.4	.4	.1	.1	.0	.0	.0	15.7	85.7	13	76.47
1986	22.1	101.8	13.9	2.7	.5	.2	.2	.0	.0	.0	.0	6.7	148.3	9	52.94
1987	8.9	17.5	2.1	.7	.2	.1	.0	.0	.0	.0	.0	11.5	40.9	16	94.12
1988	70.6	65.7	152.2	127.4	9.8	2.9	.8	.1	.7	.3	.1	27.5	458.0	2	11.76
1989	28.6	231.1	101.3	10.6	2.6	.8	.5	.0	.0	.1	.9	8.9	385.4	5	29.41
1990	51.4	226.3	122.1	66.7	9.5	4.0	2.4	.9	.4	.3	.3	21.8	506.0	1	5.88
1991	47.7	48.2	6.8	.9	.4	.4	.2	.0	.0	.0	.2	20.4	125.2	11	64.71
1992	3.9	7.4	9.3	7.3	.2	.0	.4	.0	.0	.0	.0	20.4	48.9	15	88.24
Mean	33.5	91.4	48.4	21.0	5.8	1.8	1.0	.5	.3	.2	.2	20.8	225.0		

Table 5.4 continued

SITE NAME LOWER GOI

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	89.8	170.9	137.2	14.9	8.8	4.4	1.6	1.2	1.0	.3	.2	86.7	517.1	3	17.65
1978	89.8	170.9	137.2	14.9	8.8	4.4	1.6	1.2	1.0	.3	.2	86.7	517.1	4	23.53
1979	35.4	110.3	18.3	7.7	4.9	3.4	1.6	1.0	.8	.4	.2	64.3	248.3	8	47.06
1980	27.5	60.0	23.0	4.8	2.0	2.3	1.8	.6	.5	.2	.1	3.0	125.8	12	70.59
1981	31.2	256.3	45.2	23.2	43.5	4.1	3.8	3.3	1.2	.8	.6	.7	413.7	6	35.29
1982	26.5	31.8	11.5	3.6	3.8	.8	.3	.0	.0	.0	.0	7.6	85.8	14	82.35
1983	47.5	58.6	70.4	52.1	13.2	4.7	3.1	1.2	.7	.5	.1	4.0	255.9	7	41.18
1984	21.5	88.8	27.4	15.1	3.3	1.5	1.1	.5	.4	.7	.3	5.5	166.3	10	58.82
1985	23.2	40.9	5.2	18.7	1.8	.5	.1	.1	.0	.0	.0	20.4	110.8	13	76.47
1986	28.6	131.7	18.0	3.5	.7	.3	.2	.0	.0	.0	.0	8.7	191.8	9	52.94
1987	11.5	22.6	2.7	1.0	.3	.1	.0	.0	.0	.0	.0	14.9	53.0	16	94.12
1988	91.3	85.0	196.8	164.8	12.7	3.8	1.0	.2	.9	.4	.1	35.5	592.4	2	11.76
1989	37.0	298.9	131.1	13.7	3.3	1.1	.6	.0	.0	.1	1.2	11.5	498.5	5	29.41
1990	66.5	292.7	157.9	86.3	12.3	5.2	3.1	1.1	.6	.4	.3	28.1	654.5	1	5.88
1991	61.7	62.3	8.8	1.1	.6	.5	.3	.0	.0	.0	.3	26.4	161.9	11	64.71
1992	5.1	9.6	12.0	9.4	.2	.0	.6	.0	.0	.0	.0	26.4	63.3	15	88.24
Mean	43.4	118.2	62.7	27.2	7.5	2.3	1.3	.6	.4	.3	.2	26.9	291.0		

SITE NAME JOBAT

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	63.4	120.7	96.9	10.5	6.2	3.1	1.1	.8	.7	.3	.1	61.2	365.1	3	17.65
1978	63.4	120.7	96.9	10.5	6.2	3.1	1.1	.8	.7	.3	.1	61.2	365.1	4	23.53
1979	25.0	77.8	12.9	5.5	3.5	2.4	1.1	.7	.5	.3	.1	45.4	175.3	8	47.06
1980	19.4	42.3	16.3	3.4	1.4	1.6	1.2	.4	.3	.1	.1	2.1	88.8	12	70.59
1981	22.0	181.0	31.9	16.4	30.8	2.9	2.7	2.3	.9	.6	.4	.5	292.1	6	35.29
1982	18.7	22.4	8.1	2.5	2.7	.6	.2	.0	.0	.0	.0	5.4	60.6	14	82.35
1983	33.5	41.3	49.7	36.8	9.3	3.3	2.2	.8	.5	.4	.1	2.8	180.7	7	41.18
1984	15.2	62.7	19.4	10.7	2.3	1.1	.8	.4	.3	.5	.2	3.9	117.5	10	58.82
1985	16.4	28.9	3.7	13.2	1.3	.3	.1	.1	.0	.0	.0	14.4	78.3	13	76.47
1986	20.2	93.0	12.7	2.5	.5	.2	.2	.0	.0	.0	.0	6.1	135.4	9	52.94
1987	8.1	16.0	1.9	.7	.2	.0	.0	.0	.0	.0	.0	10.5	37.4	16	94.12
1988	64.5	60.0	139.0	116.3	8.9	2.7	.7	.1	.6	.3	.1	25.1	418.3	2	11.76
1989	26.1	211.0	92.6	9.6	2.3	.8	.5	.0	.0	.1	.8	8.1	351.9	5	29.41
1990	46.9	206.7	111.5	60.9	8.7	3.7	2.2	.8	.4	.3	.2	19.9	462.1	1	5.88
1991	43.5	44.0	6.2	.8	.4	.3	.2	.0	.0	.0	.2	18.6	114.3	11	64.71
1992	3.6	6.8	8.4	6.7	.1	.0	.4	.0	.0	.0	.0	18.6	44.7	15	88.24
Mean	30.6	83.5	44.2	19.2	5.3	1.6	.9	.5	.3	.2	.2	19.0	205.5		

SITE NAME SARDAR SAROVAR

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Anflow	Rank	Prob
1977	7752.9	18532.9	19892.7	3595.8	940.3	1221.8	388.5	413.2	352.6	212.5	139.2	797.6	54240.1	1	5.88
1978	11738.3	19560.8	8298.8	2219.6	586.2	691.5	369.6	510.3	413.7	267.8	231.7	1668.6	46557.1	3	17.65
1979	2621.1	11718.8	1312.0	581.7	370.9	698.3	250.7	173.4	106.0	69.6	46.0	3024.4	20972.7	15	88.24
1980	6006.6	12210.6	11895.9	1282.7	556.1	352.2	348.3	205.5	367.9	178.3	129.0	529.5	34062.8	7	41.18
1981	6069.5	13974.3	3437.2	1790.2	715.5	404.5	324.8	430.7	197.7	117.4	92.7	822.3	28376.8	9	52.94
1982	1632.4	10591.3	6097.2	1038.9	739.3	347.4	250.3	189.6	160.7	116.1	75.1	295.9	21534.1	14	82.35
1983	2628.2	11070.1	17829.0	5254.3	1250.8	554.0	529.7	391.7	271.4	187.6	91.5	220.4	40278.7	5	29.41
1984	1078.3	30710.8	5037.5	1254.5	532.0	385.2	362.5	427.9	226.7	128.5	75.5	141.4	40360.8	4	23.53
1985	1776.0	12076.6	3530.2	2969.9	1024.7	385.8	286.5	339.6	349.8	162.2	83.8	622.4	23607.3	11	64.71
1986	13787.0	14647.0	2103.2	1381.8	844.6	331.4	494.7	254.5	311.4	148.7	76.1	743.0	35123.3	6	35.29
1987	1011.5	3475.7	6656.5	1311.4	676.1	372.3	234.6	163.4	160.6	138.2	81.3	343.7	14625.1	16	94.12
1988	6284.5	14340.1	5599.8	3662.8	709.8	586.0	328.8	293.8	278.9	215.0	122.3	502.2	32923.9	8	47.06
1989	3165.6	10214.2	4430.2	1040.0	643.5	672.4	616.0	422.7	355.6	258.1	375.1	1311.0	23504.5	12	70.59
1990	7197.3	16590.5	15383.6	5651.0	1128.2	895.9	574.0	488.2	671.9	634.2	397.3	1289.8	50901.8	2	11.76
1991	3248.6	12259.0	4672.3	1018.4	736.7	713.0	362.5	393.4	383.6	238.0	217.6	528.0	24770.9	10	58.82
1992	495.3	8487.9	5642.5	1403.5	695.0	842.9	667.5	610.4	442.0	487.8	463.2	2063.7	22301.8	13	76.47
Mean	4780.8	13778.8	7613.7	2216.0	759.4	590.9	399.3	356.8	315.6	222.5	168.6	931.5	32133.8		

Table 5.4 Concluded

Table 5.5 Zonewise cropping patterns.

CROPPING PATTERN FOR UPPER ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 120%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy HYV	25	318	--	131	37	--	--	--	--	--	--	--	35
Paddy HYV	20	231	--	92	--	--	--	--	--	--	--	--	186
Paddy Line	10	11	--	76	--	--	--	--	--	--	--	35	347
Soyabin	7	--	--	--	--	--	--	--	--	--	--	--	107
Maize	5	58	--	--	--	--	--	--	--	--	--	--	--
RABBI													
Wheat OMV	15	--	--	--	60	68	101	109	9	--	--	--	--
Wheat HYV	15	--	--	--	--	116	51	111	132	--	--	--	--
Wheat HYV	10	--	--	--	--	138	87	116	56	--	--	--	--
Peas	5	--	--	--	--	121	95	108	--	--	--	--	--
Mustard	5	--	--	--	60	78	103	111	28	--	--	--	--
Berseem	1	--	--	--	--	188	85	116	136	--	--	--	--
Vegetables	2	--	--	--	--	141	78	109	23	--	--	--	--

CROPPING PATTERN FOR UPPER ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 195%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	43	76	--	203	--	--	--	--	--	--	--	51	152
Jowar	20	--	--	76	76	--	--	--	--	--	--	--	--
Pulses	12	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	51	152	76	--	--	--	--	--	--	--	--
Groundnut	7	--	--	102	--	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	7	--	--	152	152	152	--	--	330	305	305	305	229
RABBI													
Wheat HYV	43	--	--	--	102	152	76	152	76	--	--	--	--
Wheat local	15	--	--	--	--	76	76	76	76	--	76	--	--
Peas	4	--	--	--	--	102	102	102	--	--	--	--	--
Berseem	7	--	--	--	203	152	152	152	152	305	203	--	--
Gram	8	--	--	--	--	--	76	76	--	--	--	--	--
Vegetables	2	--	--	--	76	152	229	152	152	--	--	--	--
HOT WEATHER													
Pulses	17	--	--	--	--	--	--	--	--	--	229	229	--
Fodder	7	--	--	--	--	--	--	--	--	152	229	229	152
Vegetables	2	--	--	--	--	--	--	--	76	152	229	229	76

Table 5.5 Continued

CROPPING PATTERN FOR MIDDLE ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 152%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	30	76	--	229	--	--	--	--	--	--	--	52	229
Hy Jowar	20	--	--	76	76	--	--	--	--	--	--	--	--
Cotton	5	--	--	76	152	76	--	--	--	--	--	178	152
Groundnut	10	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	10	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	76	152	102	--	--	--	--	--	--	--	--
Fodder	1	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	3	--	--	152	152	152	76	254	229	305	305	305	229
RABBI													
Wheat HYV	46	--	--	--	102	152	76	152	127	--	--	--	--
Wheat Local	10	--	--	--	--	102	76	76	102	51	--	--	--
Peas	4	--	--	--	--	102	127	102	--	--	--	--	--
Berseem	5	--	--	--	203	152	152	152	152	304	204	--	--
Vegetables	2	--	--	--	76	152	229	204	152	--	--	--	--
Gram	4	--	--	--	--	--	76	76	--	--	--	--	--

CROPPING PATTERN FOR MIDDLE ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 193%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	40	76	--	229	--	--	--	--	--	--	--	51	229
Jowar	20	--	--	76	76	--	--	--	--	--	--	--	--
Cotton	5	--	--	76	152	76	--	--	--	--	--	178	152
Groundnut	4	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	10	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	152	102	--	--	--	--	--	--	--	--	76
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	7	--	--	152	152	152	76	254	229	305	305	305	229
RABBI													
Wheat HYV	50	--	--	--	102	152	76	152	127	--	--	--	--
Wheat Local	10	--	--	--	--	102	76	76	102	51	--	--	--
Gram	4	--	--	--	--	--	76	76	--	--	--	--	--
Berseem	7	--	--	--	203	152	152	152	152	304	203	--	--
Vegetables	2	--	--	--	76	152	229	203	152	--	--	--	--
HOT WEATHER													
Pulses	17	--	--	--	--	--	--	--	--	--	254	178	76
Fodder	7	--	--	--	--	--	--	--	--	152	229	278	152
Vegetables	2	--	--	--	--	--	--	--	76	152	229	278	76

Table 5.5 Continued

CROPPING PATTERN FOR MIDDLE ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 184%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	40	76	--	229	--	--	--	--	--	--	--	51	229
Jowar/Maize	20	--	--	76	76	--	--	--	--	--	--	--	--
Cotton	5	--	--	76	152	76	--	--	--	--	--	178	152
Groundnut	4	--	--	152	--	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	152	102	--	--	--	--	--	--	--	--	76
Sugarcane	7	--	--	152	152	152	76	254	229	305	305	305	229
RABBI													
Wheat HYV	50	--	--	--	102	152	76	152	127	--	--	--	--
Wheat Local	10	--	--	--	--	102	76	76	102	51	--	--	--
Peas	4	--	--	--	--	102	127	102	--	--	--	--	--
Gram	4	--	--	--	--	--	76	76	--	--	--	--	--
Berseem	7	--	--	--	203	152	152	152	152	304	203	--	--
Vegetables	2	--	--	--	76	152	229	203	152	--	--	--	--
HOT WEATHER													
Pulses	17	--	--	--	--	--	--	--	--	--	254	178	76
Fodder	7	--	--	--	--	--	--	--	--	152	229	278	152
Vegetables	2	--	--	--	--	--	--	--	76	152	229	278	76

CROPPING PATTERN FOR MIDDLE ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 161%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	30	76	--	229	--	--	--	--	--	--	--	52	229
Hy Jowar	20	--	--	76	76	--	--	--	--	--	--	--	--
Cotton	5	--	--	76	152	76	--	--	--	--	--	178	152
Groundnut	10	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	10	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	76	152	102	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	5	--	--	152	152	152	76	254	229	305	305	305	229
RABBI													
Wheat HYV	50	--	--	--	102	152	76	152	127	--	--	--	--
Wheat Local	10	--	--	--	--	102	76	76	102	51	--	--	--
Peas	4	--	--	--	--	102	127	102	--	--	--	--	--
Berseem	7	--	--	--	203	152	152	152	152	304	204	--	--
Vegetables	2	--	--	--	76	152	229	204	152	--	--	--	--
Gram	4	--	--	--	--	--	76	76	--	--	--	--	--

Table 5.5 Continued

CROPPING PATTERN FOR MIDDLE ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 125%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	22	76	--	229	--	--	--	--	--	--	--	52	229
Hy Jowar	10	--	--	76	76	--	--	--	--	--	--	--	--
Cotton	5	--	--	76	152	76	--	--	--	--	--	178	152
Groundnut	3	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	6	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	152	102	--	--	--	--	--	--	--	--	76
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
RABBI													
Wheat HYV	46	--	--	--	102	152	76	152	127	--	--	--	--
Wheat Local	10	--	--	--	--	102	76	76	102	51	--	--	--
Peas	6	--	--	--	--	102	127	102	--	--	--	--	--
Berseem	7	--	--	--	203	152	152	152	152	304	204	--	--
Vegetables	2	--	--	--	76	152	229	204	152	--	--	--	--
Gram	4	--	--	--	--	--	76	76	--	--	--	--	--

CROPPING PATTERN FOR MIDDLE ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 138%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	30	76	--	229	--	--	--	--	--	--	--	51	229
Jowar/Maize	15	--	--	76	76	--	--	--	--	--	--	--	--
Cotton	5	--	--	76	152	76	--	--	--	--	--	178	152
Groundnut	5	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	5	--	--	102	--	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	1	76	152	102	--	--	--	--	--	--	--	--	76
Sugarcane	4	--	--	152	152	152	76	254	229	305	305	305	229
RABBI													
Wheat HYV	30	--	--	--	102	152	76	152	127	--	--	--	--
Wheat Local	25	--	--	--	--	102	76	76	102	51	--	--	--
Peas	2	--	--	--	--	102	127	102	--	--	--	--	--
Gram	7	--	--	--	--	--	76	76	--	--	--	--	--
Linseed	2	--	--	--	--	51	51	--	--	--	--	--	--
Vegetables	1	--	--	--	76	152	229	203	152	--	--	--	--
HOT WEATHER													
Pulses	2	--	--	--	--	--	--	--	--	--	254	178	76
Fodder	1	--	--	--	--	--	--	--	--	152	229	278	152
Vegetables	1	--	--	--	--	--	--	--	76	152	229	278	76

Table 5.5 Continued

CROPPING PATTERN FOR LOWER ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 158%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	20	76	152	229	--	--	--	--	--	--	--	52	305
Hy Jowar	15	--	76	76	76	--	--	--	--	--	--	--	--
Cotton	25	--	--	--	76	152	76	--	--	--	--	178	152
Groundnut	5	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	7	--	--	152	--	--	--	--	--	--	--	--	--
Vegetables	2	76	76	152	102	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	5	--	--	152	152	76	254	229	279	305	305	305	229
RABBI													
Wheat HYV	40	--	--	--	102	152	76	152	76	51	--	--	--
Wheat Local	10	--	--	--	--	152	76	102	127	--	--	--	--
Peas	2	--	--	--	--	102	152	152	--	--	--	--	--
Berseem	7	--	--	--	254	152	229	152	229	305	203	--	--
Vegetables	2	--	--	--	152	229	229	229	152	--	--	--	--
Jowar	15	--	--	--	--	--	--	178	127	229	152	--	--

CROPPING PATTERN FOR LOWER ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 152%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	30	76	152	229	--	--	--	--	--	--	--	52	305
Jowar	20	--	76	76	76	--	--	--	--	--	--	--	--
Cotton	5	--	--	--	76	152	76	--	--	--	--	178	152
Groundnut	10	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	10	--	--	152	--	--	--	--	--	--	--	--	--
Vegetables	2	76	76	152	102	--	--	--	--	--	--	--	--
Fodder	1	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	3	--	--	152	152	76	254	229	279	305	305	305	229
RABBI													
Wheat HYV	46	--	--	--	102	152	76	152	76	51	--	--	--
Wheat Local	10	--	--	--	--	152	76	102	127	--	--	--	--
Peas	4	--	--	--	--	102	152	152	--	--	--	--	--
Berseem	5	--	--	--	254	152	229	152	229	305	203	--	--
Vegetables	2	--	--	--	152	229	229	229	152	--	--	--	--
Gram	4	--	--	--	--	--	102	127	--	--	--	--	--

Table 5.5 Continued

CROPPING PATTERN FOR LOWER ZONE MAJOR RESERVOIRS (IRRIGATION INTENSITY = 131%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	15	76	152	229	--	--	--	--	--	--	--	52	305
Jowar	10	--	76	76	76	--	--	--	--	--	--	--	--
Cotton	25	--	--	--	76	152	76	--	--	--	--	178	152
Groundnut	5	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	3	--	--	152	--	--	--	--	--	--	--	--	--
Vegetables	2	76	76	152	102	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	8	--	--	152	152	76	254	229	279	305	305	305	229
RABBI													
Wheat HYV	40	--	--	--	102	152	76	152	76	51	--	--	--
Wheat Local	10	--	--	--	--	152	76	102	127	--	--	--	--
Peas	2	--	--	--	--	102	152	152	--	--	--	--	--
Berseem	7	--	--	--	254	152	229	152	229	305	203	--	--
Vegetables	2	--	--	--	152	229	229	229	152	--	--	--	--

CROPPING PATTERN FOR UPPER ZONE MEDIUM RESERVOIRS AND PUMPING SCHEMES (IRRIGATION INTENSITY = 154%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	40	76	--	203	--	--	--	--	--	--	--	51	152
Jowar/Maize	15	--	--	76	76	--	--	--	--	--	--	--	--
Pulses	10	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	51	152	76	--	--	--	--	--	--	--	--
Groundnut	5	--	--	102	--	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	5	--	--	152	152	152	--	--	330	305	305	305	229
RABBI													
Wheat HYV	40	--	--	--	102	152	76	152	76	--	--	--	--
Wheat local	11	--	--	--	--	76	76	76	76	--	76	--	--
Peas	4	--	--	--	--	102	102	102	--	--	--	--	--
Berseem	7	--	--	--	203	152	152	152	152	305	203	--	--
Gram	8	--	--	--	--	--	76	76	--	--	--	--	--
Vegetables	2	--	--	--	76	152	229	152	152	--	--	--	--
Linseed	3	--	--	--	--	51	51	--	--	--	--	--	--

Table 5.5 Continued

CROPPING PATTERN FOR MIDDLE ZONE MEDIUM RESERVOIRS AND PUMPING SCHEMES
(IRRIGATION INTENSITY = 161%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	30	76	--	229	--	--	--	--	--	--	--	52	229
Hy Jowar	20	--	--	76	76	--	--	--	--	--	--	--	--
Cotton	5	--	--	76	152	76	--	--	--	--	--	178	152
Groundnut	10	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	10	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	76	152	102	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	5	--	--	152	152	152	76	254	229	305	305	305	229
RABBI													
Wheat HYV	50	--	--	--	102	152	76	152	127	--	--	--	--
Wheat Local	10	--	--	--	--	102	76	76	102	51	--	--	--
Peas	4	--	--	--	--	102	127	102	--	--	--	--	--
Berseem	7	--	--	--	203	152	152	152	152	304	204	--	--
Vegetables	2	--	--	--	76	152	229	204	152	--	--	--	--
Gram	4	--	--	--	--	--	76	76	--	--	--	--	--

CROPPING PATTERN FOR LOWER ZONE MEDIUM RESERVOIRS AND PUMPING SCHEMES
(IRRIGATION INTENSITY = 158%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	20	76	152	229	--	--	--	--	--	--	--	52	305
Hy Jowar	15	--	76	76	76	--	--	--	--	--	--	--	--
Cotton	25	--	--	--	76	152	76	--	--	--	--	178	152
Groundnut	5	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	7	--	--	152	--	--	--	--	--	--	--	--	--
Vegetables	2	76	76	152	102	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
Sugarcane	5	--	--	152	152	76	254	229	279	305	305	305	229
RABBI													
Wheat HYV	40	--	--	--	102	152	76	152	76	51	--	--	--
Wheat Local	10	--	--	--	--	152	76	102	127	--	--	--	--
Peas	2	--	--	--	--	102	152	152	--	--	--	--	--
Berseem	7	--	--	--	254	152	229	152	229	305	203	--	--
Vegetables	2	--	--	--	152	229	229	229	152	--	--	--	--
Jowar	15	--	--	--	--	--	--	178	127	229	152	--	--

Table 5.5 Continued

CROPPING PATTERN FOR UPPER ZONE MINOR RESERVOIRS (IRRIGATION INTENSITY = 116%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	35	76	--	203	--	--	--	--	--	--	--	51	152
Jowar/Maize	11	--	--	76	76	--	--	--	--	--	--	--	--
Pulses	5	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	51	152	76	--	--	--	--	--	--	--	--
Groundnut	5	--	--	102	--	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
RABBI													
Wheat HYV	30	--	--	--	102	152	76	152	76	--	--	--	--
Wheat local	12	--	--	--	--	76	76	76	76	--	76	--	--
Berseem	7	--	--	--	203	152	152	152	152	305	203	--	--
Gram	5	--	--	--	--	--	76	76	--	--	--	--	--
Vegetables	2	--	--	--	76	152	229	152	152	--	--	--	--

CROPPING PATTERN FOR MIDDLE ZONE MINOR RESERVOIRS (IRRIGATION INTENSITY = 125%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	22	76	--	229	--	--	--	--	--	--	--	52	229
Hy Jowar	10	--	--	76	76	--	--	--	--	--	--	--	--
Cotton	5	--	--	76	152	76	--	--	--	--	--	178	152
Groundnut	3	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	6	--	--	102	--	--	--	--	--	--	--	--	--
Vegetables	2	76	76	152	102	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
RABBI													
Wheat HYV	46	--	--	--	102	152	76	152	127	--	--	--	--
Wheat Local	10	--	--	--	--	102	76	76	102	51	--	--	--
Peas	6	--	--	--	--	102	127	102	--	--	--	--	--
Berseem	7	--	--	--	203	152	152	152	152	304	204	--	--
Vegetables	4	--	--	--	76	152	229	204	152	--	--	--	--
Gram	4	--	--	--	--	--	76	76	--	--	--	--	--

Table 5.5 Continued

CROPPING PATTERN FOR LOWER ZONE MINOR RESERVOIRS (IRRIGATION INTENSITY = 123%)

Crop Name	Area(Ha)	Water Depth at Field in mm											
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
KHARIF													
Paddy	15	76	152	229	--	--	--	--	--	--	--	52	305
Hy Jowar	10	--	76	76	76	--	--	--	--	--	--	--	--
Cotton	25	--	--	--	76	152	76	--	--	--	--	178	152
Groundnut	5	--	--	152	--	--	--	--	--	--	--	--	--
Pulses	3	--	--	152	--	--	--	--	--	--	--	--	--
Vegetables	2	76	76	152	102	--	--	--	--	--	--	--	--
Fodder	2	--	--	102	--	--	--	--	--	--	--	--	--
RABBI													
Wheat HYV	40	--	--	--	102	152	76	152	76	51	--	--	--
Wheat Local	10	--	--	--	--	152	76	102	127	--	--	--	--
Peas	2	--	--	--	--	102	152	152	--	--	--	--	--
Berseem	7	--	--	--	254	152	229	152	229	305	203	--	--
Vegetables	2	--	--	--	152	229	229	229	152	--	--	--	--

Table 5.5 Concluded

Table 5.6 Salient features of major reservoirs in Narmada basin.

S.N.	Name of Reservoir, River, Guaging Site, Purpose(s) Status, Dist (Km) from River/Trib	Catchment Area(sqkm) @ dam site, @ guaging site, Their ratio & Submergence Area(Ha)	Estimated Cost(Cr)& Reference Year.	Total evapo-ration (Mcm), & monthly evapo-ration July to June (m)	River bed level, DSL & GSL (RL in m)	Gross Dead & Live Storage (Mcm)	Reservoir Elevation Capacity Relation Coeffi-cients.	Reservoir Area Capacity Relation Coeffi-cients.	CCA, Annual Irrigation (Ha) & Irrigation Intensity (%)	Monthly Irrigation Requirement in (%)	Water Supply (Mcm)& Monthly Water Supply Requir-eements. (%)	Monthly Hydro-Power Requir-ements. (%)	Installed Capacity (Mw), Ann-ual Firm Power(Mw) & Firm Energy (Mkwh) TWL (m)	Gross Use(Mcm) Irrig-ation	Upstream & %ages Water Supply & Hydro Power Project Evapo-ration
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	
1.	UPPER	1244	7.25	42	701.04	338	701.276	0.1697	18616	26.47				201.6	7.3
	NARMADA,	16576	(1971)	0.144	720.85	85	0.471	0.1297	-	0.00				4.58	8.33
	NARMADA,	0.0750	18.2	0.142	731.82	253	-0.0039	-0.0002	195	11.99				0.15	8.33
	JAMTARA,	3638	(1978)	0.147	(MP)	(MP)	1.70E-5	4.62E-7	(MP)	4.34				18.45	8.33
	IRRIGATION,		52.88	0.141	701.04	155	-3.57E-8		13482	11.44				11.71	8.33
	PROPOSED,		(1990)	0.121	720.24	70	2.85E-11		14144	8.94				12.97	8.33
	77			0.105	725.47	85			120	12.02				8.98	8.33
				0.113	(PR)	(PR)			(PR)	6.12				11.91	8.33
				0.130						0.00				9.21	8.33
				0.174						0.00				4.94	8.33
				0.210						0.71				17.38	8.33
				0.253						17.99				4.57	8.33
				0.176										9.95	8.33
2.	RAGHAVPUR,	3160	2.70	28	597.14	319	597.056	-0.29				8.33	20		
	NARMADA,	16576	(1971)	0.144	630.94	67	0.78	0.0985				8.33	4		
	JAMTARA,	0.1906	5.15	0.142	648.00	252	-0.006	-6.47E-5				8.33	31.5		
	HYDROPOWER,	2367	(1978)	0.147			2.25E-5					8.33	598.93		
	PROPOSED,			0.141			-4.68E-8					8.33			
	135			0.121			4.9E-11					8.33			
				0.105			-2.05E-14					8.33			
				0.113								8.33			
				0.130								8.33			
				0.174								8.33			
				0.210								8.33			
				0.253								8.33			
				0.176											

Table 5.6 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
3. ROSRA,	4312	4.7	41	499.87	559	508.301	-0.031				8.33	35	
NARMADA,	16576	(1971)	0.144	529.74	62	0.325	0.056				8.33	7	
JAMTARA,	0.2601	9.01	0.142	551.08	497	-0.001	-2.43E-6				8.33	61.32	
HYDROPOWER,	3199	(1978)	0.147			1.5E-6	5.52E-9				8.33	499.87	
PROPOSED,			0.141			-9.9E-10	-6.4E-13				8.33		
206			0.121			2.45E-13					8.33		
			0.105								8.33		
			0.113								8.33		
			0.130								8.33		
			0.174								8.33		
			0.210								8.33		
			0.253								8.33		
			0.176										
4. UPPER	1606	4.55+1.8	102	580.64	969	580.919	0.10699	10117	3.51				177
BURHNER,	16576	(1971)	0.144	609.6	377	0.139	0.056	-	0.104				4.661
BURHNER,	0.0969	68.97	0.142	619.35	592	-0.0002	0.00016	195	13.82				0.156
JAMTARA,	8256	(1978)	0.147			2.618E-7	-3.47E-7		8.93				18.423
IRRIGATION,			0.141			-1.55E-10	4.116E-10		10.8				11.562
PROPOSED			0.121			4.37E-14	-2.73E-13		7.13				12.946
111			0.105			-3.42E-18	7.52E-17		10.33				9.045
			0.113						8.46				12.09
			0.130						5.79				9.127
			0.174						10.94				4.828
			0.210						10.56				15.84
			0.253						9.609				4.419
			0.176										9.948
5. HALON,	715	5.5	25	595.58	197	596.381	-0.0481	11376	3.51				185
HALON,	16576	(1971)	0.144	612.95	39	0.783915	0.09714	-	0.104				4.536
JAMTARA,	0.0431	18.08	0.142	624.23	158	-0.01205	0.0009	195	13.82				0.149
IRRIGATION,	2307	(1978)	0.147			9.77E-5	-9.27E-6		8.93				18.46
PROPOSED,			0.141			-3.78E-7	3.05E-8		10.8				11.795
109			0.121			5.51E-10	-2.88E-11		7.13				12.99
			0.105						10.33				8.95
			0.113						8.46				11.79
			0.130						5.79				9.26
			0.174						10.94				5.011
			0.210						10.56				18.32
			0.253						9.609				9.95
			0.176										

Table 5.4 Continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
6.	BASANIA,	9583	5.0+9.7	160	435.56	1911	445.902	-0.14			-	8.33	60	
	(SIGARPUR)	16576	(1971)	0.144	462.08	112	0.085	0.075			8.33	8.33	20	
	NARMADA,	0.5781	114	0.142	481.89	1799	-6.84E-5	4.6E-5			8.33	8.33	175.20	
	JAMTARA,	14201	(1978)	0.147			-1.72E-08	-6.8E-8			8.33	8.33	437.08	
	W/S & H.P.			0.141				3.63E-11			8.33	8.33		
	PROPOSED,			0.121				-8.73E-15			8.33	8.33		
	251			0.105				7.73E-19			8.33	8.33		
				0.113							8.33	8.33		
				0.130							8.33	8.33		
				0.174							8.33	8.33		
				0.210							8.33	8.33		
				0.253							8.33	8.33		
				0.176							8.33			
7.	MATIYARI,	158.75	6.14	-	471.76	56.8	476.639	0.426	10120	3.51				
	MATIYARI,	16576	(1971)	0.144	484.94	5.68	0.922	0.145	13662	0.104				
	JAMTARA,	0.0096	20.25	0.142	497.43	51.12	-0.013	-6.96E-7	135	13.82				
	IRRIGATION,	679	(1978)	0.147			6.18E-5			8.93				
	COMPLETED,		44.30	0.141						10.8				
	-		(1991)	0.121						7.13				
				0.105						10.33				
				0.113						8.46				
				0.130						5.79				
				0.174						10.94				
				0.210						10.56				
				0.253						9.609				
				0.176										
8.	BARGI,	14556	-	308	366.98	3920	367.45	0.0255	157000	3.77	54(170)	8.33	80+15	2506.74 537.3
	NARMADA,	16576	(1971)	0.146	403.56	740	0.084	0.1072	(192000)	3.03	8.33	8.33	50(INI)	4.335 12.283
	JAMTARA,	0.8781	262.9	0.231	422.76	3180	-6.44E-5	-2.05E-5	219800	8.85	8.33	8.33	7 (FIN)	0.142 22.536
	IRRIGATION,	27297	(1978)	0.147			2.56E-8	2.65E-9	(271000)	16.44	8.33	8.33	438(INI)	17.373 14.225
	W/S,H.P.		566.34	0.156			-4.9E-12		194	15.70	8.33	8.33	61 (FIN)	10.833 7.477
	COMPLETED,		(1982)	0.122			3.58E-16		(140)	5.61	8.33	8.33	368.2	12.352 5.967
	378			0.105						7.92	8.33	8.33		8.511 5.587
				0.112						6.13	8.33	8.33		11.549 5.247
				0.131						10.82	8.33	8.33		8.931 5.300
				0.177						5.18	8.33	8.33		5.140 5.193
				0.208						6.33	8.33	8.33		15.013 5.141
				0.247						10.22	8.33	8.33		6.052 4.943
				0.174							8.33			7.448 6.077

Table 5.6 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	
9. ATARIA,	554	4.5	26	386.18	141	393.205	-0.0015	12950	3.327				120	
HIRAN,	67190	(1971)	0.063	(384.04)	(110)	0.27264	0.2847	19685	0.647				2.641	
MORTAKKA,	0.0083	21.44	0.058	400.51	17	-0.0012	-0.00055	152	14.676				0.358	
IRRIGATION,	2671	(1978)	0.079	(398.98)	(8)	2.009E-6	-5.48E-6		10.863				12.902	
PROPOSED,			0.102	409.65	124		3.16E-8		12.589				11.377	
148			0.079	(409.04)	(103)		4.25E-11		7.985				14.460	
			0.067						12.446				10.35	
			0.071						10.719				15.019	
			0.094						4.748				12.32	
			0.185						4.388				4.344	
			0.295						6.690				2.899	
			0.396						11.007				3.923	
			0.196										9.410	
10. CHINKI,	22414	22	94	316.99	623	317.164	0.0138	68799	2.92				2002.6	43.139
NARMADA,	67190	(1971)	0.137	340.77	413	0.094	0.1161	-	0.278				2.7142	8.33
MORTAKKA,	0.3336	76.57	0.122	343.81	210	-0.00011	2.01E-5	193	12.960				0.3496	8.33
IRRIGATION,	7649	(1978)	0.136			4.475E-8	-1.5E-8		9.165				13.4398	8.33
PROPOSED,			0.141			3.82E-11	-3.34E-12		10.46				11.1517	8.33
489			0.104						6.33				13.83	8.33
			0.082						10.90				9.50	8.33
			0.092						9.60				14.31	8.33
			0.113						5.63				11.83	8.33
			0.171						9.09				4.60	8.33
			0.200						9.69				3.60	8.33
			0.243						12.98				4.63	8.33
			0.201										9.99	8.33
11. SHER,	881	COST OF	28	381	255	383.439	-0.37	COMBINED	2.124				116	
SHER,	67190	PRJ.NOS	0.137	401.22	32	0.808	0.122	CCA FOR	0.139				2.606	
MORTAKKA,	0.0129	11+12+13	0.122	415.44	223	-0.01	-5.91E-5	PRJ. NOS.	5.928				0.359	
IRRIGATION,	2752	= 31.00	0.136			5.77E-5		11,12,13	11.70				12.61	
PROPOSED,		(1971)	0.141			-1.49E-7		= 64752	5.41				11.37	
53		= 93.23	0.104			1.42E-10			3.97				14.623	
		(1978)	0.082					-	5.59				10.663	
			0.092						4.95				15.22	
			0.113					COMMON	4.97				12.448	
			0.171					IRRG. INT	12.22				4.24	
			0.200					184	18.27				2.805	
			0.243						24.71				3.804	
			0.201										9.232	

Table 5.6 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
12. MACHREWA,	471		9	387.1	100	390.14	-0.127		2.124				105
MACHREWA,	67190		0.137	401.42	17	0.689	0.084		0.139				2.599
MORTAKKA,	0.00694		0.122	419.4	83	-0.0058	-0.00012		5.928				0.359
IRRIGATION,	728		0.136			1.86E-5			11.70				12.555
PROPOSED,			0.141						5.410				11.387
55			0.104						3.97				14.653
			0.082						5.59				10.723
			0.092						4.95				15.261
			0.113						4.97				12.472
			0.171						12.22				4.225
			0.200						18.27				2.787
			0.243						24.71				3.782
			0.201										9.199
13. SHAKKAR,	1479		26	366.67	440	369.395	0.04125		2.124				187
SHAKKAR,	67190		0.137	413	47	1.790	0.048		0.139				2.527
MORTAKKA,	0.0218		0.122	447.45	393	-0.024	0.00026		5.928				0.36
IRRIGATION,	2428		0.136			0.000168	-2.85E-6		11.70				11.956
PROPOSED,			0.141			-6.31E-7	1.28E-8		5.41				11.38
-			0.104			1.29E-9	-2.49E-11		3.97				14.988
			0.082			-1.35E-12	1.77E-14		5.59				11.366
			0.092			5.73E-16			4.95				15.678
			0.113						4.97				12.735
			0.171						12.22				4.037
			0.200						18.27				2.594
			0.243						24.71				3.538
			0.241										8.834
14. SITAREWA,	202	2.5	9	657.76	104	659.448	-0.085				8.33	15.0	
SITAREWA,	67190	(1971)	0.137	680.62	30	1.0359	0.096				8.33	4.0	
MORTAKKA,	0.0030	4.51	0.122	690.98	74	-0.0122	5.36E-6				8.33	31.5	
HYDROPOWER,	992	(1978)	0.136			4.87E-5					8.33	459.64	
PROPOSED,			0.141								8.33		
71			0.104								8.33		
			0.082								8.33		
			0.092								8.33		
			0.113								8.33		
			0.171								8.33		
			0.200								8.33		
			0.243								8.33		
			0.201										

Table 5.6 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
15. DUDHI,	808	18	28	356.01	203	356.695	-0.167	50588	2.85				85
DUDHI,	67190	(1971)	0.137	374.6	28	1.42	0.126	-	0.36				2.548
MORTAKKA,	0.01189	42.36	0.122	386.18	175	-0.036	-8.82E-5	161	14.61				0.36
IRRIGATION,	2333	(1978)	0.136			0.00047			11.37				12.135
PROPOSED,			0.141			-3.31E-6			13.51				11.379
71			0.104			1.25E-8			8.52				14.888
			0.082			-2.42E-11			13.83				11.174
			0.092			1.899E-14			11.57				15.55
			0.113						4.87				12.656
			0.171						3.45				4.093
			0.200						4.62				2.652
			0.243						10.45				3.611
			0.201										8.944
16. BARNA,	1176	-	78	313.94	529	312.915	-0.13	549.5	4.065				57
BARNA,	67190	(1971)	0.155	338.02	74	0.50	0.0089	60512	4.065				2.39
MORTAKKA,	0.0173	14.88	0.146	348.39	455	-0.00328	0.0023	121	13.375				0.363
IRRIGATION,	7689	(1978)	0.155			1.095E-5	-1.297E-5		15.328				10.825
COMPLETED,		15.27	0.163			-1.91E-8	3.22E-8		14.108				11.384
29		(1980)	0.132			1.67E-11	-3.63E-11		11.484				15.62
			0.116			-5.71E-15	1.52E-14		13.588				12.58
			0.121						10.12				16.46
			0.179						7.90				13.23
			0.186						0.00				3.68
			0.220						0.788				2.229
			0.252						5.08				3.078
			0.199										8.145
17. TAWA,	5983	-	747	309.07	2311	312.965	0.0489	242820	4.68				833
TAWA,	5983	(1971)	0.155	332.84	225	0.088	0.054	332915	4.46				2.4
BAGRATAWA,	1.00	91.42	0.146	355.4	2086	-9.01E-5	7.4E-5	125 & 138	11.55				0.362
IRRIGATION,	20056	(1978)	0.155			4.56E-8	-4.6E-8	(RBC&LBC)	13.34				11.63
COMPLETED,			0.163			-1.06E-11	8.64E-12		11.44				11.38
32			0.132			9.34E-16			8.95				15.37
			0.116						11.85				12.1
			0.121						8.09				16.16
			0.179						7.58				13.04
			0.186						3.00				3.82
			0.220						4.197				2.37
			0.252						10.84				3.26
			0.199										8.415

Table 5.6 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
18. KOLAR,	508	7.25	-	420.93	270	425.024	0.14	45087	4.828	56.6			27
KOLAR,	67190	(1971)	0.200	431.33	5	0.820000	0.165000	60867	7.388	8.33			2.509
MORTAKKA,	0.0075	38.4	0.120	462.20	265	-0.01000	-0.00066	134	0.403	8.33			0.361
IRRIGATION	1882	(1978)	0.120			6.60E-05	1.780E-06	(121)	8.680	8.33			11.813
WATERSUPPLY,	(2500)	133.14	0.120			-1.89E-7	-1.91E-09		11.98	8.33			11.38
ONGOING,		(1990)	0.100			1.99E-10			17.7	8.33			15.068
74		165.40	0.080						18.185	8.33			11.52
			0.090						16.385	8.33			15.778
			0.120						11.485	8.33			12.798
			0.190						3.105	8.33			3.992
			0.230						0.00	8.33			2.548
			0.370						0.00	8.33			3.48
			0.280										8.747
19. MORAND,	1041	COST OF	35	319.43	293	322.744	-0.0274	COMBINED	2.196				90,
MORAND,	67190	PRJ. NO.S	0.133	346.86	35	0.91	0.0999	CCA	0.366				2.348
MORTAKKA,	0.0153	19+20	0.136	367.89	258	-0.0088	-6.5E-05	OF 19+20	9.217				0.363
IRRIGATION,	2995	16.00	0.146			4.01E-05	1.05E-07	52206	11.389				10.475
PROPOSED,		(1971)	0.160			-8.31E-08	5.27E-10	-	16.518				11.385
63		64.10	0.127			6.36E-11		125	14.309				15.815
		(1978)	0.116						17.587				12.957
			0.120						13.938				16.710
			0.137						3.176				13.385
			0.179						1.711				3.571
			0.211						2.423				2.117
			0.240						7.165				2.935
			0.286										7.931
20. GANJAL,	435		35	333.15	136	348.588	-0.06		2.196				17,
GANJAL,	67190		0.133	359.05	16	0.60088	0.098		0.366				2.196
MORTAKKA,	0.0064		0.136	375.51	120	-0.00489	-0.001		9.217				0.366
IRRIGATION,	1062		0.146			1.382E-05	2.23E-05		11.389				9.217
PROPOSED,			0.160				-1.37E-07		16.518				11.389
61			0.127				2.76E-10		14.309				16.518
			0.116						17.587				14.309
			0.120						13.938				17.587
			0.137						3.176				13.938
			0.179						1.711				3.176
			0.211						2.423				1.711
			0.240						7.165				2.423
			0.286										7.165

Table 5.6 Continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	
21.	SUKTA,	469	-	17	381.62	89.3	382.815	-0.02	17643	4.105	4.24			11	
	SUKTA,	67190	(1971)	0.141	399.97	11.3	2.890	0.12	19533	4.105	8.33			2.196	
	MORTAKKA,	0.0069	8.7	0.146	410.55	78	-0.157	-0.00098	110	12.575	8.33			0.366	
	W/S,IRRIG.,	1350	(1978)	0.144			0.0041	0.00011		15.28	8.33			9.217	
	COMPLETED,	(1206)	11.9	0.166			-5.33E-05	-3.42E-06		14.37	8.33			11.389	
	86		(1982)	0.137			3.380E-07	4.36E-08		11.63	8.33			16.518	
				0.123			-8.31E-10	-2.49E-10		13.71	8.33			14.309	
				0.131				5.29E-13		10.09	8.33			17.59	
				0.149						7.97	8.33			13.94	
				0.209						0.00	8.33			3.18	
				0.227						0.895	8.33			1.711	
				0.254						5.257	8.33			2.423	
				0.191										7.165	
22.	CHHOTA TAWA,	1515	-	27	273.41	269	276.758	-0.1545	20000	4.105				253	
	CHHOTA TAWA,	67190	(1971)	0.141	294.74	59	0.432847	0.152	-	4.105				2.667	
	MORTAKKA,	0.0223	31.6	0.146	302.36	210	-0.0023964	0.0003195	105	12.575				0.315	
	IRRIGATION,	4492	(1978)	0.144			4.16E-06	-6.37E-07		15.28				9.217	
	PROPOSED,			0.166				2.31E-10		14.37				11.39	
	45			0.137						11.63				16.52	
				0.123						13.71				14.31	
				0.131						10.09				17.59	
				0.149						7.97				13.94	
				0.209						0.00				3.18	
				0.227						0.895				1.711	
				0.254						5.26				2.423	
				0.191										7.165	
23.	NARMADA	61642	-	1136	176.78	12220	176.95	-5.262	123000	2.245	0.06MAF	8.33	1000	11594	261.27
	SAGAR,	67190	(1971)	0.141	243.23	2470	0.05739	0.122585	169000	2.325	8.33	8.33	226(INI)	2.744	8.98
	NARMADA,	0.9174	332.8	0.146	262.13	9750	-1.8E-05	2.26E-05	206	6.49	8.33	8.33	100(FIN)	0.3121	11.56
	MORTAKKA,	91348	(1978)	0.144			2.7E-09	-1.99E-08		11.1	8.33	8.33	1980(INI)	13.36	9.54
	IRRIGATION		1993.67	0.166			-1.9E-13	4.12E-12		11.58	8.33	8.33	876 (FIN)	10.08	8.16
	HP & W/S,		(1988)	0.137			5.3E-18	-3.3E-16		3.73	8.33	8.33	197.51	12.34	7.8
	ONGOING,			0.123				9.58E-21		12.05	8.33	8.33		8.28	7.74
	845			0.131						5.74	8.33	8.33		12.79	7.7
				0.149						12.73	8.33	8.33		10.7	7.69
				0.209						7.29	8.33	8.33		5.06	7.68
				0.227						12.64	8.33	8.33		6.14	7.65
				0.254						12.08	8.33	8.33		6.99	7.63
				0.191										11.20	7.86

Table 5.4 Continued...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
24. OMKARESHWAR,	64880	-	172	160.63	987	160.504	-1.189	146800	14.02		8.33	520	492.81 354.93
NARMADA,	89345	(1971)	0.141	193.54	688	0.134	0.059	283324	5.0		8.33	131.2(INI)	1.75 8.33
GARUDESHWAR,	0.7262	182.8	0.146	196.6	299	-0.0003	0.00018	203	11.91		8.33	61.6(FIN)	4.495 8.33
IRRIGATION	9393	(1978)	0.144			4.39E-07	-2.81E-07		11.71		8.33	1149(INI)	8.98 8.33
HYDROPOWER,		788.03	0.166			-3.34E-10	1.35E-10		9.9		8.33	540 (FIN)	10.98 8.33
ONGOING,		(1990)	0.137			9.77E-14			10.0		8.33	162.76	14.93 8.33
899		1784.29	0.123						4.85		8.33		10.03 8.33
		(1993)	0.131						1.36		8.33		11.46 8.33
			0.149						3.18		8.33		8.5 8.33
			0.202						4.79		8.33		6.67 8.33
			0.227						8.28		8.33		3.34 8.33
			0.254						15.5		8.33		7.28 8.33
			0.191										11.53 8.33
25. MAHESHWAR,	69184	-	100	138.99	483	139.85	0.65				8.33	400	
NARMADA,	89345	(1971)	0.146	162.2	445	0.089	0.0575				8.33	93.9(INI)	
GARUDESHWAR,	0.77435	73.3	0.138	176.76	28	-0.00011	0.00015				8.33	48.6(FIN)	
HYDROPOWER,	4856	(1978)	0.147			5.9E-08	-1.15E-07				8.33	823 (INI)	
ONGOING,		465.63	0.141								8.33	426 (FIN)	
941		(1990)	0.127								8.33	139.29	
			0.109								8.33		
			0.116								8.33		
			0.135								8.33		
			0.180								8.33		
			0.215								8.33		
			0.254								8.33		
			0.177										
26. UPPER BEDA,	544	4.0	21	287.73	160	288.689	-0.0155	10927	2.17				33
BEDA,	89345	(1971)	0.146	297.18	17	0.62952	0.109015	-	6.96				1.745
GARUDESHWAR,	0.0061	20.84	0.138	312.42	143	-0.01171	-0.00121	152	13.73				4.44
IRRIGATION,	1497	(1978)	0.147			0.0001197	2.02E-05		9.86				8.74
PROPOSED,			0.141			-5.59E-07	-1.2E-07		12.43				11.23
72			0.127			9.52E-10	2.37E-10		8.5				15.52
			0.109						12.55				10.20
			0.116						8.45				11.57
			0.135						6.37				8.45
			0.180						2.84				6.42
			0.215						3.73				3.01
			0.254						11.84				7.21
			0.177										11.45

Table 5.6 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
27. MAN,	865	5.00	25	226.46	267	232.736	0.04357	16722	1.76				28
MAN,	89345	(1971)	0.139	251.46	33	0.52273	0.061443	26993	4.56				1.723
GARUDESHWAR,	0.00970	19.9	0.123	273.41	234	-0.0022	3.24E-05	158	9.28				4.258
IRRIGATION,	1829	(1978)	0.164		(MP)	3.33E-06	-1.17E-07	(MP)	10.7				7.9
ONGOING,		44.01	0.157		145.03			12950	14.23				12.04
37		(1990)	0.127		19.16			-	9.83				17.51
			0.108		125.87			-	11.35				10.76
			0.114		(PR)			(PR)	8.55				11.9
			0.131						6.97				8.298
			0.176						3.74				5.57
			0.209						7.37				1.895
			0.239						11.634				6.958
			0.194										11.17
28. LOWER GOI,	1119	6.00	21	260.3	213	263.126	-0.012	10927	2.9				123
GOI,	89345	(1971)	0.146	284.38	26	0.96	0.0446	-	7.11				1.742
GARUDESHWAR,	0.0125	22.79	0.138	304.19	187	-0.01	0.0011	139	12.92				4.42
IRRIGATION,	1643	(1978)	0.147			5.15E-05	-9.38E-06		6.7				8.62
PROPOSED,			0.141			-1.17E-07	2.2E-08		12.26				11.84
53			0.127			9.96E-11			8.53				15.8
			0.109						11.64				10.28
			0.116						8.65				11.61
			0.135						4.8				8.43
			0.180						3.48				6.3
			0.215						6.92				2.86
			0.254						14.08				7.17
			0.177										11.411
29. JOBAT,	790	3.5	21	232.56	155	239.25	0.29	13760	1.397				120
HATNI,	89345	(1971)	0.145	252.98	23	0.746	0.087	-	2.63				1.74
GARUDESHWAR,	0.0084	14.2	0.129	268.53	132	-0.0091	0.00039	-	9.77				4.43
IRRIGATION,	1554	(1978)	0.143		(MP)	5.75E-05	-2.99E-06	(MP)	13.13				8.68
ONGOING,		30.93	0.153		77.84	-1.72E-07	5.12E-09	11250	12.79				11.28
58		(1990)	0.111		12.16	1.96E-10		14858	8.86				15.65
			0.099		65.16			131	11.63				10.23
			0.106		(PR)			(PR)	9.14				11.59
			0.124						7.15				8.44
			0.181						4.18				6.36
			0.232						8.28				2.94
			0.287						11.04				7.19
			0.223										11.433

Table 5.6 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
30. SARDAR	88000	-	600	18	9500	18.014	3.23	2120000	14.02	1.06MAF	8.33	1450	-
SAROVAR,	89345	(1971)	0.145	110.64	3700	0.0376	-0.014	1792000+	5.0	8.33	8.33	415(INI)	
NARMADA,	0.9849	1500	0.129	138.68	5800	-4.19E-06	4.025E-05	73000	11.91	8.33	8.33	59(INTMED)	
GARUDESHWAR,	37590	(1978)	0.143			1.65E-10	-1.17E-08	203	11.71	8.33	8.33	0 (FIN)	
IRRIGATION		6406	0.153				1.58E-12		9.9	8.33	8.33	3635(INI)	
W/S & HP,		(1986)	0.111				-1.00E-16		10.0	8.33	8.33	517(INTMED)	
ONGOING,			0.099				2.44E-21		4.85	8.33	8.33	0 (FIN)	
1163			0.106						1.36	8.33	8.33	24.38	
			0.124						3.18	8.33	8.33		
			0.181						4.79	8.33	8.33		
			0.232						8.28	8.33	8.33		
			0.287						15.5	8.33	8.33		
			0.223							8.33			

Table 5.6 Concluded

Abbreviations:

MP - Master Plan
PR - Project Reports
INI - Initial
INTMED - Intermediate
FIN - Final
MAF - Million acre-feet
Mcm - Million cubic meters
Mkwh - Million kilo-watt hours
CCA - Culturable command area
DSL - Dead storage level
GSL - Gross storage level
TWL - Tail water level
Cr - Rs. Crores
RL - Reduced level

Table 5.7 Planwise demand Pattern for Narmada basin.

Plan Period (Five Yearly)	Irrigation Demand (Mcm)	Hydropower Demand Installed Capacity (Mw)
IV (65-70)	-	-
V (70-75)	4813	1276
VI (75-80)	11044	2085
VII (80-85)	19004	1803
VIII (85-90)	24865	1384
IX (90-95)	28937	1190

Table 5.8 Status of major reservoirs in Narmada basin.

Sr.No.	Name of the reservoir	Name of River/ Tributary	Catchment Area (sq.km.)	Status of the reservoir
1.	Upper Narmada	Narmada	1243	Proposed
2.	Raghavpur	Narmada	3160	Proposed
3.	Rosra	Narmada	4312	Proposed
4.	Upper Burhner	Burhner	1606	Proposed
5.	Halon	Halon	715	Proposed
6.	Basania(Sigarpur)	Narmada	9583	Proposed
7.	Matiyari	Matiyari	158	Completed
8.	Bargi	Narmada	14556	Completed
9.	Ataria	Hiran	554	Proposed
10.	Chinki	Narmada	22414	Proposed
11.	Sher	Sher	881	Proposed
12.	Machrewa	Machrewa	471	Proposed
13.	Shakker	Shakker	1479	Proposed
14.	Sitarewa	Sitarewa	202	Proposed
15.	Dudhi	Dudhi	808	Proposed
16.	Barna	Barna	1170	Completed
17.	Tawa	Tawa	5983	Completed
18.	Kolar	Kolar	508	Ongoing
19.	Morand	Morand	1041	Proposed
20.	Ganjal	Ganjal	435	Proposed
21.	Sukta	Sukta	469	Completed
22.	Chhota Tawa	Chhota Tawa	1515	Proposed
23.	Narmada Sagar	Narmada	61642	Ongoing
24.	Omkareshwar	Narmada	64880	Ongoing
25.	Maheshwar	Narmada	69184	Ongoing
26.	Upper Beda	Beda	544	Proposed
27.	Man	Man	865	Ongoing
28.	Lower Goi	Goi	1119	Proposed
29.	Jobat	Hatni	790	Ongoing
30.	Sardar Sarovar	Narmada	88000	Ongoing

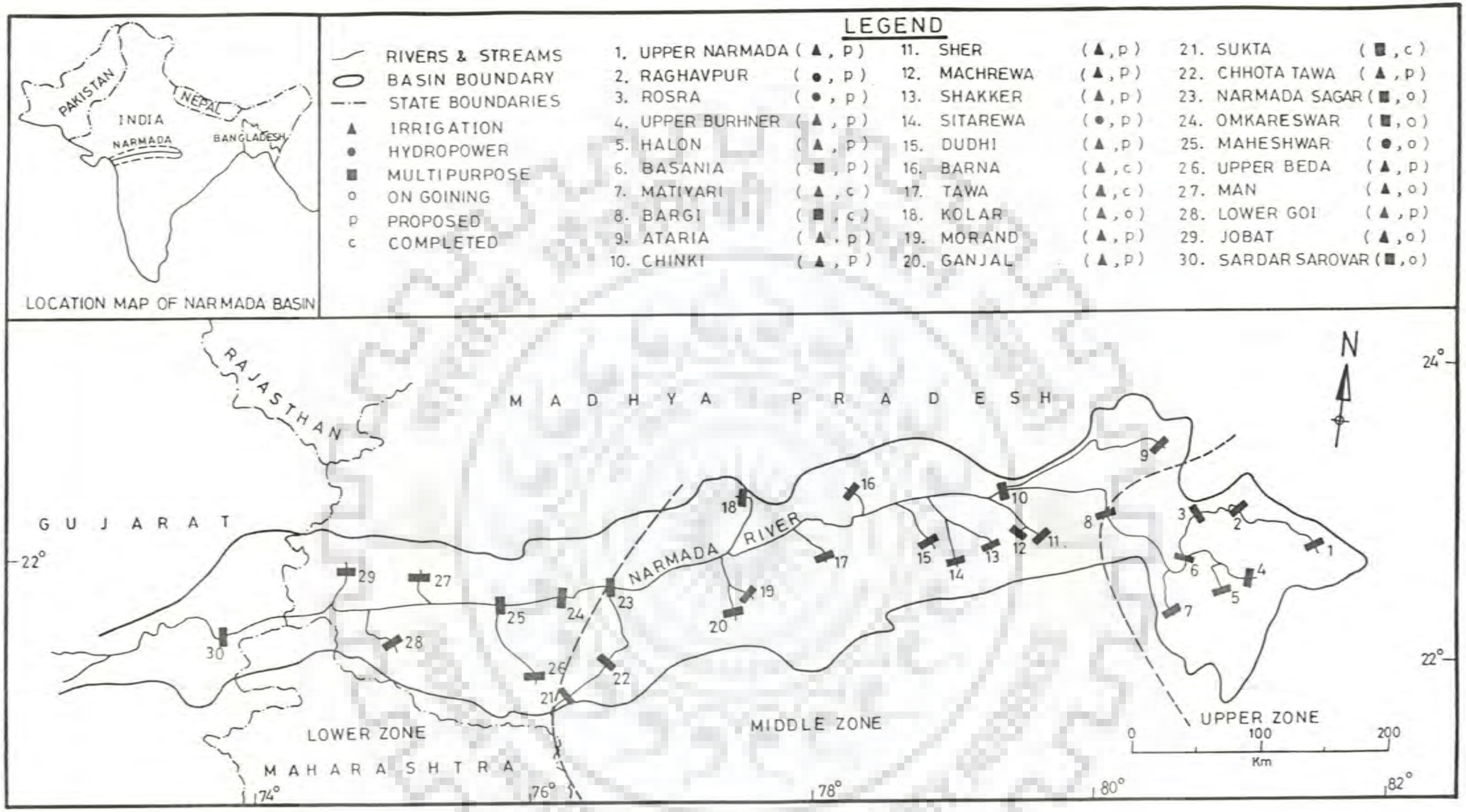


PLATE I : MAP OF NARMADA BASIN

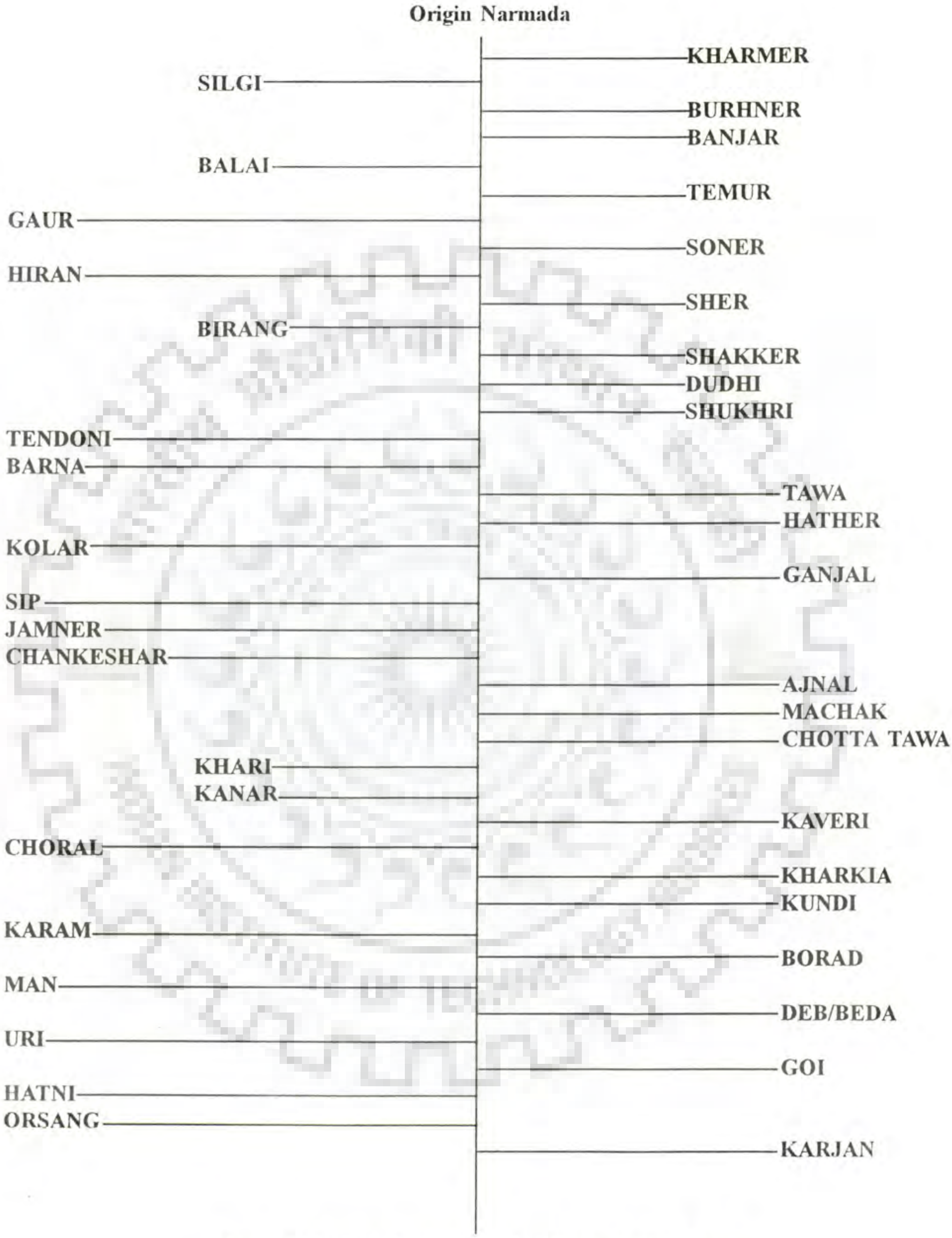


Fig. 5.1 Principal tributaries in Narmada river basin

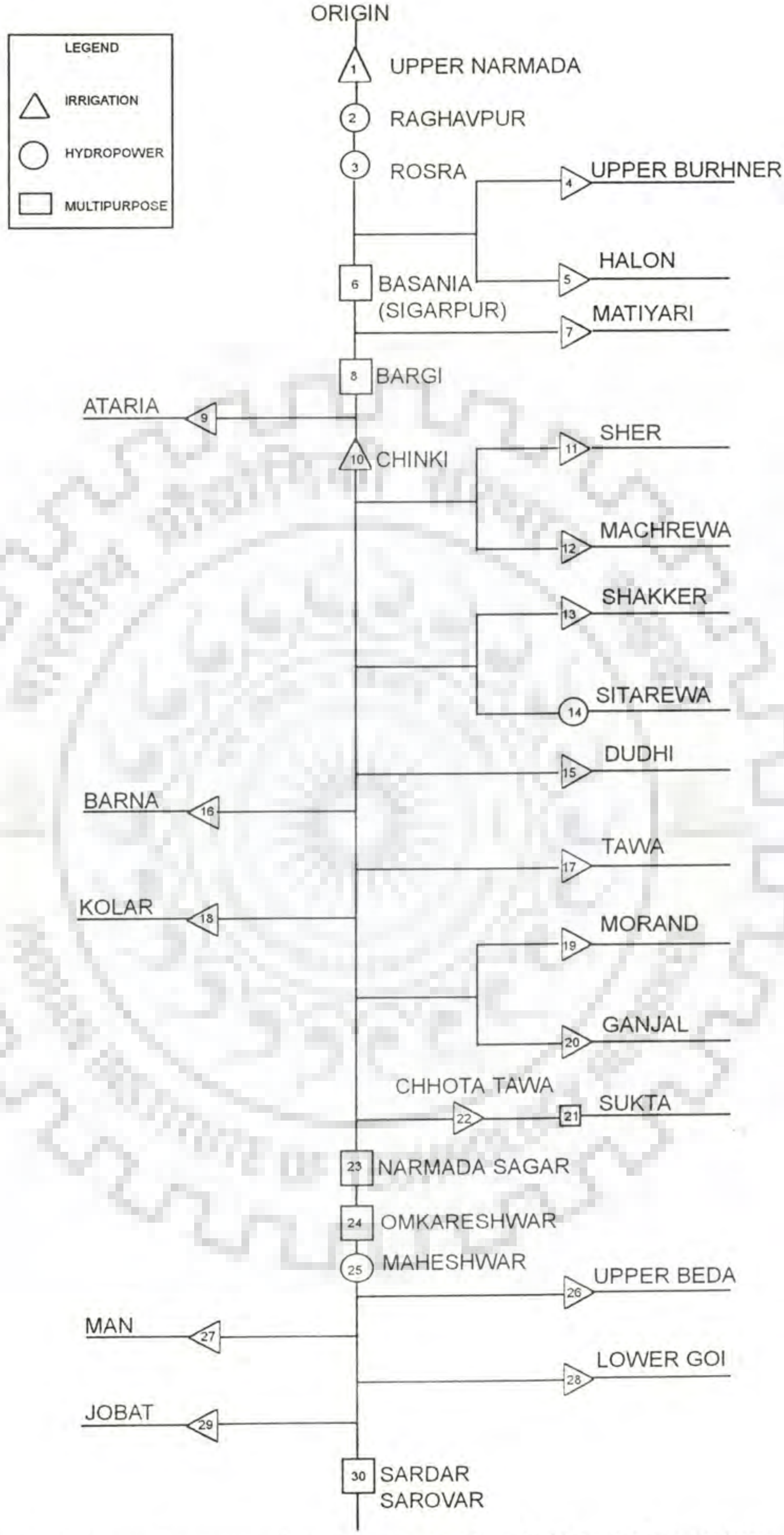


Fig. 5.2. Line diagram of major reservoirs in Narmada system

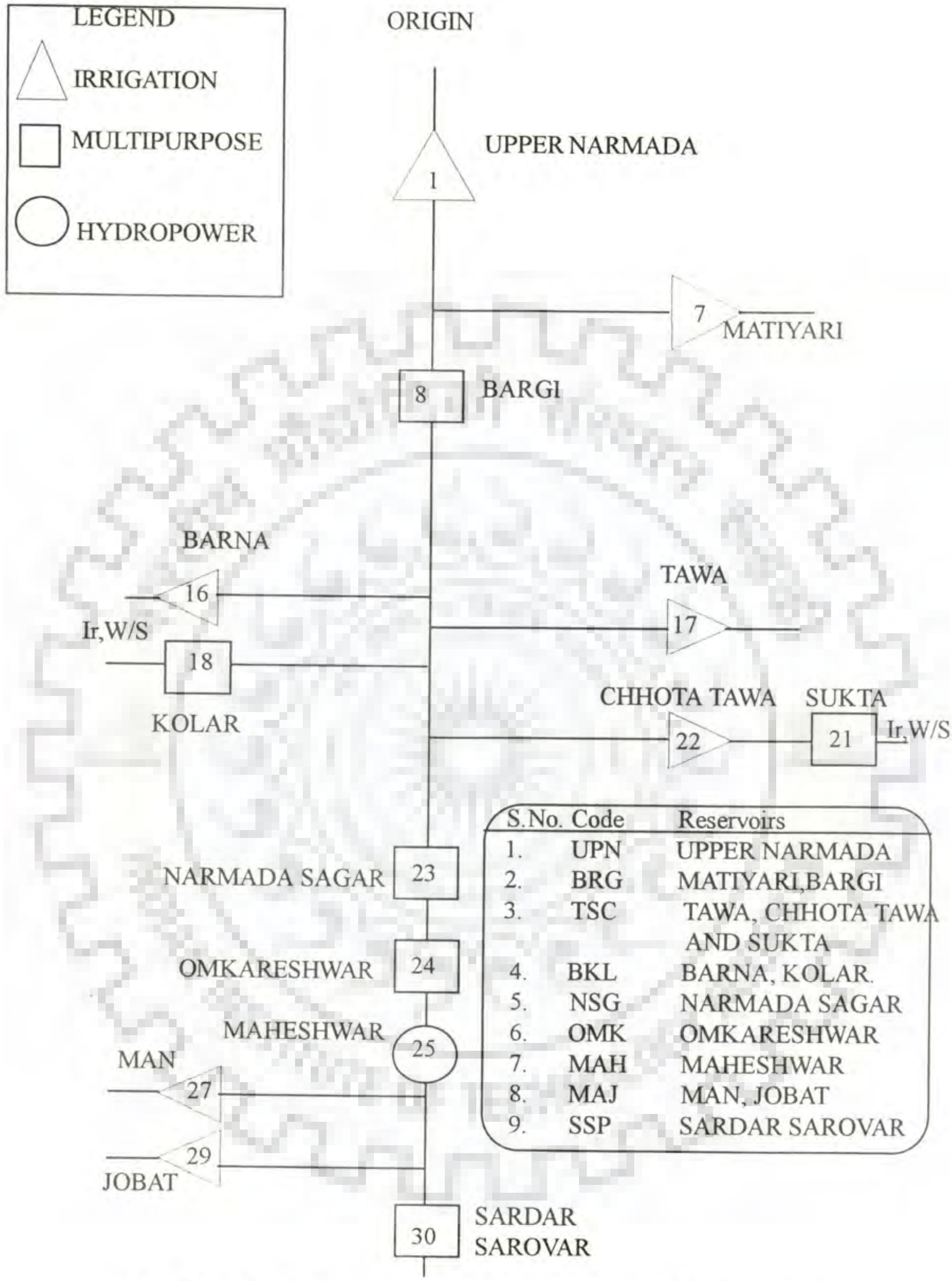
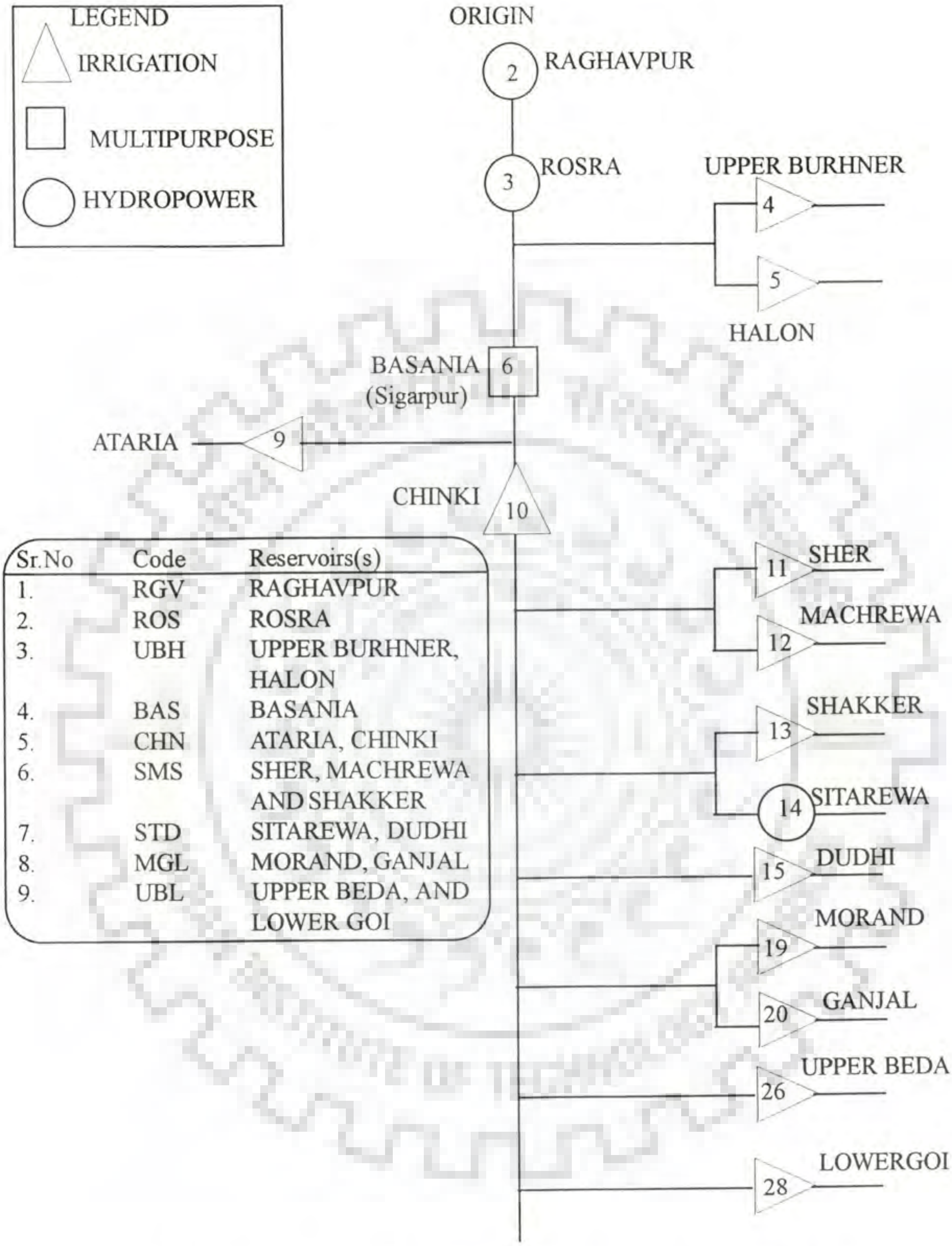


Fig. 5.3 Line diagram of Phase -I reservoirs (1979-2000)



Sr.No	Code	Reservoirs(s)
1.	RGV	RAGHAVPUR
2.	ROS	ROSRA
3.	UBH	UPPER BURHNER, HALON
4.	BAS	BASANIA
5.	CHN	ATARIA, CHINKI
6.	SMS	SHER, MACHREWA AND SHAKKER
7.	STD	SITAREWA, DUDHI
8.	MGL	MORAND, GANJAL
9.	UBL	UPPER BEDA, AND LOWER GOI

Fig. 5.4 Line diagram of Phase II reservoirs (2000-2024)

COMPUTATIONS, RESULTS, AND DISCUSSION

6.1 GENERAL

Both, namely simulation and analytical models were employed for fixing the targets and sequencing of 30 major reservoirs in the Narmada River Basin system. The simulation model was used to obtain the usewise targets that can be met by the reservoir and also to analyse the effect of the presence of upstream reservoir(s) on the performance of the corresponding immediate downstream reservoir. There were obvious difficulties in the computations owing to a large number of reservoirs in the system. In order to tackle these, as envisaged in the Master Plan, two Phases of basin development were considered. In Phase I, 14 major reservoirs were included, whereas in Phase II the remaining reservoirs were considered. Further, in Phase I, the number 14 was brought down to a smaller number by clubbing some of the neighbouring reservoirs. The combination of clubbed and un-clubbed reservoirs were now called projects. The Phase I had 9 projects. Similarly, the 16 Phase II reservoirs were clubbed into 9 projects. In Phase I and Phase II, all (2^9=512) project combinations were simulated and each simulation run was carried out from upstream to downstream in a given systematic project combination and all the reservoirs included in a combination were simulated. Subsequently, a suitable backward dynamic programming algorithm was evolved to obtain the sequence of development of the projects at the minimum total annual cost for both Phase I and Phase II in order to study the effects of demand patterns, planning horizons, allowable deficits in meeting demands and relevant penalty cost on the sequencing.

6.2 DATA COLLECTION, PROCESSING, AND PRESENTATION

Since the complete system involved as many as 30 major reservoirs, significant amount of efforts and time were required to be devoted for collection, processing, and presentation of data. The basic data were meticulously derived from the Master Plan Reports, Project Reports, and other numerous State as well as Central Government publications (Master Plan, Volumes I,IA,II,V,VII, 1972; Project Reports (Matiyari, Bargi, Ataria, Tawa, Kolar, Narmada Sagar, and Omkareshwar etc.); Report of the Narmada Water Resources Development Committee, 1965). These data were further processed to make them amenable for presentation and computer program usage. The schedules for presentation were carefully designed so as to make the information both complete as well as compact. This naturally called for a lot of trials and efforts.

6.2.1 For Simulation

6.2.1.1 Streamflow data

Simulation model considered monthly flows starting from July. Two sets of monthly flows namely, 16-years and 22-years, were considered (Tables 5.3, 5.4). In case of 16-years flow data, daily flows at 11 gauging sites were available in 77 column coded format. It involved a large number of values (11*16*365) and hence a computer program was developed to read and decode these values. Monthly flows were further calculated and transferred to the reservoir sites in the ratio of catchment areas (catchment area of reservoir site to catchment area of the nearest similar gauging site) using the programs developed for the purpose. In case of 22-years flow data, monthly flows at 4 important gauging sites were readily available in the Master Plan Report which were then transferred to various reservoirs using the same criterion which was used for effecting the transfer in the case of 16-years flow data.

6.2.1.2 Annual targets

6.2.1.2.1 Usewise downstream annual targets:

Initial trial values of the downstream annual irrigation requirements for simulation were decided on the basis of 75%

dependable annual flow criterion using the annual flow series at each reservoir site obtained above. The annual flow series values were arranged in the descending order and were ranked for selecting the 75% dependable annual flow value. However, the initial trial values of downstream annual water supply and hydropower requirements were directly extracted from the Master Plan and Project Reports.

6.2.1.2.2 Usewise upstream annual targets:

The data on water use upstream of a reservoir by minor and medium schemes, pumping schemes and evaporation were available in the Master Plan Report. The initial trial value for annual irrigation requirement upstream of a reservoir was arrived at by adding the the relevant values for minor schemes, medium schemes and pumping schemes which are situated at the immediate upstream of the reservoir under consideration. The upstream use for water supply and hydropower were combined into one value. The initial trial value of annual water supply upstream of a reservoir was taken as relevant value corresponding to evaporation.

6.2.1.3 Monthly requirements (percentages)

6.2.1.3.1 Usewise downstream monthly requirements (percentages):

The downstream monthly irrigation requirements for a few reservoirs were available in the Project Reports and were used for these reservoirs. For the remaining reservoirs, these percentages were calculated using Master Plan data on cropping pattern, annual intensity, and monthly crop water requirements. This involved a lot of data handling and repetitive computations and hence a computer program was developed to handle this task. The downstream monthly water supply as well as hydropower requirements were assumed to be uniform and were taken as 8.33% for all the months.

6.2.1.3.2 Usewise upstream monthly requirements (percentages):

The monthly irrigation requirements for minor and medium schemes, and pumping schemes located at the immediate upstream of a given reservoir, were calculated using relevant cropping patterns and monthly crop water requirements. These were suitably combined and represented for three months of July, August, and September because upstream use is only for these three months. The upstream monthly water supply and hydropower requirements were assumed to be uniform.

6.2.1.4 Reservoir capacity vs. elevation and reservoir capacity vs. reservoir area curves and relationships

Development of these relationships and curves for as many as 30 reservoirs was undoubtedly a huge task. It involved tabulation of the reservoir levels, reservoir capacities, and reservoir areas corresponding to all the 30 reservoirs from various Project Reports and other sources. These values were then fed into a Computer Grapher package for obtaining the best fit curves and equations. After a lot of trials based on visualisation and engineering judgment, only those curves and equations were selected which were observed to be smooth and befitting in the desired range of capacity values. The equations thus selected were further scrutinized for monotonic gradual increase to avoid oscillation, high jump etc. by a computer program. These were then included in the function subprograms AREA and ELEVAT of the simulation program (Appendix 6-I).

6.2.2 For Sequencing

6.2.2.1 Planning horizon

As per revision in Master Plan, Phase I was to be developed in 20 years (four 5-year plans) and Phase II was to be developed in 25 years (five 5-year plans). Thus, total system was to be developed in 45 years (nine 5-year plans). Accordingly, planning horizon consisted of a number of planning periods. Each planning period was taken equal to a five year plan period. Various planning horizons such as 20 years, 30 years, and 40 years were selected. Thus, there were 4, 6, and 8 five year plan periods under consideration in each Phase.

6.2.2.2 Targets of project combination (states)

The final simulated targets for each project appearing in the the various states were obtained from the corresponding simulation runs undertaken with due consideration given to the effect of upstream reservoir(s) as explained in the earlier sections. The usewise capacity of each state was then calculated by summing up the final simulated usewise target for each project appearing in that state.

6.2.2.3 Cost

The capital costs of the various reservoirs in the system were available in the documents such as Master Plan, project reports and seminar reports, etc.. The usewise break-up of the capital costs were also available for Unit-I (Reservoir and Dam cost), Unit-II (Irrigation cost) and Unit-III (Hydropower cost) at 1978 price level. The annual cost of each reservoir was then derived by taking into account the following components of the annual cost.

(i) Annual interest on the capital cost @12%

(ii) Annual depreciation cost

- (a) Unit-II @1%
- (b) Unit-III @2%

(iii) Annual operation and maintenance cost

(a) Unit-I @0.6%

(b) Unit-II @1%

(c) Unit-III @2%

Alternatively, for Table 6.1(b) depreciation cost was also found by using sinking fund method. The same has been used for sequencing program. Accordingly, Table 6.1(a) and Table 6.1(b) give the usewise, capital and annual costs of the major reservoirs in the Narmada basin.

6.2.2.4 Demand patterns

Data on irrigation and firm hydropower demands on the system for various five year plan periods were available in the Master Plan(1972) and Report of the Narmada Water Resources Development Committee(1965). The cumulative values of these were plotted on ordinary graph by considering a dimensionless time scale. Using this plot and other considerations, the alternative cumulative demand patterns for Phase I and Phase II were derived for the purpose of study. Various total planning horizons, i.e., Phase I planning horizons, and Phase II planning horizons were tried. For Phase II sequencing computations, it was assumed that Phase I development was fully achieved and hence the demands at the end of Phase I planning horizon were deducted from the demands of Phase II and the demand pattern for Phase II was obtained for sequencing of Phase II projects.

6.2.2.5 Allowable deficit, excess, and penalty cost

In the absence of any information available to consider the penalty which should be superimposed in case there is a shortfall or excess in the supply, in order to make a particular development state either infeasible or inefficient, the allowable deficit and excess for Phase I were taken in the interval of 100 Mcm to 2000 Mcm for irrigation and 10 Mw to 100 Mw for firm hydropower whereas for Phase II these were taken as 100 Mcm to 1000 Mcm for irrigation and 0 Mw to 10 Mw for firm hydropower. The penalty cost for not meeting the demand was taken arbitrarily as 0.001 to 0.15 Rs. Crores per Mcm for irrigation and 0.1 to 1.65 Rs. Crores per Mw for firm hydropower for the purpose of analysis. (1 crore = 10^7)

6.3 STEPS IN COMBINED USE OF SIMULATION AND SEQUENCING MODELS

The steps followed in combined use of simulation and sequencing models can be broadly recapitulated as follows:

Initially, line diagram showing relative locations of all the 30 major reservoirs in the river basin was prepared(Fig. 5.2). Then, assuming that all reservoirs are existing in the system, each individual reservoir was simulated starting from the uppermost reservoir and by adding the immediate downstream reservoir in parallel or in series by also accounting for the upstream effects for fixing the final simulated irrigation targets from every reservoir with irrigation.

Secondly, Phase I reservoirs were isolated and the line diagram showing the relative locations of the 14 Phase I reservoirs only was prepared(Fig. 5.3). From this, it was possible to combine some of the similar neighbouring reservoirs and representing the system by calling them projects, totally nine in numbers only for limiting the size of the problem. The simulation runs were to be undertaken for all possible 512(actually 375) project combinations resulting from these 9 projects starting from upstream to downstream by adding a project one by one in a systematic manner for finding the final simulated firm hydropower target from every reservoir with hydropower in each project combination. In each case, the irrigation targets were kept constant as obtained in the previous para. Further, sequencing of the Phase I projects was done using the sequencing model.

Finally, Phase II reservoirs were isolated and the line diagram showing relative locations of the 16 Phase II reservoirs only was prepared(Fig. 5.4). From this, it was possible to combine some of the similar neighbouring reservoirs and representing the system again by nine projects. Then simulation runs were to be undertaken for all the possible 512(actually 17) combinations as explained for Phase I for finding the final simulated firm hydropower target from every reservoir with hydropower in each project combination. In each case, the Phase I projects located at the upstream of the projects appearing in the Phase II combinations were assumed to be present and hence were included in the simulation runs of the corresponding Phase II combinations. Further, sequencing of the Phase II projects was obtained using the sequencing model.

6.4 COMPUTATIONS

6.4.1 Strategy for Simulation Computations

6.4.1.1 Criteria for finalisation of targets

The upstream and downstream usewise targets for every reservoir are arrived at by iteratively carrying out simulation runs with modifications in the target values until the following project dependability criteria, in terms of the number of successful years, are satisfied as per the priority of the uses, i.e.,
(i) 100% for water supply, (ii) 75% for irrigation, and
(iii) 100% for hydropower(firm power).

6.4.1.1.1 Reservoir by reservoir analysis:

To begin with, the reservoir by reservoir analysis of all the

30 reservoirs is carried out using a flexible simulation model developed for the purpose. This exercise is undertaken starting from the uppermost reservoir, mainly for fixing the irrigation targets of the reservoirs. It is also possible to have an insight into the initial and final firm power targets of various purely hydropower and multipurpose reservoirs. One by one every immediate downstream reservoir is added and before adding a downstream reservoir, the targets of all the upstream reservoirs were already simulated and finalised.

Two available sets of monthly flow data having record lengths of 16-years and 22-years are used for simulation. The operation policies for individual reservoir operation and for reservoirs in combination are as explained in Chapter 3. The results obtained are compared with the project provisions as per Master Plan. The comparative statement of the simulation results with the Master Plan provisions is presented in Table 6.2. It can be seen from this table that the values of the targets in every reservoir in each project combination of the 22-year simulation are closely matching with the Master Plan provisions for most of the reservoirs. The targets for the reservoirs in series below Omkareshwar (including itself) are observed to be not matching. It is understood that these reservoirs are expected to receive regulated flows from the upstream Narmada Sagar reservoir. This could not be ascertained as the operation policy of Narmada Sagar reservoir has not yet been decided.

Finalisation of irrigation target of each reservoir is done by considering the 75% project dependability criterion and target proposed in the Master Plan. The minimum is taken as final irrigation target. In case of a multipurpose reservoir, first irrigation target is finalised and then firm power target is fixed on the basis of 100% project dependability criterion. The initial firm power target is decided by assuming the absence of all the upstream reservoirs, whereas, the final firm power target decision assumes presence of all the upstream reservoirs. For the reasons mentioned in earlier para, the targets for the reservoirs below Omkareshwar (including itself) are taken as per the Master Plan/ project report provisions.

6.4.1.1.2 Necessity of combining reservoirs:

The State Governments of Madhya Pradesh and Gujarat have planned to build two reservoirs at Punasa (Narmada Sagar) and Navagam (Sardar Sarovar) respectively, which are actually the focal point of a much larger and ambitious river development plan. The present study has been applied to the complete system of 30 major reservoirs. There were obvious difficulties in this application owing to the large size of the system, a large number of reservoirs and variations in sizes of these reservoirs. As stated in the Chapter 5, the development is envisaged in two Phases resulting in distribution of 30 reservoirs into 14 Phase I and 16 Phase II reservoirs. It is decided to take advantage of this available decomposition criterion for the benefit of application of proposed methodology. The system is thus divided into two sub-systems consisting of Phase I and Phase II reservoirs respectively. However, since it is proposed to simulate all the possible reservoir combinations, and the number of these combinations increases in geometric progression with every additional reservoir added to the system, it became imperative to club some of the similar neighbouring reservoirs to reduce the total number of reservoirs which will include a set of unclubbed and clubbed reservoirs in the resulting representative system in each Phase. This has scaled down the total number of combinations, efforts, time and memory requirements of sequencing the computer program.

The reservoirs are suitably clubbed by applying the following guidelines.

(i) As far as possible, the reservoirs in series are not clubbed and considered individually because targets of these reservoirs are affected by the presence of upstream reservoirs.

(ii) Reservoirs situated across the tributaries are independent of each other (parallel reservoirs) and hence considered suitable for the purpose of clubbing.

(iii) Reservoirs having small targets (size) are considered suitable for clubbing so that the sizes of the projects in the resulting system are comparable.

(iv) Reservoirs which are neighbouring and hydrologically similar are considered suitable for clubbing.

The list of the code of the projects (clubbed reservoirs) and the reservoirs included therein for both the Phases is given in the Table 6.3. Further, the Table 6.4 gives the information of various costs of the projects (clubbed reservoirs).

6.4.1.2 Phase I simulation runs

The list of 14 major reservoirs considered in Phase I is already given in the Table 6.3. By applying the guidelines as mentioned earlier the 14 reservoirs in Phase I system are converted to a nine projects system. This has resulted in scaling down the number of project combinations to be simulated from 2^{14} to 2^{9}. All the project combinations are identified in terms of project name codes by using a computer program. Further since the projects(clubbed reservoirs) namely, TSC, BKL and MAJ are parallel projects this number 512 could be brought down to 375 because of the fact that the parallel projects are independent and as such their targets do not get affected by presence or absence of any other reservoir(s) in the system. These 375 combinations out of total 512 are identified using a computer program developed for the purpose. Accordingly, 375 data files are painstakingly prepared for undertaking simulation runs using the simulation computer program. It was indeed an herculean task to prepare such data files.

By virtue of reservoir by reservoir analysis the 75% dependable irrigation targets are already known. The main aim of carrying out Phase I simulation runs is therefore to obtain the simulated firm power targets of series reservoirs by taking into account the effect of upstream reservoirs. The 22 year monthly flow data are used and the operation policies for individual reservoir operation and for reservoirs in combination are as explained in Chapter 3. The irrigation and firm hydropower targets and corresponding average annual releases for the Phase I project combinations as obtained from the simulation runs are presented in Table 6.5. This table gives these values for all the 512 combinations in place of 375 combinations. It is clearly seen that for parallel projects TSC, BKL, and MAJ these values are unchanged.

6.4.1.3 Phase II simulation runs

The list of 16 major reservoirs considered in Phase II is already given in the Table 6.3. By applying the guidelines as mentioned earlier these 16 reservoirs in Phase II system are converted to 9 projects system. This has resulted in scaling down the number of project combinations to be simulated from 2^{16} to 2^9. All the project combinations are identified in terms of project name codes by using a computer program. Further, since the projects (clubbed reservoirs) namely, UBH, SMS, STD, MGL, UBL are parallel projects, this number 512 could be brought down to 34 because of the fact that the parallel projects are independent. The reasons for this number being so small are as below:

a) Series projects namely, RGV, ROS, BAS, CHN are situated at the upstream portion of the system.

b) Most of the projects added at the downstream portion of the system are parallel projects and thus unaffected by the presence or absence of any other projects in the system.

c) Further, the series project CHN being only irrigation project, it is not required to undertake all the corresponding runs for studying the effect on firm hydropower target. This has further brought down the number of simulations to 17.

These 17 combinations out of total 512 are identified using a computer program developed for the purpose.

As was done for Phase I simulation runs, the simulated irrigation and firm hydropower targets and corresponding average annual releases for the 17 Phase II project combinations as obtained from the simulation runs are presented in Table 6.6.

6.4.2 Strategy for sequencing Model

The sequencing and capacity expansion model considers the targets that can be met by various project combinations taking into account hydrological interdependence of the projects, various usewise demand patterns for different planning horizons, and usewise annual cost of the project combinations. It is also tried to incorporate the aspects such as the allowable deficit in meeting demand and pertaining penalty cost on account of this. A backward dynamic programming process is then applied in which states are defined by the project combinations and stages to go (stages in forward process) are defined by the number of periods in the planning horizon.

In Phase I nine projects (representing 14 reservoirs) are considered whereas in Phase II again nine projects (representing the remaining 16 reservoirs) are sequenced at the minimum total annual cost. The list of major reservoirs and projects considered in Phase I and Phase II is already given in the Table 6.3.

6.4.2.1 Annual cost

The information regarding fixed annual cost, design OMR (Operation and Maintenance) cost, total annual cost, and design release (Mcm) for the individual reservoirs and projects(clubbed reservoirs) is presented in the Table 6.1(b) and Table 6.4

respectively. The depreciation cost has been found by sinking fund method. A computer program is developed for this purpose. The usewise design target is taken as per the provisions in the Master Plan (termed as the design target) and the usewise design release (obtained earlier in simulation) is then equal to the release (termed as design release) which would have been required to satisfy this design target. The OMR cost component of the annual cost of a state (project combination) in the sequencing program is assumed to be a variable and function of the average annual release corresponding to the target as obtained from simulation. This cost is found by multiplying the design annual OMR cost per unit of design release (Mcm) corresponding to design target (as envisaged in Master Plan) by actual release corresponding to the actual target. The usewise annual cost of each state is obtained by adding individual usewise annual cost of the projects included in that state.

6.4.2.2 Planning horizons

Eventhough Phase I period is coming to an end by 2000 A.D., the development of the system is still in its initial stages. From this, it is evident that the planning horizons of 20 years and 25 years for Phase I and Phase II respectively considered in the Master Plan are not sufficient for full development of the system. Keeping this in mind, it is proposed to try sequencing by considering extended planning horizons. Planning horizons of 20, 30, and 40 years with 4, 6, and 8 five-year planning periods are tried for each Phase.

6.4.2.3 Targets and demand patterns

The usewise targets are considered in three categories such as (i) Master Plan targets, (ii) 22-year simulation targets, and (iii) Mixed targets. Comparative statement of these categories is presented in Table 6.7. Accordingly, usewise demand patterns for the three planning horizons are derived by comparing the demand forecast given in the Master plan and total target that can be supplied in each of the category. As far as possible it is tried to spread the demands uniformly over the planning horizon. These typical demand patterns for various cases are presented in the Table 6.8.

6.4.2.4 Allowable shortage, excess, and penalty cost

Penalty cost for shortage in meeting demand and also for supplying excess capacity beyond upper limit is considered for analysing the effect on sequencing. As mentioned earlier, the allowances are decided on the basis of judgment and total capacity of the system. In view of this, the allowable deficit and excess for Phase I are taken in the interval of 100 Mcm to 2000 Mcm for irrigation and 10 Mw to 100 Mw for firm hydropower whereas for Phase II these are taken as 100 Mcm to 1000 Mcm for irrigation and 0 Mw to 10 Mw for firm hydropower. The increment in these intervals is decided on the basis of trials carried out using the sequencing computer program.

The penalty cost for not meeting the demand within allowable shortage and for supplying within allowable excess beyond upper limit is taken arbitrarily in the interval of 0.001 to 0.15 Rs. Crores per Mcm for irrigation and 0.1 to 1.65 Rs. Crores per Mw for hydropower for the purpose of analysis. The increment in these intervals is decided on the basis of trials carried out using the sequencing computer program. It is also attempted to study the effect of application of variable penalty cost for different slabs in given allowances. Further, periodwise (stagewise) variation in the penalty cost is also considered.

The upper limits on supply are considered in two ways such as (i) Uniform upper limit as total system capacity for all planning periods, and (ii) Next period demand as upper limit in current period. Various values of allowances and penalty costs are tried for the purpose of analysis. The information (options) of various pairs of usewise allowable shortages and allowable excesses considered and corresponding pairs of usewise penalty costs levied for Phase I and Phase II is presented in the Table 6.9(a). Out of these the finalised values and classes of allowances and penalties are indicated in the Table 6.9(b).

For Phase II sequencing computations, it is assumed that Phase I development was fully achieved. The nomenclatures used are given in the Table 6.10. The sequences obtained for various categories for different penalty conditions are given in Table 6.11 for Phase I, and in Table 6.12 for Phase II.

Table 6.1(a) Total and annual costs of major reservoirs in Narmada basin (Rs. Crores)

Sr. No.	Name of the Reservoir	Total Cost and Year	Unit 1	Unit 2	Unit 3	Annual Cost: Interest on Total Cost @ 12%	Depreciation Unit 2 @ 1%	Depreciation Unit 3 @2%	OMR Cost Unit 1 @0.6%	OMR Cost Unit 2 @ 1%	OMR Cost Unit 3 @ 2%	Total Annual Cost
1.	Upper Narmada	7.25(1971)	4.19	3.06	-	.87	.031	-	.025	.031	-	.96
		18.2(1978)	10.5	7.61	-	2.18	.076	-	.063	.076	-	2.40
		52.88(1990)	30.55	22.33	-	6.35	.224	-	.183	.224	-	6.98
2.	Raghavpur	2.70(1971)									.026	.384
		5.15(1978)	2.67	-	2.45	.618	-	.05	.016	-	.05	.733
3.	Rosra	4.70(1971)	4.7								.045	.669
		9.01(1978)	4.67	-	4.34	1.081	-	.087	.028	-	.087	1.28
4.	Upper Burhner	6.35(1971)	3.67	2.68	-	.762	.0268	-	.0022	.0268	-	.818
		68.97(1978)	39.85	29.13	-	8.277	.291	-	.239	.292	-	9.10
5.	Halon	5.50(1971)	3.18									.72
		18.08(1978)	10.44	7.64	-	2.170	.0764	-	.063	.0764	-	2.39
6.	Basania(Sigarpur)	14.7(1971)									.142	2.09
		114 (1978)	59.12	-	54.88	13.68	-	1.098	.355	-	1.098	16.2
7.	Matiyari	6.14(1971)	3.56	2.58	-	.736	.0259	-	.0213	.0259	-	.81
		20.25(1978)								.0854		2.67
		44.30(1990)								.1868	-	5.84
8.	Bargi	75 (1971)								.410	.0115	10.3
		263(1978)								1.438	.6055	36.2
		566(1982)	191.3	309.8	65.2	67.96	3.098	1.304	1.15	3.098	1.304	77.9

Table 6.1(a) Continued

Sr. No.	Name of the Reservoir	Total Cost and Year	Unit 1	Unit 2	Unit 3	Annual Cost: Interest on Total Cost @ 12%	Depreciation Unit 2 @ 1%	Depreciation Unit 3 @2%	OMR Cost Unit 1 @0.6%	OMR Cost Unit 2 @ 1%	OMR Cost Unit 3 @ 2%	Total Annual Cost
9.	Ataria	7.22(1981)	4.17	3.05	-	.866	.0305	-	.025	.0305	-	.952
		21.44(1978)	12.39	9.06	-	2.573						2.83
10.	Chinki	22 (1971)				2.64				.093		2.79
		76.57(1978)	44.23	32.34	-	9.19	.3234	-	.2654	.3234	-	10.1
11.	(Sher+	31 (1971)				3.72						4.09
12.	Machrewa+	93.23(1978)	53.86	39.37	-	11.188	.3937	-	.3232	.3937	-	12.3
13.	Shakker)											
14.	Sitarewa	2.5 (1971)										.356
		4.51(1978)	2.339	-	2.17	.541	.0434	.014	-	-	.0434	.642
15.	Dudhi	18 (1971)				2.16						2.37
		42.36(1978)	24.47	17.89	-	5.083	.1789	-	.1468	.1789	-	5.59
16.	Barna	9.2 (1971)				1.104						1.21
		14.88(1978)				1.786						1.96
		15.27(1980)	9.29	5.98	-	1.832	.0598	-	.0557	.0598	-	2.01
17.	Tawa	40 (1971)				4.8						4.58
		98.6(1978)	30.32	68.25	-	10.97	.6825	-	.1819	.6825	-	12.4
18.	Kolar	7.25(1971)	3.73	3.52	-	.87	.0352	-	.0224	.0352	-	.963
		38.4(1978)	38.4			4.61						5.1
		133.14(1990)				15.977						17.7

Table 6.1(a) Continued

Sr. No.	Name of the Reservoir	Total Cost and Year	Unit 1	Unit 2	Unit 3	Annual Cost: Interest on Total Cost @ 12%	Depreciation Unit 2 @ 1%	Depreciation Unit 3 @2%	OMR Cost Unit 1 @0.6%	OMR Cost Unit 2 @ 1%	OMR Cost Unit 3 @ 2%	Total Annual Cost
19.	(Morand+	16 (1971)				1.92						2.11
20.	Ganjal)	64.1(1978)	37.03	27.07	-	7.692	.2707	-	.2222	.2707	-	8.46
21.	Sukta	5.0 (1971)				.6						.643
		8.7 (1978)				1.044						1.12
		11.9(1982)	9.6	2.29		1.428	.0229	-	.0576	.0229	-	1.53
22.	Chhota Tawa	6.5 (1971)				.78						.857
		31.6(1978)	18.26	13.34	-	3.792	.1334	-	.1095	.1334	-	4.17
23.	Narmada Sagar	107 (1971)				12.84				.2908	.665	15.0
		332.8(1978)				39.94				.9047	2.07	46.6
		1993.7(1988)	832.3	542	619.4	239.24	5.4198	12.39	4.99	5.42	12.39	279.4
24.	Omkareshwar	75.0(1971)				9.0				.3096	.517	10.8
		182.8(1978)				21.94				.7546	1.26	26.2
		788.0(1990)	191.4	325.3	271.4	95.56	3.2531	5.427	1.15	3.25	5.43	113.1
25.	Maheshwar	19.0(1971)				2.28					.059	2.58
		73.3(1978)				8.796					.228	9.96
		465.6(1990)	241.5	-	224.2	55.876	-	4.483	1.449	-	1.45	63.3
26.	Upper Beda	4.0 (1971)				.48						.528
		20.8(1978)	12.04	8.8	-	2.501	.088	-	.0722	.088	-	2.75

Table 6.1(a) Continued

Sr. No.	Name of the Reservoir	Total Cost and Year	Unit 1	Unit 2	Unit 3	Annual Cost: Interest on Total Cost @ 12%	Depreciation Unit 2 @ 1%	Depreciation Unit 3 @2%	OMR Cost Unit 1 @0.6%	OMR Cost Unit 2 @ 1%	OMR Cost Unit 3 @ 2%	Total Annual Cost
27.	Man	5.0 (1971)				.6						.652
		19.9(1978)				2.388						2.56
		44.0(1990)	30.12	13.89	-	5.281	.1389	-	.1807	.1389	-	5.74
28.	Lower Goi	6.0 (1971)				.72						.791
		22.79(1978)	13.17	9.624	-	2.735	.0962	-	.0789	.0962	-	3.01
29.	Jobat	3.5 (1971)				.42						.458
		14.2(1978)				1.704						1.86
		30.93(1990)	19.96	10.97	-	3.712	.1097	-	.1198	.1097	-	4.05
30.	Sardar Sarovar	(1971)										-
		6406(1990)	936.1	4406	980	768.7	44.07	19.6	5.617	44.07	19.6	901.7

Table 6.1(a) Concluded

Table 6.1(b) Total and annual costs (fixed and OMR) in Rs. Crores of major reservoirs in Narmada basin (as per year 1978 estimates).

Sr. No.	Name of the Reservoir, Life (Years)	Total Cost	Unit 1	Unit 2	Unit 3	Annual Cost Fixed Cost	OMR Cost (per Mcm) Unit 2	OMR Cost (per Mcm) Unit 3	Total Annual Cost	Design Release (Mcm) Unit 2	Design Release (Mcm) Unit 3
1.	Upper Narmada (50)	18.2	10.5	7.61	-	2.58	0.00037	0.00	2.68	287	-
2.	Raghavpur (50)	5.15	2.67	-	2.45	0.75	-	0.00015	0.82	-	335
3.	Rosra (50)	9.01	4.67	-	4.34	1.31	-	0.00013	1.45	-	652
4.	Upper Burhner (50)	68.97	39.9	29.1	-	9.82	0.00162	-	10.22	245	-
5.	Halon (50)	18.1	10.44	7.64	-	2.57	0.00059	-	2.68	176	-
6.	Basania (50)	114.0	59.12	-	54.88	16.62	-	0.00063	18.31	-	1755
7.	Matiyari (50)	20.3	11.7	8.53	-	2.88	0.00269	-	3.00	44	-
8.	Bargi (100)	263	88.8	143.8	30.27	33.35	0.00034	0.00014	34.84	2641	4198
9.	Ataria (50)	21.44	12.4	9.06	-	3.05	0.00094	-	3.18	132	-
10.	Chinki (50)	76.57	44.2	32.34	-	10.9	0.00055	-	11.34	801	-
11. 12. 13.	(Sher+ Machrewa+ Shakker) (50)	93.23	53.86	39.37	-	13.27	0.00073	-	13.81	736	-
14.	Sitarewa (50)	4.51	2.339	-	2.17	0.66	-	0.00065	0.72	-	69
15.	Dudhi (50)	42.36	24.5	17.89	-	6.03	0.00123	-	6.28	199	-

Table 6.1(b) Continued

Sr. No.	Name of the Reservoir, Life (Years)	Total Cost	Unit 1	Unit 2	Unit 3	Annual Cost: Fixed Cost	Annual Cost: OMR Cost (per Mcm) Unit 2	Annual Cost: OMR Cost (per Mcm) Unit 3	Annual Cost: Total Annual Cost	Design Release (Mcm) Unit 2	Design Release (Mcm) Unit 3
16.	Barna (50)	14.9	9.05	5.83	-	2.14	0.00023	-	2.23	385	-
17.	Tawa (50)	98.6	30.3	68.25	-	13.0	0.00015	-	13.31	2021	-
18.	Kolar (50)	38.4	19.8	18.64	-	5.37	0.00111	-	5.57	178	-
19. 20.	(Morand+ Ganjal) (50)	64.1	37.0	27.07	-	9.13	0.00090	-	9.50	413	-
21.	Sukta (50)	8.7	7.01	1.69	-	1.32	0.00063	-	1.39	111	-
22.	Chhota Tawa (50)	31.6	18.3	13.3	-	4.50	0.00077	-	4.68	236	-
23.	Narmada Sagar (100)	332.8	139	90.5	103	42.94	0.00063	0.00013	46.39	2220	15361
24.	Omkareshwar (100)	182.8	44.4	75.5	63	22.99	0.00016	0.00008	24.70	2790	15410
25.	Maheshwar (50)	73.3	38.01	-	35.3	10.69	-	0.00004	11.77	-	15286
26.	Upper Beda (50)	20.8	12.04	8.8	-	2.97	0.00082	-	3.09	147	-
27.	Man (50)	19.9	13.62	6.28	-	2.92	0.00060	-	3.05	227	-
28.	Lower Goi (50)	22.8	13.17	9.6	-	3.24	0.00077	-	3.38	172	-
29.	Jobat (50)	14.2	9.15	5.05	-	2.06	0.00083	-	2.15	110	-
30.	Sardar Sarovar (100)	1500	250	1000	250	185.6	0.00024	0.00032	193.1	10357	15622

Table 6.1(b) Concluded

Table 6.2 Comparative statement of individual reservoir simulation results.

SN	Name of Reservoir	Use	Targets					
			Master Plan		16 Year Simulation		22 Year Simulation	
			Upstream	Downstream	Upstream	Downstream	Upstream	Downstream
1.	Upper	W/S	7.3	-	7	-	1	-
	Narmada	IR	201.6	280(320)	115.6	312	120	301
2.	Raghavpur	HP	-	35040 Mwh	-	35040 Mwh	-	35040 Mwh
3.	Rosra	HP	-	61320 Mwh	-	58520 Mwh	-	61320 Mwh
4.	Upper Burhner	IR	177	150(253)	137	150	157	253
5.	Halon	IR	185	175(200)	63	195	70	190
6.	Basania	W/S	-	100	-	100	-	100
		HP	-	175200 Mwh	-	140360 Mwh	-	175200 Mwh
7.	Matiari	IR	173.7	-	-	44	-	44
8.	Bargi	W/S	537.3	-	-	0	537	50
		IR	2506.7	3530(3830)	-	3010	1657	3540
		HP	-	61320 Mwh	-	0 Mwh	-	61320 Mwh
9.	Ataria	IR	120	150(176)	10	95	50	140
10.	Chinki	W/S	43.14	-	-	-	43	-
		IR	2003	1130(1220)		400	103	820
11.	Sher	IR	116	¦	42	240	79	238
12.	Machrewa	IR	105	¦)980(1043)	22	97	40	105
13.	Shakker	IR	187	¦	102	443	135	443
14.	Sitarewa	HP	-	35040 Mwh	-	32340 Mwh	-	32340 Mwh
15.	Dudhi	IR	85	645(683)	55	208	70	212
16.	Barna	IR	57	404(482)	1.75	209	57	415
17.	Tawa	IR	833	2390(2656)	10	1116	590	2116
18.	Kolar	W/S	-	-	-	56.6	-	0
		IR	27	205(231)	24	147	27	189
19.	Morand	IR	90	¦ ¦)457(506)	50	300	90	300
20.	Ganjal	IR	17	¦	20	130	17	143
21.	Sukta	W/S	-	-	-	4.54	-	3.54
		IR	11	109(126)	10.8	66.92	-	110.5
22.	Chhota Tawa	IR	253	226(263)	35	200	147.9	250
23.	Narmada	W/S	261.27	-	0	74	220	74
	Sagar	IR	11594	2220(3300)	1894	2220	4100	2220
		HP	-	876000 Mwh	-	499000 Mwh	-	968000 Mwh
24.	Omkare-	W/S	354.9	-	682.81	-	355	-
	shwar	IR	492.8	2790(3010)	-	557	493	2710
		HP	-	540000 Mwh	-	13600 Mwh	-	243200 Mwh
25.	Maheshwar	HP	-	426000 Mwh	-	5000 Mwh	0	55000 Mwh
26.	UpperBeda	IR	33	155(176)	10.8	90	33	160
27.	Man	IR	28	211(236)	17	145	28	236
28.	Lower Goi	IR	123	170(191)	21	155	119	176
29.	Jobat	IR	120	112(133)	15	105.25	80	112
30.	Sardar	IR	-	10357	-	4812	-	7300
	Sarovar	HP	-	0 Mwh	-	147000 Mwh	-	1173800 Mwh

Notes: 1. All values are in Mcm unless specified.
2. Value in bracket is Gross Irrigation.
3. W/S : Water supply, IR : Irrigation, HP : Hydropower.

Table 6.3 List of projects and reservoirs.

Sr.No.	Code of the Project (clubbed)	Name(s) of the Reservoirs included
Phase I		
1.	UPN	Upper Narmada
2.	BRG	Matiyari AND Bargi
3.	TSC	Tawa, Sukta AND Chhota Tawa
4.	BKL	Barna AND Kolar
5.	NSG	Narmada Sagar
6.	OMK	Omkareshwar
7.	MAH	Maheshwar
8	MAJ	Man AND Jobat
9.	SSP	Sardar Sarovar
Phase II		
1.	RGV	Raghavpur
2.	ROS	Rosra
3.	UBH	Upper Burhner AND Halon
4.	BAS	Basania(Sigarpur)
5.	CHN	Ataria AND Chinki
6.	SMS	Sher, Machrewa, AND Shakker
7.	STD	Sitarewa AND Dudhi
8.	MGL	Morand AND Ganjal
9.	UBL	Upper Beda AND Lower Goi

Table 6.4 Information of fixed and OMR costs of projects

Sr.No.	Code of the Project	Fixed Cost	Design OMR Cost Per Mcm	
			Unit 2	Unit 3
Phase I				
1.	UPN	2.58	0.00037	--
2.	BRG	36.23	0.00303	0.00014
3.	TSC	18.82	0.00156	--
4.	BKL	7.51	0.00135	--
5.	NSG	42.94	0.00063	0.00013
6.	OMK	22.99	0.00016	0.00008
7.	MAH	10.69	--	0.00004
8	MAJ	4.97	0.00143	--
9.	SSP	185.60	0.00024	0.00032
Phase II				
1.	RGV	0.75	--	0.00015
2.	ROS	1.31	--	0.00013
3.	UBH	12.39	0.00222	--
4.	BAS	16.62	--	0.00063
5.	CHN	13.95	0.00149	--
6.	SMS	13.27	0.00073	--
7.	STD	6.69	0.00123	0.00065
8.	MGL	9.13	0.00090	0.00000
9.	UBL	6.21	0.00159	--

Table 6.5 Simulation results of phase I combinations

No.	Project combination	Annual target IRRG (Mcm)	Annual target HP (MW)	Average Annual Release IRRG (Mcm)	Average Annual Release HP (Mcm)
1	0/	0.	0.	0.	0.
2	UPN/	301.	0.	287.	0.
3	BRG/	3284.	50.	3240.	4198.
4	UPN/BRG/	3284.	42.	3240.	3528.
5	TSC/	2480.	0.	2368.	0.
6	UPN/TSC/	2480.	0.	2368.	0.
7	BRG/TSC/	2480.	0.	2368.	0.
8	UPN/BRG/TSC/	2480.	0.	2368.	0.
9	BKL/	604.	0.	563.	0.
10	UPN/BKL/	604.	0.	563.	0.
11	BRG/BKL/	604.	0.	563.	0.
12	UPN/BRG/BKL/	604.	0.	563.	0.
13	TSC/BKL/	604.	0.	563.	0.
14	UPN/TSC/BKL/	604.	0.	563.	0.
15	BRG/TSC/BKL/	604.	0.	563.	0.
16	UPN/BRG/TSC/BKL/	604.	0.	563.	0.
17	NSG/	2274.	226.	2257.	15361.
18	UPN/NSG/	2274.	221.	2256.	14997.
19	BRG/NSG/	2274.	164.	2280.	11125.
20	UPN/BRG/NSG/	2274.	164.	2280.	11125.
21	TSC/NSG/	2274.	161.	2291.	10939.
22	UPN/TSC/NSG/	2274.	161.	2291.	10939.
23	BRG/TSC/NSG/	2274.	148.	2254.	10047.
24	UPN/BRG/TSC/NSG/	2274.	148.	2265.	10085.
25	BKL/NSG/	2274.	190.	2284.	12886.
26	UPN/BKL/NSG/	2274.	188.	2283.	12762.
27	BRG/BKL/NSG/	2274.	163.	2280.	11055.
28	UPN/BRG/BKL/NSG/	2274.	162.	2280.	10978.
29	TSC/BKL/NSG/	2274.	159.	2289.	10823.
30	UPN/TSC/BKL/NSG/	2274.	156.	2290.	10590.
31	BRG/TSC/BKL/NSG/	2274.	146.	2249.	9930.
32	UPN/BRG/TSC/BKL/NSG/	2274.	147.	2254.	9969.
33	OMK/	2790.	132.	2541.	15411.
34	UPN/OMK/	2790.	132.	2541.	15397.
35	BRG/OMK/	2790.	131.	2541.	15309.
36	UPN/BRG/OMK/	2790.	131.	2541.	15309.
37	TSC/OMK/	2790.	131.	2541.	15309.
38	UPN/TSC/OMK/	2790.	131.	2541.	15309.
39	BRG/TSC/OMK/	2790.	129.	2541.	15108.

Table 6.5 Continued

No.	Project combination	Annual target IRRG (Mcm)	Annual target HP (MW)	Average Annual Release IRRG (Mcm)	Average Annual Release HP (Mcm)
40	UPN/BRG/TSC/OMK/	2790.	129.	2541.	15108.
41	BKL/OMK/	2790.	135.	2541.	15739.
42	UPN/BKL/OMK/	2790.	132.	2541.	15376.
43	BRG/BKL/OMK/	2790.	130.	2541.	15243.
44	UPN/BRG/BKL/OMK/	2790.	130.	2541.	15243.
45	TSC/BKL/OMK/	2790.	131.	2541.	15309.
46	UPN/TSC/BKL/OMK/	2790.	130.	2541.	15243.
47	BRG/TSC/BKL/OMK/	2790.	129.	2541.	15096.
48	UPN/BRG/TSC/BKL/OMK/	2790.	129.	2541.	15096.
49	NSG/OMK/	2790.	119.	2541.	13934.
50	UPN/NSG/OMK/	2790.	119.	2541.	13934.
51	BRG/NSG/OMK/	2790.	120.	2541.	13982.
52	UPN/BRG/NSG/OMK/	2790.	120.	2541.	13975.
53	TSC/NSG/OMK/	2790.	119.	2541.	13908.
54	UPN/TSC/NSG/OMK/	2790.	120.	2541.	13982.
55	BRG/TSC/NSG/OMK/	2790.	120.	2541.	13982.
56	UPN/BRG/TSC/NSG/OMK/	2790.	120.	2541.	14021.
57	BKL/NSG/OMK/	2790.	120.	2541.	13982.
58	UPN/BKL/NSG/OMK/	2790.	120.	2541.	13975.
59	BRG/BKL/NSG/OMK/	2790.	120.	2541.	13973.
60	UPN/BRG/BKL/NSG/OMK/	2790.	120.	2541.	13973.
61	TSC/BKL/NSG/OMK/	2790.	120.	2541.	13975.
62	UPN/TSC/BKL/NSG/OMK/	2790.	119.	2541.	13934.
63	BRG/TSC/BKL/NSG/OMK/	2790.	120.	2541.	13973.
64	UPN/BRG/TSC/BKL/NSG/OMK/	2790.	120.	2541.	14049.
65	MAH/	0.	94.	0.	15286.
66	UPN/MAH/	0.	94.	0.	15286.
67	BRG/MAH/	0.	93.	0.	15156.
68	UPN/BRG/MAH/	0.	93.	0.	15156.
69	TSC/MAH/	0.	93.	0.	15183.
70	UPN/TSC/MAH/	0.	93.	0.	15175.
71	BRG/TSC/MAH/	0.	92.	0.	14924.
72	UPN/BRG/TSC/MAH/	0.	92.	0.	14924.
73	BKL/MAH/	0.	94.	0.	15268.
74	UPN/BKL/MAH/	0.	94.	0.	15268.
75	BRG/BKL/MAH/	0.	93.	0.	15138.
76	UPN/BRG/BKL/MAH/	0.	93.	0.	15138.
77	TSC/BKL/MAH/	0.	94.	0.	15230.
78	UPN/TSC/BKL/MAH/	0.	94.	0.	15230.
79	BRG/TSC/BKL/MAH/	0.	93.	0.	15170.
80	UPN/BRG/TSC/BKL/MAH/	0.	93.	0.	15170.
81	NSG/MAH/	0.	90.	0.	14571.
82	UPN/NSG/MAH/	0.	90.	0.	14571.

Table 6.5 Continued

No.	Project combination	Annual target		Average Annual Release	
		IRRG (Mcm)	HP (MW)	IRRG (Mcm)	HP (Mcm)
83	BRG/NSG/MAH/	0.	90.	0.	14571.
84	UPN/BRG/NSG/MAH/	0.	90.	0.	14571.
85	TSC/NSG/MAH/	0.	90.	0.	14571.
86	UPN/TSC/NSG/MAH/	0.	90.	0.	14571.
87	BRG/TSC/NSG/MAH/	0.	90.	0.	14571.
88	UPN/BRG/TSC/NSG/MAH/	0.	90.	0.	14571.
89	BKL/NSG/MAH/	0.	90.	0.	14571.
90	UPN/BKL/NSG/MAH/	0.	90.	0.	14571.
91	BRG/BKL/NSG/MAH/	0.	90.	0.	14571.
92	UPN/BRG/BKL/NSG/MAH/	0.	90.	0.	14571.
93	TSC/BKL/NSG/MAH/	0.	90.	0.	14571.
94	UPN/TSC/BKL/NSG/MAH/	0.	90.	0.	14571.
95	BRG/TSC/BKL/NSG/MAH/	0.	90.	0.	14571.
96	UPN/BRG/TSC/BKL/NSG/MAH/	0.	90.	0.	14571.
97	OMK/MAH/	0.	89.	0.	14524.
98	UPN/OMK/MAH/	0.	89.	0.	14524.
99	BRG/OMK/MAH/	0.	89.	0.	14524.
100	UPN/BRG/OMK/MAH/	0.	89.	0.	14524.
101	TSC/OMK/MAH/	0.	89.	0.	14524.
102	UPN/TSC/OMK/MAH/	0.	89.	0.	14524.
103	BRG/TSC/OMK/MAH/	0.	89.	0.	14524.
104	UPN/BRG/TSC/OMK/MAH/	0.	89.	0.	14524.
105	BKL/OMK/MAH/	0.	89.	0.	14524.
106	UPN/BKL/OMK/MAH/	0.	89.	0.	14524.
107	BRG/BKL/OMK/MAH/	0.	89.	0.	14524.
108	UPN/BRG/BKL/OMK/MAH/	0.	89.	0.	14524.
109	TSC/BKL/OMK/MAH/	0.	89.	0.	14524.
110	UPN/TSC/BKL/OMK/MAH/	0.	89.	0.	14524.
111	BRG/TSC/BKL/OMK/MAH/	0.	89.	0.	14524.
112	UPN/BRG/TSC/BKL/OMK/MAH/	0.	89.	0.	14524.
113	NSG/OMK/MAH/	0.	89.	0.	14516.
114	UPN/NSG/OMK/MAH/	0.	89.	0.	14516.
115	BRG/NSG/OMK/MAH/	0.	89.	0.	14516.
116	UPN/BRG/NSG/OMK/MAH/	0.	89.	0.	14516.
117	TSC/NSG/OMK/MAH/	0.	89.	0.	14516.
118	UPN/TSC/NSG/OMK/MAH/	0.	89.	0.	14516.
119	BRG/TSC/NSG/OMK/MAH/	0.	89.	0.	14516.
120	UPN/BRG/TSC/NSG/OMK/MAH/	0.	89.	0.	14516.
121	BKL/NSG/OMK/MAH/	0.	89.	0.	14516.
122	UPN/BKL/NSG/OMK/MAH/	0.	89.	0.	14516.
123	BRG/BKL/NSG/OMK/MAH/	0.	89.	0.	14516.
124	UPN/BRG/BKL/NSG/OMK/MAH/	0.	89.	0.	14516.
125	TSC/BKL/NSG/OMK/MAH/	0.	89.	0.	14516.
126	UPN/TSC/BKL/NSG/OMK/MAH/	0.	89.	0.	14516.

Table 6.5 Continued

No.	Project combination	Annual target IRRG (Mcm)	Annual target HP (MW)	Average Annual Release IRRG (Mcm)	Average Annual Release HP (Mcm)
127	BRG/TSC/BKL/NSG/OMK/MAH/	0.	89.	0.	14516.
128	UPN/BRG/TSC/BKL/NSG/OMK/MAH/	0.	89.	0.	14516.
129	MAJ/	348.	0.	337.	0.
130	UPN/MAJ/	348.	0.	337.	0.
131	BRG/MAJ/	348.	0.	337.	0.
132	UPN/BRG/MAJ/	348.	0.	337.	0.
133	TSC/MAJ/	348.	0.	337.	0.
134	UPN/TSC/MAJ/	348.	0.	337.	0.
135	BRG/TSC/MAJ/	348.	0.	337.	0.
136	UPN/BRG/TSC/MAJ/	348.	0.	337.	0.
137	BKL/MAJ/	348.	0.	337.	0.
138	UPN/BKL/MAJ/	348.	0.	337.	0.
139	BRG/BKL/MAJ/	348.	0.	337.	0.
140	UPN/BRG/BKL/MAJ/	348.	0.	337.	0.
141	TSC/BKL/MAJ/	348.	0.	337.	0.
142	UPN/TSC/BKL/MAJ/	348.	0.	337.	0.
143	BRG/TSC/BKL/MAJ/	348.	0.	337.	0.
144	UPN/BRG/TSC/BKL/MAJ/	348.	0.	337.	0.
145	NSG/MAJ/	348.	0.	337.	0.
146	UPN/NSG/MAJ/	348.	0.	337.	0.
147	BRG/NSG/MAJ/	348.	0.	337.	0.
148	UPN/BRG/NSG/MAJ/	348.	0.	337.	0.
149	TSC/NSG/MAJ/	348.	0.	337.	0.
150	UPN/TSC/NSG/MAJ/	348.	0.	337.	0.
151	BRG/TSC/NSG/MAJ/	348.	0.	337.	0.
152	UPN/BRG/TSC/NSG/MAJ/	348.	0.	337.	0.
153	BKL/NSG/MAJ/	348.	0.	337.	0.
154	UPN/BKL/NSG/MAJ/	348.	0.	337.	0.
155	BRG/BKL/NSG/MAJ/	348.	0.	337.	0.
156	UPN/BRG/BKL/NSG/MAJ/	348.	0.	337.	0.
157	TSC/BKL/NSG/MAJ/	348.	0.	337.	0.
158	UPN/TSC/BKL/NSG/MAJ/	348.	0.	337.	0.
159	BRG/TSC/BKL/NSG/MAJ/	348.	0.	337.	0.
160	UPN/BRG/TSC/BKL/NSG/MAJ/	348.	0.	337.	0.
161	OMK/MAJ/	348.	0.	337.	0.
162	UPN/OMK/MAJ/	348.	0.	337.	0.
163	BRG/OMK/MAJ/	348.	0.	337.	0.
164	UPN/BRG/OMK/MAJ/	348.	0.	337.	0.
165	TSC/OMK/MAJ/	348.	0.	337.	0.
166	UPN/TSC/OMK/MAJ/	348.	0.	337.	0.
167	BRG/TSC/OMK/MAJ/	348.	0.	337.	0.
168	UPN/BRG/TSC/OMK/MAJ/	348.	0.	337.	0.
169	BKL/OMK/MAJ/	348.	0.	337.	0.

Table 6.5 Continued

No.	Project combination	Annual target		Average Annual Release	
		IRRG (Mcm)	HP (MW)	IRRG (Mcm)	HP (Mcm)
170	UPN/BKL/OMK/MAJ/	348.	0.	337.	0.
171	BRG/BKL/OMK/MAJ/	348.	0.	337.	0.
172	UPN/BRG/BKL/OMK/MAJ/	348.	0.	337.	0.
173	TSC/BKL/OMK/MAJ/	348.	0.	337.	0.
174	UPN/TSC/BKL/OMK/MAJ/	348.	0.	337.	0.
175	BRG/TSC/BKL/OMK/MAJ/	348.	0.	337.	0.
176	UPN/BRG/TSC/BKL/OMK/MAJ/	348.	0.	337.	0.
177	NSG/OMK/MAJ/	348.	0.	337.	0.
178	UPN/NSG/OMK/MAJ/	348.	0.	337.	0.
179	BRG/NSG/OMK/MAJ/	348.	0.	337.	0.
180	UPN/BRG/NSG/OMK/MAJ/	348.	0.	337.	0.
181	TSC/NSG/OMK/MAJ/	348.	0.	337.	0.
182	UPN/TSC/NSG/OMK/MAJ/	348.	0.	337.	0.
183	BRG/TSC/NSG/OMK/MAJ/	348.	0.	337.	0.
184	UPN/BRG/TSC/NSG/OMK/MAJ/	348.	0.	337.	0.
185	BKL/NSG/OMK/MAJ/	348.	0.	337.	0.
186	UPN/BKL/NSG/OMK/MAJ/	348.	0.	337.	0.
187	BRG/BKL/NSG/OMK/MAJ/	348.	0.	337.	0.
188	UPN/BRG/BKL/NSG/OMK/MAJ/	348.	0.	337.	0.
189	TSC/BKL/NSG/OMK/MAJ/	348.	0.	337.	0.
190	UPN/TSC/BKL/NSG/OMK/MAJ/	348.	0.	337.	0.
191	BRG/TSC/BKL/NSG/OMK/MAJ/	348.	0.	337.	0.
192	UPN/BRG/TSC/BKL/NSG/OMK/MAJ/	348.	0.	337.	0.
193	MAH/MAJ/	348.	0.	337.	0.
194	UPN/MAH/MAJ/	348.	0.	337.	0.
195	BRG/MAH/MAJ/	348.	0.	337.	0.
196	UPN/BRG/MAH/MAJ/	348.	0.	337.	0.
197	TSC/MAH/MAJ/	348.	0.	337.	0.
198	UPN/TSC/MAH/MAJ/	348.	0.	337.	0.
199	BRG/TSC/MAH/MAJ/	348.	0.	337.	0.
200	UPN/BRG/TSC/MAH/MAJ/	348.	0.	337.	0.
201	BKL/MAH/MAJ/	348.	0.	337.	0.
202	UPN/BKL/MAH/MAJ/	348.	0.	337.	0.
203	BRG/BKL/MAH/MAJ/	348.	0.	337.	0.
204	UPN/BRG/BKL/MAH/MAJ/	348.	0.	337.	0.
205	TSC/BKL/MAH/MAJ/	348.	0.	337.	0.
206	UPN/TSC/BKL/MAH/MAJ/	348.	0.	337.	0.
207	BRG/TSC/BKL/MAH/MAJ/	348.	0.	337.	0.
208	UPN/BRG/TSC/BKL/MAH/MAJ/	348.	0.	337.	0.
209	NSG/MAH/MAJ/	348.	0.	337.	0.
210	UPN/NSG/MAH/MAJ/	348.	0.	337.	0.
211	BRG/NSG/MAH/MAJ/	348.	0.	337.	0.
212	UPN/BRG/NSG/MAH/MAJ/	348.	0.	337.	0.
213	TSC/NSG/MAH/MAJ/	348.	0.	337.	0.

Table 6.5 Continued

No.	Project combination	Annual target IRRG (Mcm)	Annual target HP (MW)	Average Annual Release IRRG (Mcm)	Average Annual Release HP (Mcm)
214	UPN/TSC/NSG/MAH/MAJ/	348.	0.	337.	0.
215	BRG/TSC/NSG/MAH/MAJ/	348.	0.	337.	0.
216	UPN/BRG/TSC/NSG/MAH/MAJ/	348.	0.	337.	0.
217	BKL/NSG/MAH/MAJ/	348.	0.	337.	0.
218	UPN/BKL/NSG/MAH/MAJ/	348.	0.	337.	0.
219	BRG/BKL/NSG/MAH/MAJ/	348.	0.	337.	0.
220	UPN/BRG/BKL/NSG/MAH/MAJ/	348.	0.	337.	0.
221	TSC/BKL/NSG/MAH/MAJ/	348.	0.	337.	0.
222	UPN/TSC/BKL/NSG/MAH/MAJ/	348.	0.	337.	0.
223	BRG/TSC/BKL/NSG/MAH/MAJ/	348.	0.	337.	0.
224	UPN/BRG/TSC/BKL/NSG/MAH/MAJ/	348.	0.	337.	0.
225	OMK/MAH/MAJ/	348.	0.	337.	0.
226	UPN/OMK/MAH/MAJ/	348.	0.	337.	0.
227	BRG/OMK/MAH/MAJ/	348.	0.	337.	0.
228	UPN/BRG/OMK/MAH/MAJ/	348.	0.	337.	0.
229	TSC/OMK/MAH/MAJ/	348.	0.	337.	0.
230	UPN/TSC/OMK/MAH/MAJ/	348.	0.	337.	0.
231	BRG/TSC/OMK/MAH/MAJ/	348.	0.	337.	0.
232	UPN/BRG/TSC/OMK/MAH/MAJ/	348.	0.	337.	0.
233	BKL/OMK/MAH/MAJ/	348.	0.	337.	0.
234	UPN/BKL/OMK/MAH/MAJ/	348.	0.	337.	0.
235	BRG/BKL/OMK/MAH/MAJ/	348.	0.	337.	0.
236	UPN/BRG/BKL/OMK/MAH/MAJ/	348.	0.	337.	0.
237	TSC/BKL/OMK/MAH/MAJ/	348.	0.	337.	0.
238	UPN/TSC/BKL/OMK/MAH/MAJ/	348.	0.	337.	0.
239	BRG/TSC/BKL/OMK/MAH/MAJ/	348.	0.	337.	0.
240	UPN/BRG/TSC/BKL/OMK/MAH/MAJ/	348.	0.	337.	0.
241	NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
242	UPN/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
243	BRG/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
244	UPN/BRG/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
245	TSC/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
246	UPN/TSC/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
247	BRG/TSC/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
248	UPN/BRG/TSC/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
249	BKL/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
250	UPN/BKL/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
251	BRG/BKL/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
252	UPN/BRG/BKL/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
253	TSC/BKL/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
254	UPN/TSC/BKL/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
255	BRG/TSC/BKL/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.
256	UPN/BRG/TSC/BKL/NSG/OMK/MAH/MAJ/	348.	0.	337.	0.

Table 6.5 Continued

No.	Project combination	Annual target		Average Annual Release	
		IRRG (Mcm)	HP (MW)	IRRG (Mcm)	HP (Mcm)
257	SSP/	7300.	415.	6820.	15623.
258	UPN/SSP/	7300.	414.	6820.	15580.
259	BRG/SSP/	7300.	407.	6813.	15322.
260	UPN/BRG/SSP/	7300.	407.	6813.	15322.
261	TSC/SSP/	7300.	408.	6817.	15366.
262	UPN/TSC/SSP/	7300.	410.	6812.	15451.
263	BRG/TSC/SSP/	7300.	403.	6764.	15171.
264	UPN/BRG/TSC/SSP/	7300.	403.	6764.	15171.
265	BKL/SSP/	7300.	414.	6819.	15580.
266	UPN/BKL/SSP/	7300.	413.	6818.	15560.
267	BRG/BKL/SSP/	7300.	405.	6813.	15257.
268	UPN/BRG/BKL/SSP/	7300.	405.	6813.	15257.
269	TSC/BKL/SSP/	7300.	407.	6816.	15322.
270	UPN/TSC/BKL/SSP/	7300.	408.	6813.	15343.
271	BRG/TSC/BKL/SSP/	7300.	402.	6749.	15128.
272	UPN/BRG/TSC/BKL/SSP/	7300.	402.	6749.	15128.
273	NSG/SSP/	7300.	226.	6674.	8510.
274	UPN/NSG/SSP/	7300.	226.	6674.	8510.
275	BRG/NSG/SSP/	7300.	226.	6688.	8510.
276	UPN/BRG/NSG/SSP/	7300.	226.	6688.	8510.
277	TSC/NSG/SSP/	7300.	243.	6665.	9133.
278	UPN/TSC/NSG/SSP/	7300.	231.	6669.	8682.
279	BRG/TSC/NSG/SSP/	7300.	171.	6682.	6447.
280	UPN/BRG/TSC/NSG/SSP/	7300.	172.	6679.	6469.
281	BKL/NSG/SSP/	7300.	251.	6661.	9434.
282	UPN/BKL/NSG/SSP/	7300.	243.	6664.	9133.
283	BRG/BKL/NSG/SSP/	7300.	226.	6684.	8489.
284	UPN/BRG/BKL/NSG/SSP/	7300.	226.	6677.	8510.
285	TSC/BKL/NSG/SSP/	7300.	238.	6667.	8962.
286	UPN/TSC/BKL/NSG/SSP/	7300.	232.	6669.	8747.
287	BRG/TSC/BKL/NSG/SSP/	7300.	130.	6676.	4901.
288	UPN/BRG/TSC/BKL/NSG/SSP/	7300.	130.	6664.	4901.
289	OMK/SSP/	7300.	388.	6829.	14613.
290	UPN/OMK/SSP/	7300.	388.	6829.	14591.
291	BRG/OMK/SSP/	7300.	380.	6829.	14312.
292	UPN/BRG/OMK/SSP/	7300.	380.	6829.	14312.
293	TSC/OMK/SSP/	7300.	384.	6792.	14462.
294	UPN/TSC/OMK/SSP/	7300.	383.	6791.	14419.
295	BRG/TSC/OMK/SSP/	7300.	379.	6756.	14277.
296	UPN/BRG/TSC/OMK/SSP/	7300.	379.	6756.	14277.
297	BKL/OMK/SSP/	7300.	386.	6829.	14548.
298	UPN/BKL/OMK/SSP/	7300.	386.	6829.	14526.
299	BRG/BKL/OMK/SSP/	7300.	380.	6826.	14290.
300	UPN/BRG/BKL/OMK/SSP/	7300.	380.	6826.	14290.

Table 6.5 Continued

No.	Project combination	Annual target		Average Annual Release	
		IRRG (Mcm)	HP (MW)	IRRG (Mcm)	HP (Mcm)
301	TSC/BKL/OMK/SSP/	7300.	381.	6791.	14355.
302	UPN/TSC/BKL/OMK/SSP/	7300.	383.	6790.	14419.
303	BRG/TSC/BKL/OMK/SSP/	7300.	377.	6756.	14204.
304	UPN/BRG/TSC/BKL/OMK/SSP/	7300.	377.	6756.	14204.
305	NSG/OMK/SSP/	7300.	212.	6674.	7973.
306	UPN/NSG/OMK/SSP/	7300.	212.	6675.	7973.
307	BRG/NSG/OMK/SSP/	7300.	218.	6676.	8210.
308	UPN/BRG/NSG/OMK/SSP/	7300.	218.	6679.	8210.
309	TSC/NSG/OMK/SSP/	7300.	236.	6664.	8896.
310	UPN/TSC/NSG/OMK/SSP/	7300.	222.	6671.	8338.
311	BRG/TSC/NSG/OMK/SSP/	7300.	156.	6647.	5862.
312	UPN/BRG/TSC/NSG/OMK/SSP/	7300.	151.	6644.	5674.
313	BKL/NSG/OMK/SSP/	7300.	245.	6660.	9220.
314	UPN/BKL/NSG/OMK/SSP/	7300.	242.	6663.	9112.
315	BRG/BKL/NSG/OMK/SSP/	7300.	198.	6659.	7436.
316	UPN/BRG/BKL/NSG/OMK/SSP/	7300.	192.	6661.	7243.
317	TSC/BKL/NSG/OMK/SSP/	7300.	213.	6671.	8016.
318	UPN/TSC/BKL/NSG/OMK/SSP/	7300.	205.	6673.	7715.
319	BRG/TSC/BKL/NSG/OMK/SSP/	7300.	130.	6589.	4901.
320	UPN/BRG/TSC/BKL/NSG/OMK/SSP/	7300.	130.	6581.	4901.
321	MAH/SSP/	7300.	394.	6822.	14849.
322	UPN/MAH/SSP/	7300.	394.	6822.	14828.
323	BRG/MAH/SSP/	7300.	389.	6821.	14634.
324	UPN/BRG/MAH/SSP/	7300.	389.	6821.	14634.
325	TSC/MAH/SSP/	7300.	387.	6821.	14570.
326	UPN/TSC/MAH/SSP/	7300.	386.	6821.	14548.
327	BRG/TSC/MAH/SSP/	7300.	358.	6817.	13478.
328	UPN/BRG/TSC/MAH/SSP/	7300.	358.	6817.	13478.
329	BKL/MAH/SSP/	7300.	394.	6822.	14828.
330	UPN/BKL/MAH/SSP/	7300.	393.	6821.	14806.
331	BRG/BKL/MAH/SSP/	7300.	388.	6821.	14591.
332	UPN/BRG/BKL/MAH/SSP/	7300.	388.	6821.	14591.
333	TSC/BKL/MAH/SSP/	7300.	385.	6820.	14505.
334	UPN/TSC/BKL/MAH/SSP/	7300.	385.	6820.	14505.
335	BRG/TSC/BKL/MAH/SSP/	7300.	352.	6816.	13258.
336	UPN/BRG/TSC/BKL/MAH/SSP/	7300.	352.	6816.	13258.
337	NSG/MAH/SSP/	7300.	208.	6730.	7823.
338	UPN/NSG/MAH/SSP/	7300.	208.	6730.	7823.
339	BRG/NSG/MAH/SSP/	7300.	208.	6738.	7823.
340	UPN/BRG/NSG/MAH/SSP/	7300.	208.	6738.	7823.
341	TSC/NSG/MAH/SSP/	7300.	208.	6730.	7823.
342	UPN/TSC/NSG/MAH/SSP/	7300.	208.	6730.	7823.
343	BRG/TSC/NSG/MAH/SSP/	7300.	200.	6706.	7544.
344	UPN/BRG/TSC/NSG/MAH/SSP/	7300.	200.	6704.	7544.

Table 6.5 Continued

No.	Project combination	Annual target		Average Annual Release	
		IRRG (Mcm)	HP (MW)	IRRG (Mcm)	HP (Mcm)
345	BKL/NSG/MAH/SSP/	7300.	208.	6730.	7823.
346	UPN/BKL/NSG/MAH/SSP/	7300.	208.	6730.	7823.
347	BRG/BKL/NSG/MAH/SSP/	7300.	208.	6738.	7823.
348	UPN/BRG/BKL/NSG/MAH/SSP/	7300.	208.	6738.	7823.
349	TSC/BKL/NSG/MAH/SSP/	7300.	208.	6730.	7823.
350	UPN/TSC/BKL/NSG/MAH/SSP/	7300.	208.	6730.	7823.
351	BRG/TSC/BKL/NSG/MAH/SSP/	7300.	200.	6688.	7541.
352	UPN/BRG/TSC/BKL/NSG/MAH/SSP/	7300.	198.	6679.	7457.
353	OMK/MAH/SSP/	7300.	390.	6854.	14677.
354	UPN/OMK/MAH/SSP/	7300.	390.	6854.	14677.
355	BRG/OMK/MAH/SSP/	7300.	382.	6848.	14376.
356	UPN/BRG/OMK/MAH/SSP/	7300.	382.	6848.	14376.
357	TSC/OMK/MAH/SSP/	7300.	382.	6821.	14376.
358	UPN/TSC/OMK/MAH/SSP/	7300.	378.	6820.	14226.
359	BRG/TSC/OMK/MAH/SSP/	7300.	330.	6813.	12421.
360	UPN/BRG/TSC/OMK/MAH/SSP/	7300.	330.	6813.	12421.
361	BKL/OMK/MAH/SSP/	7300.	389.	6853.	14656.
362	UPN/BKL/OMK/MAH/SSP/	7300.	389.	6853.	14634.
363	BRG/BKL/OMK/MAH/SSP/	7300.	382.	6837.	14376.
364	UPN/BRG/BKL/OMK/MAH/SSP/	7300.	382.	6837.	14376.
365	TSC/BKL/OMK/MAH/SSP/	7300.	376.	6820.	14140.
366	UPN/TSC/BKL/OMK/MAH/SSP/	7300.	373.	6819.	14053.
367	BRG/TSC/BKL/OMK/MAH/SSP/	7300.	321.	6812.	12099.
368	UPN/BRG/TSC/BKL/OMK/MAH/SSP/	7300.	321.	6812.	12099.
369	NSG/OMK/MAH/SSP/	7300.	204.	6689.	7672.
370	UPN/NSG/OMK/MAH/SSP/	7300.	204.	6674.	7672.
371	BRG/NSG/OMK/MAH/SSP/	7300.	204.	6683.	7672.
372	UPN/BRG/NSG/OMK/MAH/SSP/	7300.	204.	6683.	7672.
373	TSC/NSG/OMK/MAH/SSP/	7300.	208.	6698.	7823.
374	UPN/TSC/NSG/OMK/MAH/SSP/	7300.	204.	6691.	7672.
375	BRG/TSC/NSG/OMK/MAH/SSP/	7300.	165.	6659.	6211.
376	UPN/BRG/TSC/NSG/OMK/MAH/SSP/	7300.	165.	6656.	6211.
377	BKL/NSG/OMK/MAH/SSP/	7300.	205.	6698.	7715.
378	UPN/BKL/NSG/OMK/MAH/SSP/	7300.	204.	6685.	7672.
379	BRG/BKL/NSG/OMK/MAH/SSP/	7300.	204.	6683.	7672.
380	UPN/BRG/BKL/NSG/OMK/MAH/SSP/	7300.	204.	6681.	7672.
381	TSC/BKL/NSG/OMK/MAH/SSP/	7300.	220.	6666.	8274.
382	UPN/TSC/BKL/NSG/OMK/MAH/SSP/	7300.	204.	6695.	7672.
383	BRG/TSC/BKL/NSG/OMK/MAH/SSP/	7300.	140.	6610.	5266.
384	UPN/BRG/TSC/BKL/NSG/OMK/MAH/SSP/	7300.	140.	6599.	5266.
385	MAJ/SSP/	7300.	414.	6820.	15580.
386	UPN/MAJ/SSP/	7300.	407.	6819.	15322.
387	BRG/MAJ/SSP/	7300.	406.	6812.	15279.
388	UPN/BRG/MAJ/SSP/	7300.	406.	6812.	15279.

Table 6.5 Continued

No.	Project combination	Annual target		Average Annual Release	
		IRRG (Mcm)	HP (MW)	IRRG (Mcm)	HP (Mcm)
389	TSC/MAJ/SSP/	7300.	409.	6814.	15407.
390	UPN/TSC/MAJ/SSP/	7300.	409.	6811.	15407.
391	BRG/TSC/MAJ/SSP/	7300.	402.	6750.	15150.
392	UPN/BRG/TSC/MAJ/SSP/	7300.	402.	6750.	15150.
393	BKL/MAJ/SSP/	7300.	413.	6819.	15537.
394	UPN/BKL/MAJ/SSP/	7300.	412.	6817.	15515.
395	BRG/BKL/MAJ/SSP/	7300.	405.	6812.	15236.
396	UPN/BRG/BKL/MAJ/SSP/	7300.	405.	6812.	15236.
397	TSC/BKL/MAJ/SSP/	7300.	406.	6815.	15300.
398	UPN/TSC/BKL/MAJ/SSP/	7300.	409.	6811.	15386.
399	BRG/TSC/BKL/MAJ/SSP/	7300.	401.	6746.	15085.
400	UPN/BRG/TSC/BKL/MAJ/SSP/	7300.	401.	6746.	15085.
401	NSG/MAJ/SSP/	7300.	200.	6668.	7544.
402	UPN/NSG/MAJ/SSP/	7300.	200.	6668.	7544.
403	BRG/NSG/MAJ/SSP/	7300.	200.	6682.	7544.
404	UPN/BRG/NSG/MAJ/SSP/	7300.	200.	6683.	7544.
405	TSC/NSG/MAJ/SSP/	7300.	228.	6663.	8596.
406	UPN/TSC/NSG/MAJ/SSP/	7300.	227.	6666.	8553.
407	BRG/TSC/NSG/MAJ/SSP/	7300.	130.	6639.	4901.
408	UPN/BRG/TSC/NSG/MAJ/SSP/	7300.	130.	6638.	4901.
409	BKL/NSG/MAJ/SSP/	7300.	237.	6658.	8919.
410	UPN/BKL/NSG/MAJ/SSP/	7300.	228.	6664.	8596.
411	BRG/BKL/NSG/MAJ/SSP/	7300.	200.	6671.	7544.
412	UPN/BRG/BKL/NSG/MAJ/SSP/	7300.	200.	6665.	7544.
413	TSC/BKL/NSG/MAJ/SSP/	7300.	208.	6665.	7844.
414	UPN/TSC/BKL/NSG/MAJ/SSP/	7300.	208.	6666.	7844.
415	BRG/TSC/BKL/NSG/MAJ/SSP/	7300.	130.	6617.	4901.
416	UPN/BRG/TSC/BKL/NSG/MAJ/SSP/	7300.	130.	6611.	4901.
417	OMK/MAJ/SSP/	7300.	386.	6830.	14548.
418	UPN/OMK/MAJ/SSP/	7300.	386.	6830.	14540.
419	BRG/OMK/MAJ/SSP/	7300.	378.	6828.	14248.
420	UPN/BRG/OMK/MAJ/SSP/	7300.	378.	6828.	14248.
421	TSC/OMK/MAJ/SSP/	7300.	383.	6791.	14419.
422	UPN/TSC/OMK/MAJ/SSP/	7300.	382.	6791.	14376.
423	BRG/TSC/OMK/MAJ/SSP/	7300.	378.	6756.	14226.
424	UPN/BRG/TSC/OMK/MAJ/SSP/	7300.	384.	6749.	14441.
425	BKL/OMK/MAJ/SSP/	7300.	386.	6830.	14514.
426	UPN/BKL/OMK/MAJ/SSP/	7300.	385.	6830.	14497.
427	BRG/BKL/OMK/MAJ/SSP/	7300.	378.	6816.	14248.
428	UPN/BRG/BKL/OMK/MAJ/SSP/	7300.	378.	6816.	14248.
429	TSC/BKL/OMK/MAJ/SSP/	7300.	381.	6789.	14333.
430	UPN/TSC/BKL/OMK/MAJ/SSP/	7300.	382.	6780.	14376.
431	BRG/TSC/BKL/OMK/MAJ/SSP/	7300.	376.	6753.	14161.
432	UPN/BRG/TSC/BKL/OMK/MAJ/SSP/	7300.	376.	6753.	14161.

Table 6.5 Continued

No.	Project combination	Annual target		Average Annual Release	
		IRRG (Mcm)	HP (MW)	IRRG (Mcm)	HP (Mcm)
433	NSG/OMK/MAJ/SSP/	7300.	181.	6666.	6826.
434	UPN/NSG/OMK/MAJ/SSP/	7300.	183.	6666.	6877.
435	BRG/NSG/OMK/MAJ/SSP/	7300.	192.	6674.	7221.
436	UPN/BRG/NSG/OMK/MAJ/SSP/	7300.	159.	6654.	5996.
437	TSC/NSG/OMK/MAJ/SSP/	7300.	218.	6654.	8210.
438	UPN/TSC/NSG/OMK/MAJ/SSP/	7300.	162.	6655.	6100.
439	BRG/TSC/NSG/OMK/MAJ/SSP/	7300.	130.	6558.	4901.
440	UPN/BRG/TSC/NSG/OMK/MAJ/SSP/	7300.	130.	6554.	4901.
441	BKL/NSG/OMK/MAJ/SSP/	7300.	213.	6643.	8016.
442	UPN/BKL/NSG/OMK/MAJ/SSP/	7300.	196.	6651.	7393.
443	BRG/BKL/NSG/OMK/MAJ/SSP/	7300.	148.	6634.	5588.
444	UPN/BRG/BKL/NSG/OMK/MAJ/SSP/	7300.	130.	6627.	4901.
445	TSC/BKL/NSG/OMK/MAJ/SSP/	7300.	184.	6653.	6920.
446	UPN/TSC/BKL/NSG/OMK/MAJ/SSP/	7300.	172.	6654.	6469.
447	BRG/TSC/BKL/NSG/OMK/MAJ/SSP/	7300.	130.	6539.	4901.
448	UPN/BRG/TSC/BKL/NSG/OMK/MAJ/SSP/	7300.	130.	6527.	4901.
449	MAH/MAJ/SSP/	7300.	395.	6813.	14866.
450	UPN/MAH/MAJ/SSP/	7300.	394.	6813.	14828.
451	BRG/MAH/MAJ/SSP/	7300.	389.	6812.	14634.
452	UPN/BRG/MAH/MAJ/SSP/	7300.	389.	6812.	14634.
453	TSC/MAH/MAJ/SSP/	7300.	387.	6812.	14570.
454	UPN/TSC/MAH/MAJ/SSP/	7300.	386.	6812.	14548.
455	BRG/TSC/MAH/MAJ/SSP/	7300.	354.	6807.	13323.
456	UPN/BRG/TSC/MAH/MAJ/SSP/	7300.	354.	6807.	13323.
457	BKL/MAH/MAJ/SSP/	7300.	394.	6813.	14832.
458	UPN/BKL/MAH/MAJ/SSP/	7300.	393.	6813.	14806.
459	BRG/BKL/MAH/MAJ/SSP/	7300.	388.	6812.	14591.
460	UPN/BRG/BKL/MAH/MAJ/SSP/	7300.	388.	6813.	14591.
461	TSC/BKL/MAH/MAJ/SSP/	7300.	385.	6812.	14484.
462	UPN/TSC/BKL/MAH/MAJ/SSP/	7300.	385.	6812.	14475.
463	BRG/TSC/BKL/MAH/MAJ/SSP/	7300.	348.	6807.	13108.
464	UPN/BRG/TSC/BKL/MAH/MAJ/SSP/	7300.	348.	6807.	13108.
465	NSG/MAH/MAJ/SSP/	7300.	208.	6692.	7840.
466	UPN/NSG/MAH/MAJ/SSP/	7300.	208.	6692.	7840.
467	BRG/NSG/MAH/MAJ/SSP/	7300.	208.	6701.	7840.
468	UPN/BRG/NSG/MAH/MAJ/SSP/	7300.	208.	6701.	7840.
469	TSC/NSG/MAH/MAJ/SSP/	7300.	208.	6702.	7840.
470	UPN/TSC/NSG/MAH/MAJ/SSP/	7300.	208.	6698.	7840.
471	BRG/TSC/NSG/MAH/MAJ/SSP/	7300.	188.	6680.	7092.
472	UPN/BRG/TSC/NSG/MAH/MAJ/SSP/	7300.	188.	6677.	7092.
473	BKL/NSG/MAH/MAJ/SSP/	7300.	208.	6702.	7840.
474	UPN/BKL/NSG/MAH/MAJ/SSP/	7300.	208.	6702.	7840.
475	BRG/BKL/NSG/MAH/MAJ/SSP/	7300.	208.	6701.	7840.
476	UPN/BRG/BKL/NSG/MAH/MAJ/SSP/	7300.	208.	6701.	7840.

Table 6.5 Continued

No.	Project combination	Annual target		Average Annual Release	
		IRRG (Mcm)	HP (MW)	IRRG (Mcm)	HP (Mcm)
477	TSC/BKL/NSG/MAH/MAJ/SSP/	7300.	208.	6701.	7840.
478	UPN/TSC/BKL/NSG/MAH/MAJ/SSP/	7300.	208.	6700.	7840.
479	BRG/TSC/BKL/NSG/MAH/MAJ/SSP/	7300.	188.	6661.	7092.
480	UPN/BRG/TSC/BKL/NSG/MAH/MAJ/SSP/	7300.	174.	6661.	6555.
481	OMK/MAH/MAJ/SSP/	7300.	390.	6845.	14677.
482	UPN/OMK/MAH/MAJ/SSP/	7300.	390.	6845.	14677.
483	BRG/OMK/MAH/MAJ/SSP/	7300.	382.	6831.	14372.
484	UPN/BRG/OMK/MAH/MAJ/SSP/	7300.	382.	6831.	14372.
485	TSC/OMK/MAH/MAJ/SSP/	7300.	378.	6811.	14248.
486	UPN/TSC/OMK/MAH/MAJ/SSP/	7300.	374.	6810.	14097.
487	BRG/TSC/OMK/MAH/MAJ/SSP/	7300.	325.	6803.	12240.
488	UPN/BRG/TSC/OMK/MAH/MAJ/SSP/	7300.	325.	6803.	12240.
489	BKL/OMK/MAH/MAJ/SSP/	7300.	389.	6845.	14634.
490	UPN/BKL/OMK/MAH/MAJ/SSP/	7300.	388.	6845.	14591.
491	BRG/BKL/OMK/MAH/MAJ/SSP/	7300.	381.	6821.	14355.
492	UPN/BRG/BKL/OMK/MAH/MAJ/SSP/	7300.	381.	6821.	14355.
493	TSC/BKL/OMK/MAH/MAJ/SSP/	7300.	381.	6812.	14355.
494	UPN/TSC/BKL/OMK/MAH/MAJ/SSP/	7300.	379.	6811.	14260.
495	BRG/TSC/BKL/OMK/MAH/MAJ/SSP/	7300.	331.	6804.	12451.
496	UPN/BRG/TSC/BKL/OMK/MAH/MAJ/SSP/	7300.	331.	6804.	12451.
497	NSG/OMK/MAH/MAJ/SSP/	7300.	204.	6658.	7689.
498	UPN/NSG/OMK/MAH/MAJ/SSP/	7300.	204.	6658.	7689.
499	BRG/NSG/OMK/MAH/MAJ/SSP/	7300.	204.	6668.	7689.
500	UPN/BRG/NSG/OMK/MAH/MAJ/SSP/	7300.	204.	6668.	7689.
501	TSC/NSG/OMK/MAH/MAJ/SSP/	7300.	204.	6674.	7689.
502	UPN/TSC/NSG/OMK/MAH/MAJ/SSP/	7300.	204.	6660.	7689.
503	BRG/TSC/NSG/OMK/MAH/MAJ/SSP/	7300.	134.	6623.	5029.
504	UPN/BRG/TSC/NSG/OMK/MAH/MAJ/SSP/	7300.	134.	6620.	5029.
505	BKL/NSG/OMK/MAH/MAJ/SSP/	7300.	204.	6663.	7689.
506	UPN/BKL/NSG/OMK/MAH/MAJ/SSP/	7300.	204.	6652.	7689.
507	BRG/BKL/NSG/OMK/MAH/MAJ/SSP/	7300.	183.	6652.	6877.
508	UPN/BRG/BKL/NSG/OMK/MAH/MAJ/SSP/	7300.	183.	6649.	6877.
509	TSC/BKL/NSG/OMK/MAH/MAJ/SSP/	7300.	203.	6649.	7629.
510	UPN/TSC/BKL/NSG/OMK/MAH/MAJ/SSP/	7300.	198.	6650.	7457.
511	BRG/TSC/BKL/NSG/OMK/MAH/MAJ/SSP/	7300.	134.	6568.	5047.
512	UPN/BRG/TSC/BKL/NSG/OMK/MAH/MAJ/SSP/	7300.	134.	6557.	5047.

Note : Hydropower targets are firm.

Table 6.5 Concluded

Table 6.6 Simulations results of Phase II combinations

Project combination	Downstream most project			
	Target		Release	
	Irrigation (Mcm)	Hydropower (MW)	Irrigation (Mcm)	Hydropower (Mcm)
1. RGV	--	4.00	--	313.80
2. ROS	--	7.00	--	506.67
3. RGV/ROS	--	7.00	--	506.67
4. UBH	443	--	421.34	--
5. BAS	--	20.00	--	1744.58
6. RGV/BAS	--	20.00	--	1744.58
7. ROS/BAS	--	20.00	--	1744.58
8. RGV/ROS/BAS	--	19.20	--	1641.32
9. UBH/BAS	--	20.00	--	1726.71
10. RGV/UBH/BAS	--	16.46	--	1401.89
11. ROS/UBH/BAS	--	14.17	--	1203.28
12. RGV/ROS/UBH/BAS	--	16.24	--	1373.16
13. CHN	960	--	933	--
14. SMS	786	--	736	--
15. STD	212	4.00	199	69
16. MGL	443	--	413	--
17. UBL	336	--	319	--

Table 6.7 Comparative statement of targets for various categories.

SN	Name of Clubbed Project	Targets					
		Master Plan		Mixed		22 Year Simulation	
		Irrigation (Mcm)/(Mha)	Hydro-power (Mw)	Irrigation (Mcm)/(Mha)	Hydro-power (Mw)	Irrigation (Mcm)/(Mha)	Hydro-power (Mw)
PHASE-I							
1.	UPN	320(0.019)	-	301(0.019)	-	301(0019)	-
2.	BRG	3574(0.23)	50	3284(0.23)	50	3584(0.23)	50
3.	TSC	2762(0.28)	-	2480(0.25)	-	2480(0.25)	-
4.	BKL	609(0.106)	-	604(0.106)	-	604(0.106)	-
5.	NSG	2294(0.12)	226	2294(0.12)	226	2294(0.12)	226
6.	OMK	2790(0.15)	132	2790(0.15)	132	2790(0.15)	132
7.	MAH	-	94	-	94	-	94
8.	MAJ	348(0.03)	-	348(0.03)	-	348(0.03)	-
9.	SSP	10357(2.12)	415	10357(2.12)	415	7300(1.49)	415
MAXIMUM TARGETS		23054(3.06)	917	22434(3.02)	517	19701(2.40)	540
PHASE-II							
1.	RGV	-	4	-	4	-	4
2.	ROS	-	7	-	7	-	7
3.	UBH	453(0.021)	-	443(0.021)	-	443(0.021)	-
4.	BAS	-	20	-	20	-	20
5.	CHN	1280(0.082)	-	645(0.041)	-	960(0.061)	-
6.	SMS	980(0.065)	-	786(0.052)	-	786(0.052)	-
7.	STD	645(0.051)	4	212(0.017)	4	212(0.017)	4
8.	MGL	457(0.052)	-	443(0.052)	-	443(0.052)	-
9.	UBL	346(0.022)	-	336(0.022)	-	336(0.022)	-
MAXIMUM TARGETS		4161(0.293)	35	2865(0.205)	31	3180(0.225)	31

Table 6.8 Typical demand patterns for various cases.

S.N.	Period	Mixed Targets				Simulation Targets				Master Plan Targets			
		Phase I		Phase II		Phase I		Phase II		Phase I		Phase II	
		Irri-gation	Hydro-power	Irri-gation	Hydro-power	Irri-gation	Hydro-power	Irri-gation	Hydro-power	Irri-gation	Hydro-power	Irri-gation	Hydro-power
T1	1	4350	70	350	10	4350	70	350	10	4350	70	1000	5
	2	8700	100	800	20	8700	100	350	10	8700	300	2000	20
	3	16500	320	1600	30	16500	320	1500	30	16500	620	3100	25
	4	22438	490	2865	31	19700	510	3180	30	23054	910	4161	35
T2	1	2350	30	350	10	2350	30	350	10	2350	30	350	10
	2	4350	70	800	20	4350	70	800	20	4350	70	800	20
	3	7350	90	1200	25	7350	90	1200	25	7350	90	1200	25
	4	9700	100	1700	30	9700	100	1700	30	9700	100	1700	30
	5	16500	320	2265	30	16500	420	2265	30	16500	320	2565	30
	6	22438	490	2865	31	19700	490	3180	31	23054	910	4161	31
T3	1	2350	30	350	10	2350	30	350	10	2350	30	350	10
	2	4350	70	600	15	4350	70	600	15	4350	70	800	15
	3	7350	90	900	20	7350	90	900	20	7350	90	1200	20
	4	9700	100	1200	25	9700	100	1200	25	9700	100	1700	25
	5	11700	150	1700	27	11700	150	1700	27	11700	150	2700	27
	6	16500	220	2065	30	13500	420	2065	30	16500	420	3065	30
	7	19700	350	2265	30	15700	450	2265	30	19700	650	3565	30
	8	22438	520	2865	31	19700	510	3180	31	23054	910	4161	31

Table 6.9(a) Various commonly considered allowable deficits/excesses and penalty costs (Options)

Deficit		Excess		Penalty		Remarks
Irri-gation (Mcm)	Hydro-power (Mw)	Irri-gation (mcm)	Hydro-power (Mw)	Irri-gation	Hydro-power	
0	0	0	0	0.00	0.00	No penalty
100	10	100	10	0.15	1.65	
100	5	100	5	0.01	0.50	
200	10	200	10	0.02	1.00	
300	15	300	15	0.005	0.25	
400	20	400	20	0.0025	0.50	
500	25	500	25	0.02	0.75	
700	35	700	35	0.009	0.45	
900	45	900	45	0.025	1.10	
1000	50	1000	50	0.03	1.25	
1200	60	1200	60	0.001	0.10	
1300	65	1300	65			
1500	75	1500	75			
2000	100	2000	100			
slabs						
(i) Two slabs						
100	5	300	15			
500	25	800	40			
(ii) Three slabs						
100	5	100	5			
500	25	500	25			
1000	50	1000	50			

Note: Penalty is in Rs. Crores per unit of Mcm for irrigation and per unit of Mw for hydropower.

Table 6.9(b) Finalised values and classes of allowances and penalties

Notation for type of deficit/excess	Deficit/excess		Notation for type of penalty	Penalty		Remarks
	Irri-gation	Hydro-power		Irri-gation	Hydro-power	
ADE0,AEX0	0	0	PN0	0.00	0.0	
ADE1,AEX1	100	5 or 10	PN1	0.01	0.5	
ADE2,AEX2	200	5 or 10	PN2	0.02	1.0	
ADE3,AEX3	300	15 or 30	PN3	0.03	1.25	
ADE4,AEX4	400	10 or 20	PN4	0.15	1.65	
ADE5,AEX5	500	25 or 50				
ADE6,AEX6	800	40 or 80				
ADE7,AEX7	1000	50 or 100				
ADE8	ADE1 and ADE5		PN5	PN1 and PN3		2 slabs
AEX8	AEX1 and AEX5					2 slabs
ADE9	ADE3 and ADE6		PN6	PN2 and PN4		2 slabs
AEX9	AEX3 and AEX6					2 slabs
ADE10	ADE1, ADE5 and ADE7		PN7	PN1, PN2 and PN4		3 slabs
AEX10	AEX1, AEX5 and AEX7					3 slabs

Table 6.10 The nomenclatures used in sequencing model.

A - Phase I,
B - Phase II,
1 - Mixed targets,
2 - Simulation targets,
3 - Master plan targets,
T1 - 4 planning periods,
T2 - 6 planning periods, and
T3 - 8 planning planning periods.
Thus, CASE-A1(T1) indicates Phase I, mixed targets and 4 planning periods.

Likewise,
CASE-A1(T2) indicates Phase I, mixed targets and 6 planning periods.
CASE-A1(T3) indicates Phase I, mixed targets and 8 planning periods.
CASE-A2(T1) indicates Phase I, simulation targets and 4 planning periods.
CASE-A2(T2) indicates Phase I, simulation targets and 6 planning periods.
CASE-A2(T3) indicates Phase I, simulation targets and 8 planning periods.
CASE-A3(T1) indicates Phase I, master plan targets and 4 planning periods.
CASE-A3(T2) indicates Phase I, master plan targets and 6 planning periods.
CASE-A3(T3) indicates Phase I, master plan targets and 8 planning periods.
CASE-B1(T1) indicates Phase II, mixed targets and 4 planning periods.
CASE-B1(T2) indicates Phase II, mixed targets and 6 planning periods.
CASE-B1(T3) indicates Phase II, mixed targets and 8 planning periods.
CASE-B2(T1) indicates Phase II, simulation targets and 4 planning periods.
CASE-B2(T2) indicates Phase II, simulation targets and 6 planning periods.
CASE-B2(T3) indicates Phase II, simulation targets and 8 planning periods.
CASE-B3(T1) indicates Phase II, master plan targets and 4 planning periods.
CASE-B3(T2) indicates Phase II, master plan targets and 6 planning periods.
CASE-B3(T3) indicates Phase II, master plan targets and 8 planning periods.

Table 6.11 Sequencing of Phase I projects.

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irrigation	Hydropower		Irrigation	Hydropower
CASE-A1: Phase I projects for mixed targets.						
CASE-A1(T1)						
[*i*]						
Next period demand	1	4350	70	TSC/OMK	5270	131
as upper limit, with	2	8700	100	UPN/BKL/NSG/MAJ	8797	275
ADE0-PN0 and	3	16500	320	SSP	19154	447
AEX0-PN0; FMIN=810.5	4	22438	490	BRG/MAH	22438	532.2
[*j*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*k*] Same sequencing and FMIN as above for ADE8-PN5 and AEX9-PN6.						
[*l*]						
Last period demand	1	4350	70	TSC/OMK	5270	131
as upper limit, with	2	8700	100	UPN/BKL/NSG/MAJ	8797	275
ADE0-PN0 and	3	16500	320	SSP	19154	447
AEX0-PN0; FMIN=810.5	4	22438	490	BRG/MAH	22438	532.2
[*m*] Same sequencing and FMIN as above for ADE-PN4 and AEX2-PN2.						
[*n*]						
Next period demand	1	4350	70	TSC/OMK	5270	131
as upper limit, with	2	8700	100	UPN/BRG	8855	171.3
ADE10-PN7 and	3	16500	320	SSP	19212	550.6
AEX10-PN7; FMIN=787.1	4	22438	490	BKL/NSG/MAH/MAJ	22438	532.2
[*o*]						
Next period demand	1	4350	70	TSC/OMK	5270	131
as upper limit, with	2	8700	100	UPN/BRG	8855	171.3
ADE10-PN7 and	3	16500	420*	SSP	19212	550.6
AEX10-PN7; FMIN=787.1	4	22438	490	BKL/NSG/MAH/MAJ	22438	532.2
CASE-A1(T2)						
[*i*]						
Next period demand	1	2350	30	BRG	3284	50
as upper limit, with	2	4350	70	UPN/OMK	6375	173
ADE0-PN0 and	3	7350	90	TSC	8855	171.3
AEX0-PN0	4	9700	100	NSG	11129	310.4
FMIN=1045.2	5	16500	320	SSP	21486	461.1
	6	22438	490	BKL/MAH/MAJ	22438	532.2
[*j*]						
Last period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131
ADE0-PN0 and	3	7350	90	BRG	8855	179.3
AEX0-PN0	4	9700	100	UPN/BKL/MAJ	9807	171.3
FMIN=975.2	5	16500	320	NSG/SSP	22438	439.1
	6	22438	490	MAH	22438	532.2

Note: FMIN is the present worth of total annual cost of the sequence.

Table 6.11 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*k*]						
Next period demand	1	2350	30	BRG	3284	50
as upper limit, with	2	4350	70	UPN/OMK	6375	173
ADE1-PN4 and	3	7350	90	BKL/MAJ	7327	172.5
AEX1-PN4	4	9700	100	TSC	9807	171.2
FMIN=1022.3	5	16500	320	NSG/SSP	22438	439.1
	6	22438	490	MAH	22438	532.2
[*l*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*m*]						
Next period demand	1	2350	30	BRG	3284	50
as upper limit, with	2	4350	70	UPN/OMK	6375	173
ADE8-PN5 and	3	7350	90	BKL	6979	172.5
AEX9-PN6	4	9700	100	TSC	9459	171.2
FMIN=1023.2	5	16500	320	NSG/SSP	22090	439.1
	6	22438	490	MAH/MAJ	22438	532.2
[*n*]						
Next period demand	1	2350	30	TSC	2480	-
as upper limit, with	2	4350	70	OMK	5270	131
ADE10-PN7 and	3	7350	90	BRG	8554	179.3
AEX10-PN7	4	9700	100	NSG	10828	317.5
FMIN=1035.2	5	16500	320	SSP	21185	473.2
	6	22438	490	UPN/BKL/MAH/MAJ	22438	532.2
CASE-A1(T3)						
[*i*]						
Last period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131.0
ADE0-PN0 and	3	7350	90	BRG	8855	179.3
AEX0-PN0	4	9700	100	UPN/BKL/MAJ	9807	171.3
FMIN=1475.3	5	11700	150	NSG	12081	308.9
	6	16500	220	SSP	22438	439.1
	7	19700	350	-	22438	439.1
	8	22438	520	MAH	22438	532.2
[*j*] Same sequencing and FMIN as above for ADE1-PN4 and AEX1-PN2.						
[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*l*]						
Last period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131.0
ADE8-PN5 and	3	7350	90	BRG	8855	179.3
AEX9-PN6	4	9700	100	UPN/BKL	9459	171.3
FMIN=1461.9	5	11700	150	NSG	11733	308.9
	6	16500	220	SSP	22090	439.1
	7	19700	350	-	22090	439.1
	8	22438	520	MAH/MAJ	22438	532.2

Table 6.11 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*m*]						
Last period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131.0
ADE10-PN7 and	3	7350	90	NSG	7544	280
AEX10-PN7	4	9700	100	BRG	10828	317.5
FMIN=1487.2	5	11700	150	UPN/BKL	11733	308.9
	6	16500	220	SSP	22090	439.1
	7	19700	350	-	22090	439.1
	8	22438	520	MAH/MAJ	22438	532.2

CASE-A2: Phase I projects for simulation targets.

CASE-A2(T1)

[*i*]						
Next period demand	1	4350	70	TSC/OMK	5270	131
as upper limit, with	2	8700	100	UPN/BKL/NSG/MAJ	8817	275
ADE0-PN0 and	3	16500	320	SSP	16117	447
AEX0-PN0; FMIN=810.1	4	19702	510	BRG/MAH	19701	540.1
Last period demand	1	4350	70	TSC/OMK	5270	131
as upper limit, with	2	8700	100	UPN/BKL/NSG/MAJ	8817	275
ADE0-PN0 and	3	16500	320	SSP	16117	447
AEX0-PN0; FMIN=810.1	4	19702	510	BRG/MAH	19701	540.1

[*j*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.
[*k*] Same sequencing as above for ADE8-PN5 and AEX9-PN6 with FMIN=822.7

[*l*]						
Next period demand	1	4350	70	TSC/OMK	5270	131
as upper limit, with	2	8700	100	BRG	8854	179.3
ADE4-PN4 and	3	16500	320	UPN/BKL/NSG/MAJ/SSP	19701	447
AEX2-PN2; FMIN=842.4	4	19702	510	MAH	19701	540.1
[*m*]						
Next period demand	1	4350	70	TSC/OMK	5270	131
as upper limit, with	2	8700	100	BRG	8854	179.3
ADE10-PN7 and	3	16500	320	NSG/MAJ/SSP	18796	447.7
AEX10-PN7; FMIN=831.3	4	19702	510	UPN/BKL/MAH	19701	540.1
[*n*]						
Next period demand	1	4350	70	TSC/OMK	5270	131
as upper limit, with	2	8700	100	BRG	8854	179.3
ADE10-PN7 and	3	16500	420*	NSG/MAJ/SSP	18796	447.7
AEX10-PN7; FMIN=831.3	4	19702	510	UPN/BKL/MAH	19701	540.1

Table 6.11 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
CASE-A2(T2)						
[*i*]						
Next period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131
ADE0-PN0 and	3	7350	90	BRG	8855	171.3
AEX0-PN0	4	9700	100	UPN/BKL	9759	179.2
FMIN=924.2	5	16500	420	SSP	17509	556.5
	6	19700	490	NSG/MAH/MAJ	19701	540.1
[*j*]						
Next period demand	1	2350	30	BRG	3584	50
as upper limit, with	2	4350	70	UPN/BKL/MAH	4489	143
ADE4-PN4 and	3	7350	90	TSC/MAJ	7317	143.2
AEX2-PN2	4	9700	100	NSG	9611	286.2
FMIN=1065	5	16500	420	SSP	16911	460.3
	6	19700	490	OMK	19701	540.1
[*k*]						
Next period demand	1	2350	30	BRG	3584	50
as upper limit, with	2	4350	70	BKL	4188	50
ADE8-PN5 and	3	7350	90	OMK	6978	180.5
AEX9-PN6	4	9700	100	UPN/TSC	9759	179.2
FMIN=1029.1	5	16500	420	NSG/SSP	19353	447.1
	6	19700	490	MAH/MAJ	19701	540.1
[*l*]						
Next period demand	1	2350	30	TSC	2480	-
as upper limit, with	2	4350	70	OMK	5270	181.1
ADE10-PN7 and	3	7350	90	BRG	8854	179.3
AEX10-PN7	4	9700	100	UPN/BKL	9759	179.2
FMIN=1013.7	5	16500	420	NSG/SSP	16353	447.1
	6	19700	490	MAH/MAJ	19701	540.1
CASE-A2(T3)						
[*i*]						
Next period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131
ADE0-PN0 and	3	7350	90	BRG	8855	179.3
AEX0-PN0	4	9700	100	UPN/BKL	9759	179.2
FMIN=1468.7	5	11700	150	NSG	12053	316.9
	6	13500	420	SSP	19353	447.1
	7	15700	450	MAH	19353	546
	8	19700	510	MAJ	19701	540.1

Table 6.11 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*j*]						
Last period demand as upper limit, with ADE0-PN0 and AEX0-PN0 FMIN=1646.1	1	2350	30	OMK	2790	131.9
	2	4350	70	BRG	6374	181
	3	7350	90	UPN/BKL/MAJ	7627	180.5
	4	9700	100	NSG	9921	331.1
	5	11700	150	SSP	17221	461.3
	6	13500	420	-	17221	461.3
	7	15700	450	-	17221	461.3
	8	19700	510	TSC/MAH	19701	540.1
[*k*]						
Next period demand as upper limit, with ADE4-PN4 and AEX2-PN2 FMIN=1611.3	1	2350	30	BRG	3584	50
	2	4350	70	OMK	6374	181
	3	7350	90	UPN/BKL	7279	180.5
	4	9700	100	TSC	9759	179.2
	5	11700	150	NSG	12053	316.9
	6	13500	420	SSP	19353	447.1
	7	15700	450	-	19353	447.1
	8	19700	510	MAH/MAJ	19701	540.1
[*l*]						
Last period demand as upper limit, with ADE4-PN4 and AEX2-PN2 FMIN=1462.1	1	2350	30	OMK	2790	131.9
	2	4350	70	TSC	5270	131
	3	7350	90	BRG	8854	179.3
	4	9700	100	UPN/BKL	9759	179.2
	5	11700	150	NSG	12053	316.9
	6	13500	420	SSP	19353	447.1
	7	15700	450	-	19353	546
	8	19700	510	MAH/MAJ	19701	540.1
[*m*] Same sequencing as above for ADE10-PN7 and AEX10-PN7 with FMIN=1475						
[*n*]						
Next period demand as upper limit, with ADE8-PN5 and AEX9-PN6 FMIN=1609.6	1	2350	30	BRG	3584	50
	2	4350	70	OMK	6374	181
	3	7350	90	UPN/MAJ	7023	181
	4	9700	100	TSC	9503	179.3
	5	11700	150	NSG	11797	318.4
	6	13500	420	SSP	19097	448.6
	7	15700	450	-	19097	448.6
	8	19700	510	BKL/MAH	19701	540.1

Table 6.11 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*o*]						
Last period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131
ADE8-PN5 and	3	7350	90	BRG	8854	179.3
AEX9-PN5	4	9700	100	UPN/MAJ	9508	179.3
FMIN=1459.6	5	11700	150	NSG	11797	318.4
	6	13500	420	SSP	19097	448.6
	7	15700	450	-	19097	448.6
	8	19700	510	BKL/MAH	19701	540.1
[*p*]						
Next period demand	1	2350	30	TSC	2480	-
as upper limit, with	2	4350	70	OMK	5170	131
ADE10-PN7 and	3	7350	90	BRG	8854	179.3
AEX10-PN7	4	9700	100	UPN/BKL	9759	179.2
FMIN=1515.6	5	11700	150	NSG	12053	316.9
	6	13500	420	SSP	19353	447.1
	7	15700	450	MAH	19353	546
	8	19700	510	MAJ	19701	540.1

CASE-A3: Phase I projects for master plan targets.
CASE-A3(T1)

[*i*]						
Next period demand	1	4350	70	TSC/OMK	5552	131.9
as upper limit, with	2	8700	300	UPN/BKL/NSG/MAJ	8775	357.9
ADE0-PN0 and	3	16500	620	SSP	19132	772.9
AEX0-PN0; FMIN=811.6	4	23054	910	BRG/MAH	23054	916.8
[*j*]						
Last period demand	1	4350	70	TSC/OMK	5552	131.9
as upper limit, with	2	8700	300	UPN/BKL/NSG/MAJ	8775	357.9
ADE0-PN0 and	3	16500	620	SSP	19132	772.9
AEX0-PN0; FMIN=811.6	4	23054	910	BRG/MAH	23054	916.8

[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.

[*l*]						
Next period demand	1	4350	70	TSC/OMK	5552	131.9
as upper limit, with	2	8700	300	BRG	9126	181.9
ADE1-PN4 and	3	16500	620	SSP	19483	596.9
AEX1-PN2; FMIN=794.5	4	23054	910	UPN/BKL/NSG/MAH/MAJ	23054	916.

[*m*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.
[*n*] Same sequencing as above for ADE8-PN5 and AEX9-PN6 with FMIN=792
[*o*] Same sequencing as above for ADE10-PN7 and AEX10-PN7 with FMIN=884.

Table 6.11 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
CASE-A3(T2)						
[*i*]						
Next period demand	1	2350	30	BRG	3574	50
as upper limit, with	2	4350	70	UPN/BKL/MAH	4503	143.9
ADE0-PN0 and	3	7350	90	TSC/MAJ	7613	143.9
AEX0-PN0	4	9700	100	OMK	10403	275.8
FMIN=1016.3	5	16500	320	SSP	20760	690.8
	6	23054	890	NSG	23054	916.8
[*j*]						
Next period demand	1	2350	30	BRG	3574	50
as upper limit, with	2	4350	70	UPN/BKL/MAH	4503	143.9
ADE1-PN4 and	3	7350	90	TSC	7265	143.9
AEX1-PN2	4	9700	100	OMK	10055	275.8
FMIN=1012.6	5	16500	320	SSP	20412	690.8
	6	23054	890	NSG/MAJ	23054	916.8
[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*l*]						
Next period demand	1	2350	30	BRG	3574	50
as upper limit, with	2	4350	70	UPN/MAJ	4242	50
ADE8-PN5 and	3	7350	90	OMK	7032	181.9
AEX9-PN6	4	9700	100	TSC	9794	181.9
FMIN=985.2	5	16500	320	SSP	20151	596.9
	6	23054	890	BKL/NSG/MAH	23054	916.8
[*m*]						
Next period demand	1	2350	30	TSC	2762	-
as upper limit, with	2	4350	70	OMK	5552	131.9
ADE10-PN7 and	3	7350	90	BRG	9126	181.9
AEX10-PN7	4	9700	100	UPN/MAJ	9794	181.9
FMIN=975.2	5	16500	320	SSP	20151	596.9
	6	23054	890	BKL/NSG/MAH	23054	916.8
CASE-A3(T3)						
[*i*]						
Next period demand	1	2350	30	BRG	3574	50
as upper limit, with	2	4350	70	UPN/BKL/MAH	4503	143.9
ADE0-PN0 and	3	7650	90	TSC/MAJ	7613	143.9
AEX0-PN0	4	9700	100	OMK	10403	275.8
FMIN=1593.8	5	11700	150	NSG	12697	501.8
	6	16500	420	SSP	23054	916.8
	7	19700	650	-	23054	916.8
	8	23054	910	-	23054	916.8

Table 6.11 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*j*]						
Last period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5552	131.9
ADE0-PN0 and	3	7650	90	BRG	9126	181.9
AEX0-PN0	4	9700	100	UPN/MAJ	9794	181.9
FMIN=1465.9	5	11700	150	NSG	12088	407.9
	6	16500	420	SSP	22445	822.9
	7	19700	650	-	22445	822.9
	8	23054	910	BKL/MAH	23054	916.8
[*k*]Same sequencing as above for ADE4-PN4 and AEX2-PN2 with FMIN=1466.2						
[*l*]Same sequencing as above for ADE10-PN7 and AEX10-PN7 with FMIN=1509.						
[*m*]						
Next period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5552	131.9
ADE4-PN4 and	3	7650	90	BRG	9126	181.9
AEX2-PN2	4	9700	100	UPN/MAJ	9794	181.9
FMIN=1466.2	5	11700	150	NSG	12088	407.9
	6	16500	420	SSP	22445	822.9
	7	19700	650	-	22445	822.9
	8	23054	910	BKL/MAH	23054	916.8
[*n*]						
Last period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5552	131.9
ADE8-PN5 and	3	7650	90	BRG	9126	181.9
AEX9-PN6	4	9700	100	UPN	9446	181.9
FMIN=1476.1	5	11700	150	NSG	11740	407.9
	6	16500	420	SSP	22097	822.9
	7	19700	650	-	22097	822.9
	8	23054	910	BKL/MAH/MAJ	23054	916.8

Table 6.11 Concluded

Table 6.12 Sequencing of Phase II projects.

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
CASE-B1: Phase II projects for mixed targets.						
CASE-B1(T1)						
[*i*]						
Next period demand	1	350	10	RGV/ROS/MGL	443	11
as upper limit, with	2	800	20	UBH/BAS	886	27.24
ADE0-PN0 and	3	1500	25	SMS	1672	27.24
AEX0-PN0; FMIN=202.3	4	2865	31	UBL/CHN/STD	2865	31.24
[*j*]						
Next period demand	1	350	10	RGV/ROS/UBL	336	11
as upper limit, with	2	800	20	MGL	779	11
ADE4-PN4 and	3	1500	25	BAS/SMS	1565	30.2
AEX2-PN2; FMIN=182.3	4	2865	31	UBH/CHN/STD	2865	31.24
[*k*] Same sequencing as above for ADE2-PN2 and AEX2-PN2 with FMIN=171.9						
[*l*] Same sequencing as above for ADE3-PN2 and AEX3-PN2 with FMIN=171.8						
[*m*]						
Next period demand	1	350	10	RGV/ROS/UBL	336	11
as upper limit, with	2	800	20	STD/MGL	991	15
ADE4-PN4 and	3	1500	20*	SMS	1777	15
AEX2-PN2; FMIN=177	4	2865	31	UBH/BAS/CHN	2865	31.24
[*n*]						
Next period demand	1	350	10	RGV/ROS	-	11
as upper limit, with	2	800	20	SMS	786	11
ADE8-PN5 and	3	1500	30	BAS/MGL/UBL	1565	30.2
AEX9-PN6; FMIN=179.9	4	2865	31	UBH/CHN/STD	2865	31.24
[*o*]						
Next period demand	1	350	10	RGV/ROS/UBL	336	11
as upper limit, with	2	800	20	SMS	1122	11
ADE10-PN7 and	3	1500	30	BAS/MGL	1565	30.2
AEX10-PN7; FMIN=201	4	2865	31	UBH/CHN/STD	2865	31.24
CASE-B1(T2)						
[*i*]						
Next period demand	1	350	10	BAS/SMS	786	20
as upper limit, with	2	800	20	UBL	1122	20
ADE0-PN0 and	3	1200	25	RGV/STD	1334	28
AEX0-PN0	4	1700	30	ROS/MGL	1777	34.2
FMIN=329.3	5	2265	30	CHN	2422	34.2
	6	2865	31	UBH	2865	31.24

Table 6.12 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*j*]						
Next period demand	1	350	10	RGV/ROS/SMS	786	11
as upper limit, with	2	800	20	-	786	11
ADE2-PN4 and	3	1200	25	BAS/MGL	1229	30.2
AEX2-PN2	4	1700	30	STD/UBL	1777	34.2
FMIN=305.7	5	2265	30	CHN	2422	34.2
	6	2865	31	UBH	2865	31.24
[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*l*] Same sequencing as above for ADE10-PN7 and AEX10-PN7 with FMIN=326.						
[*m*]						
Next period demand	1	350	10	RGV/ROS	-	11
as upper limit, with	2	800	20	SMS	786	11
ADE8-PN5 and	3	1200	25	UBL	1122	11
AEX9-PN6	4	1700	30	BAS/CHN	1767	30.2
FMIN=301.4	5	2265	30	MGL	2210	30.2
	6	2865	31	UBH/STD	2865	31.24
CASE-B1(T3)						
[*i*]						
Last period demand	1	350	10	RGV/ROS/SMS	786	11
as upper limit, with	2	600	15	STD	998	15
ADE0-PN0 and	3	900	20	BAS	998	34.2
AEX0-PN0	4	1200	25	UBL	1334	34.2
FMIN=412.1	5	1700	27	MGL	1777	34.2
	6	2065	30	CHN	2422	34.2
	7	2265	30	-	2422	34.2
	8	2865	31	UBH	2865	31.24
[*j*]						
Next period demand	1	350	10	RGV/ROS/SMS	786	11
as upper limit, with	2	600	15	-	786	11
ADE2-PN4 and	3	900	20	MGL	1229	11
AEX2-PN2	4	1200	25	BAS	1229	30.2
FMIN=409.2	5	1700	27	CHN	1874	30.2
	6	2065	30	UBL	2210	30.2
	7	2265	30	STD	2422	34.2
	8	2865	31	UBH	2865	31.24
[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						

Table 6.12 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*l*]						
Next period demand	1	350	10	ROS	-	7
as upper limit, with	2	600	15	SMS	786	7
ADE8-PN5 and	3	900	20	-	786	7
AEX9-PN6	4	1200	25	BAS/MGL	1229	27
FMIN=399.6	5	1700	27	UBL	1565	27
	6	2065	30	RGV/CHN	2210	30.2
	7	2265	30	-	2210	30.2
	8	2865	31	UBH/STD	2865	31.24
[*m*]						
Next period demand	1	350	10	RGV/ROS/MGL	443	11
as upper limit, with	2	600	15	UBH	886	11
ADE10-PN7 and	3	900	20	-	886	11
AEX10-PN7	4	1200	25	BAS/UBL	1222	27.24
FMIN=464.1	5	1700	27	SMS	2008	27.24
	6	2065	30	STD	2220	31.24
	7	2265	30	-	2220	31.24
	8	2865	31	CHN	2865	31.24

CASE-B2: Phase II projects for simulation targets.

CASE-B2(T1)

[*i*]						
Next period demand	1	350	10	RGV/ROS/MGL	443	11
as upper limit, with	2	800	20	UBH/BAS	886	27.24
ADE0-PN0 and	3	1500	30	SMS/STD	1884	31.24
AEX0-PN0; FMIN=202.8	4	3180	31	UBL/CHN	3180	31.24
[*j*]						
Next period demand	1	350	10	RGV/ROS/UBL	336	11
as upper limit, with	2	800	20	MGL	779	11
ADE2-PN4 and	3	1500	30	BAS/SMS	1565	30.2
AEX2-PN2; FMIN=182.8	4	3180	31	UBH/CHN/STD	3180	31.24

[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.
[*l*] Same sequencing as above for ADE3-PN2 and AEX3-PN2 with FMIN=172.2

[*m*]						
Next period demand	1	350	10	RGV/ROS/UBL	336	11
as upper limit, with	2	800	20	CHN	1296	11
ADE4-PN4 and	3	1500	20*	STD	1508	15
AEX2-PN2; FMIN=175	4	3180	31	UBH/BAS/SMS/MGL	3180	31.24

Table 6.12 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*n*]						
Next period demand	1	350	10	RGV/ROS	-	11
as upper limit, with	2	800	20	SMS	786	11
ADE8-PN5 and	3	1500	30	BAS/CHN	1746	30.2
AEX9-PN6; FMIN=180	4	3180	31	UBH/STD/MGL/UBL	3180	31.24
[*o*]						
Next period demand	1	350	10	RGV/ROS/CHN	960	11
as upper limit, with	2	800	20	BAS	960	30.2
ADE10-PN7 and	3	1500	30	SMS	1746	30.2
AEX10-PN7; FMIN=195.2	4	3180	31	UBH/STD/MGL/UBL	3180	31.24
[*p*]						
Next period demand	1	350	10	RGV/ROS/SMS	786	11
as upper limit, with	2	800	20	-	786	11
ADE10-PN7 and	3	1500	25*	BAS/CHN	1746	30.2
AEX10-PN7; FMIN=202	4	3180	31	UBH/CHN/STD	3180	31.24
CASE-B2(T2)						
[*i*]						
Next period demand	1	350	10	BAS/SMS	786	20
as upper limit, with	2	800	20	UBL	1122	20
ADE0-PN0 and	3	1200	25	RGV/STD	1334	28
AEX0-PN0	4	1700	30	ROS/MGL	1777	34.2
FMIN=330.2	5	2265	30	CHN	2737	34.2
	6	3180	31	UBH	3180	31.24
[*j*]						
Next period demand	1	350	10	RGV/ROS/SMS	786	11
as upper limit, with	2	800	20	-	786	11
ADE2-PN4 and	3	1200	25	BAS/CHN	1746	30.2
AEX2-PN2	4	1700	30	-	1746	30.2
FMIN=296.1	5	2265	30	STD/UBL	2294	34.2
	6	3180	31	UBH/MGL	3180	31.24
[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*l*]						
Next period demand	1	350	10	RGV/ROS	-	11
as upper limit, with	2	800	20	CHN	960	11
ADE8-PN5 and	3	1200	25	-	960	11
AEX9-PN6	4	1700	30	BAS/SMS	1746	30.2
FMIN=287	5	2265	30	UBL	2082	30.2
	6	3180	31	UBH/STD/MGL	3180	31.24

Table 6.12 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*m*]						
Next period demand	1	350	10	RGV/ROS/SMS	786	11
as upper limit, with	2	800	20	-	786	11
ADE10-PN7 and	3	1200	25	BAS/MGL	1229	30.2
AEX10-PN7	4	1700	30	CHN	2189	30.2
FMIN=322.8	5	2265	30	UBL	2525	30.2
	6	3180	31	UBH/STD	3180	31.24
CASE-B2(T3)						
[*i*]						
Last period demand	1	350	10	RGV/ROS/CHN	960	11
as upper limit, with	2	600	15	BAS	960	30.2
ADE0-PN0 and	3	900	20	-	960	30.2
AEX0-PN0	4	1200	25	UBL	1296	30.2
FMIN=389.4	5	1700	27	SMS	2082	30.2
	6	2065	30	-	2082	30.2
	7	2265	30	STD	2294	34.2
	8	3180	31	UBH/MGL	3180	31.24
[*j*]						
Next period demand	1	350	10	RGV/ROS/SMS	786	11
as upper limit, with	2	600	15	-	786	11
ADE2-PN4 and	3	900	20	UBL	1122	11
AEX2-PN2	4	1200	25	BAS	1122	30.2
FMIN=395.2	5	1700	27	CHN	2082	30.2
	6	2065	30	-	2082	30.2
	7	2265	30	STD	2294	34.2
	8	3180	31	UBH/MGL	3180	31.24
[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*l*]						
Next period demand	1	350	10	ROS	-	7
as upper limit, with	2	600	15	SMS	786	7
ADE8-PN5 and	3	900	20	-	786	7
AEX9-PN6	4	1200	25	BAS/MGL	1229	27
FMIN=393.4	5	1700	27	-	1229	27
	6	2065	30	RGV/CHN	2189	30.2
	7	2265	30	-	2189	30.2
	8	3180	31	UBH/STD/UBL	3180	31.24

Table 6.12 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*m*]						
Next period demand	1	350	10	RGV/ROS/MGL	443	11
as upper limit, with	2	600	15	STD	655	15
ADE10-PN7 and	3	900	20	UBH	1098	15
AEX10-PN7	4	1200	25	-	1098	15
FMIN=464.6	5	1700	27	BAS/CHN	2058	31.24
	6	2065	30	-	2058	31.24
	7	2265	30	UBL	2394	31.24
	8	3180	31	SMS	3180	31.24
CASE-B3: Phase II projects for master plan targets.						
CASE-B3(T1)						
[*i*]						
Last period demand	1	1000	5	ROS/CHN	1280	7
as upper limit, with	2	2000	20	BAS/SMS	2260	27
ADE0-PN0 and	3	3100	25	STD/UBL	3251	31
AEX0-PN0; FMIN=216.2	4	4161	35	RGV/UBH/MGL	4161	35
[*j*] Same sequencing as above for ADE10-PN7 and AEX10-PN7 with FMIN=229.						
[*k*]						
Next period demand	1	1000	5	RGV/STD/UBL	991	8
as upper limit, with	2	2000	20	ROS/CHN	2271	15
ADE2-PN4 and	3	3100	25	SMS	3251	15
AEX2-PN2; FMIN=206.6	4	4161	35	UBH/BAS/MGL	4161	35
[*l*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*m*]						
Next period demand	1	1000	5	ROS/CHN	1280	7
as upper limit, with	2	2000	20	RGV/STD	1925	15
ADE3-PN2 and	3	3100	25	SMS	2905	15
AEX3-PN2; FMIN=189.6	4	4161	35	UBH/BAS/MGL/UBL	4161	35
[*n*] Same sequencing as above for ADE8-PN5 and AEX9-PN6 with FMIN = 211.						
CASE-B3(T2)						
[*i*]						
Next period demand	1	350	10	BAS/MGL	457	20
as upper limit, with	2	800	20	UBL	803	20
ADE0-PN0 and	3	1200	25	RGV/STD	1448	28
AEX0-PN0	4	1700	30	ROS/UBH	1901	35
FMIN=318.5	5	2565	30	SMS	2881	35
	6	4161	35	CHN	4161	35

Table 6.12 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*j*]						
Next period demand as upper limit, with ADE2-PN4 and AEX2-PN2 FMIN=285.3	1	350	10	ROS/STD	645	11
	2	800	20	RGV/UBL	991	15
	3	1200	25	MGL	1448	15
	4	1700	30	BAS/CHN	2728	35
	5	2565	30	-	2728	35
	6	4161	35	UBH/SMS	4161	35
[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*l*]						
Next period demand as upper limit, with ADE8-PN5 and AEX9-PN6 FMIN=271.7	1	350	10	ROS/STD	645	11
	2	800	20	RGV	645	15
	3	1200	25	UBL	991	15
	4	1700	30	BAS/CHN	2271	35
	5	2565	30	MGL	2728	35
	6	4161	35	UBH/SMS	4161	35
[*m*]						
Next period demand as upper limit, with ADE10-PN7 and AEX10-PN7 FMIN=319.5	1	350	10	ROS/STD	645	11
	2	800	20	RGV/UBL	991	15
	3	1200	25	MGL	1448	15
	4	1700	30	UBH/BAS	1901	35
	5	2565	30	SMS	2881	35
	6	4161	35	CHN	4161	35
CASE-B3(T3)						
[*i*]						
Last period demand as upper limit, with ADE0-PN0 and AEX0-PN0 FMIN=402.7	1	350	10	ROS/STD	645	11
	2	800	20	RGV/CHN	1925	15
	3	1200	20	BAS	1925	35
	4	1700	25	-	1925	35
	5	2700	27	SMS	2905	35
	6	3065	30	UBL	3251	35
	7	3565	30	MGL	3708	35
	8	4161	35	UBH	4161	35

Table 6.12 Continued

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
[*j*]						
Next period demand as upper limit, with ADE2-PN4 and AEX2-PN2 FMIN=411.9	1	350	10	ROS/STD	645	11
	2	800	20	RGV	645	15
	3	1200	20	SMS	1625	15
	4	1700	25	-	1625	15
	5	2700	27	BAS/CHN	2905	35
	6	3065	30	UBL	3251	35
	7	3565	30	MGL	3708	35
	8	4161	35	UBH	4161	35
[*k*] Same sequencing and FMIN as above for ADE4-PN4 and AEX2-PN2.						
[*l*]						
Next period demand as upper limit, with ADE8-PN5 and AEX9-PN6 FMIN=418.2	1	350	10	RGV/STD	645	8
	2	800	20	-	645	8
	3	1200	20	UBL	991	8
	4	1700	25	BAS/CHN	2271	28
	5	2700	27	-	2271	28
	6	3065	30	ROS/SMS	3251	35
	7	3565	30	MGL	3708	35
	8	4161	35	UBH	4161	35
[*m*]						
Next period demand as upper limit, with ADE10-PN7 and AEX10-PN7 FMIN=460.3	1	350	10	ROS/STD	645	11
	2	800	20	RGV	645	15
	3	1200	20	SMS	1625	15
	4	1700	25	-	1625	15
	5	2700	27	CHN	2905	15
	6	3065	30	BAS/UBL	3251	35
	7	3565	30	MGL	3708	35
	8	4161	35	UBH	4161	35

Table 6.12 Concluded

ANALYSIS AND CONCLUSIONS

7.1 GENERAL

The analysis in this chapter is primarily based on the models formulated in the Chapters 3 and 4. These models were applied to the Narmada river system in India described in Chapter 5. The Chapter 6 gives computational procedure and other data needed. The proposed, ongoing and existing major reservoirs were considered and were numbered sequentially from upstream to downstream. In all 30 major reservoirs were taken into account for analysis out of which, 10 are situated on the main river (in series with each other on main river), the remaining 20 on nineteen tributaries, which include 2 in series on a tributary, and the other 18 are independent of each other and situated on eighteen tributaries (in parallel). Thus, it is a series-parallel configuration. The computations were basically done in the following manner.

Initially, line diagram showing relative locations of all the 30 major reservoirs in the river basin was prepared. Then, assuming that all reservoirs are existing in the system, each individual reservoir was simulated starting from the uppermost reservoir and by adding the immediate downstream reservoir in parallel or in series by also accounting for the upstream effects for fixing the final simulated irrigation targets from every reservoir with irrigation.

Secondly, Phase I reservoirs were isolated and the line diagram showing the relative locations of the 14 Phase I reservoirs only was prepared. From this, it was possible to combine some of the similar neighbouring reservoirs and representing the system by calling them projects, totally nine in numbers only, for limiting the size of the problem. The simulation runs were then undertaken for only 375 combinations (due to presence of some parallel projects) out of all the possible 512 combinations resulting from these 9 projects starting from upstream to downstream by adding a project one by one in a systematic manner for finding the final simulated firm hydropower targets from every reservoir with hydropower in each project combination. In each case, the irrigation targets were kept constant as obtained in the previous para. Further, sequencing of the Phase I projects was done using the sequencing model.

Finally, Phase II reservoirs were isolated and the line diagram showing relative locations of the 16 Phase II reservoirs only was prepared. Like in Phase I, it was again possible to combine some of the similar neighbouring reservoirs and representing the system again by nine projects. Then simulation runs were undertaken for only 17 combinations (due to presence of some parallel projects) out of all the possible 512 combinations as explained for Phase I for finding the final simulated firm hydropower target from every reservoir with hydropower in each project combination. In each case, the Phase I projects located at the upstream of the projects appearing in the Phase II combinations were assumed to be present and hence were included in the simulation runs of the corresponding Phase II combinations. Further, sequencing of the Phase II projects was obtained using the sequencing model.

7.2 SIMULATION MODEL RESULTS AND ANALYSIS

7.2.1 Important Features Different from Earlier Studies

The important features of the detailed simulation model runs in this work which are noteworthy and different from earlier studies carried out by others are as follows:

(i) Reservoir by reservoir analysis was carried out using detailed simulation model. A total system consisting of a large number of reservoirs(30) was analysed for deciding annual irrigation targets of reservoirs with irrigation and initial and the final annual firm hydropower targets for reservoirs with hydropower.

(ii) The effect of the presence of upstream reservoir(s) on the performance of the downstream reservoir, especially on the firm hydropower targets of reservoirs with hydropower has been analysed and quantified by considering multireservoir, multipurpose operation policy for reservoirs.

(iii) All the possible alternative reservoir combinations were simulated using detailed simulation model for the purpose of reservoir/project sequencing model to be used later on. Hence no scope for missing any prospective alternative and also no need for any criteria for discontinuing simulations as specified in some earlier approaches used in sequencing (Kuiper and Ortolano, 1973).

(iv) The input data such as cumulative flows pertaining to all the potential reservoir sites in a particular river system can be read only once into a file. This stored data can be later on used to determine the intermediate catchment flow (net flow) contribution for every reservoir in a set of reservoirs of any given alternative reservoir combinations to be simulated with ease (here 512 combinations). This reduces the difficult and herculean task of data handling. The subroutine NTFLO computes the net flow at a given site.

(v) Further, individual variable input data files can be prepared for each reservoir and can be appended easily for any reservoir configuration/combination.

(vi) Similarly a large number of function subprograms are an essential part for reservoir storage-area-elevation curves in the multireservoir simulation program. In this simulation program, these curves for all the potential reservoir sites are given in function subprograms (one each for curves of reservoir storage-area, reservoir storage-elevation). These curves can be picked up for any reservoir in a particular reservoir combination. This also reduces the herculean task in simulation.

(vii) There were obvious difficulties in identification of the project combinations and their constituents due to a large number of these possible combinations. Hence a computer program was prepared to handle this task.

(viii) It is required to carry out simulation runs only for a less number of project combinations out of total 2^n, due to the presence of some parallel reservoirs in the system. The particular combinations for which it was required to carry out actual simulation runs could be identified using a computer program developed for this purpose.

(ix) In general, it is felt that the developed program is a feasible, efficient, flexible, convenient and useful tool for undertaking simulation studies on a multipurpose and multireservoir system.

7.2.2 Discussion of Simulation Model Results

7.2.2.1 Phase I simulations

The detailed simulation model was applied to various alternative configurations of projects (combinations) of Phase I. The results of the Phase I simulations indicating constituents of the project combinations, usewise simulated targets, and usewise releases are already given in the Table 6.5. In this Phase I a total number of 375 simulation runs were required out of the total 512 project combinations due to presence of some parallel projects. In this Phase I system most of the series reservoirs, namely Narmada Sagar, Omkareshwar, Maheshwar, and Sardar Sarovar are located at the downstream portion of the system and hence the number of combinations for actual simulation runs was found to be very large.

The time phasing of the individual mega reservoirs could not be considered because such consideration would have increased the number of possible combinations enormously. It also would have rendered a lot of difficulties in the preparation of pertaining data files. The Table 7.1 gives insight into the possible number of reservoir combinations for various cases of time phasing of the individual reservoirs, namely, Bargi, Narmada Sagar, Omkareshwar, and Sardar Sarovar. As the concerned series projects are located at the downstream portion of the system this number has become so large.

The effect of presence of upstream reservoir(s) on the downstream reservoir was realised in terms of the variations in the annual firm hydropower targets and average annual releases and also in terms of the number of deficit years for both irrigation and hydropower. Table 7.2 shows the range of firm hydropower targets and releases for series reservoirs.

7.2.2.2 Phase II simulations

The detailed simulation model was applied to various alternative configurations(combinations) of Phase II projects. The results of the Phase II simulations indicating constituents of the project combinations, usewise targets, and usewise releases are already tabulated in the Table 6.6. In this Phase II system all the series reservoirs, namely Raghavpur, Rosra, Basania, and Chinki are located at the upstream portion of the system and hence the number of combinations for actual simulation runs is found to be very small. It was required to carry out simulation runs only for 17 project combinations out of total 512 due to presence of some parallel projects in the system. For this case, it was not required to consider any time phasing of individual reservoirs owing to small sizes of the reservoirs. The effect of presence of upstream reservoir(s) on the downstream reservoir was realised in terms of the variations in the annual firm hydropower targets and average annual releases and also in terms of the number of deficit years for both irrigation and hydropower. Table 7.3 shows the range of firm hydropower targets and releases for such downstream series reservoirs.

7.3 DP SEQUENCING MODEL RESULTS AND ANALYSIS

7.3.1 Important Features Different from Earlier Studies

The important features of DP sequencing model in this work which are noteworthy and different from earlier studies carried out by others are as follows:

(i) Identification of possible states (project combinations/configurations) and their constituents for computations of DP sequencing by computer program was a herculean task as the number of possible states increases geometrically with every additional project. The subroutines CODE(NP) and CODE1(NP) have been developed and found to be very effective in handling this task.

(ii) Since time is involved in sequencing, it is essentially a backward dynamic programming process, and the same has been followed.

(iii) Multiple facility system and multiple uses of water have been considered in the analysis.

(iv) All possible states (project combinations) are investigated in every period hence the optimality is guaranteed.

(v) The annual OMR cost estimates of the reservoir, irrigation works, and hydropower at a site are based on their respective average annual release (yield) from the reservoir as obtained in simulation.

(vi) A penalty cost for allowing the system demand to go unsatisfied when the total capacity (target supplied) provided is less than the required demand in every period within allowable shortage has been included in the model.

(vii) An upper limit above the system demand upto which an additional capacity may be provided has been incorporated. A provision for allowing the total capacity provided being exceeded over this upper limit at every period, within an allowable value has also been incorporated. A penalty cost for supplying within this allowable excess of upper limit is considered.

(viii) Variation in penalty is considered in two ways, (a) periodwise and (b) by considering different slabs of allowance and applying different penalty in each slab.

(ix) Once fixed input data (such as targets, releases, costs, etc.) for a particular system are read separately then the program can be used repetitively without hesitation as the number of variable input data (such as demands, upper limits, allowable shortages/excesses, penalty costs, etc.) is small and as such the program can be considered less data intensive.

(x) The subroutine SERCH writes the results in the form of projects added and total capacity attained by the system at the end of every period.

(xi) In general, it is felt that the developed program is a feasible, efficient, flexible, convenient and useful tool for obtaining sequencing.

7.3.2 Discussion of DP Model Results

The targets have been considered in three different categories as explained below. First, the simulation category, in which targets and releases as obtained after relevant simulation runs are considered. Second, the Master Plan category, in which targets are taken purely as per Master Plan provisions and releases are assumed to be equal to targets. Thirdly, the mixed category, in which targets and releases for the three series reservoirs/projects Omkareshwar, Maheshwar and Sardar Sarovar are taken as per Master Plan (for the reasons mentioned in para 6.4.1.1.1) and for the remaining reservoirs as per simulation.

For mixed targets of Phase I, the effect of change in shortage/excess and penalty cost on sequences with short interval of 100 Mcm units in the range (0 Mcm to 2000 Mcm) for irrigation and 10 Mw units in the range (0 Mw to 100 Mw) for hydropower on sequencing was studied in detail. Based on this, the final classes of allowances and penalties for the purpose of analysis were decided and shown in the Table 6.9(b).

Although categorization of the targets and classification of allowances and penalties has been done to develop various expansion scenarios in the absence of the required data available, it is felt that such categorization and classification is adequate for the preinvestment capacity expansion analysis.

Phase I sequencing

The DP sequencing model was applied to 9 Phase I projects and the results were given in the Table 6.11.

Phase II sequencing

The DP sequencing model was applied to 9 Phase II projects and the results were given in the Table 6.12.

The DP sequencing model was made more realistic and practicable by introducing some constraints depicting a few policy and practical aspects, as mentioned in 7.3.1. The comparative statement of sequences for various cases in both the Phases is shown in Table 7.4. Eventhough Phase II system appears to be relatively small in size compared to Phase I system, no attempt was made to deviate from this in order to keep the problem more realistic and close to real life situation in the Narmada river system.

The Table 6.11 and the Table 6.12, gave sequencing of the projects, capacity attained at each period and minimum cost for various cases whereas the Table 7.4 gives the comparison of sequences. After scrutinizing the various planning scenarios arising out of the sequences obtained for various cases, the minimum cost sequences in each target category are selected and recommended. The recommended periodwise sequences of development, total capacity attained and minimum total cost of such recommended sequences for each target category are indicated in the Table 7.6 alongwith the shortage/excess type and the penalty class for the three planning horizons. As more capacity is to be supplied in Phase I the number of planning periods should be kept more than that for Phase II. Accordingly, 8 and 6 planning periods are suggested respectively for Phase I and Phase II developments keeping in mind the slow pace of ongoing development of Narmada river basin. The Table 7.7 gives the sequences for these recommended planning horizons for each target category and for each Phase. The Table 7.8(a) indicates the details of these sequences. The Figs. 7.1(a),(b); 7.2(a),(b); 7.3(a),(b); 7.4(a),(b); 7.5(a),(b); and 7.6(a),(b) show the schematic representations of these sequences with respect to demand and supply for irrigation and hydropower.

7.3.2.1 Analysis of Phasewise mixed target category sequencing

The Figs. 7.1(a) and (b) present the details of the minimum total annual cost (FMIN=Rs. 1461.9 Crores) mixed target category Phase I sequence at Deficit-Penalty class of ADE8-PN5, i.e., allowable irrigation deficit in the range 100 to 500 Mcm and allowable hydropower deficit in the range 5 to 25 Mw and the penalty in the range 0.01 to 0.03 Rs. Crores per Mcm for irrigation and in the range 0.5 to 1.25 Rs. Crores per Mw for hydropower; and Excess-Penalty class AEX9-PN6, i.e., allowable irrigation excess beyond the upper limit in the range 300 to 800 Mcm and allowable hydropower excess beyond the upper limit in the range 15 to 40 Mw and the penalty in the range 0.02 to 0.15 Rs. Crores per Mcm for irrigation and in the range 1.0 to 1.65 Rs. Crores per Mw for hydropower. These figures indicate almost full irrigation supply by 6th period only, because of appearance of large reservoirs, namely, Omkareshwar, Tawa, Bargi, Narmada Sagar and Sardar Sarovar in the sequence by that time. The rate of irrigation supply is observed to be uniform and matching with demand upto 5^{th} period beyond which there is a surplus irrigation supply till last period. The hydropower supply is fully achieved by the end of the Phase I planning horizon (8^{th} period) at an almost uniform rate with no addition during 2^{nd}, 4^{th}, and 7^{th} periods in which only irrigation reservoirs are added. The sequence shows surplus in hydropower supply throughout the Phase I planning horizon of 8 periods.

The Figs. 7.2(a) and (b) present the details of the minimum total annual cost (FMIN=Rs. 305.7 Crores) mixed target category Phase II sequence at Deficit-Penalty and Excess-Penalty classes of ADE4-PN4 (allowable irrigation deficit of 400 Mcm with penalty of Rs. 0.15 Crores per Mcm and allowable hydropower deficit of 10 Mw with penalty of 1.65 Crores per Mw) and AEX2-PN2 (allowable irrigation excess beyond the upper limit of 200 Mcm with penalty of Rs. 0.02 Crores per Mcm and allowable hydropower excess beyond the upper limit of 5 Mw with penalty of 1.0 Crores per Mw) respectively. These figures indicate uniform rate of irrigation supply and matching with demand beyond 2^{nd} period. The hydropower supply is observed to be erratic due to less number and small size of Phase II hydropower projects. It also shows 2 no addition periods, i.e., 2^{nd}, and 5^{th}. The reduction in hydropower supply in the last period is due to addition of UBH irrigation project which is situated at the upstream of the BAS hydropower project. The sequence shows almost matching supply and demand throughout the Phase II planning horizon of 6 periods except for surplus irrigation upto 2nd period and shortage in hydropower during 2nd and 3rd periods.

7.3.2.2 Analysis of Phasewise simulation target category sequencing

The Figs. 7.3(a) and (b) depict the details of the minimum total annual cost (FMIN=Rs. 1468.7 Crores) simulation target category Phase I sequence at Deficit-Penalty and Excess-Penalty classes of ADE0-PN0 and AEX0-PN0 respectively, i.e., no allowances and no penalty. The Fig. 7.3(a) shows that the availability of full irrigation supply, the rate and the surplus irrigation supplies match with the mixed target category results. The hydropower supply is fully achieved by 7th period at an almost uniform rate with no addition during 2nd and 4th periods in which only irrigation reservoirs are added. The sequence shows surplus in hydropower supply throughout the Phase I planning horizon as in mixed target category result.

The Figs. 7.4(a) and (b) depict the details of the minimum total annual cost (FMIN=Rs. 287.0 Crores) simulation target category Phase II sequence at Deficit-Penalty and Excess-Penalty classes of ADE8-PN5 and AEX9-PN6 respectively (the details of these classes already explained in the previous case). The irrigation as well as hydropower supply is observed to be erratic due to delayed additions of reservoirs such as SMS, UBH (irrigation) and BAS (hydropower). It also shows 3 no addition periods, i.e., 2nd, 3rd, and 5th for hydropower. The sequence shows shortage of irrigation and hydropower supply.

7.3.2.3 Analysis of Phasewise master plan target category sequencing

The Figs. 7.5(a) and (b) present the details of the minimum total annual cost (FMIN=Rs. 1466.2 Crores) master plan target category Phase I sequence at Deficit-Penalty and Excess-Penalty classes of ADE4-PN4 and AEX2-PN2 respectively (the details of these classes already explained in the mixed category case). From Fig. 7.5(a) it is found that the availability of full irrigation supply, the rate and the surplus irrigation supplies also match with mixed target and simulation target categories as seen earlier. The hydropower supply is fully achieved by the end of 8th period at a non-uniform rate with no addition during 2nd, 4th, and 7th periods in which only irrigation reservoirs are added. The surplus in hydropower supply in Phase I planning horizon is similar as obtained earlier.

The Figs. 7.6(a) and (b) present the details of the minimum total annual cost (FMIN=Rs. 285.3 Crores) master plan target category Phase II sequence at Deficit-Penalty and Excess-Penalty classes of ADE4-PN4 and AEX2-PN2 respectively (the details of these classes already explained in the mixed category case). These figures indicate uniform rate of irrigation supply matching with demand but erratic hydropower supply. The shortage in hydropower supply from 2nd to 5th period is due to delayed appearance of BAS(20 MW) in the sequence. It also shows 3 no addition periods, i.e., 3rd, 5th, and 6th. The sequence shows matching supply and demand with no shortage for irrigation throughout the Phase II planning horizon for surplus irrigation and shortage in hydropower from 2nd to 4th period.

7.3.2.4 Discussion on Combined Phase I and Phase II sequencing

Sequencing with allowances and penalties

After combining the results for Phase I and Phase II and thereby considering the total planning horizon of 14 periods, the Table 7.9 gives the names of the reservoirs to be added in each planning period for the complete system of 30 reservoirs. For a hydropower reservoir, it is possible to use its full potential until the upstream reservoir(s) affecting this potential appear in the sequencing of the system. The Table 7.9 also indicates the hydropower potential, and its availability period for hydropower reservoirs. Figs.7.7(a),(b),and (c); Figs.7.8(a),(b),and (c); and Figs.7.9(a),(b),and (c) show the schematic representation of the combined Phase I and Phase II developments for all the three target categories over the total planning horizon of 14 periods with respect to irrigation(Mcm) demand and supply, hydropower(Mw) demand and supply, and irrigation area(Mha) supply.

Figs. 7.7(a), and (b) present the combined Phase I and Phase

II sequence for mixed target category with total annual cost, FMIN of Rs. 1777.6 Crores over combined planning horizon of 14 periods which includes 8 of Phase I and 6 of Phase II. Figs. 7.8(a), and (b) present the combined Phase I and Phase II sequence for simulation target category with total annual cost, FMIN of Rs. 1755.7 Crores over combined planning horizon of 14 periods. Figs. 7.9(a), and (b) present the combined Phase I and Phase II sequence for master plan target category with total annual cost, FMIN of Rs. 1751.5 Crores over combined planning horizon of 14 periods. For these sequences, barring the time spell between 5th and 8th periods wherein SSP, a large project has been added, the irrigation supply and demand are observed to be matching. Hydropower supply is found to be in surplus throughout the planning horizon because of excess supply carried over from Phase I. The Phase I series projects catering to hydropower are going to be affected by those Phase II projects which are located upstream of them. This may result in reduction in subsequent hydropower supply from these projects and adjust the excess supply carried over from Phase I. Demarcation of the two Phases is indicated clearly in each figure. It is to be noted here, that due to the scale effect the Phase II development may not be properly reflected in the combined representations. The Figs. 7.7(c), 7.8(c), and 7.9(c) show the periodwise irrigation supply area fulfilled (in Mha) from the above mentioned sequences alongwith the existing development. The variations are same.

The tradeoff between irrigation and hydropower supply from all the above mentioned sequences is analysed to study the relation between these water uses. The combined presentation is made in Fig. 7.10 for the recommended sequences. It reveals that the horizontal portion of the tradeoff curve indicates addition of purely irrigation project whereas the vertical portion of such curve reflects addition of purely hydropower project in the given sequence. The figure shows that the trend in tradeoff is almost similar upto the 5^{th} or 6^{th} planning periods. Upto this period reservoirs with medium supply are added. Thereafter there is a sudden large addition of irrigation and hydropower supply due to the presence of SSP in the next period. After this period reservoirs with small supply are added.

Sequencing without allowances and penalties (No Penalty)

In case no allowances are permitted in practice, the Table 7.8(b) gives the sequencing data for the abovementioned categories for no penalty. Figs. 7.11(a), and (b) present the combined Phase I and Phase II sequence for mixed target category with total annual cost, FMIN of Rs. 1804.6 Crores over combined planning horizon of 14 periods which includes 8 of Phase I and 6 of Phase II. Figs. 7.12(a), and (b) present the combined Phase I and Phase II sequence for simulation target category with total annual cost, FMIN of Rs. 1798.9 Crores over combined planning horizon of 14 periods. Figs. 7.13(a), and (b) present the combined Phase I and Phase II sequence for master plan target category with total annual cost, FMIN of Rs. 1784.4 Crores over combined planning horizon of 14 periods. The mixed and simulation target sequences are almost similar. Phase I development in all the three sequences is similar whereas the Phase II development is varying. The Irrigation demand and supply are found to be matching in case of all sequences except for a short spell, i.e., from 5^{th} to 7^{th} period due addition of the SSP reservoir. The hydropower demand and supply are matching only in case of master plan category sequencing and for the remaining two categories the supply is in surplus.

The combined presentation of tradeoff between irrigation area and hydropower supply is made in Fig. 7.14. The trend is similar to the tradeoff of the recommended sequences with allowances and penalties except that the variation in tradeoff is uniform in Phase II.

7.4 COMPARISON OF RESULTS WITH PROJECT AND MASTER PLAN PROVISIONS

The Provisions

The information pertaining to the development of the Narmada river basin prior to the award of the Narmada Water Disputes Tribunal is obtained from various sources and is presented in the form of the Table 7.5. This includes data on proposed water utilization for irrigation(Mcm), irrigation(Lakh acres), hydropower (Mw of installed capacity) at 60% load factor in every plan period from IV^{th} five year plan(1965-1970) to IX^{th} five year plan(1990-1995) and the names of the reservoirs to be added in every plan period (total seven periods) from IV^{th} five year plan(1965-1970) to X^{th} five year plan(1995-2000). This development assumed beginning of preliminary construction works in 1965, i.e, prior to the preparation and revision of Master Plan.

Nevertheless, after the award of the Tribunal there were revisions in the Master Plan for obvious reasons and it was proposed to develop the Narmada valley in two Phases over a span of 45 years between 1979 and 2024. In the first Phase (Phase I, 1979-2000) covering a period of 20 years, it was planned (i) to build facilities for utilising the irrigation potential created by the already completed reservoirs, namely, Barna, Tawa, and Sukta, (ii) to complete the then ongoing Bargi, Matiyari, and Kolar reservoirs, (iii) to accelerate the then newly started reservoirs in the VI^{th} plan under Narmada Sagar complex (comprising Narmada Sagar, Omkareshwar, Maheshwar), Man and Jobat, and (iv) to take up Upper Narmada, Bargi diversion and Chhota Tawa reservoirs and Sardar Sarovar in Gujarat. The line diagram in Fig. 5.3 shows the relative positions of these reservoirs. In the Phase II of development (2000-2024), the remaining 16 reservoirs were to be taken up so as to complete the development of the Narmada valley by 2024. The line diagram in Fig. 5.4 shows the relative positions of these reservoirs. The phasing due to revision in the Master Plan, however, did not indicate the planwise addition of reservoirs. Further, as stated earlier, the pace of development is very slow and as such there is further scope for rearrangement in the order of reservoirs to be added and also for extension of the existing planning horizon.

Existing development

The information available to date reveals that the Bargi reservoir is completed in 1971(2^{nd} period) but the infrastructure development is still ongoing, the reservoirs Barna, and Tawa are completed in 1978(3^{rd} period) and Sukta is completed in 1984(4^{th} period).

The Figs. 7.7(c), 7.8(c) and 7.9(c) schematically showed the recommended sequences and existing development in terms of irrigation supply (Mha) fulfilled. The comparison of the recommended sequences (14 periods) with the existing development of the system (as stated earlier) shows that

(i) Bargi which was expected to come in the 2^{nd} period, appears in the 3^{rd} period,

(ii) Tawa, and Sukta which were expected to come in the 3^{rd} period, appear in the 2^{nd} period, and

(iii) Barna, which was expected to come in the 3^{rd} period, appears in the 4^{th} period.

Thus, the study shows that there are insignificant deviations in the periods of appearance of abovementioned projects.

Old sequencing (before Master Plan revision)

Table 7.10 gives the comparison of the various sequences(orders) of development for capacity expansion of the Narmada reservoir system. In order to facilitate comparison with old sequencing, two periods of the recommended sequences are merged into one period and accordingly results are shown in the Table 7.10. Table 7.11 gives the abbreviations used for reservoirs in old sequencing. Figs.7.15(a),(b),(c),and (d) schematically show these orders of development with respect to irrigation area(Mha) supply. The mega projects such as Narmada Sagar(NSG) and Sardar Sarovar(SSP) are found to be appearing early in the sequences whereas small and moderate size projects are appearing towards the later part of the planning horizon. (seven periods, in this case). For old sequencing each period is of 5 years whereas for the recommended sequences each period should be of 10 years, thereby recommending the planning horizon of 70 years. Looking at the present pace of actual development in the Narmada basin, this extension of planning horizon is appropriate and hence necessary.

The Figs. 7.16(a),(b),and (c) show the recommended sequences, percentage demand and supply for both irrigation(Mcm) and hydropower for each of the target category. In terms of the percentages, the irrigation supply and demand for the recommended sequences are observed to be matching throughout the planning horizon except for the 3rd period whereas for the hydropower, demand and supply are parallel throughout the planning horizon with surplus supply upto 4^{th} period. The 80% of the total sequence cost is required by 3^{rd} period. The figures clearly show the dominance of Phase I projects in overall development.

The sequencing for actual implementation

Ultimately, the simulation category sequencing is preferred and suggested for implementation due to the following reasons:

(a) The usewise targets that can be supplied by the various projects have been obtained by using the detailed simulation model developed for this purpose.

(b) The effect of the upstream projects on the hydropower targets has been quantified using relevant multireservoir operation policy in the detailed simulation model. The same has been duly accounted and used in sequencing model.

(c) The OMR cost of the project is considered as function of the actual release in simulation category sequencing only thereby making this category sequencing more realistic.

(d) The major portion of sequence (Phase I) falls under the No allowances-No penalty class. Thus, development follows the demand pattern more closely.

The Table 7.12 shows the zonewise (agroclimatic) development of the basin for the simulation target sequencing (suggested for implementation) alongwith irrigation supply in Mha in each zone. The Upper Zone projects appear in the 3^{rd}, 4^{th}, 9^{th}, 12^{th}, and 14^{th} periods; the Middle Zone projects appear in the 2^{nd}, 4^{th}, 5^{th}, 10^{th}, 12^{th}, and 14^{th} periods; and the Lower Zone projects appear in the 1st, 6th, 7th, 8th, and 13th periods. By and large, the zonewise distribution of projects as per sequencing appears to be balanced and as per usual expectations in overall development. However, in lower zone there is no addition of any project(s) for 5 periods after appearance of Omkareshwar in the very first period. Lower zone development is almost complete by 8th period because most of the projects are included in Phase I development. For the remaining two zones, the development is evenly spread all over the planning horizon.

A line diagram indicating locations and the period of appearance of the reservoirs for simulation target sequencing (suggested for implementation) is given in Fig. 7.17.

7.5 CONCLUSIONS

In this study an attempt was made to apply the major advances in systems analysis by employing a blend of simulation and sequencing models. These models were effectively used for analysing a complex water resources system successfully.

The problem addressed in this study was of obtaining a sequence of development of the reservoirs in a multipurpose, multifacility system consisting of 30 major reservoirs on the Narmada river in Central India, to meet current and forecasted growth in the demands of water for irrigation and hydropower. The various alternative configurations of these reservoirs were analysed based on the project proposals and engineering considerations for obtaining the optimal reservoir targets and subsequently the optimal sequencing of these reservoirs.

The approach was to arrive at a suitable methodology to identify the minimum cost sequence of river basin reservoirs subjected to technological, economical and policy constraints. The development has been envisaged in two Phases as stipulated in the Master Plan. The Phase I and the Phase II consisted of 14 and 16 reservoirs respectively. In view of the large number of reservoirs being involved and the planning nature of the present study, the neighbouring similar reservoirs have been suitably clubbed into 9 each and were called projects in both the Phases. A deterministic backward dynamic programming process which is suitable for tackling the sequencing problem, has been adopted in both the Phases. Computer programs were suitably developed and modified and were used for simulation as well as for sequencing of the system.

The final recommended optimal sequences of development, i.e., the capacity expansion path of reservoirs for the Narmada river basin system, the targets (capacity) that can be supplied at every stage (time period), minimum cost of sequence alongwith the shortage/excess type and the penalty class were shown in the Table 7.6, Table 7.7, and Table 7.8(a), and also in the Figs. 7.1 to 7.6. The Table 7.9 gave the names of the reservoirs to be added in each of the total 14 planning periods for the complete system of 30 reservoirs. It also indicated the hydropower potential, and its availability period for hydropower reservoirs. The Figs.7.7(a),(b),and (c), Figs.7.8(a),(b),and (c), and Figs.7.9(a),(b),and (c) showed the schematic representation of the combined Phase I and Phase II developments and existing development. The Fig.7.10 showed the tradeoff between irrigation and hydropower supply for the recommended sequences. The details of the sequences with no allowances and penalties for the three target categories were enlisted in the Table 7.8(b) and the Figs. 7.11(a), (b); 7.12(a), (b); and 7.13(a), (b) showed these no penalty sequences schematically. The Fig. 7.14 presented the tradeoff between irrigation (Mha) and hydropower supply for these no penalty sequences.

As per the Figs. 7.7(c), 7.8(c), and 7.9(c), the comparison of the sequences with the existing development showed that there are insignificant deviations in the periods of appearance of the existing projects, namely, Bargi, Tawa, Sukta, and Barna. After merging two periods of the recommended sequences into one for the sake of comparison, the Table 7.10 gave the comparison of the various sequences(orders) of development for capacity expansion of the Narmada reservoir system and the Figs. 7.15(a),(b),(c),and (d) schematically showed these orders of development. The Figs. 7.16(a),(b),and (c) showed the recommended sequences, percentage demand and supply for both irrigation(Mcm) and hydropower for each of the target category.

The Table 7.12 showed the agroclimatic zonewise development of the basin for the simulation target sequencing (suggested for implementation) alongwith irrigation supply in Mha in each zone. The zonewise distribution of projects as per sequencing appears to be balanced and as per usual expectations in overall development. The Fig. 7.17 presented the simulation target sequencing (suggested for implementation) in the form of line diagram.

The following observations are noteworthy:

(i) A detailed simulation model can be effectively used for fixing the annual irrigation targets and also for quantifying the effect of upstream reservoir(s) on annual firm hydropower targets.

(ii) Presence of an irrigation or a multipurpose reservoir at the upstream reduces the annual firm hydropower target of a given downstream reservoir.

(iii) Presence of a purely hydropower reservoir at the upstream increases the annual firm hydropower target of a given downstream reservoir.

(iv) Sequencing is found to be sensitive to the annual cost, mainly operation and maintenance cost (as the annual capital cost is fixed), demand rate, allowable shortage in meeting the demand, upper limit on supplying in excess without penalty, upper limit on allowable excess with penalty, penalty costs for these allowances and the number of planning periods considered.

(v) The effects of these factors are more pronounced in case of 6 and 8 planning periods as compared to 4 periods.

(vi) Most commonly, small reservoirs are exchanged in the modified sequence due to changes in these factors.

(vii) Most commonly, multipurpose reservoir is replaced by another multipurpose reservoir while effecting the modification in the sequence due to changes in these factors.

(viii) Reservoirs (like Narmada Sagar and Sardar Sarovar) are observed to be less sensitive to the changes in various factors and tend to occupy almost a fixed position in a sequence.

(ix) The comparison of the recommended sequences with the existing development showed that there are insignificant deviations in the periods of appearance of existing projects, namely, Bargi, Tawa, Sukta, and Barna.

(x) The simulation target category sequencing is preferred and suggested for implementation.

(xi) The zonewise distribution of projects as per sequencing suggested for implementation appears to be balanced and as per usual expectations in overall development.

At last to summarize the outcomes of this study, the following conclusions may be drawn:

(i) The Simulation - Optimization models have been applied to a real life water resources system which is under initial stages of development at present.

(ii) All the possible reservoir combinations are simulated and subsequently considered in the sequencing. This allows to consider all the possible new configurations (possible states) at every stage which can be formulated by adding all the remaining unsequenced prospective reservoirs/projects one by one and selecting among them the most economically feasible reservoir/project which can be sequenced. Hence, the analysis is likely to guarantee the optimal solution.

(iii) Due to availability of fast and large computing systems, it was possible to simulate all possible reservoir combinations using a big flexible simulation program and further it was also possible to consider all the states (project combinations) in the sequencing program.

(iv) Due to the incorporation of the aspect of quantification of the effect of the presence of upstream reservoir(s) on the target(s) of the immediate downstream reservoir, the results obtained are more realistic.

(v) In most cases of the conventional planning practice, reservoirs are planned on an individual basis. Even in integrated planning of water resources by conventional methods, the choice is limited to a few alternatives which the planner could conceive from his intuition, experience and judgment. Since exhaustive analysis of all the possible combinations of reservoirs involves huge computations, such analysis was seldom attempted in the past. However, nowadays it is very much possible to carry out such analysis using modern computing facilities and techniques within reasonable limits of time and efforts.

(vi) It is felt that the developed programs are efficient, flexible, convenient and useful tools for obtaining sequencing of a large multipurpose, multireservoir system.

(vii) As stated in Chapter 5, only economic objective has been considered and used as a vehicle only in order to establish the sequencing model as a tool for satisfying the water needs. In this, only capital cost has been accounted although social and environmental costs may have considerable weightage for the Narmada system, in particular, which is in the limelight of controversies nowadays.

(viii) Based on the conclusions mentioned so far, it can thus be finally concluded that the approach used in the present study is feasible and can be adopted to analyse such similar large and complex river basin planning expansion and sequencing problems as carried out for Narmada river basin.

7.6 SUGGESTIONS FOR FUTURE WORK

(i) This study provides further scope of applying other techniques like Mixed Integer Programming, LP-DP combination, Heuristic approach etc.

(ii) The multiobjective criteria of evaluation may be incorporated.

(iii) The chance-constrained problem may be formulated and solved.

(iv) The price elasticity of demand may be taken into consideration.

(v) The operation of the system may be considered at different hydropower load factors. For a hydropower reservoir, it is possible to use its full potential until the upstream affecting reservoirs appear in the sequencing of the system.

(vi) In case of major reservoirs such as Bargi and Omkareshwar, and reservoirs such as Narmada Sagar and Sardar Sarovar, the time phasing of individual reservoirs may be considered. A lot of efforts may be required to prepare a code for identifying the constituent reservoirs of the combinations, the scale of the constituent reservoirs and for preparation of pertaining data files for simulations. Keeping track of all the combinations, their constituents, and level/stage of development of the constituents (in case of time phasing) may be a major impediment in this endeavor. An attempt can be made to overcome this.

(vii) Planning period wise availability of funds for development can be considered as a constraint and problem can then be solved as a capital budgeting problem using a suitable model and optimization technique.

(viii) The strategy may be applied to many of the pending real life planning problems, new or in initial stages of development.

Table 7.1 Statement showing possible number of combinations for various cases of time phasing of Phase I reservoirs

Sr.No.	Project Code	Case I NLEV	Case I NCOMB	Case II NLEV	Case II NCOMB	Case III NLEV	Case III NCOMB	Additional II	Additional III
1.	UPN	2	2	2	2	2	2	0	0
2.	**BRG**	**2**	4	**2**	8	3	6	0	2
3.	TSC	2	8	2	8	2	12	0	4
4.	BKL	2	16	2	16	2	24	0	8
5.	**NSG**	**2**	32	**3**	48	**3**	72	16	40
6.	**OMK**	**2**	64	**2**	96	3	216	32	152
7.	MAH	2	128	2	192	2	432	64	304
8.	MAJ	2	256	2	384	2	864	128	608
9.	**SSP**	**2**	**512**	**3**	**1152**	**3**	**2592**	**640**	**2080**

Note : Case I : No time phasing of any reservoir.
Case II : Time phasing of NSG and SSP.
Case III: Time phasing of BRG, NSG, OMK, and SSP.
NLEV : Number of levels of capacity.
NCOMB : Number of possible combinations (cumulative).

Table 7.2 Range of firm hydropower targets and releases for series Phase I reservoirs (From 22 year simulation)

Sr. No.	Reservoir Code	Annual firm hydro-power target (Mw) Maximum	Minimum	Average annual Release (Mcm) Maximum	Minimum
1.	BRG	50.00	42.00	4198.0	3528.0
2.	NSG	226.00	146.00	15361.0	9930.0
3.	OMK	131.90	119.00	15397.0	13980.0
4.	MAH	93.90	89.00	15286.0	14516.0
5.	SSP	415.00	134.00	15263.0	10057.0

Table 7.3 Range of firm hydropower targets and releases for series Phase II reservoirs (From 22 year simulation)

Sr. No.	Reservoir Code	Annual firm hydro-power target (Mw) Maximum	Minimum	Average annual Release (Mcm) Maximum	Minimum
1.	RGV	4.00	4.00	313.0	313.0
2.	ROS	7.00	7.00	507.0	507.0
3.	BAS	20.00	14.17	1745.0	1203.0

Table 7.4 Comparison of sequences for various cases (Next period demand as upper limit)

ADE0-PN0, and AEXO-PN0.

Period	CASE-A1(T1)	CASE-A2(T1)	CASE-A3(T1)	CASE-B1(T1)	CASE-B2(T1)	CASE-B3(T1)
1	TSC/OMK	TSC/OMK	TSC/OMK	RGV/ROS/MGL	RGV/ROS/MGL	ROS/CHN
2	UPN/BKL/NSG/MAJ	UPN/BKL/NSG/MAJ	UPN/BKL/NSG/MAJ	UBH/BAS	UBH/BAS	BAS/SMS
3	SSP	SSP	SSP	SMS	SMS/STD	STD/UBL
4	BRG/MAH	BRG/MAH	BRG/MAH	UBL/CHN/STD	UBL/CHN	RGV/UBH/MGL
TMIN	810.5	810.1	811.6	202.3	202.8	216.2

Period	CASE-A1(T2)	CASE-A2(T2)	CASE-A3(T2)	CASE-B1(T2)	CASE-B2(T2)	CASE-B3(T2)
1	BRG	OMK	BRG	BAS/SMS	BAS/SMS	BAS/MGL
2	UPN/OMK	TSC	UPN/BKL/MAH	UBL	UBL	UBL
3	TSC	BRG	TSC/MAJ	RGV/STD	RGV/STD	RGV/STD
4	NSG	UPN/BKL	OMK	ROS/MGL	ROS/MGL	ROS/UBH
5	SSP	SSP	SSP	CHN	CHN	SMS
6	BKL/MAH/MAJ	NSG/MAH/MAJ	NSG	UBH	UBH	CHN
TMIN	1045.2	924.2	1016.3	329.3	330.2	318.5

Period	CASE-A1(T3)	CASE-A2(T3)	CASE-A3(T3)	CASE-B1(T3)	CASE-B2(T3)	CASE-B3(T3)
1	OMK	OMK	BRG	RGV/ROS/SMS	RGV/ROS/CHN	ROS/STD
2	TSC	TSC	UPN/BKL/MAH	STD	BAS	RGV/CHN
3	BRG	BRG	TSC/MAJ	BAS	-	BAS
4	UPN/BKL/MAJ	UPN/BKL	OMK	UBL	UBL	-
5	NSG	NSG	SSP	MGL	SMS	SMS
6	SSP	SSP	NSG	CHN	-	UBL
7	-	MAH	-	-	STD	MGL
8	MAH	MAJ	-	UBH	UBH/MGL	UBH
TMIN	1475.3	1468.7	1593.8	412.1	389.4	402.7

ADE4-PN4, and AEX2-PN2.

Period	CASE-A1(T1)	CASE-A2(T1)	CASE-A3(T1)	CASE-B1(T1)	CASE-B2(T1)	CASE-B3(T1)
1	TSC/OMK	TSC/OMK	TSC/OMK	RGV/ROS/UBL	RGV/ROS/UBL	RGV/STD/UBL
2	UPN/BKL/NSG/MAJ	BRG	UPN/BKL/NSG/MAJ	MGL	MGL	ROS/CHN
3	SSP	UPN/BKL/NSG/MAJ/SSP	SSP	BAS/SMS	BAS/SMS	SMS
4	BRG/MAH	MAH	BRG/MAH	UBH/CHN/STD	UBH/CHN/STD	UBH/BAS/MGL
TMIN	810.5	842.4	811.6	182.3	182.8	206.6

Table 7.4 Continued

Period	CASE-A1(T2)	CASE-A2(T2)	CASE-A3(T2)	CASE-B1(T2)	CASE-B2(T2)	CASE-B3(T2)
1	BRG	BRG	BRG	RGV/ROS/SMS	RGV/ROS/SMS	ROS/STD
2	UPN/OMK	UPN/BKL/MAH	UPN/BKL/MAH	-	-	RGV/UBL
3	BKL/MAJ	TSC/MAJ	TSC	BAS/MGL	BAS/CHN	MGL
4	TSC	NSG	OMK	STD/UBL	-	BAS/CHN
5	NSG/SSP	SSP	SSP	CHN	STD/UBL	-
6	MAH	OMK	NSG/MAJ	UBH	UBH/MGL	UBH/SMS
FMIN	1022.3	1065.0	1012.6	305.7	296.1	285.3

Period	CASE-A1(T3)	CASE-A2(T3)	CASE-A3(T3)	CASE-B1(T3)	CASE-B2(T3)	CASE-B3(T3)
1	OMK	BRG	OMK	RGV/ROS/SMS	RGV/ROS/SMS	ROS/STD
2	TSC	OMK	TSC	-	-	RGV
3	BRG	UPN/BKL	BRG	MGL	UBL	SMS
4	UPN/BKL/MAJ	TSC	UPN/MAJ	BAS	BAS	-
5	NSG	NSG	NSG	CHN	CHN	BAS/CHN
6	SSP	SSP	SSP	UBL	-	UBL
7	-	-	-	STD	STD	MGL
8	MAH	MAH/MAJ	BKL/MAH	UBH	UBH/MGL	UBH
FMIN	1475.3	1611.3	1466.2	409.2	395.2	411.9

ADE8-PN5, and AEX9-PN6.

Period	CASE-A1(T1)	CASE-A2(T1)	CASE-A3(T1)	CASE-B1(T1)	CASE-B2(T1)	CASE-B3(T1)
1	TSC/OMK	TSC/OMK	TSC/OMK	RGV/ROS	RGV/ROS	ROS/CHN
2	UPN/BKL/NSG/MAJ	UPN/BKL/NSG/MAJ	BRG	SMS	SMS	RGV/STD
3	SSP	SSP	SSP	BAS/MGL/UBL	BAS/CHN	SMS
4	BRG/MAH	BRG/MAH	UPN/BKL/NSG/MAH/MAJ	UBH/CHN/STD	UBH/STD/MGL/UBL	UBH/BAS/MGL/UBL
FMIN	810.5	822.7	792.0	179.9	180.0	211.2

Period	CASE-A1(T2)	CASE-A2(T2)	CASE-A3(T2)	CASE-B1(T2)	CASE-B2(T2)	CASE-B3(T2)
1	BRG	BRG	BRG	RGV/ROS	RGV/ROS	ROS/STD
2	UPN/OMK	BKL	UPN/MAJ	SMS	CHN	RGV
3	BKL	OMK	OMK	UBL	-	UBL
4	TSC	UPN/TSC	TSC	BAS/CHN	BAS/SMS	BAS/CHN
5	NSG/SSP	NSG/SSP	SSP	MGL	UBL	MGL
6	MAH/MAJ	MAH/MAJ	BKL/NSG/MAH	UBH/STD	UBH/STD/MGL	UBH/SMS
FMIN	1023.2	1029.1	985.2	301.4	287.0	271.7

Table 7.4 Continued

Period	CASE-A1(T3)	CASE-A2(T3)	CASE-A3(T3)	CASE-B1(T3)	CASE-B2(T3)	CASE-B3(T3)
1	OMK	BRG	OMK	ROS	ROS	RGV/STD
2	TSC	OMK	TSC	SMS	SMS	-
3	BRG	UPN/MAJ	BRG	-	-	UBL
4	UPN/BKL	TSC	UPN	BAS/MGL	BAS/MGL	BAS/CHN
5	NSG	NSG	NSG	UBL	-	-
6	SSP	SSP	SSP	RGV/CHN	RGV/CHN	ROS/SMS
7	-	-	-	-	-	MGL
8	MAH/MAJ	BKL/MAJ	BKL/MAH/MAJ	UBH/STD	UBH/STD/UBL	UBH
FMIN	1461.9	1609.6	1476.1	399.6	393.4	418.2

ADE10-PN7, and AEX10-PN7.

Period	CASE-A1(T1)	CASE-A2(T1)	CASE-A3(T1)	CASE-B1(T1)	CASE-B2(T1)	CASE-B3(T1)
1	TSC/OMK	TSC/OMK	TSC/OMK	RGV/ROS/UBL	RGV/ROS/CHN	ROS/CHN
2	UPN/BRG	BRG	BRG	SMS	BAS	BAS/SMS
3	SSP	NSG/MAJ/SSP	SSP	BAS/MGL	SMS	STD/UBL
4	BKL/NSG/MAH/MAJ	UPN/BKL/MAH	UPN/BKL/NSG/MAH/MAJ	UBH/CHN/STD	UBH/STD/MGL/UBL	RGV/UBH/MGL
FMIN	787.1	831.3	884.3	201.0	195.2	229.3

Period	CASE-A1(T2)	CASE-A2(T2)	CASE-A3(T2)	CASE-B1(T2)	CASE-B2(T2)	CASE-B3(T2)
1	TSC	TSC	TSC	RGV/ROS/SMS	RGV/ROS/SMS	ROS/STD
2	OMK	OMK	OMK	-	-	RGV/UBL
3	BRG	BRG	BRG	BAS/MGL	BAS/MGL	MGL
4	NSG	UPN/BKL	UPN/MAJ	STD/UBL	CHN	UBH/BAS
5	SSP	NSG/SSP	SSP	CHN	UBL	SMS
6	UPN/BKL/MAH/MAJ	MAH/MAJ	BKL/NSG/MAH	UBH	UBH/STD	CHN
FMIN	1035.2	1013.7	975.2	326.3	322.8	319.5

Period	CASE-A1(T3)	CASE-A2(T3)	CASE-A3(T3)	CASE-B1(T3)	CASE-B2(T3)	CASE-B3(T3)
1	OMK	TSC	OMK	RGV/ROS/MGL	RGV/ROS/MGL	ROS/STD
2	TSC	OMK	TSC	UBH	STD	RGV
3	NSG	BRG	BRG	-	UBH	SMS
4	BRG	UPN/BKL	UPN/MAJ	BAS/UBL	-	-
5	UPN/BKL	NSG	NSG	SMS	BAS/CHN	CHN
6	SSP	SSP	SSP	STD	-	BAS/UBL
7	-	MAH	-	-	UBL	MGL
8	MAH/MAJ	MAJ	BKL/MAH	CHN	SMS	UBH
FMIN	1487.2	1611.3	1509.6	464.1	464.6	460.3

Table 7.4 Concluded

Table 7.5 Narmada basin development information prior to award of Narmada Water Disputes Tribunal. (Assuming that preliminary construction works start in 1965)

Plan period(5 yr)	IV	V	VI	VII	VIII	IX	X
A. Order of development proposed before revision of Master Plan (Source: Master Plan, Vol. IA)							
Names of the reservoirs to be added	+Barna	+Tawa *Sukta	*Bargi *Narmadasagar +Jalsindhi	+Upper Burhner @Maheshwar *Harinphal *Navagam (Sardar Sarovar)	+Upper Narmada *Basania +Ataria +Chinki +Kolar +Dudhi *Omkareshwar +Man	@Rosra @Sitarewa +Morand +Ganjal +Chhota Tawa +Upper Beda +Lower Goi	@Raghavpur +Halon +Matiyari +Sher +Shakker +Machrewa +Jobat

Plan period(5 yr)	IV	V	VI	VII	VIII	IX
***B. Cumulative water utilization for irrigation (Mcm)**						
Madhya Pradesh	-	2468	4936	8947	12957	17029
Gujarat	-	2345	6108	10057	11908	11908
Total	-	4813	11044	19004	24865	28937
***C. Irrigation (Lakh acres)**						
Madhya Pradesh	-	10	20	35	50	65
Gujarat	-	10	25	40	46	46
Total	-	20	45	75	96	111
Total(Mha)	-	0.8	1.8	3.0	3.84	4.44
***D. Hydropower (Mw) of 60% LF**						
Madhya Pradesh	-	1042	1832	1592	1229	1076
Gujarat	-	234	253	211	155	114
Total	-	1276	2085	1803	1384	1190

* Source: Report of the Narmada Water Resources Development Committee, Govt. of India, Ministry of Irrigation and Power, September 1965, headed by Dr. A.N. Khosla.

Note: 1. From the VIII Plan onwards the load factor will go on decreasing and full capacity of installation utilized progressively as a peaking station. The load factor may drop down to 30% or even lower.
2. Symbols for reservoir type: + irrigation; @ hydropower; * multipurpose.

Table 7.6 Recommended sequences for various cases (Next period demand as upper limit).

[*i*]

Period	CASE-A1(T1)	CASE-A2(T1)	CASE-A3(T1)	CASE-B1(T1)	CASE-B2(T1)	CASE-B3(T1)
1	TSC/OMK	TSC/OMK	TSC/OMK	RGV/ROS	RGV/ROS	RGV/STD/UBL
2	UPN/BKL/NSG/MAJ	UPN/BKL/NSG/MAJ	BRG	SMS	SMS	ROS/CHN
3	SSP	SSP	SSP	BAS/MGL/UBL	BAS/CHN	SMS
4	BRG/MAH	BRG/MAH	UPN/BKL/NSG/MAH/MAJ	UBH/CHN/STD	UBH/STD/MGL/UBL	UBH/BAS/MGL
FMIN	787.1	810.1	792.0	179.9	180.0	206.6
DEFICIT	ADE10	ADE0	ADE8	ADE8	ADE8	ADE4
PENALTY	PN7	PN0	PN5	PN5	PN5	PN4
EXCESS	AEX10	AEX0	AEX9	AEX9	AEX9	AEX2
PENALTY	PN7	PN0	PN6	PN6	PN6	PN2

[*j*]

Period	CASE-A1(T2)	CASE-A2(T2)	CASE-A3(T2)	CASE-B1(T2)	CASE-B2(T2)	CASE-B3(T2)
1	BRG	OMK	TSC	RGV/ROS/SMS	RGV/ROS	ROS/STD
2	UPN/OMK	TSC	OMK	-	CHN	RGV/UBL
3	BKL/MAJ	BRG	BRG	BAS/MGL	-	MGL
4	TSC	UPN/BKL	UPN/MAJ	STD/UBL	BAS/SMS	BAS/CHN
5	NSG/SSP	SSP	SSP	CHN	UBL	-
6	MAH	NSG/MAH/MAJ	BKL/NSG/MAH	UBH	UBH/STD/MGL	UBH/SMS
FMIN	1022.3	924.2	975.2	305.7	287.0	285.3
DEFICIT	ADE4	ADE0	ADE10	ADE4	ADE8	ADE4
PENALTY	PN4	PN0	PN7	PN2	PN5	PN4
EXCESS	AEX2	AEX0	AEX10	AEX4	AEX9	AEX2
PENALTY	PN2	PN0	PN7	PN2	PN6	PN2

[*k*]

Period	CASE-A1(T3)	CASE-A2(T3)	CASE-A3(T3)	CASE-B1(T3)	CASE-B2(T3)	CASE-B3(T3)
1	OMK	OMK	OMK	RGV/ROS/SMS	RGV/ROS/CHN	ROS/STD
2	TSC	TSC	TSC	-	BAS	RGV/CHN
3	BRG	BRG	BRG	MGL	-	BAS
4	UPN/BKL	UPN/BKL	UPN/MAJ	BAS	UBL	-
5	NSG	NSG	NSG	CHN	SMS	SMS
6	SSP	SSP	SSP	UBL	-	UBL
7	-	MAH	-	STD	STD	MGL
8	MAH/MAJ	MAJ	BKL/MAH	UBH	UBH/MGL	UBH
FMIN	1461.9	1468.7	1466.2	409.2	389.4	402.7
DEFICIT	ADE8	ADE0	ADE4	ADE4	ADE0	ADE0
PENALTY	PN5	PN0	PN4	PN4	PN0	PN0
EXCESS	AEX9	AEX0	AEX2	AEX2	AEX0	AEX0
PENALTY	PN6	PN0	PN2	PN2	PN0	PN0

Table 7.7 Sequences for recommended planning horizons.

Phase I (Planning horizon of 8 planning periods).

Period	CASE-A1(T3)	CASE-A2(T3)	CASE-A3(T3)
1	OMK	OMK	OMK
2	TSC	TSC	TSC
3	BRG	BRG	BRG
4	UPN/BKL	UPN/BKL	UPN/MAJ
5	NSG	NSG	NSG
6	SSP	SSP	SSP
7	-	MAH	-
8	MAH/MAJ	MAJ	BKL/MAH
FMIN	1461.9	1468.7	1466.2
DEFICIT-PENALTY	ADE8-PN5	ADE0-PN0	ADE4-PN4
EXCESS-PENALTY	AEX9-PN6	AEX0-PN0	AEX2-PN2

Phase II (Planning horizon of 6 planning periods).

Period	CASE-B1(T2)	CASE-B2(T2)	CASE-B3(T2)
1	RGV/ROS/SMS	RGV/ROS	ROS/STD
2	-	CHN	RGV/UBL
3	BAS/MGL	-	MGL
4	STD/UBL	BAS/SMS	BAS/CHN
5	CHN	UBL	-
6	UBH	UBH/STD/MGL	UBH/SMS
FMIN	305.7	287.0	285.3
DEFICIT-PENALTY	ADE4-PN4	ADE8-PN5	ADE4-PN4
EXCESS-PENALTY	AEX2-PN2	AEX9-PN6	AEX2-PN2

Table 7.8(a) Recommeded Sequences data.

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
CASE-A1: Phase I projects for mixed targets. **CASE-A1(T3)**						
Last period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131.0
ADE8-PN5 and	3	7350	90	BRG	8855	179.3
AEX9-PN6	4	9700	100	UPN/BKL	9459	171.3
FMIN=1461.9	5	11700	150	NSG	11733	308.9
	6	16500	220	SSP	22090	439.1
	7	19700	350	-	22090	439.1
	8	22438	520	MAH/MAJ	22438	532.2
CASE-B1: Phase II projects for mixed targets. **CASE-B1(T2)**						
Next period demand	1	350	10	RGV/ROS/SMS	786	11
as upper limit, with	2	800	20	-	786	11
ADE2-PN4 and	3	1200	25	BAS/MGL	1229	30.2
AEX2-PN2	4	1700	30	STD/UBL	1777	34.2
FMIN=305.7	5	2265	30	CHN	2422	34.2
	6	2865	31	UBH	2865	31.24
CASE-A2: Phase I projects for simulation targets. **CASE-A2(T3)**						
Next period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131
ADE0-PN0 and	3	7350	90	BRG	8855	179.3
AEX0-PN0	4	9700	100	UPN/BKL	9759	179.2
FMIN=1468.7	5	11700	150	NSG	12053	316.9
	6	13500	420	SSP	19353	447.1
	7	15700	450	MAH	19353	546
	8	19700	510	MAJ	19701	540.1
CASE-B2: Phase II projects for simulation targets. **CASE-B2(T2)**						
Next period demand	1	350	10	RGV/ROS	-	11
as upper limit, with	2	800	20	CHN	960	11
ADE8-PN5 and	3	1200	25	-	960	11
AEX9-PN6	4	1700	30	BAS/SMS	1746	30.2
FMIN=287.0	5	2265	30	UBL	2082	30.2
	6	3180	31	UBH/STD/MGL	3180	31.24
CASE-A3: Phase I projects for master plan targets. **CASE-A3(T3)**						
Next period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5552	131.9
ADE4-PN4 and	3	7650	90	BRG	9126	181.9
AEX2-PN2	4	9700	100	UPN/MAJ	9794	181.9
FMIN=1466.2	5	11700	150	NSG	12088	407.9
	6	16500	420	SSP	22445	822.9
	7	19700	650	-	22445	822.9
	8	23054	910	BKL/MAH	23054	916.8
CASE-B3: Phase II projects for master plan targets. **CASE-B3(T2)**						
Next period demand	1	350	10	ROS/STD	645	11
as upper limit, with	2	800	20	RGV/UBL	991	15
ADE2-PN4 and	3	1200	25	MGL	1448	15
AEX2-PN2	4	1700	30	BAS/CHN	2728	35
FMIN=285.3	5	2565	30	-	2728	35
	6	4161	35	UBH/SMS	4161	35

Table 7.8(b) No Penalty Sequences data.

Details of upper limit, deficit, excess & penalties	Period	Demand		Sequence of project(s) added	Total Capacity	
		Irri-gation	Hydro-power		Irri-gation	Hydro-power
CASE-A1: Phase I projects for mixed targets. **CASE-A1(T3)**						
Last period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131.0
ADE0-PN0 and	3	7350	90	BRG	8855	179.3
AEX0-PN0	4	9700	100	UPN/BKL/MAJ	9807	171.3
FMIN=1475.3	5	11700	150	NSG	12081	308.9
	6	16500	220	SSP	22438	439.1
	7	19700	350	-	22438	439.1
	8	22438	520	MAH	22438	532.2
CASE-B1: Phase II projects for mixed targets. **CASE-B1(T2)**						
Next period demand	1	350	10	BAS/SMS	786	20
as upper limit, with	2	800	20	UBL	1122	20
ADE0-PN0 and	3	1200	25	RGV/STD	1334	28
AEX2-PN2	4	1700	30	ROS/MGL	1777	34.2
FMIN=329.3	5	2265	30	CHN	2422	34.2
	6	2865	31	UBH	2865	31.24
CASE-A2: Phase I projects for simulation targets. **CASE-A2(T3)**						
Next period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5270	131
ADE0-PN0 and	3	7350	90	BRG	8855	179.3
AEX0-PN0	4	9700	100	UPN/BKL	9759	179.2
FMIN=1468.7	5	11700	150	NSG	12053	316.9
	6	13500	420	SSP	19353	447.1
	7	15700	450	MAH	19353	546
	8	19700	510	MAJ	19701	540.1
CASE-B2: Phase II projects for simulation targets. **CASE-B2(T2)**						
Next period demand	1	350	10	BAS/SMS	786	20
as upper limit, with	2	800	20	UBL	1122	20
ADE0-PN0 and	3	1200	25	RGV/STD	1334	28
AEX0-PN0	4	1700	30	ROS/MGL	1777	34.2
FMIN=330.2	5	2265	30	CHN	2737	34.2
	6	3180	31	UBH	3180	31.24
CASE-A3: Phase I projects for master plan targets. **CASE-A3(T3)**						
Next period demand	1	2350	30	OMK	2790	131.9
as upper limit, with	2	4350	70	TSC	5552	131.9
ADE0-PN0 and	3	7650	90	BRG	9126	181.9
AEX0-PN0	4	9700	100	UPN/MAJ	9794	181.9
FMIN=1465.9	5	11700	150	NSG	12088	407.9
	6	16500	420	SSP	22445	822.9
	7	19700	650	-	22445	822.9
	8	23054	910	BKL/MAH	23054	916.8
CASE-B3: Phase II projects for master plan targets. **CASE-B3(T2)**						
Next period demand	1	350	10	BAS/MGL	457	20
as upper limit, with	2	800	20	UBL	803	20
ADE0-PN0 and	3	1200	25	RGV/STD	1448	28
AEX0-PN0	4	1700	30	ROS/UBH	1901	35
FMIN=318.5	5	2565	30	SMS	2881	35
	6	4161	35	CHN	4161	35

Table 7.9 Details of recommended sequences.

Per-iod	Names of reservoir(s) added	Supply (Demand) Irri-gation	Hydro-power	Remarks
[*i*]				
	CASE-A1: Phase I projects for mixed targets.			**CASE-A1(T3)**
1	Omkareshwar	2790(2350)	132(30)	1.Bargi can supply 50
2	(Tawa, Sukta, Chhota Tawa)	5270(4350)	131(70)	Mw power from 3^{rd} to
3	(Matiyari, Bargi)	8855(7350)	179(90)	8^{th} period.
4	Upper Narmada,(Barna, Kolar)	9459(9700)	171(100)	2.Narmada Sagar can
5	Narmada Sagar	11733(11700)	309(150)	supply 146 Mw from
6	Sardar Sarovar	22090(16500)	439(220)	5^{th} to 8^{th} period.
7	-	22090(19700)	439(350)	3.Omkareshwar can
8	Maheshwar, (Man, Jobat)	22438(22438)	532(520)	supply 119 Mw from 1^{st} to 8^{th} period. 4.Maheshwar can supply 89 Mw only for 8^{th} period.
	CASE-B1: Phase II projects for mixed targets.			**CASE-B1(T2)**
9	Raghavpur, Rosra, (Sher, Machrewa, Shakker)	23224(22788)	543(530)	5.Sardar Sarovar can supply 134 Mw for 8^{th}
10	-	23224(23238)	543(540)	and 9^{th} periods.
11	Basania,(Morand, Ganjal)	23667(23638)	562(545)	6.Basania can supply
12	(Sitarewa, Dudhi), (Upper Beda, Lower Goi)	24215(24138)	566(550)	16 Mw from 11^{th} to 13^{th} period.
13	(Ataria,Chinki)	24860(24703)	566(550)	
14	(Upper Burhner, Halon)	25303(25303)	563(551)	7.FMIN=(1461.9+305.7)
[*j*]				
	CASE-A2: Phase I projects for simulation targets.			**CASE-A2(T3)**
1	Omkareshwar	2790(2350)	132(30)	1.Bargi can supply 50
2	(Tawa, Sukta, Chhota Tawa)	5270(4350)	131(70)	Mw power from 3^{rd} to
3	(Matiyari, Bargi)	8855(7350)	179(90)	8^{th} period.
4	Upper Narmada, (Barna, Kolar)	9759(9700)	179(100)	2.Narmada Sagar can
5	Narmada Sagar	12053(11700)	317(150)	supply 146 Mw from
6	Sardar Sarovar	19353(13500)	447(420)	5^{th} to 8^{th} period.
7	Maheshwar	19353(15700)	546(450)	3.Omkareshwar can
8	(Man, Jobat)	19701(19700)	540(510)	supply 119 Mw from 1^{st} to 8^{th} period. 4.Maheshwar can supply 89 Mw for 7^{th} and 8^{th} periods.
	CASE-B2: Phase II projects for simulation targets.			**CASE-B2(T2)**
9	Raghavpur, Rosra	19701(20050)	551(520)	5.Sardar Sarovar can
10	(Ataria,Chinki)	20661(20500)	551(530)	supply 134 Mw for 8^{th}
11	-	20661(20900)	551(535)	and 9^{th} period.
12	Basania, (Sher, Machrewa,Shakker)	21447(21400)	570(540)	6.Basania can supply 16 Mw from 12^{th} and
13	(Upper Beda, Lower Goi)	21783(21965)	570(540)	13 th period.
14	(Upper Burhner, Halon), (Sitarewa, Dudhi), (Morand, Ganjal)	22881(22880)	571(541)	7.FMIN=(1468.7+287.0)

Table 7.9 Continued

Period	Names of reservoir(s) added	Supply (Demand) Irrigation	Supply (Demand) Hydropower	Remarks
[k]				
	CASE-A3: Phase I projects for master plan targets. CASE-A3(T3)			
1	Omkareshwar	2790(2350)	132(30)	1.Omkareshwar can supply 139 Mw throughout the planning horizon.
2	(Tawa, Sukta, Chhota Tawa)	5552(4350)	132(70)	2.Bargi can supply 50 Mw throughout the planning horizon beyond 3rd period.
3	(Matiyari, Bargi)	9126(7650)	182(90)	3.Narmada Sagar can supply 226 Mw throughout the planning horizon beyond 5th period.
4	Upper Narmada, (Man, Jobat)	9794(9700)	182(100)	
5	Narmada Sagar	12088(11700)	408(150)	
6	Sardar Sarovar	22445(16500)	823(420)	
7	-	22445(19700)	823(650)	
8	(Barna, Kolar), Maheshwar	23054(23054)	917(910)	
	CASE-B3: Phase II projects for master plan targets. CASE-B3(T2)			
9	Rosra, (Sitarewa, Dudhi)	23699(23404)	928(920)	4.Sardar Sarovar can supply 415 Mw throughout the planning horizon beyond 6th period.
10	Raghavpur, (Upper Beda, Lower Goi)	24045(23854)	932(930)	5.Maheshwar can supply 94 Mw throughout the planning horizon beyond 8th period.
11	(Morand, Ganjal)	24502(24254)	932(935)	6.Basania can supply 20 Mw throughout the planning horizon beyond 8th period.
12	Basania, (Ataria, Chinki)	25782(24754)	952(940)	7.FMIN=(1466.2+285.3)
13	-	25782(25619)	952(940)	
14	(Upper Burhner, Halon), (Sher, Machrewa, Shakker)	27215(27215)	952(945)	

Note: (i) Eventhough firm power targets supplied by Phase I hydropower reservoirs will go on decreasing progressively beyond the 8th period it expected to meet the shortfall arising out of this alternatively from thermal power or otherwise.

(ii) Firm hydropower demands are assumed monotonically increasing for making it suitable for sequencing algorithm.

Table 7.9 Concluded

Table 7.10 Comparison of orders of development for capacity expansion of Narmada reservoir system

A. Order of development proposed before revision of Master Plan (Source: Master Plan, Vol. IA)

Period(5 yr each)	I	II	III	IV	V	VI	VII
Names of the reservoirs to be added	+Barna	+Tawa *Sukta	*Bargi *Narmadasagar +Jalsindhi	+Upper Burhner @Maheshwar *Harinphal *Navagam (Sardar Sarovar)	+Upper Narmada *Basania +Ataria +Chinki +Kolar +Dudhi *Omkareshwar +Man	@Rosra @Sitarewa +Morand +Ganjal +Chhota Tawa +Upper Beda +Lower Goi	@Raghavpur +Halon +Matiyari +Sher +Shakker +Machrewa +Jobat
Cumulative water utilization for irrigation (Mcm)	482(0.06)	3264(0.32)	10394(0.71)	21004(2.84)	26820(3.17)	27956(3.28)	29510(3.37)
Cumulative Hydropower installed capacity (MW)	200	1140	1310	1565	1635	1635	1635

B. Orders of development recommended in the present study

(1) Sequencing for mixed targets (Case: A1T3B1T2)

Period(10 yr each)	I	II	III	IV	V	VI	VII
Names of the reservoirs to be added	1.Omkareshwar 2.Tawa 2.Sukta 2.Chotta Tawa	1.Matiyari 1.Bargi 2.Upper Narmada 2.Barna 2.Kolar	1.Narmadasagar 2.Sardar Sarovar	2.Maheshwar 2.Man 2.Jobat	1.Raghavpur 1.Rosra 1.Sher 1.Machrewa 1.Shakker	1.Basania 1.Morand 1.Ganjal 2.Sitarewa 2.Dudhi 2.Upper Beda 2.Lower Goi	1.Ataria 1.Chinki 2.Upper Burhner 2.Halon
Cumulative water utilization for irrigation (Mcm)	5270(0.4)	9459(0.75)	22090(3.0)	22438(3.03)	23224(3.08)	24215(3.17)	25303(3.23)
Cumulative Firm Hydropower (MW)	131	171	439	532	543	566	563

Table 7.10 Continued

Period(10 yr each)	I	II	III	IV	V	VI	VII
(2) <u>Sequencing for simulation targets (Case: A2T3B2T2)</u>							
Names of the reservoirs to be added	1.Omkareshwar 2.Tawa 2.Sukta 2.Chotta Tawa	1.Matiyari 1.Bargi 2.Upper Narmada 2.Barna 2.Kolar	1.Narmadasagar 2.Sardar Sarovar	1.Maheshwar 2.Man 2.Jobat	1.Raghavpur 1.Rosra 2.Ataria 2.Chinki	2.Basania 2.Sher 2.Machrewa 2.Shakker	1.Upper Beda 1.Lower Goi 2.Upper Burhner 2.Halon 2.Sitarewa 2.Dudhi 2.Morand 2.Ganjal
Cumulative water utilization for irrigation (Mcm)	5270(0.4)	9759(0.75)	19353(2.37)	19701(2.4)	20661(2.51)	21447(2.57)	22881(2.68)
Cumulative Firm Hydropower (MW)	131	179(129)	447(170)	540(451)	551(540)	570(551)	571(566)
(3) <u>Sequencing for master plan targets (Case: A3T3B3T2)</u>							
Names of the reservoirs to be added	1.Omkareshwar 2.Tawa 2.Sukta 2.Chotta Tawa	1.Matiyari 1.Bargi 2.Upper Narmada 2.Man 2.Jobat	1.Narmadasagar 2.Sardar Sarovar	2.Barna 2.Kolar 2.Maheshwar	1.Rosra 1.Sitarewa 1.Dudhi 2.Raghavpur 2.Upper Beda 2.Lower Goi	1.Morand 1.Ganjal 2.Basania 2.Ataria 2.Chinki	2.Upper Burhner 2.Halon 2.Sher 2.Machrewa 2.Shakker
Cumulative water utilization for irrigation (Mcm)	5552(0.43)	9794(0.71)	22445(2.95)	23054(3.05)	24045(3.14)	25782(3.28)	27215(3.36)
Cumulative Firm Hydropower (MW)	132	182	823	917	932	952	952

Note: 1. Values in bracket for irrigation indicate area in Mha. 2. Symbols for reservoir type: + irrigation; @ hydropower; * multipurpose. 3. Jalsindhi and Harinphal reservoirs deleted during Master Plan revision.
4. Reservoirs with serial number 1 in the recommended sequences are to be taken up in first five years, and with serial number 2 are to be taken up in next five years of a period of ten years. 5. Values in bracket for hydropower indicate modified previous period hydropower supply due to addition of reservoirs in the upstream of already sequenced hydropower reservoirs.

Table 7.10 Concluded

Table 7.11 Abbreviations used for reservoirs in old sequencing

Sr.No.	Code of the Reservoir	Name of the Reservoirs
1.	UPN	Upper Narmada
2.	BRN	Barna
3.	BAG	Bargi
4.	MTY	Matiyari
5.	TSK	Tawa and Sukta
6.	CHT	Chhota Tawa
7.	KLR	Kolar
8.	NSG	Narmada Sagar
9.	OMK	Omkareshwar
10.	MAH	Maheshwar
11.	MAN	Man
12.	JBT	Jobat
13.	JLS	Jalsindhi
14.	HPL	Harinphal
15.	SSP	Sardar Sarovar
16.	RGV	Raghavpur
17.	ROS	Rosra
18.	UPB	Upper Burhner
19.	HAL	Halon
20.	BAS	Basania(Sigarpur)
21.	CHN	Ataria AND Chinki
22.	SMS	Sher, Machrewa, AND Shakker
23.	STR	Sitarewa
24.	DUD	Dudhi
25.	MGL	Morand AND Ganjal
26.	UBL	Upper Beda AND Lower Goi

Table 7.12 Zonewise irrigation development (Mha) for capacity expansion of Narmada reservoir system (simulation target sequencing)

Phase I				Phase II		
Zone	Period	Project added	Irrigation	Period	Project added	Irrigation
Upper Zone	3	Bargi, Matiyari	0.2299	9	Raghavpur, Rosra	-
	4	Upper Narmada	0.0190	12	Basania	-
				14	Upper Burhner, Halon	0.0215
		Total	0.2489		Total	0.0215
Middle Zone	2	Tawa, Sukta, Chhota Tawa	0.2518	10	Ataria, Chinki	0.0613
	4	Barna, Kolar	0.1056	12	Sher, Machrewa, Shakker	0.0519
	5	Narmada Sagar	0.1230	14	Sitarewa, Dudhi, Morand, Ganjal	0.0688
		Total	0.4804		Total	0.1820
Lower Zone	1	Omkareshwar	0.1468	13	Upper Beda, Lower Goi	0.0219
	6	Sardar Sarovar	1.4942			
	7	Maheshwar	-			
	8	Man, Jobat	0.0305			
		Total	1.6715		Total	0.0219

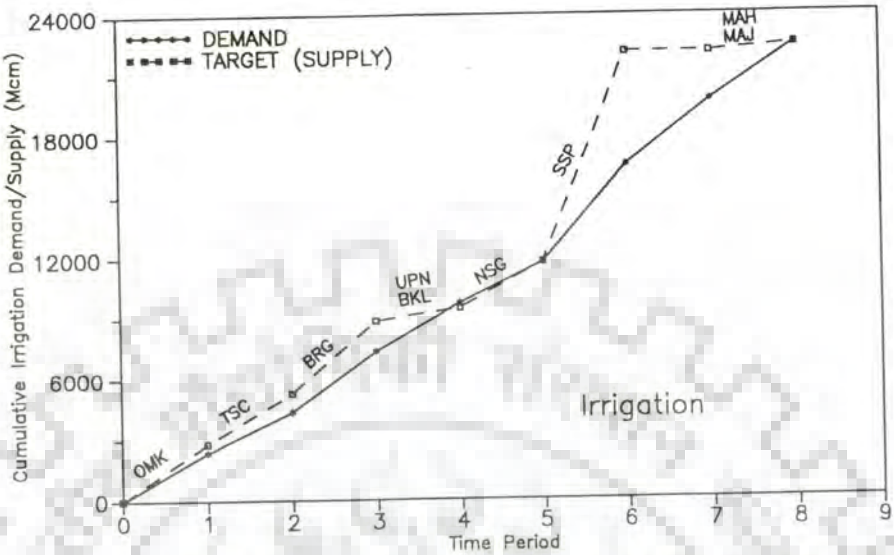


Fig.7.1(a) CASE–A1(T3):Sequencing for Phase I projects for mixed targets

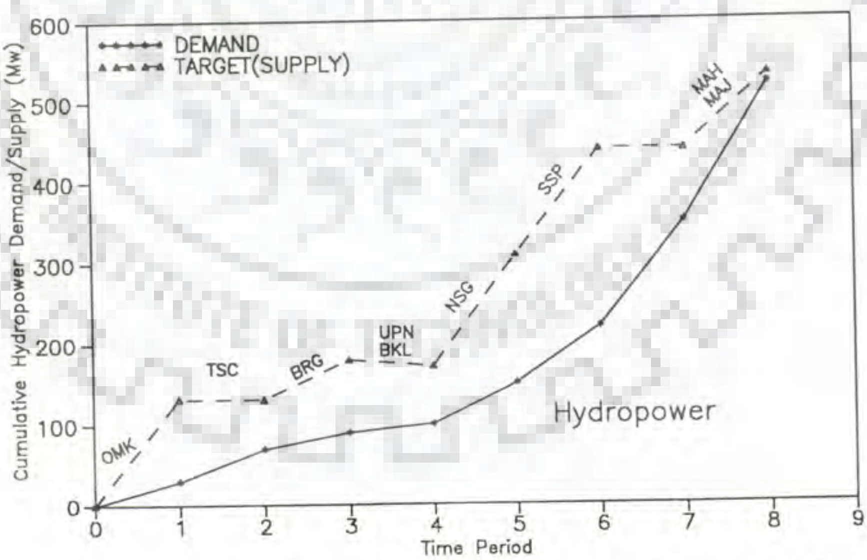


Fig.7.1(b) CASE–A1(T3):Sequencing for Phase I projects for mixed targets

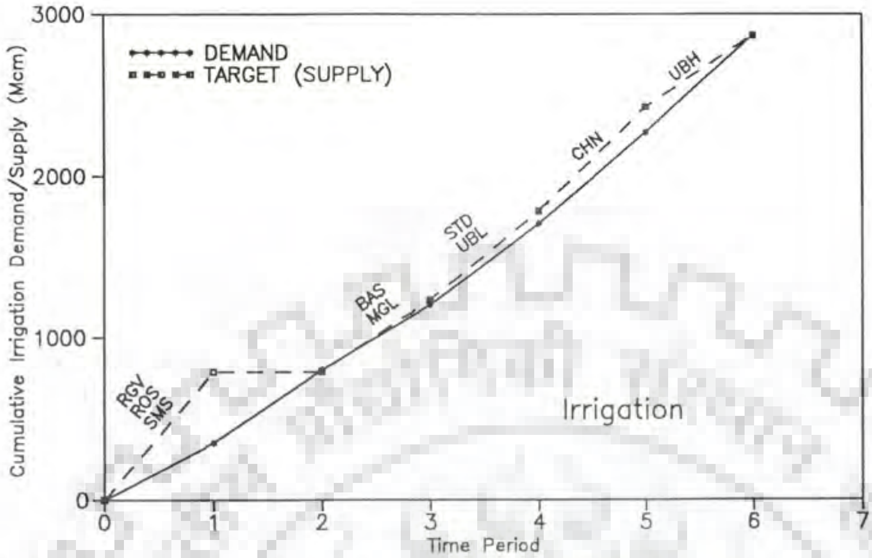


Fig.7.2(a) CASE–B1(T2): Sequencing for Phase II projects for mixed targets

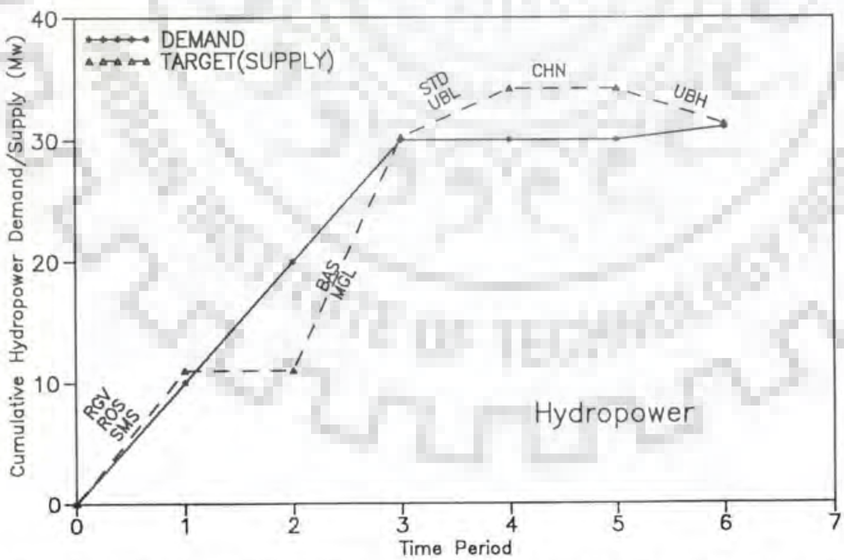


Fig.7.2(b) CASE–B1(T2):Sequencing for Phase II projects for mixed targets

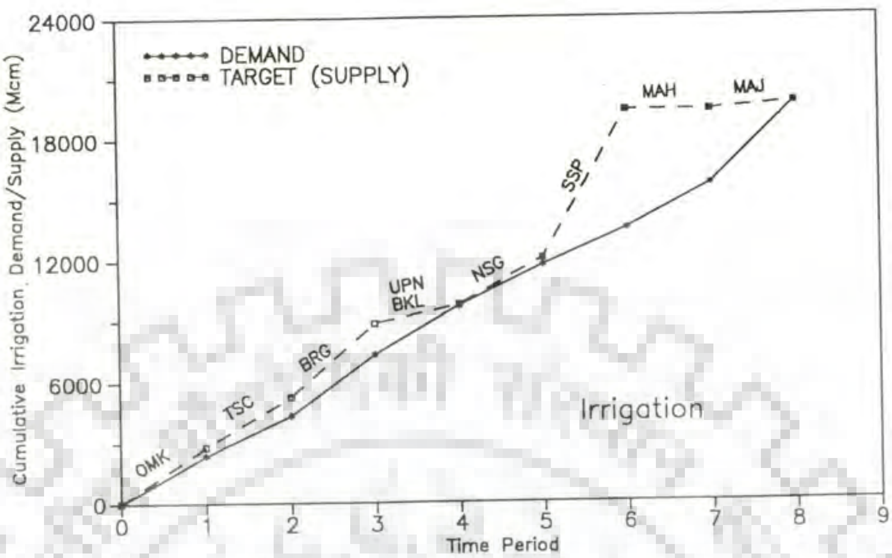


Fig.7.3(a) CASE–A2(T3): Sequencing for Phase I projects for simulation targets

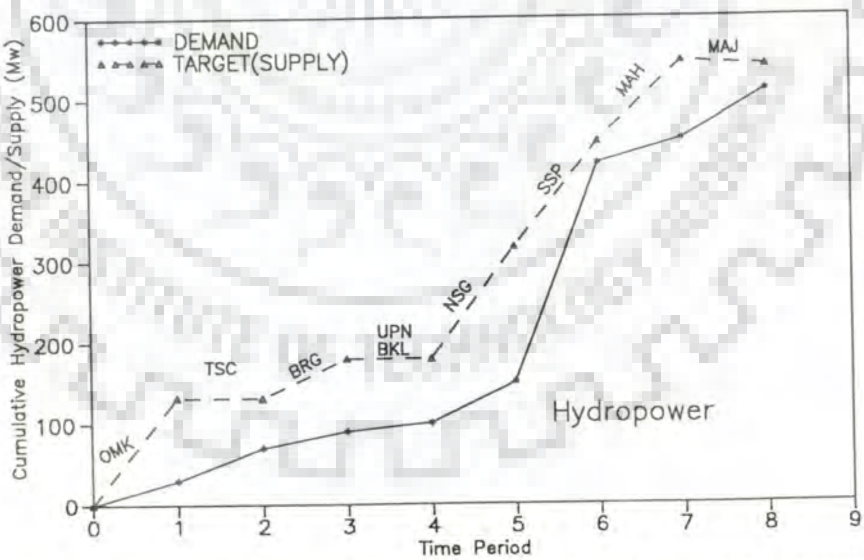


Fig.7.3(b) CASE–A2(T3): Sequencing for Phase I projects for simulation targets

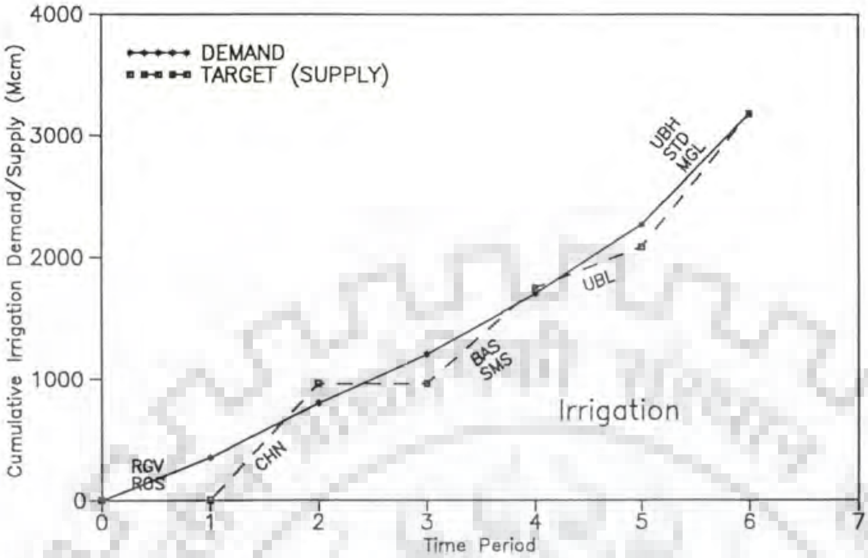


Fig.7.4(a) CASE–B2(T2):Sequencing for Phase II projects for simulation targets

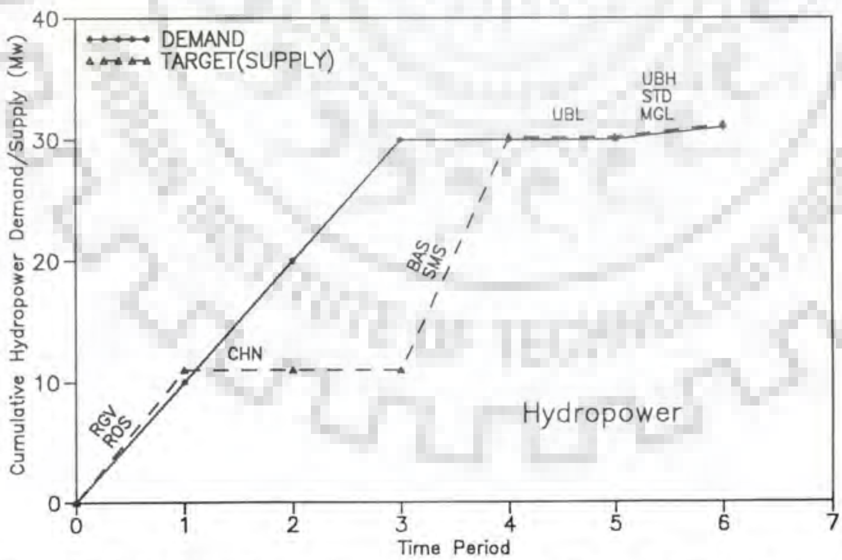


Fig.7.4(b) CASE–B2(T2):Sequencing for Phase II projects for simulation targets

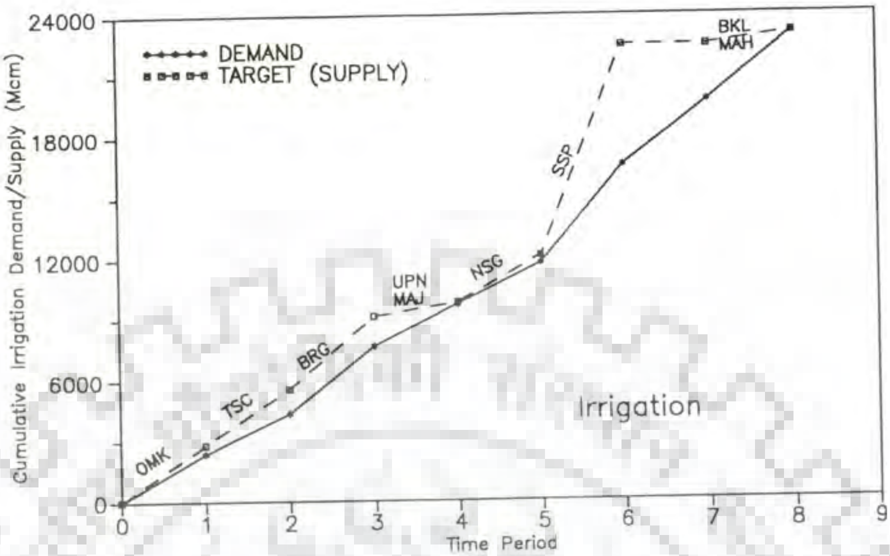


Fig.7.5(a) CASE–A3(T3):Sequencing for Phase I projects for master plan targets

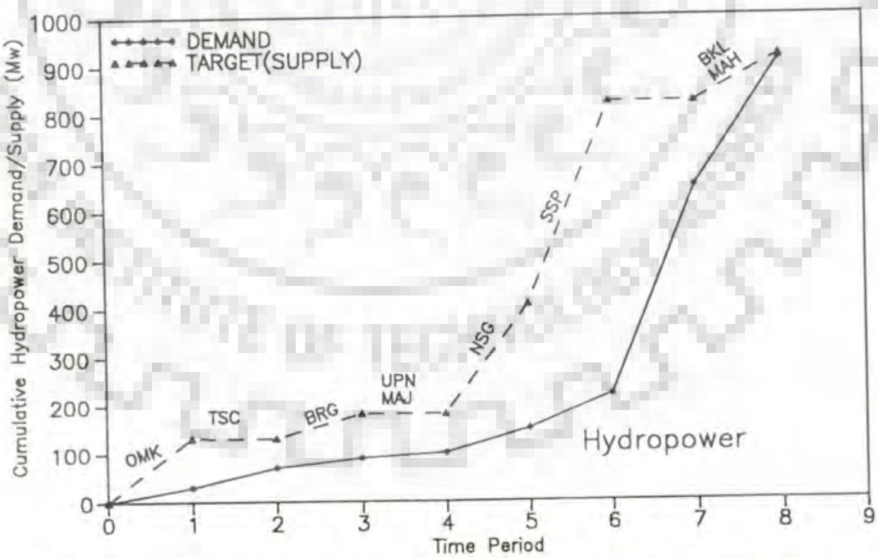


Fig.7.5(b) CASE–A3(T3):Sequencing for Phase I projects for master plan targets

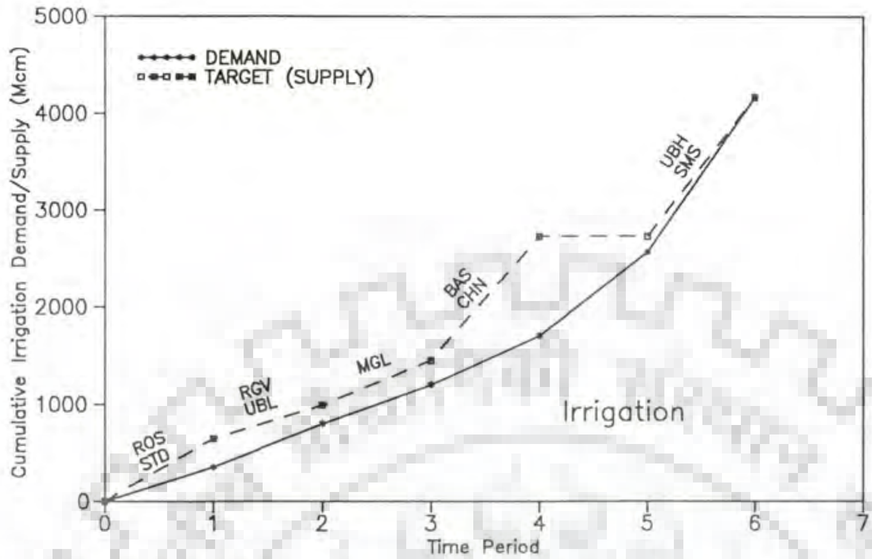


Fig.7.6(a) CASE–B3(T2):Sequencing for Phase II projects for master plan targets

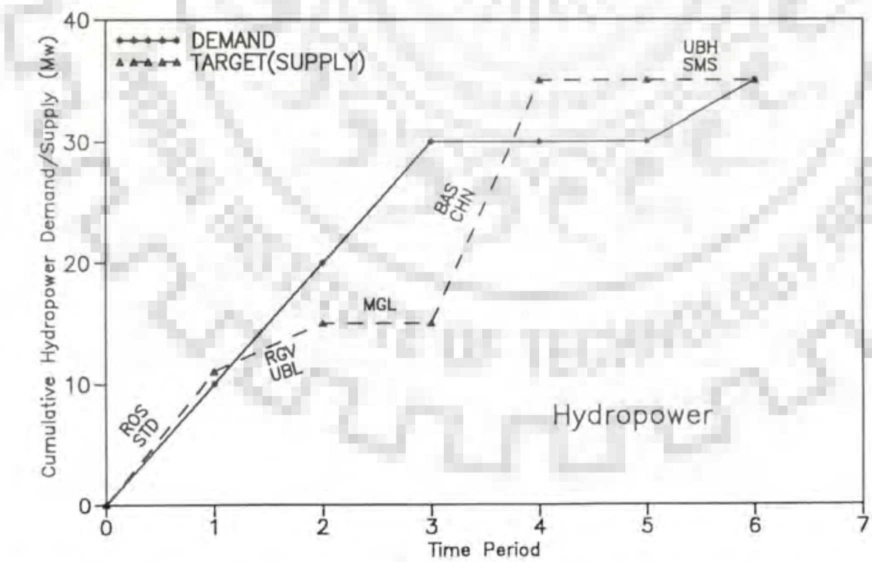


Fig.7.6(b) CASE–B3(T2):Sequencing for Phase II projects for master plan targets

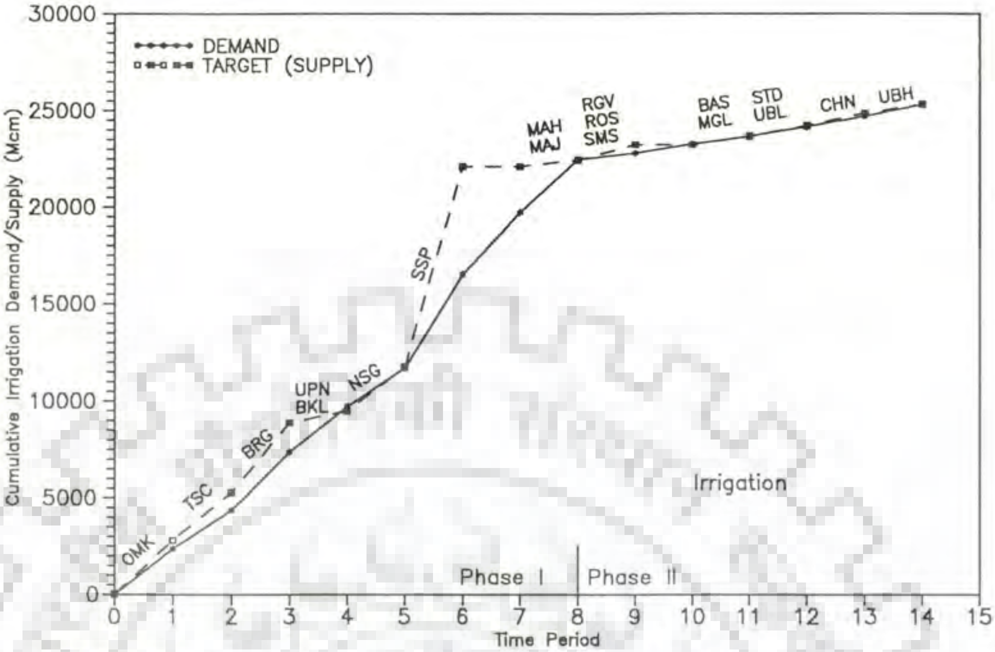


Fig.7.7(a) CASE–A1T3B1T2 Sequencing of projects for mixed targets

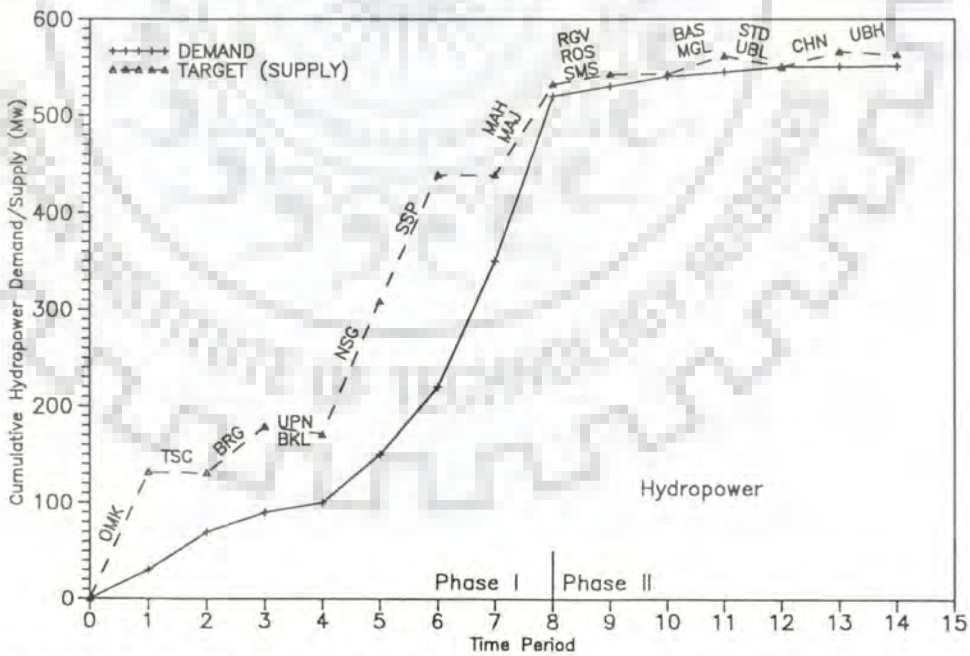


Fig.7.7(b) CASE–A1T3B1T2 Sequencing of projects for mixed targets

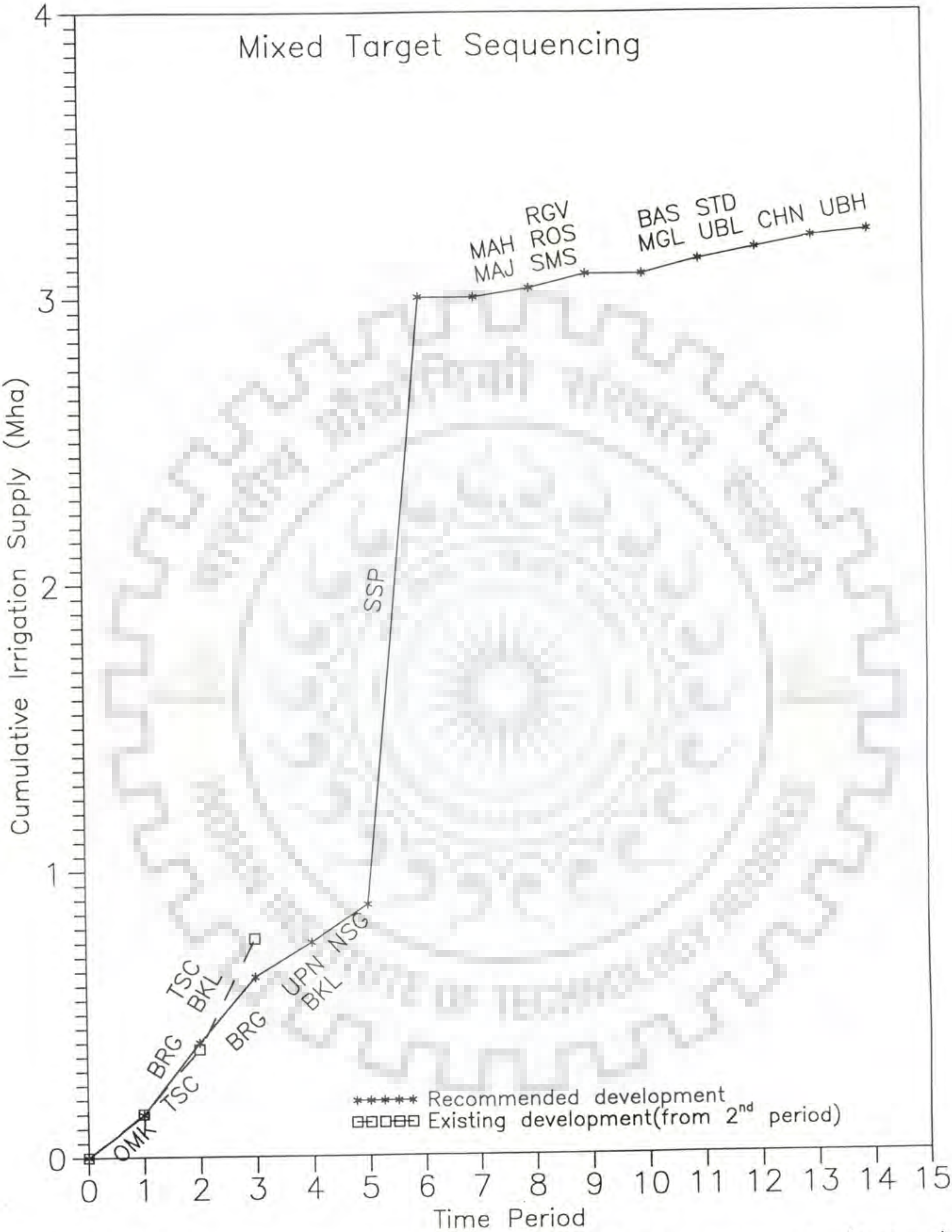


Fig.7.7(c) Cumulative irrigation supply(Mha)

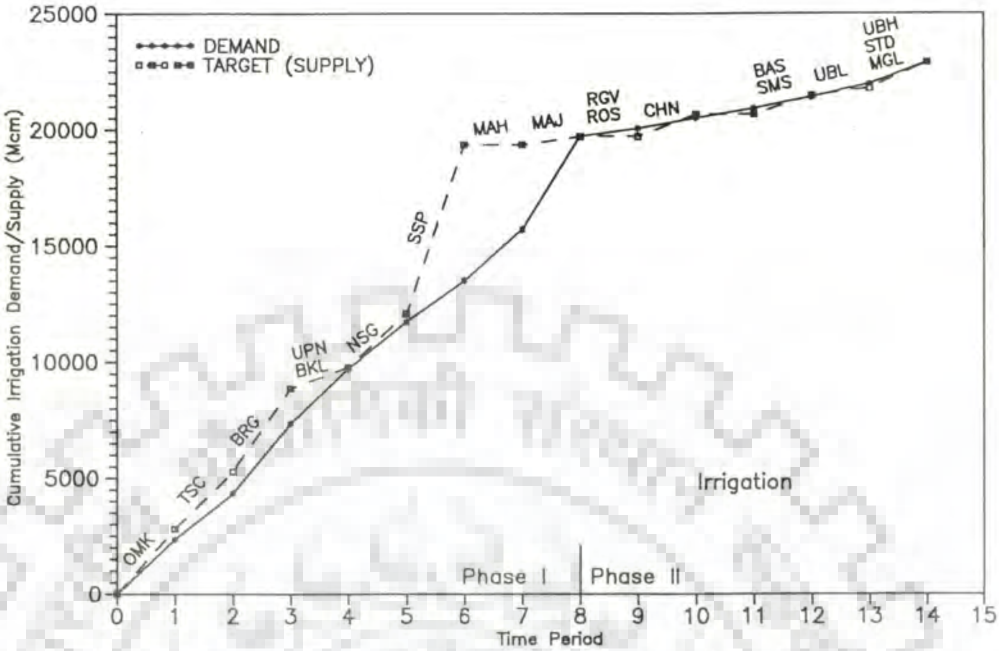


Fig.7.8(a) CASE–A2T3B2T2 Sequencing of projects for simulation targets

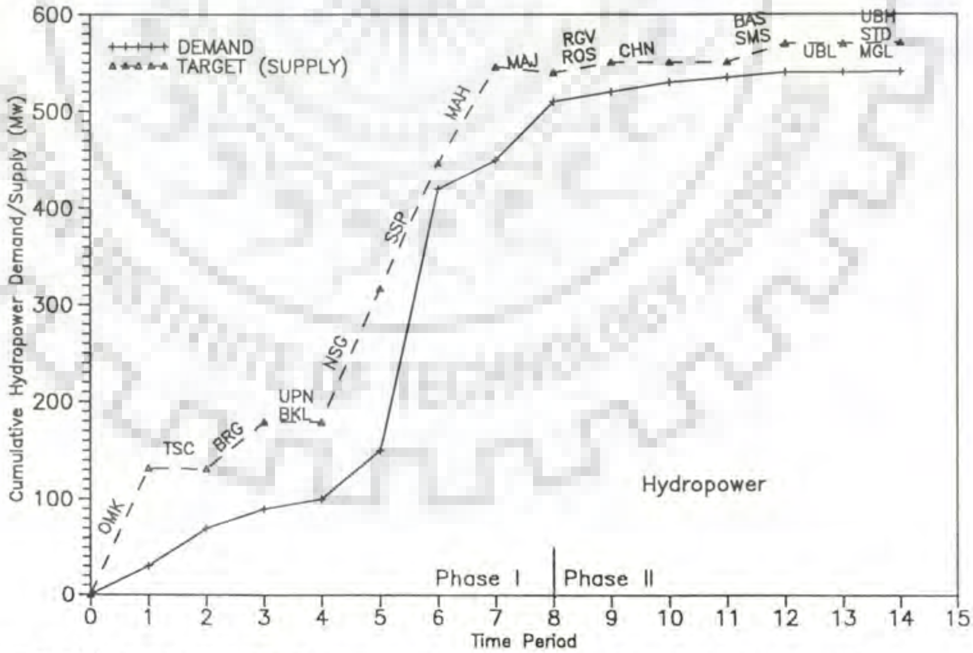


Fig.7.8(b) CASE–A2T3B2T2 Sequencing of projects for simulation targets

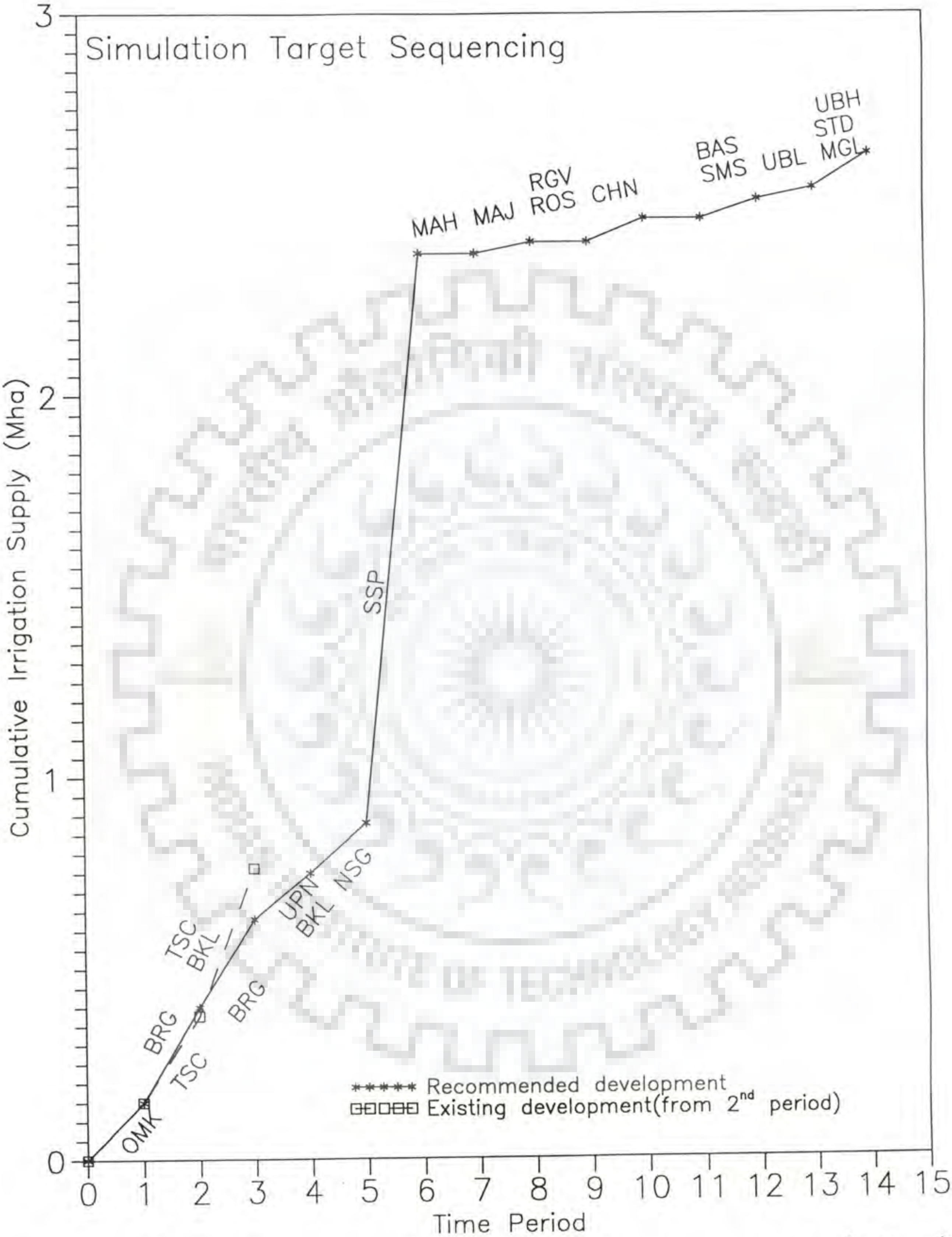


Fig.7.8(c) Cumulative irrigation supply(Mha)

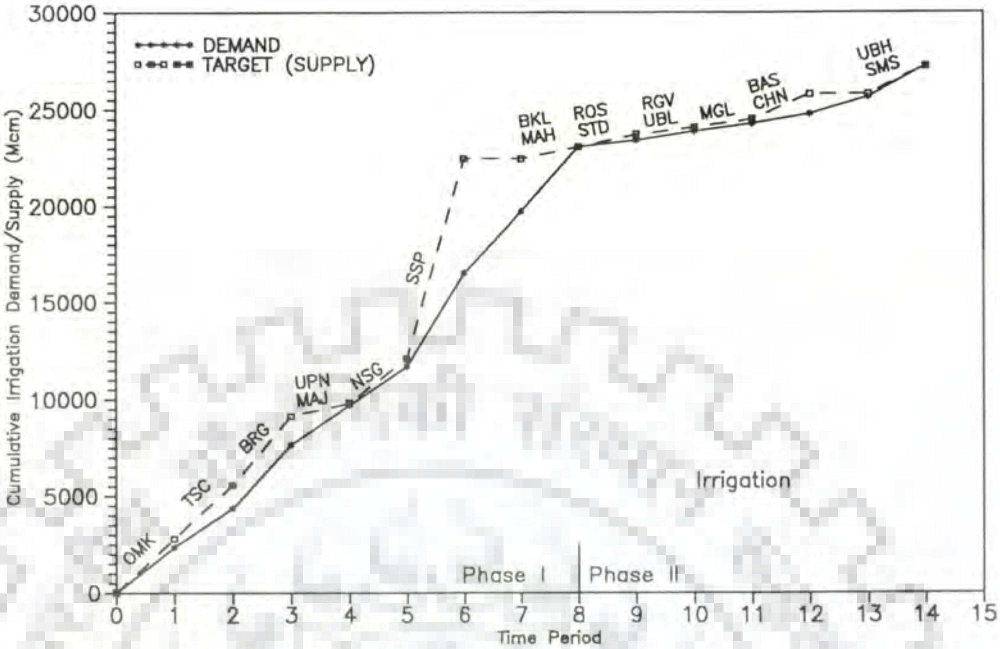


Fig.7.9(a) CASE–A3T3B3T2 Sequencing of projects for master plan targets

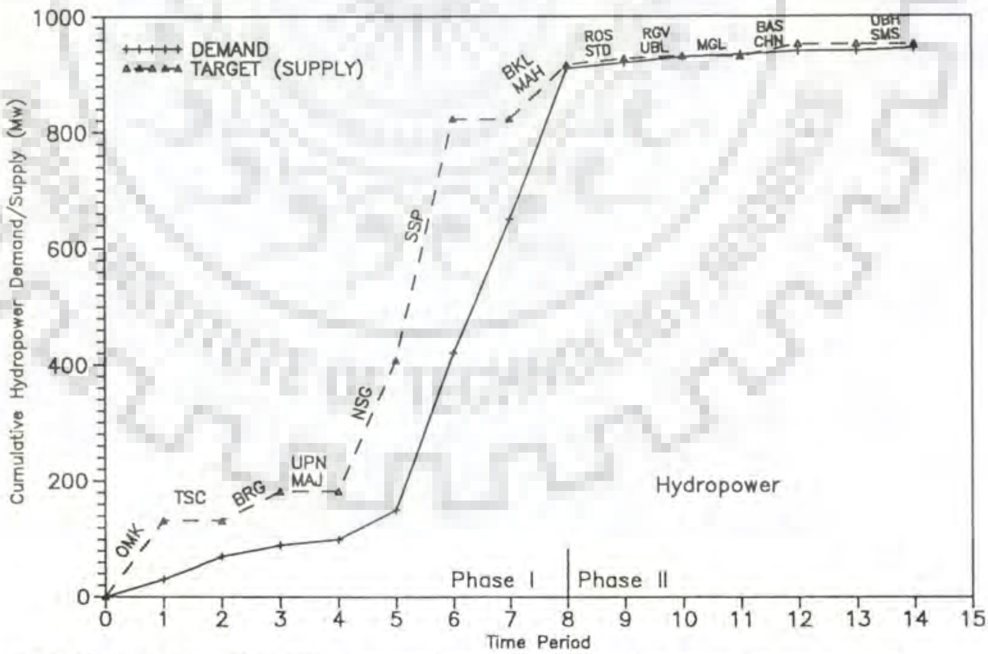


Fig.7.9(b) CASE–A3T3B3T2 Sequencing of projects for masterplan targets

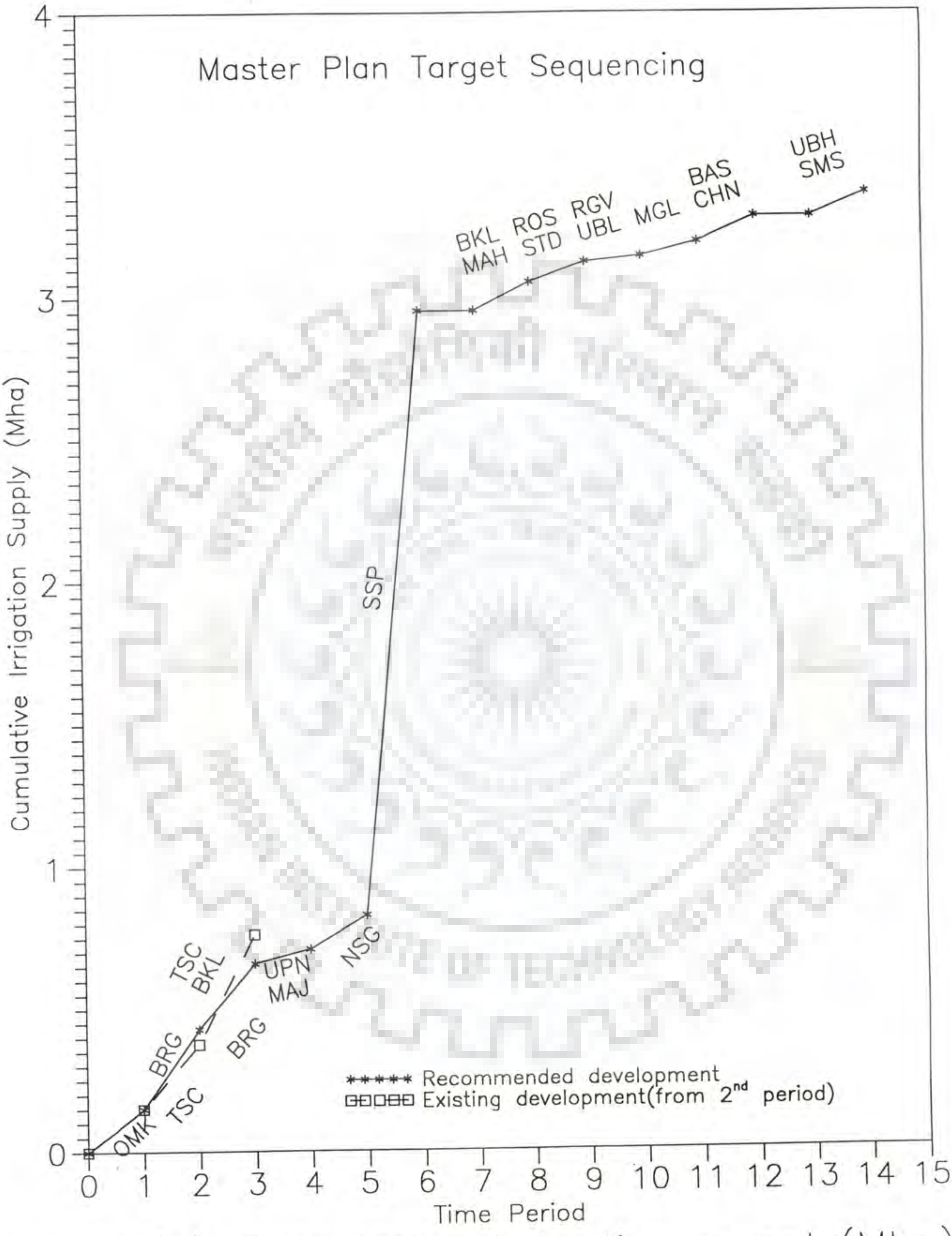


Fig.7.9(c) Cumulative irrigation supply(Mha)

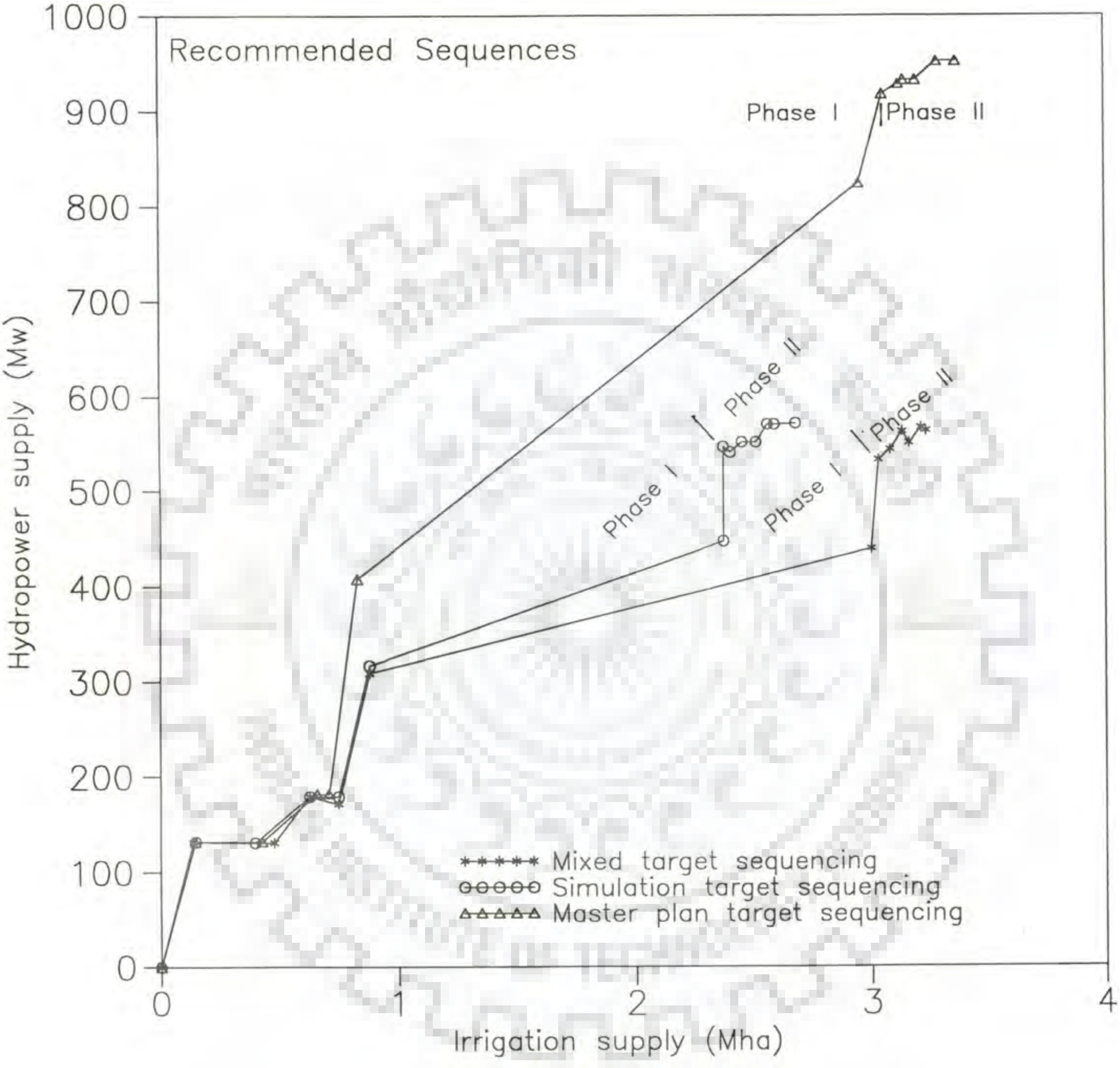


Fig.7.10 Tradeoff between irrigation and hydropower supply

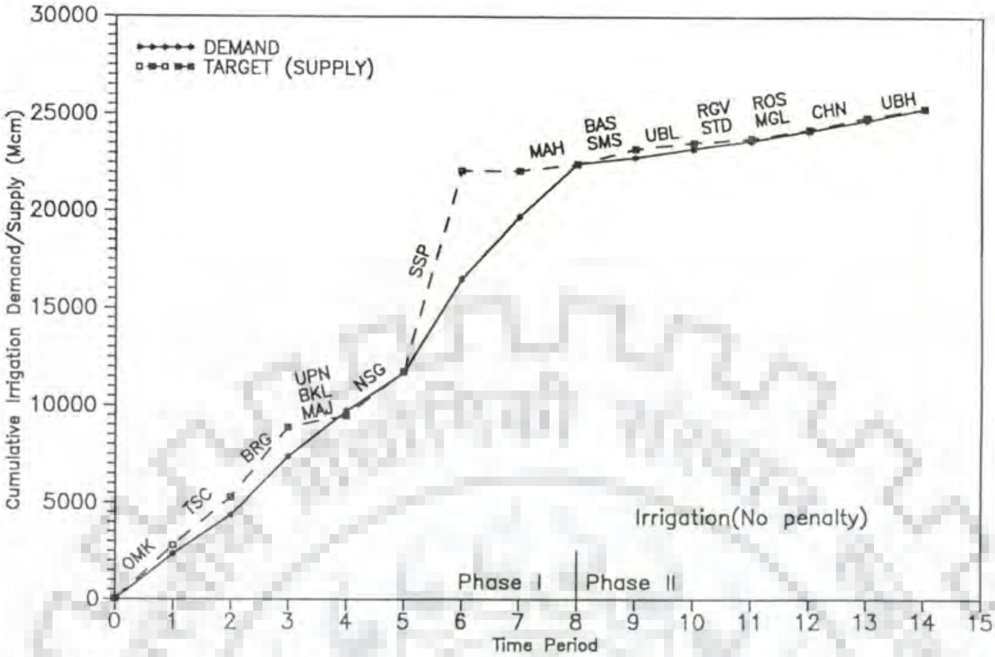


Fig.7.11(a) CASE-A1T3B1T2 Sequencing of projects for mixed targets

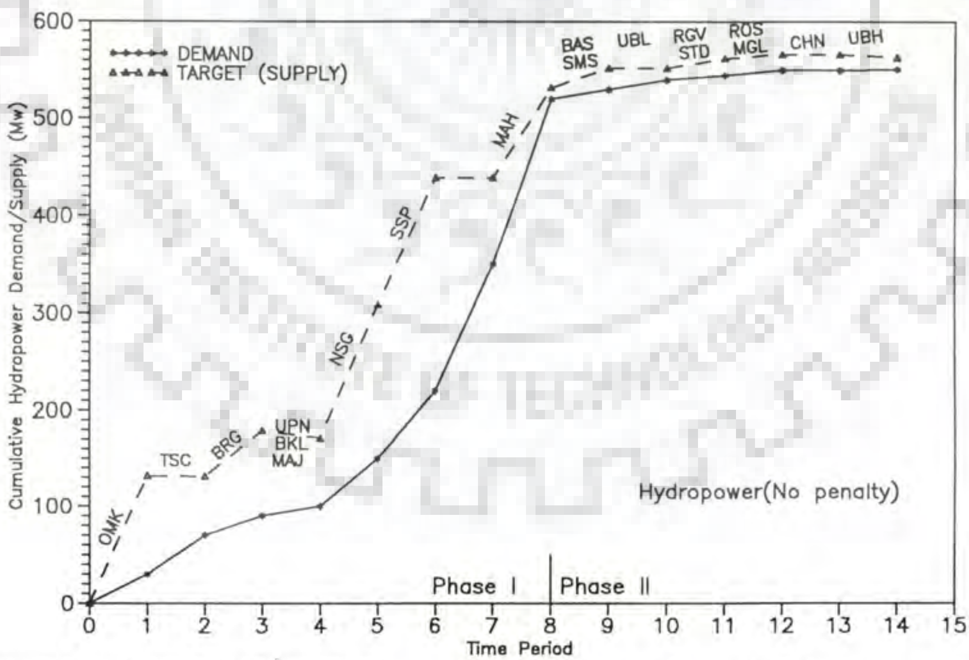


Fig.7.11(b) CASE-A1T3B1T2 Sequencing of projects for mixed targets

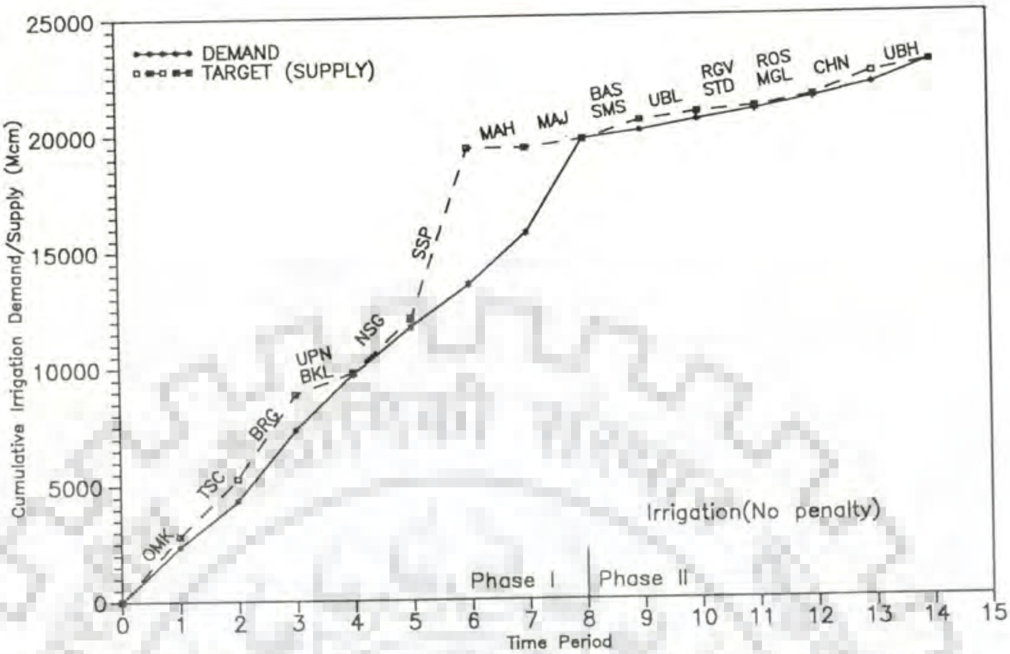


Fig.7.12(a) CASE–A2T3B2T2 Sequencing of projects for simulation targets

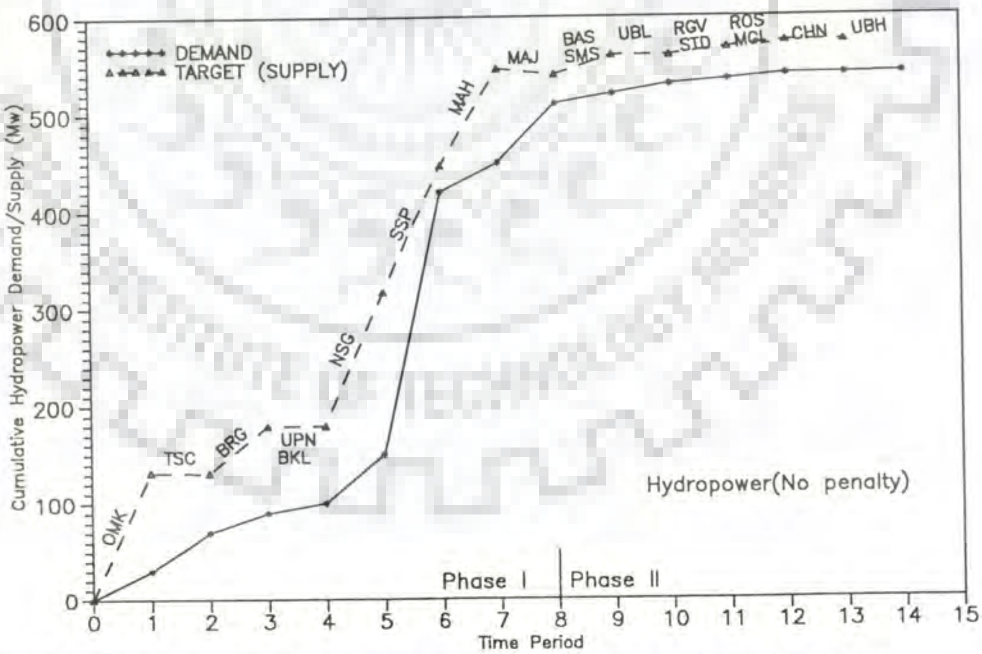


Fig.7.12(b) CASE–A2T3B2T2 Sequencing of projects for simulation targets

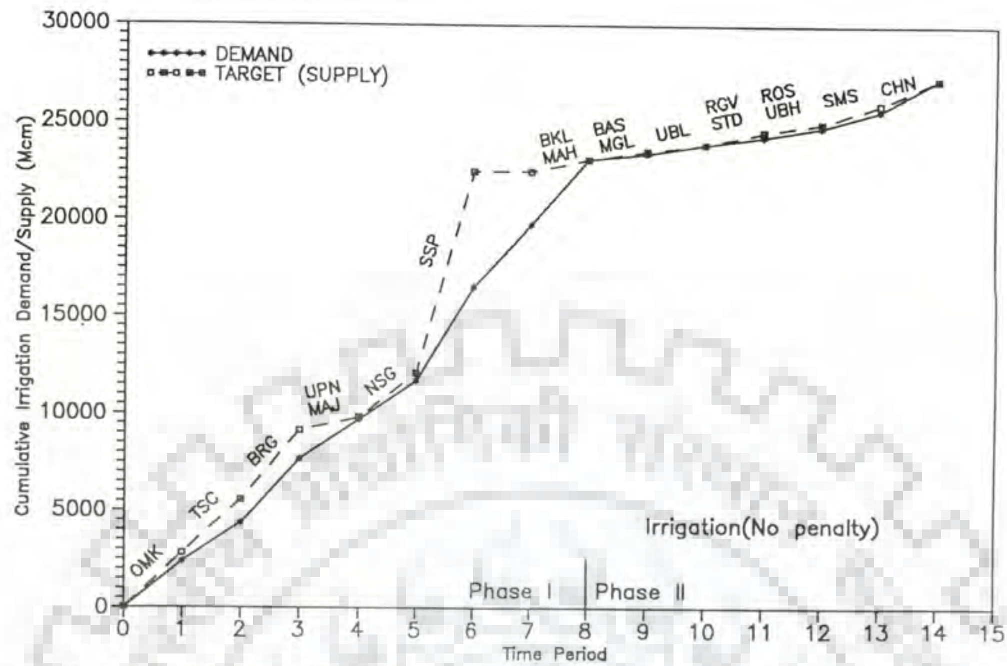


Fig.7.13(a) CASE–A3T3B3T2 Sequencing of projects for master plan targets

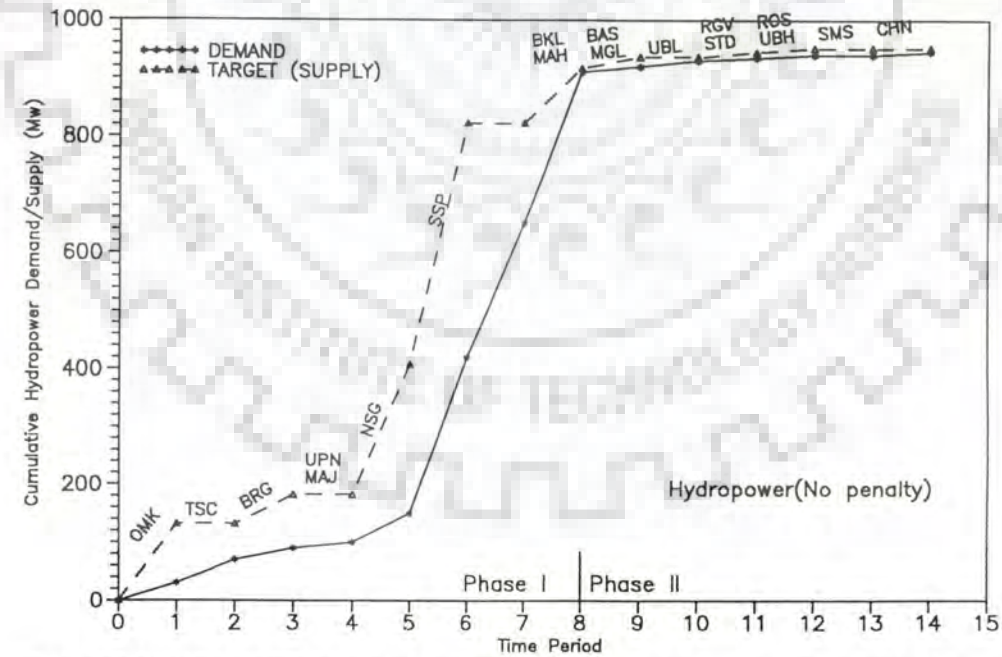


Fig.7.13(b) CASE–A3T3B3T2 Sequencing of projects for master plan targets

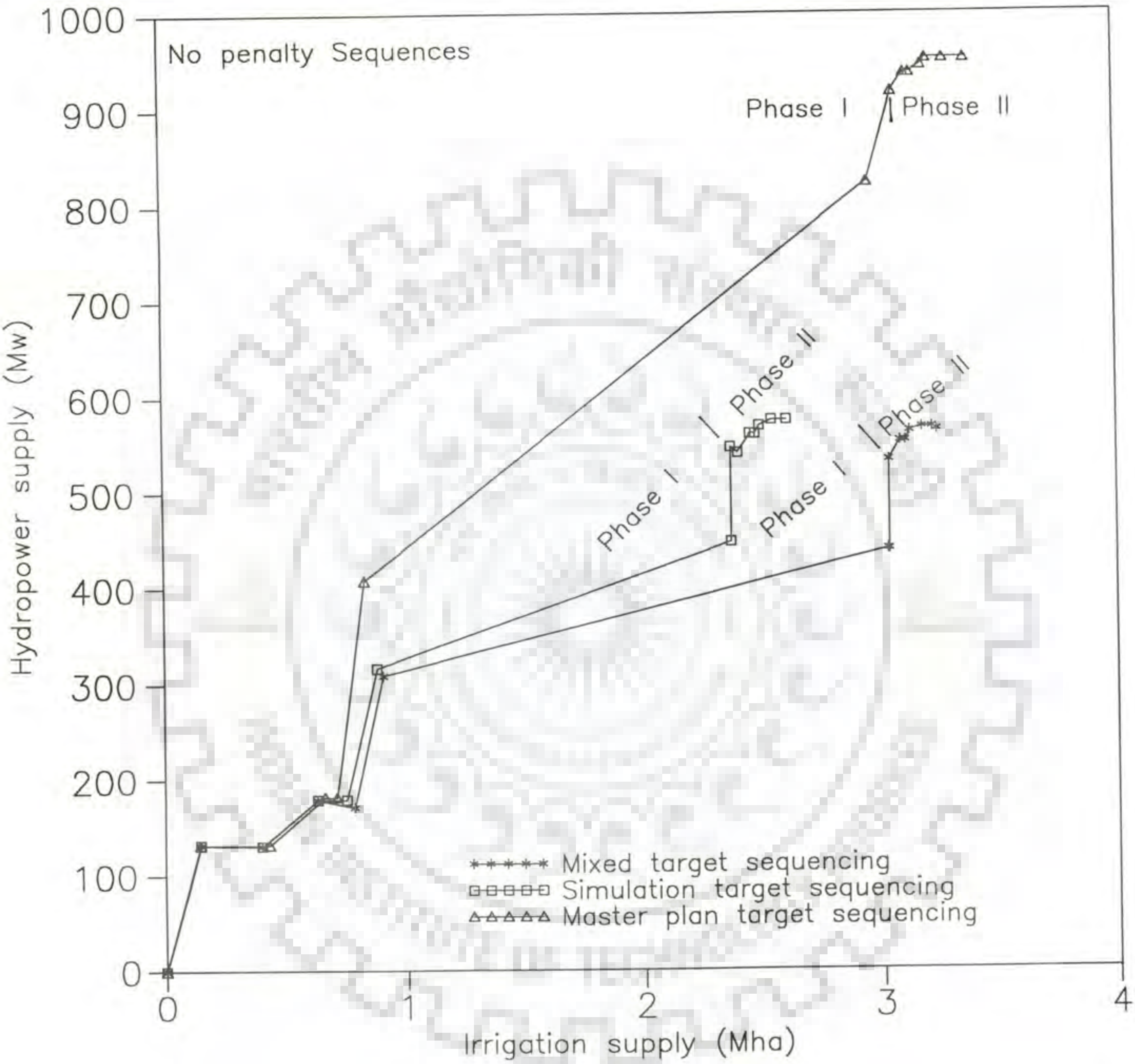


Fig.7.14 Tradeoff between irrigation and hydropower supply

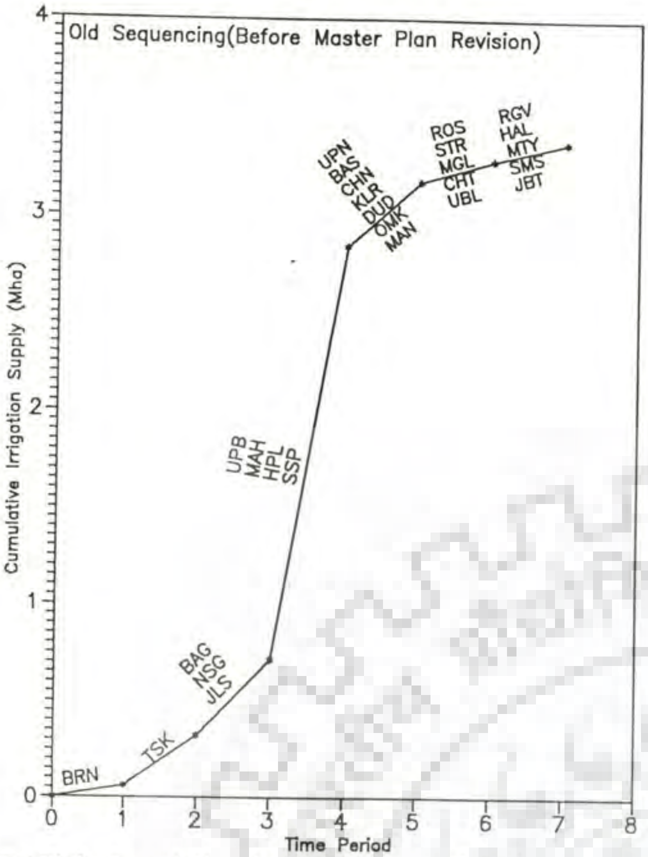


Fig.7.15(a) Cumulative irrigation supply(Mha)

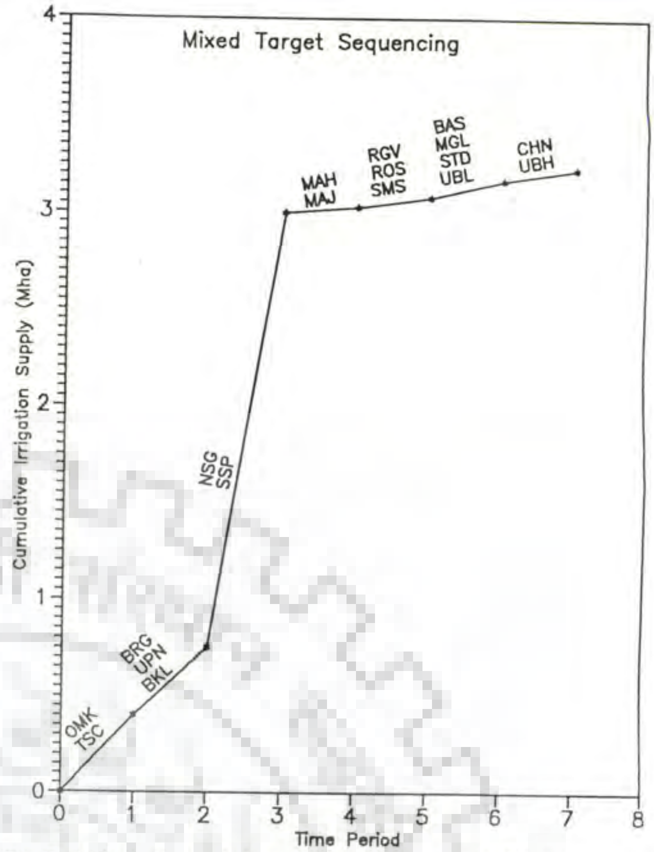


Fig.7.15(b) Cumulative irrigation supply(Mha)

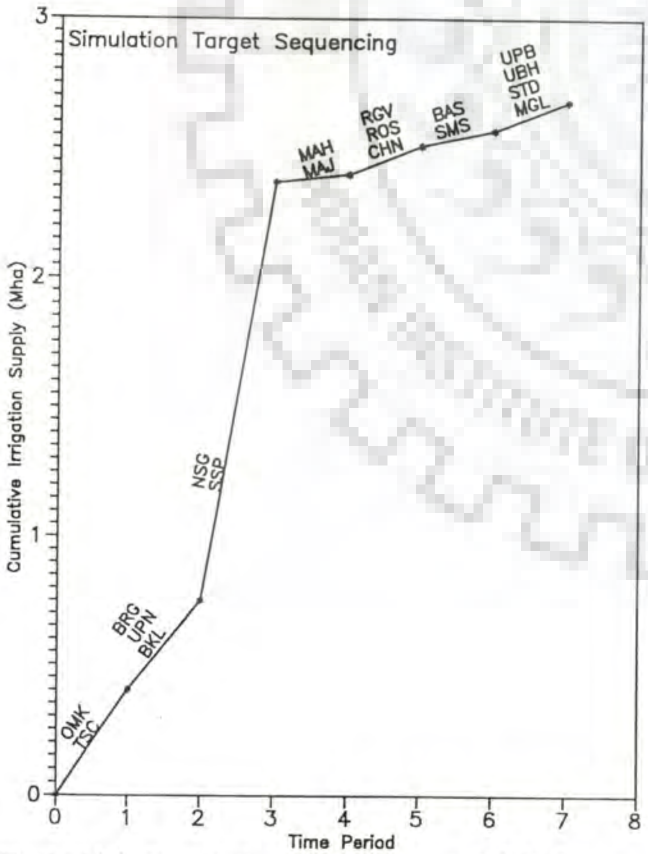


Fig.7.15(c) Cumulative irrigation supply(Mha)

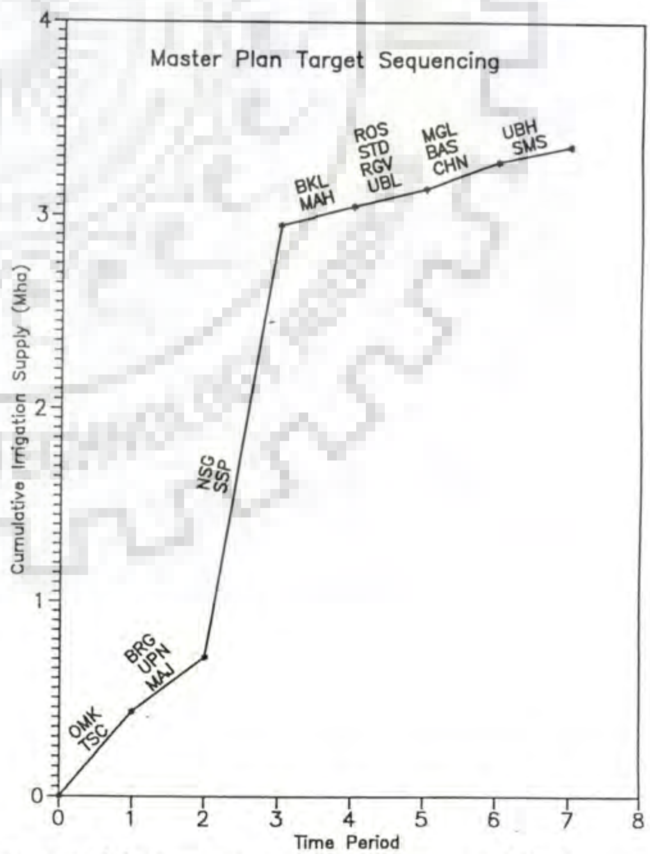


Fig.7.15(d) Cumulative irrigation supply(Mha)

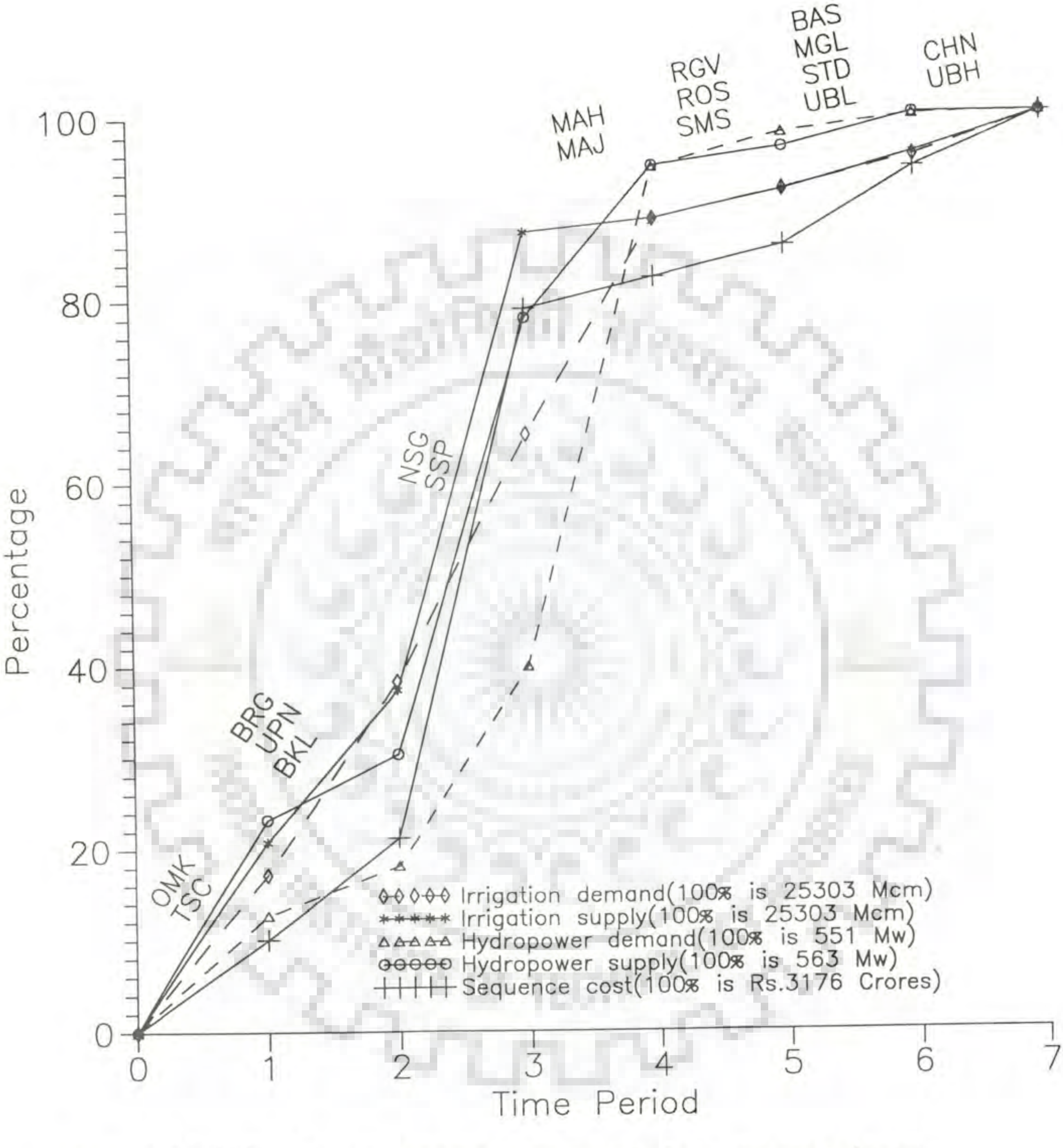


Fig.7.16(a) Mixed target sequencing percentages

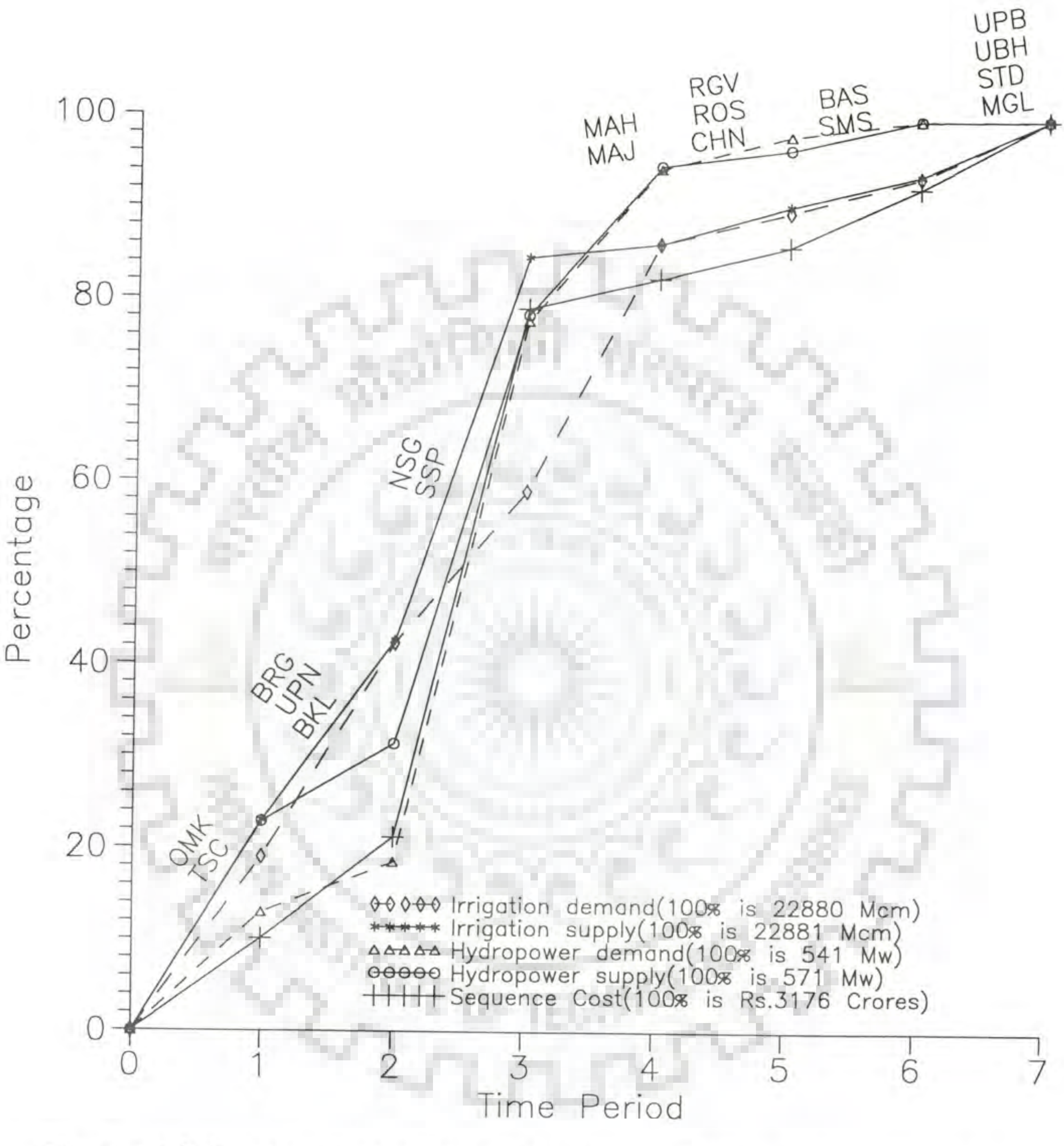


Fig.7.16(b) Simulation target sequencing percentages

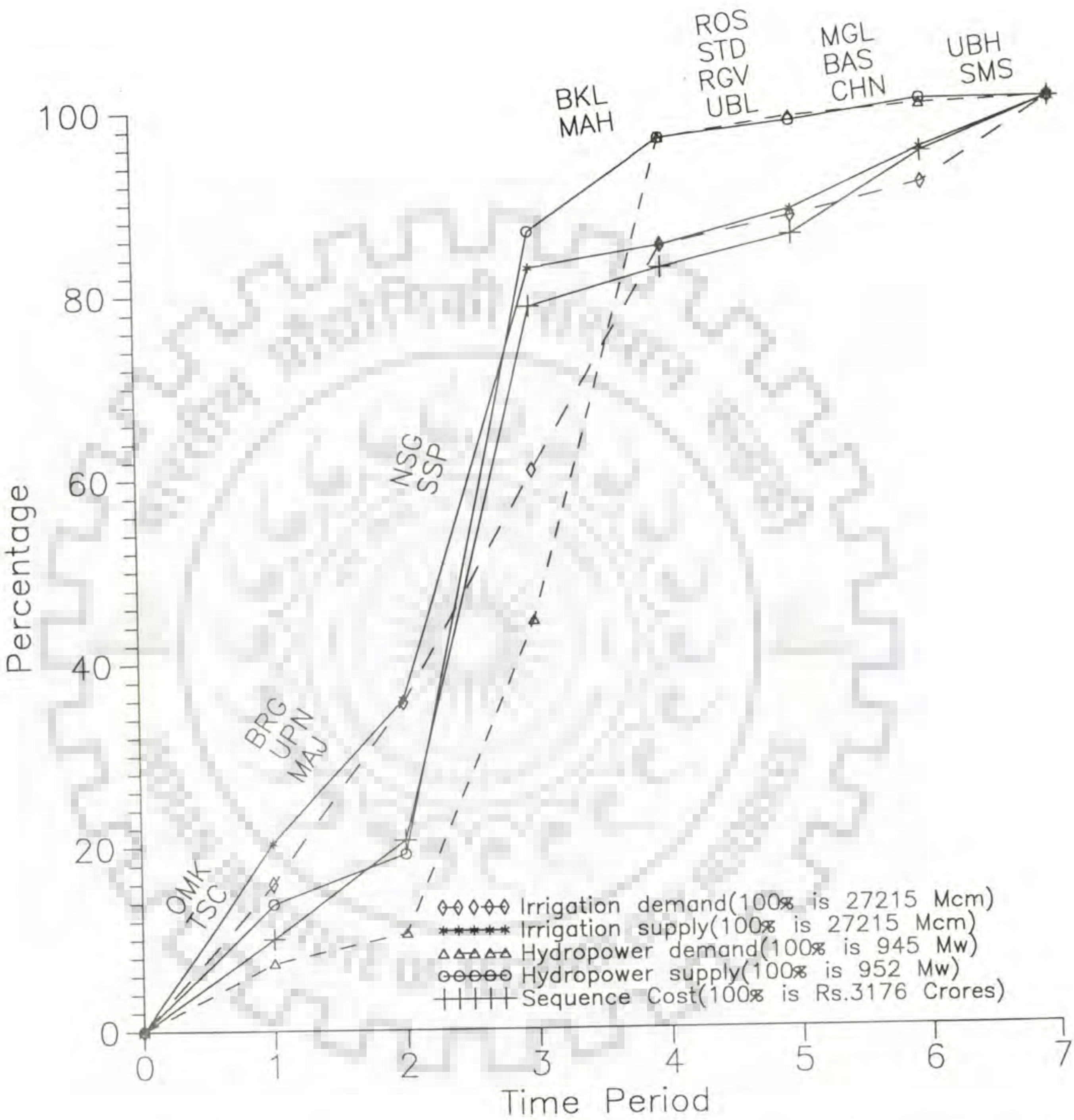


Fig.7.16(c) Master plan target sequencing percentages

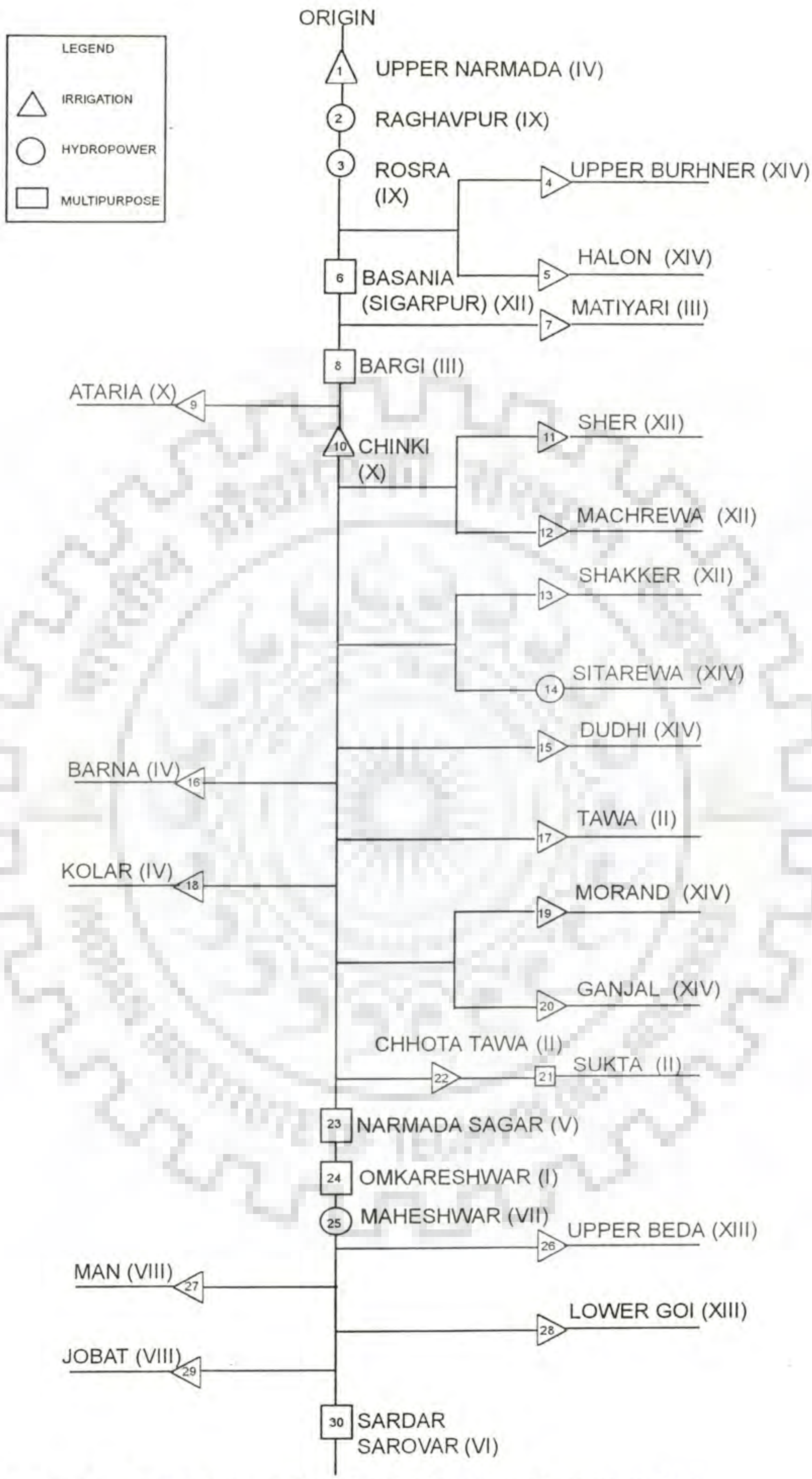


Fig. 7.17. Line diagram for simulation target sequencing

Note: Number in bracket indicates period of appearance of reservoir in the sequence

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Appendix 3-I

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C     **************************************************************
C     * PROGRAM FOR SIMULATION OF MULTIRESERVOIR, MULTIPURPOSE    *
C     *               WATER RESOURCES SYSTEM.                     *
C     *               PREPARED BY M.L.WAIKAR                      *
C     *             SUPERVISOR DR. D.K.SRIVASTAVA                 *
C     **************************************************************
      CHARACTER*7 FNAM
      CHARACTER*11 FILE1,FILE2,FILE3,FILE4,FILE5,FILE6,
     1 FILE7,FILE8,FILE11
      CHARACTER*20  SITENAMO(30),SITENEW(30)
      DIMENSION CRLDT1(30,12,10),ISITE(33),NFYRE(30)
      DIMENSION AVREU(33),AVRED(33),XXXX(33),YYYY(33)
      DIMENSION XXII(30,4),YYII(30,4),ARIIU(30,4),ARIID(30,4)
      DIMENSION XXXII(30),YYYII(30),PPPII(30),QQQII(30)
      DIMENSION S(30,13),FLOW(30,25,12),P(30,25,12)
      DIMENSION AREQ1(30,10),NTREQ(30,10),PREU1(30,12,10)
      DIMENSION REQD1(30,12,10),RENE1(30,12,10)
      DIMENSION PREQ1(30,12,10),AREU1(30,10),NTREU(30,10)
      DIMENSION REQU1(30,12,10),SHARE(4,30,3),AVANS(4,30,1)
      DIMENSION DUDT1(30,12,10),RLDT1(30,12,10),DDDT1(30,12,10)
      DIMENSION SUPT1(30,12,10),AWACS(30),AWWCS(30),SPILL(30,12)
      DIMENSION NREMT(30,12),NRFUT(30,12),AVSPT(30,12)
      DIMENSION ANSPL(30,25),AASPL(30),TUSUT(30,12)
      DIMENSION AVDD1(30,12,10),AVUD1(30,12,10)
      DIMENSION CUSR1(30,25,10),CUUS1(30,25,10),AADD1(30,10)
      DIMENSION AAUD1(30,10),ANDD1(30,25,10),ANUD1(30,25,10)
      DIMENSION NADD1(30,10),NAUD1(30,10),NDDD1(30,12,10)
      DIMENSION NDUD1(30,12,10),O(30,12),CUMEL(30),CUMF(30),CUMP(30)
      DIMENSION NURCF(30),NTRCF(30,13),DSRFL(30,10),UPRFL(30,10)
      DIMENSION IUMRE(30),UPRFC(30),DSRFC(30),TFLOW(30,12)
      DIMENSION IWRT(6),EVAPO(30,12),IWRTS(30,6)
      DIMENSION NUSRE(30,10),ARU1(30,10),PRU1(30,12,10)
      DIMENSION DUD1(30,12,10),SUP1(30,12,10),REU1(30,12,10)
      DIMENSION NDSRE(30,10),ARD1(30,10),PRD1(30,12,10)
      DIMENSION DDD1(30,12,10),RLD1(30,12,10),RED1(30,12,10)
      DIMENSION AVD1(30,12,10),AVU1(30,12,10),CUR1(30,25,10)
      DIMENSION CUS1(30,25,10),AAD1(30,10),AAU1(30,10)
      DIMENSION ANU1(30,25,10),NAD1(30,10),NAU1(30,10)
      DIMENSION NDU1(30,12,10),NSTAT(30),AND1(30,25,10)
      DIMENSION REQV1(30),QMAX(30),REQA1(30),ADNC1(30),REGE1(30)
      DIMENSION ENER1(30),ADNV1(30),ADND1(30),IREQ1(30,10)
      DIMENSION IENO1(30,10),ELE(30),PHMIN(30,12),ENERG(30,12)
      DIMENSION HE(30),PPEFF(30),TWL(30),PPC(30),ENERG1(30,10)
      DIMENSION FRATN(30,10),ISPPO(30),REQE1(30,12),DEFE1(30,12)
      DIMENSION DUME1(30,12),AMDE1(30,12),NMDE1(30,12),AADE1(30,25)
      DIMENSION AMDU1(30,12),NMDU1(30,12),AADU1(30,25)
      DIMENSION SUM4(30),SUM5(30),SUM6(30),ANLEN(30,25),SPILC(30)
      DIMENSION ISHRE(30,3),NDD1(30,12,10),YMIN(30,12),YMAX(30,12)
      DIMENSION SUM(25,12),DFLOW(30,25,12),F(30,25,12),ILOC(30),
     1 NUSSI(30,13),NOUSI(30),IOPPN(30),IPCON(30)
      DIMENSION SUM1(30,25,12),SUM2(30,25,12),SUM3(30,25,12)
      COMMON/OPT1/IWDT1
      COMMON/OPT2/ISTAR
      COMMON/OPT3/IWEN1
      COMMON/OPT4/IWWT1
      COMMON/OPT5/IWAT
      COMMON/OPT6/ICOMT
      COMMON/OPT7/IELEV
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```
      COMMON/OPT8/IWRTN
      COMMON/BLK1/FLOW,TFLOW
      COMMON/BLK2/NMONT
      COMMON/BLK3/SHARE
      COMMON/BLK5/NTREQ,NTREU
      COMMON/BLK6/AVANS
      COMMON/BLK8/NSTAT
      COMMON/BLK9/AWACS,AWWCS
      COMMON/BLK10/I,J,JJ,NSHRE,IT
      COMMON/BLK11/SUM1,SUM2,SUM3
      COMMON/BLK21/SUM4,SUM5,SUM6,NFYRE
      COMMON/BLK12/S,P,YMAX,YMIN
      COMMON/BLK13/NUSRE,NDSRE
      COMMON/B11/DUDT1,RLDT1,DDDT1,SUPT1
      COMMON/B12/AVDD1,AVUD1,CUSR1,CUUS1
      COMMON/B121/AADD1,AAUD1,ANDD1,ANUD1
      COMMON/B13/NDDD1,NDUD1,NADD1,NAUD1
      COMMON/B131/XXXII,YYYII
      COMMON/B14/AVD1,AVU1,CUR1,CUS1
      COMMON/B141/AAD1,AAU1,AND1,ANU1
      COMMON/B15/NDD1,NDU1,NAD1,NAU1
      COMMON/B16/DUD1,RLD1,DDD1,SUP1
      COMMON/B161/PPPII,QQQII
      COMMON/B17/RED1,REU1
      COMMON/B18/ARU1,PRU1,AREU1,PREU1,REQU1
      COMMON/B19/ARD1,PRD1,AREQ1,PREQ1,REQD1
      COMMON/B20/REQV1,QMAX,REQA1,ADNC1,REGE1,ENER1,ADNV1,ADND1,
     1 IENO1,ELE,PHMIN,FRATN
      COMMON/B21/IREQ1
      COMMON/BLK22/SITENAMO,SITENEW
      COMMON/BLK23/XXXX,YYYY
      COMMON/BLK24/XXII,YYII
      COMMON/BLK25/ISITE,IUMRE
      COMMON/BLK26/AASPL
      COMMON/BLK27/AADE1
      COMMON/BLK55/IPCON
      COMMON/BLK56/NTRCF
      COMMON/BLK57/NURCF
      COMMON/BLK58/CRLDT1
      COMMON/BLK60/NOUSI,NUSSI
      COMMON/BLK61/ILOC
      COMMON/BLK65/F
      OPEN ( UNIT=12, FILE='BCM.LIST' )
      OPEN (UNIT=9,FILE='ALLFLOW3.DAT',STATUS='OLD')
      READ(9,*)MSITE,NYEAR,NMONT
  111 FORMAT(A20)
      DO 160 I=1,MSITE
      READ(9,111) SITENAMO(I)
      READ(9,*) ILOC(I)
      DO 161 JJ=1,NYEAR
      READ(9,*)(F(I,JJ,IT),IT=1,NMONT)
  161 CONTINUE
  160 CONTINUE
 6174 READ(12,10,END=6175)FNAM
      write(*,10)FNAM
   10 FORMAT(7A)
      CALL NAME(FILE1,FILE2,FILE3,FILE4,FILE5,FILE6,FILE7,FILE8
     1 ,FILE11,FNAM)
```

```
      OPEN(UNIT=1,FILE=FILE1)
      OPEN(UNIT=2,FILE=FILE2,STATUS='UNKNOWN')
      OPEN(UNIT=3,FILE=FILE3,STATUS='UNKNOWN')
      OPEN(UNIT=4,FILE=FILE4,STATUS='UNKNOWN')
      OPEN(UNIT=5,FILE=FILE5,STATUS='UNKNOWN')
C     OPEN(UNIT=6,FILE=FILE6,STATUS='UNKNOWN')
      OPEN(UNIT=7,FILE=FILE7,STATUS='UNKNOWN')
      OPEN(UNIT=8,FILE=FILE8,STATUS='UNKNOWN')
      OPEN(UNIT=11,FILE=FILE11,STATUS='UNKNOWN')
      WRITE(2,111)'FILE NAME=',FILE2
C     CALCULATE THE TOTAL UPSTREAM FLOW BY SUMMING UP THE MONTHLY
C     FLOWS AT THE U/S SITES
      READ(1,*)NSITE
      READ(1,*)IWDT1,ISTAR,IWEN1,IWWT1,IWAT,ICOMT,IELEV,IWRTN
      DO 550 I=1,NSITE
      READ(1,*)ISITE(I)
      READ(1,*)IUMRE(I)
      IF(IUMRE(I).EQ.1) GO TO 550
      READ(1,*)NOUSI(I)
      READ(1,*)(NUSSI(I,IK),IK=1,NOUSI(I))
  550 CONTINUE
      CALL NTFLO(NSITE,NYEAR)
      READ(1,*) KYEAR
      READ(1,*)(NSTAT(I),I=1,NSITE)
      READ(1,*)CCF
      IF(IWDT1.EQ.1) WRITE(2,*)CCF
      DO 1 I=1,NSITE
      READ(1,*)ISITE(I)
      READ(1,*)S(I,1)
      IF(IWDT1.EQ.1) WRITE(2,200)S(I,1)
  200 FORMAT(/5X,'INITIAL STORAGE='F10.3)
C      DO 2 JJ=1,NYEAR
C      KK=JJ+KYEAR
C      KKK=KK+1-1900
C      READ(1,*)(FLOW(I,JJ,IT),IT=1,NMONT)
C      IF(IWDT1.EQ.1)WRITE(2,457)KK,KKK,(FLOW(I,JJ,IT),IT=1,NMONT)
C457   FORMAT(//5X,'MONTHLY FLOW DATA,YEAR:'I4,'-',I2,
C    1        //3X,6F10.3/3X,6F10.3)
C   2  CONTINUE
      DO 558 JJ=1,NYEAR
      DO 558 IT=1,NMONT
      P(I,JJ,IT)=0.
  558 CONTINUE
      READ(1,*)IOPPN(I)
      IF(IOPPN(I).NE.1) GO TO 559
      DO 3 JJ=1,NYEAR
      KK=JJ+KYEAR
      KKK=KK+1-1900
      READ(1,*)(P(I,JJ,IT),IT=1,NMONT)
      IF (IWDT1.EQ.1)WRITE(2,40)KK,KKK,(P(I,JJ,IT),IT=1,NMONT)
   40 FORMAT(//5X,'MONTHLY PRECIPITATION ,YEAR:',I4,'-',I2,
     1 //3X,6F10.3/,3X,6F10.3)
    3 CONTINUE
  559 READ(1,*)(YMIN(I,IT),IT=1,NMONT)
      IF (IWDT1.EQ.1)WRITE (2,50)(YMIN(I,IT),IT=1,NMONT)
   50 FORMAT(//5X,'MINIMUM CAPACITY:',
     1 //,3X,6F10.3/3X,6F10.3)
      READ(1,*)(YMAX(I,IT),IT=1,NMONT)
```

```
      IF (IWDT1.EQ.1)WRITE (2,60)(YMAX(I,IT),IT=1,NMONT)
 60   FORMAT(//5X,'MAXIMUM CAPACITY:'
  1          //3X,6F10.3/3X,6F10.3)
      READ(1,*)(NTREQ(I,J),J=1,NSTAT(I))
      DO 17 J=1,NSTAT(I)
      IF (J.NE.1)GO TO 17
      READ(1,*)(AREQ1(I,II),II=1,NTREQ(I,1))
      DO 4 II=1,NTREQ(I,1)
      READ(1,*)(PREQ1(I,IT,II),IT=1,NMONT)
      DO 4 IT=1,NMONT
      REQD1(I,IT,II)=AREQ1(I,II)*PREQ1(I,IT,II)/100.0
  4   CONTINUE
 17   CONTINUE
      READ(1,*)(NDSRE(I,J),J=1,NSTAT(I))
      DO 810 J=1,NSTAT(I)
      IF(J.NE.1)GO TO 810
      READ(1,*)(ARD1(I,II),II=1,NDSRE(I,1))
      DO 812 II=1,NDSRE(I,1)
      READ(1,*)(PRD1(I,IT,II),IT=1,NMONT)
      DO 812 IT=1,NMONT
      RED1(I,IT,II)=ARD1(I,II)*PRD1(I,IT,II)/100.0
812   CONTINUE
810   CONTINUE
      READ(1,*)(NTREU(I,J),J=1,NSTAT(I))
      DO 14 J=1,NSTAT(I)
      IF(J.NE.1) GO TO 14
      READ(1,*)(AREU1(I,II),II=1,NTREU(I,1))
      DO 8 II=1,NTREU(I,1)
      READ(1,*)(PREU1(I,IT,II),IT=1,NMONT)
      DO 8 IT=1,NMONT
      REQU1(I,IT,II)=AREU1(I,II)*PREU1(I,IT,II)/100.0
  8   CONTINUE
 14   CONTINUE
      READ(1,*)(NUSRE(I,J),J=1,NSTAT(I))
      DO 710 J=1,NSTAT(I)
      IF(J.NE.1)GO TO 710
      READ(1,*)(ARU1(I,II),II=1,NUSRE(I,1))
      DO 712 II=1,NUSRE(I,1)
      READ(1,*)(PRU1(I,IT,II),IT=1,NMONT)
      DO 712 IT=1,NMONT
      REU1(I,IT,II)=ARU1(I,II)*PRU1(I,IT,II)/100.0
712   CONTINUE
710   CONTINUE
      IF(IUMRE(I).EQ.1)GO TO 603
      READ(1,*)NURCF(I)
      READ(1,*)(NTRCF(I,LL),LL=1,NURCF(I))
603   DO 602 J=1,NSTAT(I)
      READ(1,*)(UPRFL(I,II),II=1,NTREU(I,J))
602   CONTINUE
      DO 601 J=1,NSTAT(I)
      READ(1,*)(DSRFL(I,II),II=1,NTREQ(I,J))
601   CONTINUE
      READ(1,*)(EVAPO(I,IT),IT=1,NMONT)
      READ(1,*)(IWRTS(I,LL),LL=1,6)
      READ(1,*)IPRT
      READ(1,*)PPEFF(I),PPC(I),TWL(I)
      READ(1,*)(PHMIN(I,IT),IT=1,NMONT)
      READ(1,*)ISPPO(I)
```

```
      DO 3000 J=1,NSTAT(I)
      IF(J.NE.1)GO TO 3000
      READ(1,*)(IREQ1(I,II),II=1,NTREQ(I,J))
      READ(1,*)(IENO1(I,II),II=1,NTREQ(I,J))
      READ(1,*)(FRATN(I,II),II=1,NTREQ(I,1))
      READ(1,*)ISHRE(I,1)
 3000 CONTINUE
    1 CONTINUE
C       READ(1,*)(IPCON(I),I=1,NSITE)
      CLOSE (1)
C       INITIALIZATION OF VARIABLE TO ZERO
      IF (IELEV.EQ.1)WRITE(7,8086)
 8086 FORMAT(9X,'SITE STORAGE AREA EV. DEPTH   EV.VOL.    ELEVATION')
      DO 701 I=1,NSITE
      UPRFC(I)=0.
      DSRFC(I)=0.
  701 CONTINUE
      CALL INTI1(NSITE,NYEAR)
      CALL INIL1(NSITE,NYEAR)
      DO 401 I=1,NSITE
      AASPL(I)=0.0
      SUM4(I)=0.0
      SUM5(I)=0.0
      SUM6(I)=0.0
      NFYRE(I)=0
      DO 401 JJ=1,NYEAR
      ANSPL(I,JJ)=0.0
      AADE1(I,JJ)=0.0
      AADU1(I,JJ)=0.0
      ANLEN(I,JJ)=0.0
      DO 401 IT=1,NMONT
      NREMT(I,IT)=0
      NRFUT(I,IT)=0
      AVSPT(I,IT)=0
  401 CONTINUE
      DO 786 I=1,NSITE
      XXXX(I)=0
      YYYY(I)=0
      DO 788 II=1,NTREQ(I,1)
      XXII(I,II)=0.
  788 CONTINUE
      DO 789 II=1,NTREU(I,1)
      YYII(I,II)=0.
  789 CONTINUE
  786 CONTINUE
      DO 7 JJ=1,NYEAR
      DO 787 I=1,NSITE
      AVREU(I)=0.
      AVRED(I)=0.
      DO 790 II=1,NTREQ(I,1)
      ARIID(I,II)=0.
  790 CONTINUE
      DO 791 II=1,NTREU(I,1)
      ARIIU(I,II)=0.
  791 CONTINUE
  787 CONTINUE
      IF(ISTAR.EQ.1)WRITE(*,1500)JJ
 1500 FORMAT(1X,'NYEAR='I5)
```

```
      DO 11 IT=1,NMONT
      IF(ISTAR.EQ.1) WRITE(*,1501)IT
 1501 FORMAT(1X,'NMONT='I3)
      IJ=1
      DO 12 I=1,NSITE
      DO 9004 J=1,NSTAT(I)
      DO 9005 II=1,NTREQ(I,J)
      IF(J.NE.1) GO TO 9005
      CRLDT1(I,IT,II)=0
 9005 CONTINUE
 9004 CONTINUE
C     ENERGY COMPUTATION
      REQE1(I,IT)=0.
      DEFE1(I,IT)=0.
      DUME1(I,IT)=0.
      AMDE1(I,IT)=0.0
      NMDE1(I,IT)=0.0
      AMDU1(I,IT)=0.0
      NMDU1(I,IT)=0.0
      REQV1(I)=0.
      REQA1(I)=0.
      ADNV1(I)=0.
      ADNC1(I)=0.
      ADND1(I)=0.
      REGE1(I)=0.
      ENER1(I)=0.
      ENERG1(I,IT)=0.
      ELE(I)=ELEVAT(ISITE(I),S(I,IT))
      HE(I)=ELE(I)-TWL(I)
      CF=3600.*24*365./(12.*CCF)
      FACTR=9.8*HE(I)*PPEFF(I)*24*30.4
      IF (PPC(I).NE.0) QMAX(I)=PPC(I)*1000.*CF/(9.8*HE(I)*PPEFF(I))
      IF(ISTAR.EQ.1) WRITE(*,1501)IT
      IF(ISTAR.EQ.1) WRITE(*,1502)I
 1502 FORMAT(1X,'NSITE='I3)
      SPILL(I,IT)=0.0
      DO 1001 NSHRE=1,4
      DO 1001 J=1,NSTAT(I)
 1001 SHARE(NSHRE,I,J)=0
      DO 2000 J=1,NSTAT(I)
      DO 2001 II=1,NTREQ(I,J)
      IF(J.NE.1)GO TO 2001
C     ++++++++++++++++
C     OPTION FOR ENERGY
C     ++++++++++++++++
      IF(IREQ1(I,II).EQ.1)RENE1(I,IT,II)=CF*(REQD1(I,IT,II)*1000.)/
     1 FACTR
      IF(IREQ1(I,II).EQ.1)DDDT1(I,IT,II)=RENE1(I,IT,II)
      IF(IREQ1(I,II).NE.1)DDDT1(I,IT,II)=REQD1(I,IT,II)
      IF(IREQ1(I,II).EQ.1)REQV1(I)=RENE1(I,IT,II)
      IF(IREQ1(I,II).EQ.1)REQE1(I,IT)=REQD1(I,IT,II)
 2001 CONTINUE
      DO 2002 II=1,NTREU(I,J)
      IF(J.EQ.1)DUDT1(I,IT,II)=REQU1(I,IT,II)
 2002 CONTINUE
      DO 2003 II=1,NDSRE(I,J)
      IF(J.EQ.1)DDD1(I,IT,II)=0.
 2003 CONTINUE
```

```
      DO 2004 II=1,NUSRE(I,J)
      IF(J.EQ.1) DUD1(I,IT,II)=0.
 2004 CONTINUE
 2000 CONTINUE
      IF(IUMRE(I).EQ.1)TFLOW(I,IT)=FLOW(I,JJ,IT)+UPRFC(I)
      IF(IUMRE(I).NE.1)TFLOW(I,IT)=FLOW(I,JJ,IT)+SPILC(I)+UPRFC(I)+
     1 DSRFC(I)
      NSHRE=1
      IF (ISHRE(I,1).NE.1) AVANS(1,I,1)=TFLOW(I,IT)
      IF (ISHRE(I,1).NE.1) GOTO 2010
      SHARE (1,I,1)=TFLOW(I,IT)
C     USE WATER FROM SHARE1
      DO 5002 J=1,NSTAT(I)
      DO 5000 II=1,NTREU(I,J)
      IF (J.EQ.1)SUPT1(I,IT,II)=0.0
 5000 CONTINUE
      DO 5001 II=1,NTREQ(I,J)
      IF (J.EQ.1)RLDT1(I,IT,II)=0.0
 5001 CONTINUE
 5002 CONTINUE
      DO 20 J=1,NSTAT(I)
      IF(ISTAR.EQ.1) WRITE(*,1501)IT
      IF(ISTAR.EQ.1) WRITE(*,1503)
 1503 FORMAT(1X,'CALL STAT1 *1* ')
      IF(J.EQ.1)CALL STAT1(I,JJ,IT,NSHRE)
      IF(IPRT.EQ.1)CALL WRTM(IJ)
   20 CONTINUE
      DO 9006 II=1,NTREQ(I,1)
      CRLDT1(I,IT,II)=RLDT1(I,IT,II)
 9006 CONTINUE
 2010 SUMX=0
      DO 13 J=1,NSTAT(I)
      SUMX=SUMX+AVANS(NSHRE,I,J)
   13 CONTINUE
      XXX=0
      YYY=0
      PPP=0
      QQQ=0
      DO 808 II=1,NTREQ(I,1)
      XXXII(II)=0.
      PPPII(II)=0.
  808 CONTINUE
      DO 809  II=1,NTREU(I,1)
      YYYII(II)=0.
      QQQII(II)=0.
  809 CONTINUE
      ICAL=1
      IF(ISTAR.EQ.1) WRITE(*,1504)ICAL
 1504 FORMAT(1X,'ICAL*2*='I3)
      CALL CAL1(XXX,YYY,ICAL,NYEAR)
      IF(ISTAR.EQ.1) WRITE(*,1505)
 1505 FORMAT('CALL CAL11 *3*')
      CALL CAL11(PPP,QQQ,ICAL,NYEAR)
 1009 DO 5005 J=1,NSTAT(I)
      DO 5006 II=1,NTREQ(I,J)
      IF (J.EQ.1)RLDT1(I,IT,II)=0.0
 5006 CONTINUE
 5005 CONTINUE
```

```
      ZZZ=AREA(ISITE(I),S(I,IT))
      EL=ZZZ*EVAPO(I,IT)
      IF(IELEV.EQ.1)WRITE(7,8087)I,S(I,IT),ZZZ,EVAPO(I,IT),EL,ELE(I)
 8087 FORMAT(5X,I2,2X,4F10.5,3X,F10.3)
      P(I,JJ,IT)=ZZZ*P(I,JJ,IT)
      X=S(I,IT)+SUMX+P(I,JJ,IT)-EL-YMIN(I,IT)
      IF(X.LE.0.0)GO TO 1002
C     USE WATER FROM SHARE 2
      NSHRE=2
      SHARE(2,I,1)=X
      DO 5003 J=1,NSTAT(I)
      DO 5004 II=1,NTREQ(I,J)
      IF (J.EQ.1)RLDT1(I,IT,II)=0.0
 5004 CONTINUE
 5003 CONTINUE
      DO 28 J=1,NSTAT(I)
      IF(ISTAR.EQ.1) WRITE(*,1506)
 1506 FORMAT(1X,'CALL STAT1 *4*')
      IF(J.EQ.1)CALL STAT1(I,JJ,IT,NSHRE)
      IF(IPRT.EQ.1)CALL WRTM(IJ)
   28 CONTINUE
      DO 9008 II=1,NTREQ(I,1)
      CRLDT1(I,IT,II)=CRLDT1(I,IT,II)+RLDT1(I,IT,II)
 9008 CONTINUE
      SUMX=0.
      DO 46 J=1,NSTAT(I)
      SUMX=SUMX+AVANS(NSHRE,I,J)
   46 CONTINUE
      X=SUMX
      YY=X-YMAX(I,IT)+YMIN(I,IT)
      IF(YY.LE.0.0)AWACS(I)=0.
      IF(YY.GT.0.0)AWACS(I)=YY
      IF(AWACS(I).GT.0.0)AWWCS(I)=YMAX(I,IT)-YMIN(I,IT)
      IF(X.LT.0.0)X=0.0
      IF(YY.LT.0.0)AWWCS(I)=X
C     WRITE(2,*)EL,S(I,IT),SUMX,X,YY,AWACS(I),AWWCS(I)
      IF(AWACS(I).GT.0.0)SPILL(I,IT)=AWACS(I)
      IF(AWACS(I).LE.0)SPILL(I,IT)=0
      GO TO 405
 1002 SPILL(I,IT)=0.0
      SUMX=X
C     ++++++++++++++++++++++++++++++++
C     CALCULATION FOR FINAL RESERVOIR BEHAVIOUR
C     ++++++++++++++++++++++++++++++++++++++++
  405 IF(J.EQ.1)CALL DIST1(I,IT)
      ICAL=2
      IF(ISTAR.EQ.1) WRITE(*,1507)
 1507 FORMAT(1X,'ICAL=2*5* ')
      IF(ISTAR.EQ.1) WRITE(*,1508)
 1508 FORMAT(1X,'CALL CAL1*6*')
      CALL CAL1(XXX,YYY,ICAL,NYEAR)
      IF(ISTAR.EQ.1) WRITE(*,1509)
 1509 FORMAT(1X,'CALL CAL11 *7*')
      CALL CAL11(PPP,QQQ,ICAL,NYEAR)
      SUM1(I,JJ,IT)=0.
      DO 32 II=1,NTREU(I,1)
      SUM1(I,JJ,IT)=SUM1(I,JJ,IT)+UPRFL(I,II)*SUPT1(I,IT,II)
   32 CONTINUE
```

```
      UPRFC(I)=SUM1(I,JJ,IT)
      SUM2(I,JJ,IT)=0.
      SUM3(I,JJ,IT)=0.
      IF(IUMRE(I).EQ.1)GO TO 47
      DO 35 IU=1,NURCF(I)
      IUREN=NTRCF(I,IU)
      SUM3(I,JJ,IT)=SUM3(I,JJ,IT)+SPILL(IUREN,IT)
      DO 36 II=1,NTREQ(IUREN,1)
      SUM2(I,JJ,IT)=SUM2(I,JJ,IT)+DSRFL(IUREN,II)*CRLDT1(IUREN,IT,II)
   36 CONTINUE
   35 CONTINUE
   47 DSRFC(I)=SUM2(I,JJ,IT)
      SPILC(I)=SUM3(I,JJ,IT)
      O(I,IT)=XXX
      TUSUT(I,IT)=YYY
      AVREU(I)=AVREU(I)+YYY
      AVRED(I)=AVRED(I)+XXX
      DO 886 II=1,NTREU(I,1)
      ARIIU(I,II)=ARIIU(I,II)+YYYII(II)
  886 CONTINUE
      DO 887 II=1,NTREQ(I,1)
      ARIID(I,II)=ARIID(I,II)+XXXII(II)
  887 CONTINUE
C     ++++++++++++++++++++++++++++++++
C     CALCULATE FINAL RESERVOIR CONTENT
C     ++++++++++++++++++++++++++++++++
      IF(SPILL(I,IT).NE.0.)S(I,IT+1)=YMAX(I,IT)
      IF(SPILL(I,IT).EQ.0.)S(I,IT+1)=YMIN(I,IT)+SUMX
C     ++++++++++++++++++++++++++++++++
C           FOR ENERGY COMPUTATION
C           ----------------------
      IF(ISPPO(I).EQ.1.AND.SPILL(I,IT).LT.ADNC1(I))
     1 ADNC1(I)=SPILL(I,IT)
      IF(ISPPO(I).EQ.1)ENER1(I)=ENER1(I)+ADNC1(I)
      ENER1(I)=ENER1(I)/CF
      ENER1(I)=ENER1(I)*9.8*HE(I)*PPEFF(I)
      ENER1(I)=ENER1(I)*24.0*365.0/12.0
      ENERG(I,IT)=ENER1(I)/1000.0
      ANLEN(I,JJ)=ANLEN(I,JJ)+ENERG(I,IT)
      IF(IWEN1.EQ.1)WRITE(2,1516)
 1516 FORMAT(2X,'ENERGY')
      IF(IWEN1.EQ.1)WRITE(2,*)ENER1(I),ENERG(I,IT),ADNC1(I),
     1 SPILL(I,IT),REGE1(I)
      IF(ENERG(I,IT).LT.REQE1(I,IT))GO TO 6001
      IF(ENERG(I,IT).GT.REQE1(I,IT))GO TO 6002
      IF(ENERG(I,IT).EQ.REQE1(I,IT))GO TO 6003
 6001 DEFE1(I,IT)=REQE1(I,IT)-ENERG(I,IT)
      AMDE1(I,IT)=AMDE1(I,IT)+DEFE1(I,IT)/FLOAT(NYEAR)
      NMDE1(I,IT)=NMDE1(I,IT)+1
      AADE1(I,JJ)=AADE1(I,JJ)+DEFE1(I,IT)
      GO TO 6003
 6002 DUME1(I,IT)=ENERG(I,IT)-REQE1(I,IT)
      AMDU1(I,IT)=AMDU1(I,IT)+DUME1(I,IT)/FLOAT(NYEAR)
      NMDU1(I,IT)=NMDU1(I,IT)+1
      AADU1(I,JJ)=AADU1(I,JJ)+DUME1(I,IT)
 6003 IF(IWEN1.EQ.1)WRITE(2,*)ENERG(I,IT),REQE1(I,IT),DEFE1(I,IT),
     1 DUME1(I,IT),AADE1(I,JJ),AADU1(I,JJ)
C     CALCULATE STATISTICS FOR RESERVOIR BEHAVIOUR
```

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C       +++++++++++++++++++++++++++++++++++++++++++++
        IF(S(I,IT+1).LE.YMIN(I,IT))NREMT(I,IT)=NREMT(I,IT)+1
        IF(S(I,IT+1).EQ.YMAX(I,IT))NRFUT(I,IT)=NRFUT(I,IT)+1
        AVSPT(I,IT)=AVSPT(I,IT)+SPILL(I,IT)/FLOAT(NYEAR)
        ANSPL(I,JJ)=ANSPL(I,JJ)+SPILL(I,IT)
        IF(IT.EQ.1)CUMF(I)=0
        IF(IT.EQ.1)CUMP(I)=0
        IF(IT.EQ.1)CUMEL(I)=0
        IF(IT.EQ.1.AND.JJ.EQ.1)AASPL(I)=0
C       CALCULATE TOTAL EVAPORATION
        CUMEL(I)=CUMEL(I)+EL
C       CALCULATE TOTAL RESERVOIR INPUT
        CUMF(I)=CUMF(I)+TFLOW(I,IT)
        CUMP(I)=CUMP(I)+P(I,JJ,IT)
   12   CONTINUE
   11   CONTINUE
        DO 23 I=1,NSITE
        IF(AADE1(I,JJ).NE.0.)NFYRE(I)=NFYRE(I)+1
   23   CONTINUE
        DO 703 I=1,NSITE
        IF(IWWT1.EQ.1)WRITE(2,705)
        DO 704 IT=1,NMONT
        IF(IWWT1.EQ.1)WRITE(2,706)I,JJ,IT,S(I,IT),FLOW(I,JJ,IT),
     1  TFLOW(I,IT),TUSUT(I,IT),O(I,IT),SPILL(I,IT),S(I,IT+1)
  705   FORMAT(1X,'SITE',2X,'YEAR',2X,'TIME',2X,'INI. STORE',4X,
     1  'INFLOW',2X,'TOTAL FLOW',2X,'U/S SUB.',2X,'RES. REL.',5X,
     1  'SPILL',2X,'FINAL STORE.')
  706   FORMAT(I5,I6,I6,F12.3,F10.3,F12.3,F10.3,F11.3,F10.3,F13.3)
  704   CONTINUE
        XX=CUMF(I)+CUMP(I)
        YY=AVRED(I)+AVREU(I)+CUMEL(I)+ANSPL(I,JJ)
C       CHECK WATER BALANCE OF RESERVOIR
        T=S(I,NMONT+1)-S(I,1)
        B=XX-YY
        IF((T-B).GE.(-0.00001).OR.(T-B).LE.0.00001)GO TO 400
        IF(IWWT1.EQ.1) WRITE(2,96)
        IF(ISTAR.EQ.1) WRITE(*,1510)
 1510   FORMAT(1X,'WATER BALANCE FOUND INCORRECT *8*')
   96   FORMAT(//5X,'WATER BALANCE FOUND INCORRECT')
        STOP
  400   IF(IWWT1.EQ.1) WRITE(2,91)
        IF(ISTAR.EQ.1) WRITE(*,1511)
 1511   FORMAT(1X,'WATER BALANCE FOUND OK *9*')
   91   FORMAT(//5X,'WATER BALANCE FOUND OK')
        S(I,1)=S(I,NMONT+1)
        ICAL=3
        IF(ISTAR.EQ.1) WRITE(*,1512)
 1512   FORMAT(1X,'ICAL=3 *10*')
        IF(ISTAR.EQ.1) WRITE(*,1513)
 1513   FORMAT(1X,'CALL CAL1 *11* ')
        CALL CAL1(XXX,YYY,ICAL,NYEAR)
        IF(ISTAR.EQ.1) WRITE(*,1514)
 1514   FORMAT(1X,'CALL CAL11 *12*')
        CALL CAL11(PPP,QQQ,ICAL,NYEAR)
        AASPL(I)=AASPL(I)+ANSPL(I,JJ)/FLOAT(NYEAR)
        SUM4(I)=SUM4(I)+AADE1(I,JJ)/FLOAT(NYEAR)
        SUM5(I)=SUM5(I)+AADU1(I,JJ)/FLOAT(NYEAR)
        SUM6(I)=SUM6(I)+ANLEN(I,JJ)/FLOAT(NYEAR)
```

```
      IF(IWWT1.EQ.1)WRITE(2,*)SUM4(I),SUM5(I),SUM6(I)
      YYYY(I)=YYYY(I)+AVREU(I)/FLOAT(NYEAR)
      XXXX(I)=XXXX(I)+AVRED(I)/FLOAT(NYEAR)
      DO 888 II=1,NTREU(I,1)
      YYII(I,II)=YYII(I,II)+ARIIU(I,II)/FLOAT(NYEAR)
 888  CONTINUE
      DO 889 II=1,NTREQ(I,1)
      XXII(I,II)=XXII(I,II)+ARIID(I,II)/FLOAT(NYEAR)
 889  CONTINUE
 703  CONTINUE
   7  CONTINUE
      DO 501 I=1,NSITE
      DO 8990 LL=1,6
      IWRT(LL)=IWRTS(I,LL)
8990  CONTINUE
      DO 500 J=1,NSTAT(I)
      IF(ISTAR.EQ.1) WRITE(*,1515)
1515  FORMAT(1X,'CALL WRT1 *13* ')
      IF(J.EQ.1)CALL WRT1(NYEAR,NSITE,J,IWRT,NSHRE,I)
      IF(J.EQ.1)CALL WRT11(NYEAR,NSITE,J,IWRT,NSHRE,I)
 500  CONTINUE
 501  CONTINUE
 100  FORMAT(4F10.3)
      IF(IWWT1.EQ.1)WRITE(2,902)
      DO 901 I=1,NSITE
      DO 901 IT=1,NMONT
      IF(IWWT1.EQ.1)WRITE(2,903)I,IT,AVSPT(I,IT),NREMT(I,IT),
     1 NRFUT(I,IT)
 902  FORMAT(1X,'SITE',2X,'TIME',2X,'AVE. SPILL',2X,
     1 'NO. OF TIMES RES. EMPTY',2X,'NO. OF TIMES RES. FULL'/)
 903  FORMAT(I5,I6,F12.3,I25,I24)
 901  CONTINUE
      IF(IWWT1.EQ.1)WRITE(2,904)
      DO 905 I=1,NSITE
      DO 905 JJ=1,NYEAR
      IF(IWWT1.EQ.1)WRITE(2,906)I,JJ,ANSPL(I,JJ)
 904  FORMAT(1X,'SITE',2X,'YEAR',2X,'ANNUAL SPILL'/)
 906  FORMAT(I5,I6,F14.3)
 905  CONTINUE
      IF(IWWT1.EQ.1)WRITE(2,907)
      DO 908 I=1,NSITE
      IF(IWWT1.EQ.1)WRITE(2,909)I,AASPL(I)
 907  FORMAT(1X,'SITE',2X,'AVE. ANNUAL SPILL'/)
 909  FORMAT(I5,F19.3)
 908  CONTINUE
      DO 6004 I=1,NSITE
      DO 6004 IT=1,NMONT
      IF(IWWT1.EQ.1)WRITE(2,*)I,IT,AMDE1(I,IT),NMDE1(I,IT),
     1 AMDU1(I,IT),NMDU1(I,IT)
6004  CONTINUE
      CALL WRRS1(NSITE,NYEAR)
      CALL RTNFL(NSITE,NYEAR)
C      CALL FLUSH(MSITE,NSITE,NYEAR)
      GO TO 6174
6175  STOP
      END
```

```
C       ******************************************************************
C      (1)           STAT1
C       ******************************************************************
        SUBROUTINE STAT1(I,JJ,IT,NSHRE)
        DIMENSION DUDT1(30,12,10),DDDT1(30,12,10),AVANS(4,30,1)
        DIMENSION NTREQ(30,10),NTREU(30,10),SHARE(4,30,3)
        DIMENSION RLDT1(30,12,10),SUPT1(30,12,10),FRATN(30,10)
        DIMENSION REQV1(30),QMAX(30),REQA1(30),ADNC1(30),REGE1(30)
        DIMENSION ENER1(30),ADNV1(30),ADND1(30),IREQ1(30,10)
        DIMENSION IENO1(30,10),ELE(30),PHMIN(30,12),ENERG(30,12)
        COMMON/OPT2/ISTAR
        COMMON/OPT5/IWAT
        COMMON/BLK3/SHARE
        COMMON/BLK5/NTREQ,NTREU
        COMMON/BLK6/AVANS
        COMMON/B11/DUDT1,RLDT1,DDDT1,SUPT1
        COMMON/B20/REQV1,QMAX,REQA1,ADNC1,REGE1,ENER1,ADNV1,ADND1,
     1            IENO1,ELE,PHMIN,FRATN
        COMMON/B21/IREQ1
        GO TO(10,20,30)NSHRE
C       U/S USE AND D/S RELEASES FROM SHARE1 AT SITE I IN TIME T FOR
C       STATE 1
   10   AVANS(1,I,1)=SHARE(1,I,1)
        IF(ISTAR.EQ.1) WRITE(*,1516)
 1516   FORMAT(1X,'STAT1*1.1*')
        CALL WATER(AVANS(1,I,1),DUDT1,RLDT1,DDDT1,SUPT1,NTREQ(I,1),
     1  NTREU(I,1),I,IT,NSHRE,REQV1,QMAX,REQA1,ADNC1,REGE1,ENER1,ADNV1,
     2  ADND1,IREQ1,IENO1,ELE,PHMIN,FRATN)
        IF(ISTAR.EQ.1) WRITE(*,1517)
 1517   FORMAT(1X,'CALL WATER 1*1.2*')
        RETURN
C       D/S RELEASES FROM SHARE2 AT SITE I IN TIME T FOR
C       STATE 1
   20   AVANS(2,I,1)=SHARE(2,I,1)
        CALL WATER(AVANS(2,I,1),DUDT1,RLDT1,DDDT1,SUPT1,NTREQ(I,1),
     1  NTREU(I,1),I,IT,NSHRE,REQV1,QMAX,REQA1,ADNC1,REGE1,ENER1,ADNV1,
     2  ADND1,IREQ1,IENO1,ELE,PHMIN,FRATN)
        IF(ISTAR.EQ.1) WRITE(*,1518)
 1518   FORMAT(1X,'CALL WATER 2 *1.3*')
        RETURN
C       D/S RELEASES FROM SHARE3 AT SITE I IN TIME T FOR STATE 1
   30   AVANS(3,I,1)=SHARE(3,I,1)
        CALL WATER(AVANS(3,I,1),DUDT1,RLDT1,DDDT1,SUPT1,NTREQ(I,1),
     1  NTREU(I,1),I,IT,NSHRE,REQV1,QMAX,REQA1,ADNC1,REGE1,ENER1,ADNV1,
     2  ADND1,IREQ1,IENO1,ELE,PHMIN,FRATN)
        IF(ISTAR.EQ.1) WRITE(*,1519)
 1519   FORMAT(1X,'CALL WATER 3 *1.4*')
        RETURN
        END
C       ******************************************************************
C         (2)      WATER
C       ******************************************************************
        SUBROUTINE WATER(AVANW,DUDT,RLDT,DDDT,SUPT,NTREQ,NTREU,I,IT,
     1           NSHRE,REQV,QMAX,REQA,ADNLC,REGEN,ENERG,ADNLV,ADNLD,
     2           IREQ,IENO,ELE,PHMIN,FRATN)
        DIMENSION DUDT(30,12,10),RLDT(30,12,10),DDDT(30,12,10),
     1           SUPT(30,12,10),REQV(30),QMAX(30),REQA(30),ADNLC(30),
     2           REGEN(30),ENERG(30),ADNLV(30),ADNLD(30),IENO(30,10),
```

```
     3              ELE(30),PHMIN(30,12),IREQ(30,10),FRATN(30,10)
      COMMON/OPT2/ISTAR
      COMMON/OPT5/IWAT
      IF(NSHRE.NE.1)GO TO 3
      DO 1 II=1,NTREU
      IF(ISTAR.EQ.1) WRITE(*,1520)
 1520 FORMAT(1X,'WATER *1.5*')
      CALL RELES(AVANW,DUDT(I,IT,II),SUPT(I,IT,II))
      IF(ISTAR.EQ.1) WRITE(*,1521)
 1521 FORMAT(1X,'CALL RELES1 *1.6*')
      LLLL=1111
      IF(IWAT.EQ.1)WRITE(2,*)LLLL,AVANW,DUDT(I,IT,II),
     1 SUPT(I,IT,II),ELE(I),PHMIN(I,IT)
    1 CONTINUE
    3 DO 2 II=1,NTREQ
      IF(IREQ(I,II).NE.1)CALL RELES(AVANW,DDDT(I,IT,II),RLDT(I,IT,II))
      IF(ISTAR.EQ.1) WRITE(*,1522)
 1522 FORMAT(1X,'CALL RELES 2 *1.7*')
      LLLL=2222
      IF(IWAT.EQ.1)WRITE(2,*)LLLL,AVANW,DDDT(I,IT,II),
     1 RLDT(I,IT,II),ELE(I),PHMIN(I,II)
C     CALCULATE ENERGY GENERATED FROM OTHER RELEASES
C     ===============================================
      IF(IREQ(I,II).NE.1.AND.IENO(I,II).EQ.1)REGEN(I)=REGEN(I)+
     1                                RLDT(I,IT,II)*FRATN(I,II)
      IF(IREQ(I,II).NE.1.AND.IENO(I,II).EQ.1)ENERG(I)=REGEN(I)
      IF((IREQ(I,II).NE.1.AND.IENO(I,II).EQ.1).AND.(ENERG(I).GT.
     1 QMAX(I)))ENERG(I)=QMAX(I)
      LLLL=4444
      IF(IWAT.EQ.1)WRITE(2,*)LLLL,REGEN(I),RLDT(I,IT,II),
     1 FRATN(I,II),IREQ(I,II),IENO(I,II)
      IF(ELE(I).LT.PHMIN(I,IT))GO TO 2
      IF(IREQ(I,II).NE.1)GO TO 2
C     CALCULATE ADDITIONAL POWER RELEASES
C     ===================================
      CALL POWER(AVANW,REQV(I),QMAX(I),REQA(I),ADNLC(I),REGEN(I),
     1           ENERG(I),ADNLV(I),ADNLD(I),RLDT(I,IT,II))
      IF(ISTAR.EQ.1) WRITE(*,1523)
 1523 FORMAT(1X,'CALL POWER *1.8*')
      LLLL=3333
      IF (IWAT.EQ.1)WRITE(2,*)LLLL,AVANW,REQV(I),QMAX(I),REQA(I),
     1 ADNLC(I),REGEN(I),ENERG(I),ADNLV(I),ADNLD(I),RLDT(I,IT,II),
     2 ELE(I),PHMIN(I,IT)
    2 CONTINUE
      RETURN
      END
C     ***************************************************************
C     (3)        RELES
C     ***************************************************************
      SUBROUTINE RELES(AVANW,DEFCT,RLS)
      IF(AVANW.LT.DEFCT)RLS=AVANW
      IF(AVANW.GE.DEFCT)RLS=DEFCT
      AVANW=AVANW-RLS
      IF(RLS.LT.DEFCT)DEFCT=DEFCT-RLS
      IF(RLS.EQ.DEFCT)DEFCT=0
      RETURN
      END
```

```
C       ***************************************************************
C       (4)     POWER
C       ***************************************************************
        SUBROUTINE POWER(AVANW,REQV,QMAX,REQA,ADNLC,REGEN,ENERG,
     1                   ADNLV,ADNLD,RLDT)
        IF(REQV.GE.QMAX)REQA=QMAX
        IF(REQV.GE.QMAX)ADNLC=0
        IF(REQV.LT.QMAX)REQA=REQV
        IF(REQV.LT.QMAX)ADNLC=QMAX-REQV
        IF(REGEN.GE.REQA)ENERG=REQA
        IF(REGEN.GE.REQA)ADNLV=0
        IF(REGEN.LT.REQA)ENERG=REGEN
        IF(REGEN.LT.REQA)ADNLV=REQA-REGEN
        IF(ADNLV.NE.0)GO TO 9007
        IF(ADNLV.EQ.0.AND.ADNLC.NE.0.AND.(REGEN-REQA).LE.ADNLC)
     1  GO TO 9001
        ENERG=REQA+ADNLC
        ADNLC=0
        REGEN=ENERG
        GO TO 2
 9001   ENERG=REGEN
        ADNLC=QMAX-REGEN
        GO TO 2
 9007   IF(AVANW.EQ.0)GO TO 2
        IF(AVANW.LT.ADNLV)ADNLD=AVANW
        IF(AVANW.GE.ADNLV)ADNLD=ADNLV
        ADNLV=ADNLV-ADNLD
        AVANW=AVANW-ADNLD
        ENERG=ENERG+ADNLD
        REGEN=ENERG
        IF(ADNLV.NE.0.)ADNLC=0.0
        RLDT=ADNLD
    2   RETURN
        END
C       ***************************************************************
C           (5)     CAL1
C       ***************************************************************
        SUBROUTINE CAL1(XXX,YYY,ICAL,NYEAR)
        DIMENSION NTREQ(30,10),NTREU(30,10)
        DIMENSION DUDT1(30,12,10),RLDT1(30,12,10),DDDT1(30,12,10)
        DIMENSION SUPT1(30,12,10),AVDD1(30,12,10),AVUD1(30,12,10)
        DIMENSION CUSR1(30,25,10),CUUS1(30,25,10),AADD1(30,10)
        DIMENSION AAUD1(30,10),ANDD1(30,25,10),ANUD1(30,25,10)
        DIMENSION NADD1(30,10),NAUD1(30,10),NDDD1(30,12,10)
        DIMENSION NDUD1(30,12,10),XXXII(30),YYYII(30)
        COMMON/BLK5/NTREQ,NTREU
        COMMON/BLK10/I,J,JJ,NSHRE,IT
        COMMON/B11/DUDT1,RLDT1,DDDT1,SUPT1
        COMMON/B12/AVDD1,AVUD1,CUSR1,CUUS1
        COMMON/B121/AADD1,AAUD1,ANDD1,ANUD1
        COMMON/B13/NDDD1,NDUD1,NADD1,NAUD1
        COMMON/B131/XXXII,YYYII
        GO TO(10,20,30)ICAL
        DO 100 II=1,NTREQ(I,1)
        WRITE(2,*)I,ICAL,II,IT,RLDT1(I,IT,II)
  100   CONTINUE
C       CALCULATE TOTAL D/S RELEASES DEMANDWISE
   10   DO 3 II=1,NTREQ(I,1)
```

```
      CUSR1(I,JJ,II)=CUSR1(I,JJ,II)+RLDT1(I,IT,II)
      XXX=XXX+RLDT1(I,IT,II)
      XXXII(II)=XXXII(II)+RLDT1(I,IT,II)
    3 CONTINUE
      RETURN
C     CALCULATE STATISTICS FOR D/S DEMAND
   20 DO 1 II=1,NTREQ(I,1)
      IF(DDDT1(I,IT,II).GT.0.0)NDDD1(I,IT,II)=NDDD1(I,IT,II)+1
      AVDD1(I,IT,II)=AVDD1(I,IT,II)+DDDT1(I,IT,II)/FLOAT(NYEAR)
      ANDD1(I,JJ,II)=ANDD1(I,JJ,II)+DDDT1(I,IT,II)
    1 CONTINUE
C     CALCULATE STATISTICS FOR U/S DEMAND
      DO 2 II=1,NTREU(I,1)
      IF(DUDT1(I,IT,II).GT.0.0)NDUD1(I,IT,II)=NDUD1(I,IT,II)+1
      AVUD1(I,IT,II)=AVUD1(I,IT,II)+DUDT1(I,IT,II)/FLOAT(NYEAR)
      ANUD1(I,JJ,II)=ANUD1(I,JJ,II)+DUDT1(I,IT,II)
    2 CONTINUE
C     CALCULATE TOTAL D/S RELEASES DEMANDWISE
      DO 7 II=1,NTREQ(I,1)
      CUSR1(I,JJ,II)=CUSR1(I,JJ,II)+RLDT1(I,IT,II)
      XXX=XXX+RLDT1(I,IT,II)
      XXXII(II)=XXXII(II)+RLDT1(I,IT,II)
    7 CONTINUE
C     CALCULATE TOTAL U/S SUBTRATION  DEMANDWISE
      DO 4 II=1,NTREU(I,1)
      CUUS1(I,JJ,II)=CUUS1(I,JJ,II)+SUPT1(I,IT,II)
      YYY=YYY+SUPT1(I,IT,II)
      YYYII(II)=YYYII(II)+SUPT1(I,IT,II)
    4 CONTINUE
      RETURN
   30 DO 5 II=1,NTREQ(I,1)
      IF(ANDD1(I,JJ,II).GT.0.)NADD1(I,II)=NADD1(I,II)+1
      AADD1(I,II)=AADD1(I,II)+ANDD1(I,JJ,II)/FLOAT(NYEAR)
    5 CONTINUE
      DO 6 II=1,NTREU(I,1)
      IF(ANUD1(I,JJ,II).GT.0.0)NAUD1(I,II)=NAUD1(I,II)+1
      AAUD1(I,II)=AAUD1(I,II)+ANUD1(I,JJ,II)/FLOAT(NYEAR)
    6 CONTINUE
      RETURN
      END
C     *******************************************************************
C   (6)         INTI1
C     *******************************************************************
      SUBROUTINE INTI1(NSITE,NYEAR)
      DIMENSION AVDD1(30,12,10),AVUD1(30,12,10)
      DIMENSION CUSR1(30,25,10),CUUS1(30,25,10),AADD1(30,10)
      DIMENSION AAUD1(30,10),ANDD1(30,25,10),ANUD1(30,25,10)
      DIMENSION NADD1(30,10),NAUD1(30,10),NDDD1(30,12,10)
      DIMENSION NDUD1(30,12,10),NTREQ(30,10),NTREU(30,10)
      COMMON/BLK2/NMONT
      COMMON/BLK5/NTREQ,NTREU
      COMMON/B12/AVDD1,AVUD1,CUSR1,CUUS1
      COMMON/B121/AADD1,AAUD1,ANDD1,ANUD1
      COMMON/B13/NDDD1,NDUD1,NADD1,NAUD1
      DO 1 I=1,NSITE
      DO 2 JJ=1,NYEAR
      DO 3 IT=1,NMONT
      DO 4 II=1,NTREQ(I,1)
```

```
      NDDD1(I,IT,II)=0
      AVDD1(I,IT,II)=0.
      ANDD1(I,JJ,II)=0.
      CUSR1(I,JJ,II)=0.
      NADD1(I,II)=0
      AADD1(I,II)=0.
4     CONTINUE
      DO 5 II=1,NTREU(I,1)
      NDUD1(I,IT,II)=0
      AVUD1(I,IT,II)=0.
      ANUD1(I,JJ,II)=0.
      CUUS1(I,JJ,II)=0.
      NAUD1(I,II)=0
      AAUD1(I,II)=0.
5     CONTINUE
3     CONTINUE
2     CONTINUE
1     CONTINUE
      RETURN
      END
C     ****************************************************************
C      (7)        WRT1
C     ****************************************************************
      SUBROUTINE WRT1(NYEAR,NSITE,J,IWRT,NSHRE,I)
      DIMENSION S(30,13),FLOW(30,25,12),P(30,25,12)
      DIMENSION AREQ1(30,10),NTREQ(30,10),REQ1(30,12,10)
      DIMENSION PREQ1(30,12,10),AREU1(30,10),NTREU(30,10)
      DIMENSION PREU1(30,12,10),REQU1(30,12,10)
      DIMENSION SHARE(4,30,3),AVANS(4,30,1),YMIN(30,12),YMAX(30,12)
      DIMENSION DUDT1(30,12,10),RLDT1(30,12,10),DDDT1(30,12,10)
      DIMENSION AWACS(30),AWWCS(30),NSTAT(30),SUPT1(30,12,10)
      DIMENSION AVDD1(30,12,10),AVUD1(30,12,10)
      DIMENSION CUSR1(30,25,10),CUUS1(30,25,10),AADD1(30,10)
      DIMENSION AAUD1(30,10),ANDD1(30,25,10),ANUD1(30,25,10)
      DIMENSION NADD1(30,10),NAUD1(30,10),NDDD1(30,12,10)
      DIMENSION NDUD1(30,12,10),TFLOW(30,12),IWRT(6),SUM4(30),SUM5(30)
      DIMENSION SUM1(30,25,12),SUM2(30,25,12),SUM3(30,25,12)
      COMMON/BLK1/FLOW,TFLOW
      COMMON/BLK2/NMONT
      COMMON/BLK3/SHARE
      COMMON/BLK5/NTREQ,NTREU
      COMMON/BLK6/AVANS
      COMMON/BLK8/NSTAT
      COMMON/BLK9/AWACS,AWWCS
      COMMON/BLK11/SUM1,SUM2,SUM3
      COMMON/B11/DUDT1,RLDT1,DDDT1,SUPT1
      COMMON/B12/AVDD1,AVUD1,CUSR1,CUUS1
      COMMON/B121/AADD1,AAUD1,ANDD1,ANUD1
      COMMON/B13/NDDD1,NDUD1,NADD1,NAUD1
100   FORMAT(1X,30('*'),/)
101   FORMAT(/,10('-'))
210   FORMAT(1X,'SHARE NO.=',I4,4X,'WATER SHARE =',F10.3/)
 50   IF(IWRT(1).NE.1)GO TO 51
      WRITE(4,213)
      DO 28 II=1,NTREU(I,1)
      DO 29 IT=1,NMONT
      WRITE(4,214)I,J,II,IT,AVUD1(I,IT,II),NDUD1(I,IT,II)
213   FORMAT(1X,'SITE',2X,'STATE',2X,'U/S DEMAND',3X,'TIME',2X,
```

```
 1    'AVE. DEFICIT IN TIME',2X,'NO. OF DEFICITS'/)
214   FORMAT(I5,I7,I12,I7,F22.3,I17)
 29   CONTINUE
 28   CONTINUE
      WRITE(4,101)
      WRITE(4,100)
 51   IF(IWRT(2).NE.1)GO TO 52
      WRITE(4,215)
      DO 31 II=1,NTREU(I,1)
      DO 32 JJ=1,NYEAR
      WRITE(4,216)I,J,II,JJ,ANUD1(I,JJ,II)
215   FORMAT(1X,'SITE',2X,'STATE',2X,'U/S DEMAND',2X,'YEAR',2X,
 1    'ANNUAL DEFICIT')
216   FORMAT(I5,I7,I12,I6,F16.3)
 32   CONTINUE
 31   CONTINUE
      WRITE(4,101)
      WRITE(4,100)
 52   IF(IWRT(3).NE.1)GO TO 53
      WRITE(4,217)
      DO 34 II=1,NTREU(I,1)
      WRITE(4,218)I,II,AAUD1(I,II),NAUD1(I,II)
217   FORMAT(1X,'SITE',2X,'U/S DEMAND',2X,'AVE.ANNUAL DEFICIT',
 1    2X,'NO.OF ANNUAL DEFICIT'/)
218   FORMAT(I5,I12,F20.3,I22)
 34   CONTINUE
      WRITE(4,101)
      WRITE(4,100)
 53   IF(IWRT(4).NE.1)GO TO 55
      WRITE(4,201)
      DO 14 II=1,NTREQ(I,1)
      DO 15 IT=1,NMONT
      WRITE(4,202)I,J,II,IT,AVDD1(I,IT,II),NDDD1(I,IT,II)
201   FORMAT(1X,'SITE',2X,'STATE',2X,'D/S DEMAND',3X,'TIME',2X,
 1    'AVE. DEFICIT IN TIME',2X,'NO. OF DEFICITS'/)
202   FORMAT(I5,I7,I12,I7,F22.3,I17)
 15   CONTINUE
 14   CONTINUE
      WRITE(4,101)
      WRITE(4,100)
 55   IF(IWRT(5).NE.1)GO TO 56
      WRITE(4,203)
      DO 17 II=1,NTREQ(I,1)
      DO 18 JJ=1,NYEAR
      WRITE(4,204)I,J,II,JJ,ANDD1(I,JJ,II)
203   FORMAT(1X,'SITE',2X,'STATE',2X,'D/S DEMAND',2X,'YEAR',2X,
 1    'ANNUAL DEFICIT')
204   FORMAT(I5,I7,I12,I6,F16.3)
 18   CONTINUE
 17   CONTINUE
      WRITE(4,101)
      WRITE(4,100)
 56   IF(IWRT(6).NE.1)GO TO 57
      WRITE(4,207)
      DO 20 II=1,NTREQ(I,1)
      WRITE(4,208)I,II,AADD1(I,II),NADD1(I,II)
207   FORMAT(1X,'SITE',2X,'D/S DEMAND',2X,'AVE.ANNUAL DEFICIT',
 1    2X,'NO.OF ANNUAL DEFICIT'/)
```

```
  208    FORMAT(I5,I12,F20.3,I22)
   20    CONTINUE
         WRITE(4,101)
   57    RETURN
         END
C        ****************************************************************
C              (8)      WRTM
C        ****************************************************************
         SUBROUTINE WRTM(IJ)
         DIMENSION S(30,13),FLOW(30,25,12),P(30,25,12)
         DIMENSION YMIN(30,12),YMAX(30,12)
         DIMENSION AREQ1(30,10),NTREQ(30,10),REQD1(30,12,10)
         DIMENSION PREQ1(30,12,10),AREU1(30,10),NTREU(30,10)
         DIMENSION PREU1(30,12,10),REQU1(30,12,10)
         DIMENSION SHARE(4,30,3),AVANS(4,30,1),DUDT1(30,12,10)
         DIMENSION RLDT1(30,12,10),DDDT1(30,12,10),SUPT1(30,12,10)
         DIMENSION ANNLF(30,3),DFM75(30,12),AWACS(30),AWWCS(30)
         DIMENSION NSTAT(30),TFLOW(30,12),IWRT(6),SUM4(30),SUM5(30)
         DIMENSION SUM1(30,25,12),SUM2(30,25,12),SUM3(30,25,12)
         COMMON/BLK1/FLOW,TFLOW
         COMMON/BLK2/NMONT
         COMMON/BLK3/SHARE
         COMMON/BLK5/NTREQ,NTREU
         COMMON/BLK6/AVANS
         COMMON/BLK8/NSTAT
         COMMON/BLK9/AWACS,AWWCS
         COMMON/BLK10/I,J,JJ,NSHRE,IT
         COMMON/BLK11/SUM1,SUM2,SUM3
         COMMON/B11/DUDT1,RLDT1,DDDT1,SUPT1
         IF(J.NE.1)GO TO 1
         IF(NSHRE.NE.1)GO TO 10
         DO 4 II=1,NTREU(I,1)
         I1=1
         CALL WRT(SHARE(NSHRE,I,1),DUDT1(I,IT,II),SUPT1(I,IT,II),
    1             II,I1,IJ)
    4    CONTINUE
   10    DO 5 II=1,NTREQ(I,1)
         I1=2
         CALL WRT(SHARE(NSHRE,I,1),DDDT1(I,IT,II),RLDT1(I,IT,II),II,
    1             I1,IJ)
    5    CONTINUE
    1    RETURN
         END
C        ****************************************************************
C         (9)         WRT
C        ****************************************************************
         SUBROUTINE WRT(SHARE,X1,X2,II,I1,IJ)
         COMMON/BLK10/I,J,JJ,NSHRE,IT
         COMMON/OPT6/ICOMT
         IF(IJ.EQ.1.AND.ICOMT.EQ.1)WRITE(3,100)
         IJ=IJ+1
  100    FORMAT(1X,'SITE',2X,'YEAR',2X,'TIME',2X,'SHARE NO.',2X,
    1    'STATE',4X,'SHARE',2X,'USE NO.',5X,'DUDT',5X,'SUPT',5X,'DDDT',
    1     5X,'RLDT'/)
  101    FORMAT(I5,I6,I6,I11,I7,F9.2,I9,2F9.2)
  102    FORMAT(I5,I6,I6,I11,I7,F9.2,I9,18X,2F9.2)
         IF(I1.EQ.1.AND.ICOMT.EQ.1)WRITE(3,101)I,JJ,IT,NSHRE,
    1    J,SHARE,II,X1,X2
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```
      IF(I1.EQ.2.AND.ICOMT.EQ.1)WRITE(3,102)I,JJ,IT,NSHRE,
     1 J,SHARE,II,X1,X2
      RETURN
      END
C     ***********************************************************
C       (10)       FUNCTION AREA
C     ***********************************************************
      FUNCTION AREA(I,X)
C     AREA IN M.SQM. AND CAPACITY IN M.CU.M.
      GO TO(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
     1 ,21,22,23,24,25,26,27,28,29,30)I
C     UPPER NARMADA
    1 AREA = .169793 + .1297995*X - .000211911*(X**2)
     1        + 4.620022E-07*(X**3)
      RETURN
C     RAGHAVPUR
    2 AREA = -.29 + .0985*X -6.47E-05*(X**2)
      RETURN
C     ROSRA
    3 AREA=-.031+.056*X+2.43E-06*(X**2)+5.52E-09*(X**3)
     1      -6.42E-13*(X**4)
      RETURN
C     UPPER BURHNER (BURHNER)
    4 AREA=.10699+.0564409*X+.000161317*(X**2)-3.47482E-07*(X**3)+
     1 4.11661E-10*(X**4)-2.7253E-13*(X**5)+7.52987E-17*(X**6)
      RETURN
C     HALON (HALON)
    5 AREA=-.048197+.0971459*X+.000965141*(X**2)-9.27033E-6*(X**3)+
     1      3.05036E-08*(X**4)-2.88024E-11*(X**5)
      RETURN
C     BASANIA
    6 AREA=-.14+.075*X+4.59E-05*(X**2)-6.79E-08*(X**3)
     1 +3.63E-11*(X**4)-8.73E-15*(X**5)+7.73E-19*(X**6)
      RETURN
C     MATIYARI
    7 AREA=.426+.145*X-.0004*(X**2)-6.96E-07*X**3
      RETURN
C     BARGI
    8 AREA=.0255+.1072*X-2.056E-5*X**2+2.653E-9*X**3
      RETURN
C     ATARIA
    9 AREA=-.00150858+.284737*X-.000553647*(X**2)-5.48299E-6*(X**3)
     1 +3.16051E-08*(X**4)-4.25355E-11*(X**5)
      RETURN
C     CHINKI
   10 AREA= .01384620+.116194*X+2.01486E-5*(X**2)-1.50262E-8*(X**3)
     1 +3.34357E-12*(X**4)
      RETURN
C     SHER
   11 AREA=-.37 + .122*X - 5.91E-5*(X**2)
      RETURN
C     MACHREWA
   12 AREA=-0.127+.084*X-0.00012*X**2
      RETURN
C     SHAKKER (SHAKKER)
   13 AREA=0.0413+.048*X+.00026*(X**2)-2.85E-6*(X**3)
     1 +1.28E-08*(X**4)-2.49E-11*(X**5)+1.77E-14*X**6
      RETURN
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```
C        SITAREWA (SITAREWA)
   14    AREA=-.085+.096*X+5.336E-6*X**2
         RETURN
C        DUDHI (DUDHI)
   15    AREA=-.167772+.126684*X-8.82259E-5*(X**2)
         RETURN
C        BARNA (BARNA)
   16    AREA=-.013+.0089*X+.0023*(X**2)-1.297E-5*(X**3)
     1   +3.22E-08*(X**4)-3.63E-11*(X**5)+1.52E-14*X**6
         RETURN
C        TAWA (NARMADA TRIBUTARY)
   17    AREA=.0489072+.054494*X+7.40008E-5*X**2-4.59715E-08*(X**3)
     1          +8.64504E-12*(X**4)
         RETURN
C        KOLAR (KOLAR)
   18    AREA=.14+.165*X-.00066*(X**2)+1.78E-6*(X**3)
     1   -1.91E-09*(X**4)
         RETURN
C        MORAND (MORAND)
   19    AREA=-.0274137+.09990080*X-6.5212E-5*(X**2)+1.05499E-7*(X**3)
     1   +5.20699E-10*(X**4)
         RETURN
C        GANJAL (GANJAL)
   20    AREA=-0.006+.098*X-.001*(X**2)+2.23E-5*(X**3)
     1   -1.37E-07*(X**4)+2.76E-10*(X**5)
         RETURN
C        SUKTA (SUKTA)
   21    AREA=-.02+.12*X-.00098*X**2+.00011*X**3-3.427E-6*X**4+
     1   4.36E-8*X**5-2.49E-10*X**6+5.29E-13*X**7
         RETURN
C        CHHOTA TAWA (CHHOTA TAWA)
   22    AREA=-.1545+.152*X+.0003195*(X**2)-6.37E-7*(X**3)
     1    +2.31E-10*(X**4)
         RETURN
C        NARMADA SAGAR (NARMADA)
   23    AREA=-5.26261 +.12258500*X+2.26702E-05 *(X**2)-1.99152E-8*(X**3)
     1    +4.12183E-12*(X**4)-3.35597E-16*(X**5)+9.58359E-21*(X**6)
         RETURN
C        OMKARESHWAR (NARMADA)
   24    AREA=-1.189580+.05908640*X+.000184448*(X**2)-2.8143E-7*(X**3)
     1    +1.35434E-10*(X**4)
         RETURN
C        MAHESHWAR   (NARMADA)
   25    AREA=.65+.0575*X+.00015*(X**2)-1.15E-7*(X**3)
         RETURN
C        UPPER BEDA  (BEDA)
   26    AREA=-.0155457+.10901500*X-.00121645*(X**2)+2.02511E-5*(X**3)
     1    -1.20972E-07*(X**4)+2.379920E-10*(X**5)
         RETURN
C        MAN (MAN)
   27    AREA=.04357080+.06144370*X+3.24515E-5*(X**2)-1.17409E-7*(X**3)
         RETURN
C        LOWER  GOI
   28    AREA=-.0121156+.04460590*X+.00115617*(X**2)-9.38102E-6*(X**3)
     1    +2.196E-08*(X**4)
         RETURN
C        JOBAT (HATNI)
```

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   29   AREA=.029+.087*X+.00039*(X**2)-2.99E-6*(X**3)
     1   +5.12E-09*(X**4)
        RETURN
C       SARDAR SAROVAR (NARMADA)
   30   AREA=3.23-.014*X+4.025E-5*X**2-1.17E-8*X**3+1.58E-12*X**4
     1   -1.00000E-16*(X**5)+2.44000E-21*(X**6)
        RETURN
        END
C       ***********************************************************
C         (11)         FUNCTION ELEVATION
C       ***********************************************************
        FUNCTION ELEVAT(I,X)
C       ELEVAT IN M. AND CAPACITY X IN MCUM.
        GO TO(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
     1   ,21,22,23,24,25,26,27,28,29,30)I
C       UPPER NARMADA
    1   ELEVAT=701.276+.471*X-.0039*X**2+1.7E-05*X**3-3.57E-8*X**4
     1  +2.85E-11*X**5
        RETURN
C       RAGHAVPUR
    2   ELEVAT=597.056+.78*X-.0057*(X**2)+
     1  2.25E-5*(X**3)-4.68E-8*(X**4)+4.9E-11*(X**5)-2.05E-14*(X**6)
        RETURN
C       ROSRA
    3   ELEVAT=508.301+.325*X-.001*(X**2)+1.5E-06*(X**3)
     1       -9.98E-10*(X**4)+2.45E-13*(X**5)
        RETURN
C       UPPER BURHNER (BURHNER)
    4   ELEVAT=580.919+.139158*X-.000246775*(X**2)+2.61813E-07*(X**3)
     1   -1.55956E-10*(X**4)+4.37495E-14*(X**5)-3.41847E-18*(X**6)
        RETURN
C       HALON (HALON)
    5   ELEVAT=596.381+.783915*X-.012057900*(X**2)+9.77388E-5*(X**3)-
     1       3.78194E-07*(X**4)+5.51664E-10*(X**5)
        RETURN
C       BASANIA (NARMADA)
    6   ELEVAT=445.902+.0851929*X-6.84283E-05*(X**2)+1.72372E-08*(X**3)
        RETURN
C       MATIYARI (MATIYARI)
    7   ELEVAT=476.64+0.922*X-.013*(X**2)+6.18E-5*(X**3)
        RETURN
C       BARGI
    8   ELEVAT=367.45+.084*X-6.44E-5*X**2+2.556E-8*X**3-4.9E-12*X**4
     1  +3.58E-16*X**5
        RETURN
C       ATARIA
    9   ELEVAT=393.205+.2726400*X-.001200000*(X**2)+2.00900E-6*(X**3)
        RETURN
C       CHINKI
   10   ELEVAT=317.1640+.094000*X-.000110000*(X**2)+4.47500E-8*(X**3)
     1  +3.82000E-11*(X**4)
        RETURN
C       SHER
   11   ELEVAT=383.439+.808*X-.01*(X**2)+5.77E-5*(X**3)
     1    -1.49E-7*(X**4)+1.42E-10*(X**5)
        RETURN
C       MACHREWA
   12   ELEVAT=390.14+0.689 *X-.006*(X**2)+1.86E-5*(X**3)
```

```
      RETURN
C     SHAKKER (SHAKKER)
 13   ELEVAT=369.395+1.79*X-.024*(X**2)+.000168*(X**3)-
     1 6.31E-7*(X**4)+1.289E-9*(X**5)-1.35E-12*(X**6)+5.73E-16*X**7
      RETURN
C     SITAREWA (SITAREWA)
 14   ELEVAT=659.448+1.0359*X-.0122464*X**2+4.86733E-5*X**3
      RETURN
C     DUDHI (DUDHI)
 15   ELEVAT=356.695+1.42*X-.036*(X**2)+.00047*(X**3)
     1 -3.315E-6*X**4+1.25E-8*X**5-2.43E-11*X**6+1.899E-14*X**7
      RETURN
C     BARNA (BARNA)
 16   ELEVAT=312.915+.5*X-.00328*(X**2)+1.095E-5*(X**3)-
     1 1.91E-08*(X**4)+1.66813E-11*(X**5)-5.71E-15*X**6
      RETURN
C     TAWA (TAWA)
 17   ELEVAT=312.965+.088*X-9.01E-5*(X**2)+4.56E-08*(X**3)
     1 -1.06E-11*(X**4)+9.34E-16*(X**5)
      RETURN
C     KOLAR (KOLAR)
 18   ELEVAT=425.024+.82*X-.01*(X**2)+6.6E-5*(X**3)
     1 -1.89E-07*(X**4)+1.99E-10*X**5
      RETURN
C     MORAND (MORAND)
 19   ELEVAT=322.74+0.91*X-.0088*(X**2)+4.01E-5*(X**3)
     1 -8.31E-08*(X**4)+6.36E-11*(X**5)
      RETURN
C     GANJAL (GANJAL)
 20   ELEVAT=348.588+0.6008*X-.00489770*(X**2)+1.38239E-5*(X**3)
      RETURN
C     SUKTA (SUKTA)
 21   ELEVAT=382.815+2.89432*X-.157262*(X**2)+.00409659*(X**3)
     1 -5.33671E-05*(X**4)+3.38265E-07*(X**5)-8.30686E-10*(X**6)
      RETURN
C     CHHOTA TAWA (CHHOTA TAWA)
 22   ELEVAT=276.758+.432847*X-.0023964*(X**2)+4.15971E-6*(X**3)
      RETURN
C     NARMADA SAGAR (NARMADA)
 23   ELEVAT=176.95+.0571398*X-1.80293E-05*(X**2)+2.77667E-9*(X**3)
     1 -1.98994E-13*(X**4)+5.32033E-18*(X**5)
      RETURN
C     OMKARESHWAR (NARMADA)
 24   ELEVAT=160.504+.134*X-.0003*(X**2)+4.39E-07*(X**3)
     1  -3.34E-10*(X**4)+9.77E-14*X**5
      RETURN
C     MAHESHWAR   (NARMADA)
 25   ELEVAT=139.85 +.089*X-.000113*(X**2)+5.9E-8*(X**3)
      RETURN
C     UPPER BEDA  (BEDA)
 26   ELEVAT=288.689+.629528*X-.01171880*(X**2)+.000119718*(X**3)
     1 -5.59723E-07*(X**4)+9.527130E-10*(X**5)
      RETURN
C     MAN (MAN)
 27   ELEVAT=232.736+.522736*X-.00229595*(X**2)+3.33160E-6*(X**3)
      RETURN
C     LOWER  GOI
```

```
   28  ELEVAT=263.126+.96*X-.01*(X**2)+5.1E-5*(X**3)-
     1 1.17E-7*X**4+9.96E-11*X**5
       RETURN
C      JOBAT (HATNI)
   29  ELEVAT=239.25+0.746*X-.0091*(X**2)+5.75E-5*(X**3)
     1  -1.72E-07*(X**4)+1.96E-10*X**5
       RETURN
C      SARDAR SAROVAR (NARMADA)
   30  ELEVAT=18.0143+.0376265*X-4.19623E-06*(X**2)+1.65195E-10*(X**3)
       RETURN
       END
C      ****************************************************************
C          (12)        CALL11
C      ****************************************************************
       SUBROUTINE CAL11(PPP,QQQ,ICAL,NYEAR)
       DIMENSION NDSRE(30,10),NUSRE(30,10),PPPII(30),QQQII(30)
       DIMENSION DUD1(30,12,10),RLD1(30,12,10),DDD1(30,12,10)
       DIMENSION SUP1(30,12,10),AVD1(30,12,10),AVU1(30,12,10)
       DIMENSION CUR1(30,25,10),CUS1(30,25,10),AAD1(30,10)
       DIMENSION AAU1(30,10),AND1(30,25,10),ANU1(30,25,10)
       DIMENSION NAD1(30,10),NAU1(30,10),NDD1(30,12,10),NDU1(30,12,10)
       COMMON/BLK10/I,J,JJ,NSHRE,IT
       COMMON/BLK13/NUSRE,NDSRE
       COMMON/B14/AVD1,AVU1,CUR1,CUS1
       COMMON/B141/AAD1,AAU1,AND1,ANU1
       COMMON/B15/NDD1,NDU1,NAD1,NAU1
       COMMON/B16/DUD1,RLD1,DDD1,SUP1
       COMMON/B161/PPPII,QQQII
       GO TO(10,20,30)ICAL
C      CALCULATE TOTAL D/S RELEASES DEMANDWISE
   10  DO 3 II=1,NDSRE(I,1)
       CUR1(I,JJ,II)=CUR1(I,JJ,II)+RLD1(I,IT,II)
       PPP=PPP+RLD1(I,IT,II)
       PPPII(II)=PPPII(II)+RLD1(I,IT,II)
    3  CONTINUE
       RETURN
C      CALCULATE STATISTICS FOR U/S DEMAND
   20  DO 1 II=1,NDSRE(I,1)
       IF(DDD1(I,IT,II).GT.0.0)NDD1(I,IT,II)=NDD1(I,IT,II)+1
       AVD1(I,IT,II)=AVD1(I,IT,II)+DDD1(I,IT,II)/FLOAT(NYEAR)
       AND1(I,JJ,II)=AND1(I,JJ,II)+DDD1(I,IT,II)
    1  CONTINUE
C      CALCULATE STATISTICS FOR U/S DEMAND
       DO 2 II=1,NUSRE(I,1)
       IF(DUD1(I,IT,II).GT.0.0)NDU1(I,IT,II)=NDU1(I,IT,II)+1
       AVU1(I,IT,II)=AVU1(I,IT,II)+DUD1(I,IT,II)/FLOAT(NYEAR)
       ANU1(I,JJ,II)=ANU1(I,JJ,II)+DUD1(I,IT,II)
    2  CONTINUE
C      CALCULATE TOTAL D/S RELEASES DEMANDWISE
       DO 7 II=1,NDSRE(I,1)
       CUR1(I,JJ,II)=CUR1(I,JJ,II)+RLD1(I,IT,II)
       PPP=PPP+RLD1(I,IT,II)
       PPPII(II)=PPPII(II)+RLD1(I,IT,II)
    7  CONTINUE
C      CALCULATE TOTAL U/S SUBTRATION  DEMANDWISE
       DO 4 II=1,NUSRE(I,1)
       CUS1(I,JJ,II)=CUS1(I,JJ,II)+SUP1(I,IT,II)
       QQQ=QQQ+SUP1(I,IT,II)
```

```
      QQQII(II)=QQQII(II)+SUP1(I,IT,II)
    4 CONTINUE
      RETURN
   30 DO 5 II=1,NDSRE(I,1)
      IF(AND1(I,JJ,II).GT.0.)NAD1(I,II)=NAD1(I,II)+1
      AAD1(I,II)=AAD1(I,II)+AND1(I,JJ,II)/FLOAT(NYEAR)
    5 CONTINUE
      DO 6 II=1,NUSRE(I,1)
C     IF(ANU1(I,JJ,II).GT.0.)NAU1(I,II)=NAU1(I,II)+1
      IF(ANU1(I,JJ,II).GT.0.0)NAU1(I,II)=NAU1(I,II)+1
      AAU1(I,II)=AAU1(I,II)+ANU1(I,JJ,II)/FLOAT(NYEAR)
    6 CONTINUE
      RETURN
      END
C     *****************************************************************
C        (13)        INIL1
C     *****************************************************************
      SUBROUTINE INIL1(NSITE,NYEAR)
      DIMENSION AVD1(30,12,10),AVU1(30,12,10)
      DIMENSION CUR1(30,25,10),CUS1(30,25,10),AAD1(30,10)
      DIMENSION AAU1(30,10),AND1(30,25,10),ANU1(30,25,10)
      DIMENSION NAD1(30,10),NAU1(30,10),NDD1(30,12,10)
      DIMENSION NDU1(30,12,10),NUSRE(30,10),NDSRE(30,10)
      COMMON/BLK2/NMONT
      COMMON/BLK13/NUSRE,NDSRE
      COMMON/B14/AVD1,AVU1,CUR1,CUS1
      COMMON/B141/AAD1,AAU1,AND1,ANU1
      COMMON/B15/NDD1,NDU1,NAD1,NAU1
      DO 1 I=1,NSITE
      DO 2 JJ=1,NYEAR
      DO 3 IT=1,NMONT
      DO 4 II=1,NDSRE(I,1)
      NDD1(I,IT,II)=0
      AVD1(I,IT,II)=0.
      AND1(I,JJ,II)=0.
      CUR1(I,JJ,II)=0.
      NAD1(I,II)=0
      AAD1(I,II)=0.
    4 CONTINUE
      DO 5 II=1,NUSRE(I,1)
      NDU1(I,IT,II)=0
      AVU1(I,IT,II)=0.
      ANU1(I,JJ,II)=0.
      CUS1(I,JJ,II)=0.
      NAU1(I,II)=0
      AAU1(I,II)=0.
    5 CONTINUE
    3 CONTINUE
    2 CONTINUE
    1 CONTINUE
      RETURN
      END
C     *****************************************************************
C        (14)          WRT11
C     *****************************************************************
      SUBROUTINE WRT11(NYEAR,NSITE,J,IWRT,NSHRE,I)
      DIMENSION S(30,13),FLOW(30,25,12),P(30,25,12)
      DIMENSION YMIN(30,12),YMAX(30,12)
```

```
      DIMENSION ARD1(30,10),NDSRE(30,10),RED1(30,12,10)
      DIMENSION PRD1(30,12,10),ARU1(30,10),NUSRE(30,10)
      DIMENSION PRU1(30,12,10),REU1(30,12,10)
      DIMENSION SHARE(4,30,3),AVANS(4,30,1)
      DIMENSION DUD1(30,12,10),RLD1(30,12,10),DDD1(30,12,10)
      DIMENSION AWACS(30),AWWCS(30),NSTAT(30),SUP1(30,12,10)
      DIMENSION AVD1(30,12,10),AVU1(30,12,10)
      DIMENSION CUR1(30,25,10),CUS1(30,25,10),AAD1(30,10)
      DIMENSION AAU1(30,10),AND1(30,25,10),ANU1(30,25,10)
      DIMENSION NAD1(30,10),NAU1(30,10),NDD1(30,12,10)
      DIMENSION NDU1(30,12,10),TFLOW(30,12),IWRT(6),SUM4(30),SUM5(30)
      DIMENSION SUM1(30,25,12),SUM2(30,25,12),SUM3(30,25,12)
      COMMON/BLK1/FLOW,TFLOW
      COMMON/BLK2/NMONT
      COMMON/BLK3/SHARE
      COMMON/BLK6/AVANS
      COMMON/BLK8/NSTAT
      COMMON/BLK9/AWACS,AWWCS
      COMMON/BLK11/SUM1,SUM2,SUM3
      COMMON/BLK12/S,P,YMAX,YMIN
      COMMON/BLK13/NUSRE,NDSRE
      COMMON/B14/AVD1,AVU1,CUR1,CUS1
      COMMON/B141/AAD1,AAU1,AND1,ANU1
      COMMON/B15/NDD1,NDU1,NAD1,NAU1
      COMMON/B16/DUD1,RLD1,DDD1,SUP1
100   FORMAT(1X,30('*'),/)
101   FORMAT(/,10('-'))
210   FORMAT(1X,'SHARE NO.=',I4,4X,'WATER SHARE =',F10.3/)
 50   IF(IWRT(1).NE.1)GO TO 51
      WRITE(5,213)
      DO 28 II=1,NUSRE(I,1)
      DO 29 IT=1,NMONT
      WRITE(5,214)I,J,II,IT,AVU1(I,IT,II),NDU1(I,IT,II)
213   FORMAT(1X,'SITE',2X,'STATE',2X,'U/S REQUIR',3X,'TIME',2X,
    1 'AVE. DEFICIT IN TIME',2X,'NO. OF DEFICITS'/)
214   FORMAT(I5,I7,I12,I7,F22.3,I17)
 29   CONTINUE
 28   CONTINUE
      WRITE(5,101)
      WRITE(5,100)
 51   IF(IWRT(2).NE.1)GO TO 52
      WRITE(5,215)
      DO 31 II=1,NUSRE(I,1)
      DO 32 JJ=1,NYEAR
      WRITE(5,216)I,J,II,JJ,ANU1(I,JJ,II)
215   FORMAT(1X,'SITE',2X,'STATE',2X,'U/S REQUIR',2X,'YEAR',2X,
    1 'ANNUAL DEFICIT')
216   FORMAT(I5,I7,I12,I6,F16.3)
 32   CONTINUE
 31   CONTINUE
      WRITE(5,101)
      WRITE(5,100)
 52   IF(IWRT(3).NE.1)GO TO 53
      WRITE(5,217)
      DO 34 II=1,NUSRE(I,1)
      WRITE(5,218)I,II,AAU1(I,II),NAU1(I,II)
217   FORMAT(1X,'SITE',2X,'U/S REQUIR',2X,'AVE.ANNUAL DEFICIT',
    1 2X,'NO.OF ANNUAL DEFICIT'/)
```

```
218   FORMAT(I5,I12,F20.3,I22)
 34   CONTINUE
      WRITE(5,101)
      WRITE(5,100)
 53   IF(IWRT(4).NE.1)GO TO 55
      WRITE(5,201)
      DO 14 II=1,NDSRE(I,1)
      DO 15 IT=1,NMONT
      WRITE(5,202)I,J,II,IT,AVD1(I,IT,II),NDD1(I,IT,II)
201   FORMAT(1X,'SITE',2X,'STATE',2X,'D/S REQUIR',3X,'TIME',2X,
     1 'AVE. DEFICIT IN TIME',2X,'NO. OF DEFICITS'/)
202   FORMAT(I5,I7,I12,I7,F22.3,I17)
 15   CONTINUE
 14   CONTINUE
      WRITE(5,101)
      WRITE(5,100)
 55   IF(IWRT(5).NE.1)GO TO 56
      WRITE(5,203)
      DO 17 II=1,NDSRE(I,1)
      DO 18 JJ=1,NYEAR
      WRITE(5,204)I,J,II,JJ,AND1(I,JJ,II)
203   FORMAT(1X,'SITE',2X,'STATE',2X,'D/S REQUIR',2X,'YEAR',2X,
     1 'ANNUAL DEFICIT')
204   FORMAT(I5,I7,I12,I6,F16.3)
 18   CONTINUE
 17   CONTINUE
      WRITE(5,101)
      WRITE(5,100)
 56   IF(IWRT(6).NE.1)GO TO 57
      WRITE(5,207)
      DO 20 II=1,NDSRE(I,1)
      WRITE(5,208)I,II,AAD1(I,II),NAD1(I,II)
207   FORMAT(1X,'SITE',2X,'D/S REQUIR',2X,'AVE.ANNUAL DEFICIT',
     1 2X,'NO.OF ANNUAL DEFICIT'/)
208   FORMAT(I5,I12,F20.3,I22)
 20   CONTINUE
      WRITE(5,101)
 57   RETURN
      END
C     ***************************************************************
C        (15)          DIST1
C     ***************************************************************
      SUBROUTINE DIST1(I,IT)
      DIMENSION RED1(30,12,10),DDD1(30,12,10),REU1(30,12,10)
      DIMENSION DUD1(30,12,10),DDDT1(30,12,10),DUDT1(30,12,10)
      DIMENSION SUPT1(30,12,10),RLDT1(30,12,10),RLD1(30,12,10)
      DIMENSION SUP1(30,12,10)
      COMMON/B11/DUDT1,RLDT1,DDDT1,SUPT1
      COMMON/B16/DUD1,RLD1,DDD1,SUP1
      COMMON/B17/RED1,REU1
      DDD1(I,IT,1)=DDDT1(I,IT,1)
      DDD1(I,IT,2)=DDDT1(I,IT,2)
      DDD1(I,IT,3)=DDDT1(I,IT,3)
      DDD1(I,IT,4)=DDDT1(I,IT,4)
      DDD1(I,IT,5)=DDDT1(I,IT,5)
      DDD1(I,IT,6)=DDDT1(I,IT,6)
      DDD1(I,IT,7)=DDDT1(I,IT,7)
      DUD1(I,IT,1)=DUDT1(I,IT,1)
```

```
      RETURN
      END
C     ******************************************************************
C         (16)   WRT12
C     ******************************************************************
      SUBROUTINE WRT12(I,J)
      DIMENSION NUSRE(30,10),NTREU(30,10),ARU1(30,10),PRU1(30,12,10)
      DIMENSION REU1(30,12,10),PREU1(30,12,10),REQU1(30,12,10)
      DIMENSION AREU1(30,10),AREQ1(30,10)
      DIMENSION NDSRE(30,10),NTREQ(30,10),ARD1(30,10),PRD1(30,12,10)
      DIMENSION RED1(30,12,10),PREQ1(30,12,10),REQD1(30,12,10)
      COMMON/BLK2/NMONT
      COMMON/BLK5/NTREQ,NTREU
      COMMON/BLK13/NUSRE,NDSRE
      COMMON/B17/RED1,REU1
      COMMON/B18/ARU1,PRU1,AREU1,PREU1,REQU1
      COMMON/B19/ARD1,PRD1,AREQ1,PREQ1,REQD1
      WRITE(6,1008)
      DO 1005 II=1,NUSRE(I,1)
      WRITE(6,1009)I,J,II,ARU1(I,II)
1005  CONTINUE
1008  FORMAT(1X,'SITE',2X,'STATE',2X,'U/S REQUIR ACTUAL',2X
     1 ,'ANNUAL VALUE'/)
1009  FORMAT(I5,I7,I19,F14.3)
      WRITE(6,1002)
      DO 1000 II=1,NTREU(I,1)
      WRITE(6,1001)I,J,II,AREU1(I,II)
1000  CONTINUE
1002  FORMAT(//,1X,'SITE',2X,'STATE',2X,'U/S DEMAND CLUBED',2X
     1 ,'ANNUAL VALUE'/)
1001  FORMAT(I5,I7,I19,F14.3)
      DO 1017 II=1,NUSRE(I,1)
      WRITE(6,1015)
      DO 1018 IT=1,NMONT
      WRITE(6,1016)I,J,II,IT,PRU1(I,IT,II),REU1(I,IT,II)
1018  CONTINUE
1017  CONTINUE
1015  FORMAT(//,1X,'SITE',2X,'STATE',2X,'U/S REQUIR ACTUAL',2X,'TIME',
     1 2X,'PERCENT REQUIR',6X,'REQUIR'/)
1016  FORMAT(I5,I7,I19,I6,F16.3,F12.3)
      DO 1021 II=1,NTREU(I,1)
      WRITE(6,1020)
      DO 1022 IT=1,NMONT
      WRITE(6,1023)I,J,II,IT,PREU1(I,IT,II),REQU1(I,IT,II)
1022  CONTINUE
1021  CONTINUE
1020  FORMAT(//,1X,'SITE',2X,'STATE',2X,'U/S DEMAND CLUBED',2X,
     1 'TIME',2X,'PERCENT DEMAND',6X,'DEMAND'/)
1023  FORMAT(I5,I7,I19,I6,F16.3,F12.3)
      WRITE(6,2008)
      DO 2005 II=1,NDSRE(I,1)
      WRITE(6,2009)I,J,II,ARD1(I,II)
2005  CONTINUE
2008  FORMAT(1X,'SITE',2X,'STATE',2X,'D/S REQUIR ACTUAL',2X
     1 ,'ANNUAL VALUE'/)
2009  FORMAT(I5,I7,I19,F14.3)
      WRITE(6,2002)
      DO 2000 II=1,NTREQ(I,1)
```

```
      WRITE(6,2001)I,J,II,AREQ1(I,II)
 2000 CONTINUE
 2002 FORMAT(//,1X,'SITE',2X,'STATE',2X,'D/S DEMAND CLUBED',2X
     1 ,'ANNUAL VALUE'/)
 2001 FORMAT(I5,I7,I19,F14.3)
      DO 2017 II=1,NDSRE(I,1)
      WRITE(6,2015)
      DO 2018 IT=1,NMONT
      WRITE(6,2016)I,J,II,IT,PRD1(I,IT,II),RED1(I,IT,II)
 2018 CONTINUE
 2017 CONTINUE
 2015 FORMAT(//,1X,'SITE',2X,'STATE',2X,'D/S REQUIR ACTUAL',2X,
     1 'TIME',2X,'PERCENT REQUIR',6X,'REQUIR'/)
 2016 FORMAT(I5,I7,I19,I6,F16.3,F12.3)
      DO 2021 II=1,NTREQ(I,1)
      WRITE(6,2020)
      DO 2022 IT=1,NMONT
      WRITE(6,2023)I,J,II,IT,PREQ1(I,IT,II),REQD1(I,IT,II)
 2022 CONTINUE
 2021 CONTINUE
 2020 FORMAT(//,1X,'SITE',2X,'STATE',2X,'D/S DEMAND CLUBED',2X,
     1 'TIME',2X,'PERCENT DEMAND',6X,'DEMAND'/)
 2023 FORMAT(I5,I7,I19,I6,F16.3,F12.3)
      RETURN
      END
C ***********************************************************
C     (17) SUBROUTINE NAME
C***********************************************************
      SUBROUTINE NAME(FILE1,FILE2,FILE3,FILE4,FILE5,
     1 FILE6,FILE7,FILE8,FILE11,FNAM)
      CHARACTER*7 FNAM
      CHARACTER*11 FILE1,FILE2,FILE3,FILE4,FILE5,FILE6,
     1 FILE7,FILE8,FILE11
      OPEN(UNIT=10,FILE='NAME.INT')
      DATA 01,02,03,04,05,06,07,08,09/'.dat','.ot2','.ot3',
     1 '.ot4','.ot5','.ot6','.ot7','.ot8','.ot9'/
      WRITE(*,*)'ENTER THE FIRST NAME OF DATA FILE'
      WRITE(10,20)FNAM,01
      WRITE(10,20)FNAM,02
      WRITE(10,20)FNAM,03
      WRITE(10,20)FNAM,04
      WRITE(10,20)FNAM,05
      WRITE(10,20)FNAM,06
      WRITE(10,20)FNAM,07
      WRITE(10,20)FNAM,08
      WRITE(10,20)FNAM,09
   20 FORMAT(1X,7A,4A)
      CLOSE(UNIT=10)
      OPEN(UNIT=10,FILE='NAME.INT',STATUS='OLD')
      READ(10,30)FILE1
      READ(10,30)FILE2
      READ(10,30)FILE3
      READ(10,30)FILE4
      READ(10,30)FILE5
      READ(10,30)FILE6
      READ(10,30)FILE7
      READ(10,30)FILE8
      READ(10,30)FILE11
```

```
      CLOSE(UNIT=10)
   30 FORMAT(1X,11A)
      RETURN
      END
C     ***********************************************************
C      (18) SUBROUTINE NTFLO(NSITE,NYEAR)
C     SUBROUTINE FOR COMPUTING NET FLOW AT THE SITES
C     ***********************************************************
      SUBROUTINE NTFLO(NSITE,NYEAR)
      CHARACTER*20  SITENAMO(30),SITENEW(30)
      DIMENSION ISITE(33),NFYRE(30),NSTAT(30)
      DIMENSION FLOW(30,25,12),TFLOW(30,12),IUMRE(30)
      DIMENSION SUM(25,12),DFLOW(30,25,12),F(30,25,12),ILOC(30),
     1 NUSSI(30,13),NOUSI(30)
      COMMON/OPT1/IWDT1
      COMMON/BLK1/FLOW,TFLOW
      COMMON/BLK2/NMONT
      COMMON/BLK8/NSTAT
      COMMON/BLK22/SITENAMO,SITENEW
      COMMON/BLK25/ISITE,IUMRE
      COMMON/BLK60/NOUSI,NUSSI
      COMMON/BLK61/ILOC
      COMMON/BLK65/F
      DO 550 I=1,NSITE
      IF(IUMRE(I).EQ.1) GO TO 503
      DO 551 JJ=1,NYEAR
      DO 552 IT =1,NMONT
      SUM(JJ,IT)=0.
  552 CONTINUE
  551 CONTINUE
      DO 162 IK=1,NOUSI(I)
      DO 163 JJ=1,NYEAR
      DO 164 IT=1,NMONT
      K=ILOC(NUSSI(I,IK))
      SUM(JJ,IT)=SUM(JJ,IT)+F(K,JJ,IT)
  164 CONTINUE
  163 CONTINUE
  162 CONTINUE
C  CALCULATE NET MONTHLY FLOW AT THE PROJECT SITE UNDER CONSIDERATION
      DO 165 JJ=1,NYEAR
      DO 166 IT =1,NMONT
      DFLOW(ISITE(I),JJ,IT)=F(ISITE(I),JJ,IT)-SUM(JJ,IT)
      IF(DFLOW(ISITE(I),JJ,IT).LE.0) DFLOW(ISITE(I),JJ,IT)=0
      FLOW(I,JJ,IT)=DFLOW(ISITE(I),JJ,IT)
      SITENEW(I) = SITENAMO(ISITE(I))
  166 CONTINUE
  165 CONTINUE
      GO TO 550
  503 DO 504  JJ=1,NYEAR
      DO 504 IT =1,NMONT
      FLOW(I,JJ,IT)=F(ISITE(I),JJ,IT)
      SITENEW(I) = SITENAMO(ISITE(I))
  504 CONTINUE
  550 CONTINUE
      DO 555 I=1,NSITE
      IF(IWDT1.EQ.1)WRITE(2,111) SITENEW(I)
  111 FORMAT(A20)
      DO 556 JJ=1,NYEAR
```

```
      IF(IWDT1.EQ.1)WRITE(2,15)(FLOW(I,JJ,IT),IT=1,NMONT)
   15 FORMAT(1X,12(F9.2,1X))
  556 CONTINUE
  555 CONTINUE
      RETURN
      END
C*************************************************************
C       (19)  SUBROUTINE WRRS1(NSITE,NYEAR)
C       SUBROUTINE FOR WRITING RESULTS IN FILE8/FILE2
C*************************************************************
      SUBROUTINE WRRS1(NSITE,NYEAR)
      CHARACTER*20  SITENAMO(30),SITENEW(30)
      DIMENSION ISITE(33),NFYRE(30),XXXX(33),YYYY(33)
      DIMENSION XXII(30,4),YYII(30,4),AREQ1(30,10),NTREQ(30,10)
      DIMENSION PREQ1(30,12,10),REQD1(30,12,10),IUMRE(30)
      DIMENSION AREU1(30,10),NTREU(30,10),PREU1(30,12,10)
      DIMENSION REQU1(30,12,10),SPILL(30,12),AASPL(30)
      DIMENSION AADD1(30,10),AADE1(30,25)
      DIMENSION AAUD1(30,10),ANDD1(30,25,10),ANUD1(30,25,10)
      DIMENSION NADD1(30,10),NAUD1(30,10),NDDD1(30,12,10)
      DIMENSION NDUD1(30,12,10),IUMRE(30),IWRT(6),IWRTS(30,6)
      DIMENSION NUSRE(30,10),ARU1(30,10),PRU1(30,12,10),REU1(30,12,10)
      DIMENSION NDSRE(30,10),ARD1(30,10),PRD1(30,12,10),RED1(30,12,10)
      DIMENSION NSTAT(30),SUM4(30),SUM5(30),SUM6(30),IREQ1(30,10)
      DIMENSION SUM1(30,25,12),SUM2(30,25,12),SUM3(30,25,12)
      COMMON/BLK2/NMONT
      COMMON/BLK5/NTREQ,NTREU
      COMMON/BLK8/NSTAT
      COMMON/BLK10/I,J,JJ,NSHRE,IT
      COMMON/BLK11/SUM1,SUM2,SUM3
      COMMON/BLK21/SUM4,SUM5,SUM6,NFYRE
      COMMON/BLK13/NUSRE,NDSRE
      COMMON/B121/AADD1,AAUD1,ANDD1,ANUD1
      COMMON/B13/NDDD1,NDUD1,NADD1,NAUD1
      COMMON/BLK17/RED1,REU1
      COMMON/B18/ARU1,PRU1,AREU1,PREU1,REQU1
      COMMON/B21/IREQ1
      COMMON/B19/ARD1,PRD1,AREQ1,PREQ1,REQD1
      COMMON/BLK22/SITENAMO,SITENEW
      COMMON/BLK23/XXXX,YYYY
      COMMON/BLK24/XXII,YYII
      COMMON/BLK25/ISITE,IUMRE
      COMMON/BLK26/AASPL
      COMMON/BLK27/AADE1
      DO 77 I=1,NSITE
      WRITE(2,*)'SITE NAME=', SITENEW(I)
      WRITE(2,*)'SITE CODE NUMBER=',ISITE(I)
      WRITE(2,3)
    3 FORMAT(9X,'USE NO. U/S TARGET',5X,'RELEASE',8X,'DEFICIT',
     1 11X,'YR.(DEF)')
      WRITE(2,*)(II,AREU1(I,II),YYII(I,II),AAUD1(I,II),NAUD1(I,II)
     1 ,II=1,NTREU(I,1))
      WRITE(2,4)
    4 FORMAT(9X,'USE NO. D/S TARGET',5X,'RELEASE',8X,'DEFICIT',
     1 11X,'YR.(DEF)')
      WRITE(2,*)(IK,AREQ1(I,IK),XXII(I,IK),AADD1(I,IK),NADD1(I,IK)
     1 ,IK=1,NTREQ(I,1))
      WRITE(2,*)
```

```
      DO 88 MM=1,NTREQ(I,1)
      IF(IREQ1(I,MM).NE.1) GO TO 88
      WRITE(2,*)'FIRM POWER IN MW=',AREQ1(I,MM)/8760
      IF(AREQ1(I,MM).EQ.0) GO TO 88
      WRITE(2,*)'%AGE AV. ANNUAL ENERGY DEFICIT=',
     1 (SUM4(I)/AREQ1(I,MM))*100
   88 CONTINUE
      WRITE(2,1542)I,SUM6(I),SUM5(I),SUM4(I)
 1542 FORMAT(/1X,'SITE',I2,/2X,'AVERAGE ANNUAL GENERATED ENERGY=',
     1 F10.2,1X,'MW.HR',/2X,'AVERAGE ANNUAL DUMP ENERGY=',F10.2,
     2 'MW.HR',/2X,'AVERAGE ANNUAL ENERGY DEFICIT=',F10.2,'MW.HR')
      WRITE(2,*)'GENERATED, DUMP & DEFICIT POWER IM MW'
      WRITE(2,*)(SUM6(I)/8760),(SUM5(I)/8760),(SUM4(I)/8760)
      WRITE(2,*)'NUMBER OF YEARS OF DEFICITS='
      WRITE(2,*)NFYRE(I)
      WRITE(2,*)'ANNUAL DEFICITS (AADE1(I,JJ)='
      WRITE(2,*)(AADE1(I,JJ),JJ=1,NYEAR)
   79 WRITE(2,*)'ANNUAL SPILL=',AASPL(I)
   77 CONTINUE
      RETURN
      END
C     ************************************************************
C     (20)  SUBROUTINE FOR WRITING CONTRIBUTIONS FROM THE
C     RETURN FLOWS FROM UPSTREAM RESRVOIRS
C     RTNFL(NSITE,NYEAR)
C     ************************************************************
      SUBROUTINE RTNFL(NSITE,NYEAR)
      CHARACTER*20  SITENAMO(30),SITENEW(30)
      DIMENSION CRLDT1(30,12,10),ISITE(33),NTREQ(30,10)
      DIMENSION NTREU(30,10),NURCF(30),NTRCF(30,13)
      DIMENSION NSTAT(30),IPCON(30),IUMRE(30)
      DIMENSION SUM1(30,25,12),SUM2(30,25,12),SUM3(30,25,12)
      COMMON/BLK2/NMONT
      COMMON/BLK5/NTREQ,NTREU
      COMMON/BLK8/NSTAT
      COMMON/BLK11/SUM1,SUM2,SUM3
      COMMON/BLK22/SITENAMO,SITENEW
      COMMON/BLK25/ISITE,IUMRE
      COMMON/BLK55/IPCON
      COMMON/BLK56/NTRCF
      COMMON/BLK57/NURCF
      COMMON/BLK58/CRLDT1
      COMMON/OPT8/IWRTN
      WRITE(11,9016)
 9016 FORMAT(1X,'RETURN FLOW CONTRIBUTIONS'/)
      DO 9012 I=1,NSITE
      IF(IPCON(I).NE.1)GO TO 9012
      WRITE(11,9015)SITENEW(I)
 9015 FORMAT(1X,'SITE NAME=',2X,A20)
      WRITE(11,9010)
 9010 FORMAT(/1X,'SITE',2X,'YEAR',2X,'MONTH',20X,'IUREN'/1x,70('-'))
      WRITE(11,9017)(NTRCF(I,IU),IU=1,NURCF(I))
 9017 FORMAT(24X,5(I2,9X)/1X,70('-'))
      DO 9013 JJ=1,NYEAR
      DO 9013 IT=1,NMONT
      IF(IWRTN.EQ.1)WRITE(11,9011)I,JJ,IT,((CRLDT1
     1 (NTRCF(I,IU),IT,II),II=1,NTREQ(NTRCF(I,IU),1)),IU=1,NURCF(I))
 9011 FORMAT(2X,I2,4X,I2,5X,I2,5X,5(F6.3,5X))
```

```
 9013   CONTINUE
 9012   CONTINUE
        WRITE(11,9002)
 9002   FORMAT(/1X,'SITE',2X,'YEAR',2X,'MONTH',5X,'SUM1',5X,'SUM2',9X,
     1  'SUM3',/)
        DO 9000 I=1,NSITE
        IF(IPCON(I).NE.1)GO TO 9000
        DO 9001 JJ=1,NYEAR
        DO 9001 IT=1,NMONT
        IF(JJ.NE.1) GO TO 9001
        IF(IWRTN.EQ.1) WRITE(11,9003)I,JJ,IT,SUM1(I,JJ,IT),
     1  SUM2(I,JJ,IT),SUM3(I,JJ,IT)
 9003   FORMAT(2X,I2,4X,I2,5X,I2,2X,F8.3,2X,F8.3,4X,F9.3)
 9001   CONTINUE
 9000   CONTINUE
        RETURN
        END
C******************************************************************
C       (21) SUBROUTINE FOR INITIALIZING READ VARIBALES
C       SUBROUTINE FLUSH(MSITE,NSITE,NYEAR)
C******************************************************************
        SUBROUTINE FLUSH(MSITE,NSITE,NYEAR)
        DIMENSION PREQ1(30,12,10),AREU1(30,10),NTREU(30,10)
        DIMENSION REQU1(30,12,10),ISITE(33),IUMRE(30)
        DIMENSION S(30,13),FLOW(30,25,12),P(30,25,12)
        DIMENSION AREQ1(30,10),NTREQ(30,10),PREU1(30,12,10)
        DIMENSION REQD1(30,12,10),RENE1(30,12,10)
        DIMENSION NURCF(30),NTRCF(30,13),DSRFL(30,10),UPRFL(30,10)
        DIMENSION IUMRE(30),UPRFC(30),DSRFC(30),TFLOW(30,12)
        DIMENSION IWRT(6),EVAPO(30,12),IWRTS(30,6)
        DIMENSION NUSRE(30,10),ARU1(30,10),PRU1(30,12,10)
        DIMENSION REU1(30,12,10),RED1(30,12,10),FRATN(30,10)
        DIMENSION NDSRE(30,10),ARD1(30,10),PRD1(30,12,10),ISPPO(30)
        DIMENSION REQV1(30),QMAX(30),REQA1(30),ADNC1(30),REGE1(30)
        DIMENSION ENER1(30),ADNV1(30),ADND1(30),IREQ1(30,10)
        DIMENSION IENO1(30,10),ELE(30),PHMIN(30,12)
        DIMENSION HE(30),PPEFF(30),TWL(30),PPC(30)
        DIMENSION ISHRE(30,3),YMIN(30,12),YMAX(30,12)
        DIMENSION NUSSI(30,13),NOUSI(30),IOPPN(30),IPCON(30)
        COMMON/OPT1/IWDT1
        COMMON/OPT2/ISTAR
        COMMON/OPT3/IWEN1
        COMMON/OPT4/IWWT1
        COMMON/OPT5/IWAT
        COMMON/OPT6/ICOMT
        COMMON/OPT7/IELEV
        COMMON/OPT8/IWRTN
        COMMON/BLK2/NMONT
        COMMON/BLK5/NTREQ,NTREU
        COMMON/BLK12/S,P,YMAX,YMIN
        COMMON/BLK13/NUSRE,NDSRE
        COMMON/B17/RED1,REU1
        COMMON/B18/ARU1,PRU1,AREU1,PREU1,REQU1
        COMMON/B19/ARD1,PRD1,AREQ1,PREQ1,REQD1
        COMMON/B20/REQV1,QMAX,REQA1,ADNC1,REGE1,ENER1,ADNV1,ADND1,
     1  IENO1,ELE,PHMIN,FRATN
        COMMON/B21/IREQ1
        COMMON/BLK25/ISITE,IUMRE
```

```
      COMMON/BLK55/IPCON
      COMMON/BLK56/NTRCF
      COMMON/BLK60/NOUSI,NUSSI
      COMMON/BLK57/NURCF
      IWDT1 = 0
      ISTAR=0
      IWEN1=0
      IWWT1=0
      IWAT=0
      ICOMT=0
      IELEV=0
      IWRTN=0
      DO 1 I=1,NSITE
      ISITE(I)=0
      DO 1000 IK=1,NOUSI(I)
      NUSSI(I,IK)=0
1000  CONTINUE
      S(I,1)=0
      IOPPN(I)=0
      DO 1001 IT=1,NMONT
      YMIN(I,IT)=0
      YMAX(I,IT)=0
      EVAPO(I,IT)=0
      PHMIN(I,IT)=0
1001  CONTINUE
      DO 4 II=1,NTREQ(I,1)
      AREQ1(I,II)=0
      DO 4 IT=1,NMONT
      PREQ1(I,IT,II)=0
      REQD1(I,IT,II)=0.0
   4  CONTINUE
      DO 812 II=1,NDSRE(I,1)
      ARD1(I,II)=0
      DO 812 IT=1,NMONT
      PRD1(I,IT,II)=0
      RED1(I,IT,II)=0.0
 812  CONTINUE
      DO 8 II=1,NTREU(I,1)
      AREU1(I,II)=0
      DO 8 IT=1,NMONT
      PREU1(I,IT,II)=0
      REQU1(I,IT,II)=0
   8  CONTINUE
      DO 712 II=1,NUSRE(I,1)
      ARU1(I,II)=0
      DO 712 IT=1,NMONT
      PRU1(I,IT,II)=0
      REU1(I,IT,II)=0.0
 712  CONTINUE
      DO 603 LL=1,NURCF(I)
      NTRCF(I,LL)=0
 603  CONTINUE
      DO 602 II=1,NTREU(I,1)
      UPRFL(I,II)=0
 602  CONTINUE
      DO 601 II=1,NTREQ(I,1)
      DSRFL(I,II)=0
 601  CONTINUE
```

```
      DO 150 LL=1,6
      IWRTS(I,LL)=0
  150 CONTINUE
      IPRT=0
      PPEFF(I)=0
      PPC(I)=0
      TWL(I)=0
      ISPPO(I)=0
      DO  155 II=1,NTREQ(I,1)
      IREQ1(I,II)=0
      IENO1(I,II)=0
      FRATN(I,II)=0
  155 CONTINUE
      ISHRE(I,1)=0
      NTREQ(I,1)=0
      NDSRE(I,1)=0
      NTREU(I,1)=0
      NUSRE(I,1)=0
      NURCF(I)=0
      NOUSI(I)=0
      IUMRE(I)=0
    1 CONTINUE
      NSITE=0
      RETURN
      END
C*******************************************************************
C        ABBREVIATIONS USED
C*******************************************************************
C       I    =I TH SITE
C       IT   =TIME T(MONTH)
C       II   =II TH WATER USER
C       JJ   =YEAR
C       J    =STATE
C   F1OW VALUES ARE CUMULATIVE IN CASE OF SERIES PROJECTS
C   CRLDT1 = CUMULATIVE D/S RELEASES FOR CALCULATING SUM2
C   IWDT1 = OPTION TO PRINT DATA (-1) DO NOT PRINT (1) PRINT
C   ISTAR = OPTION TO PRINT STMTS ON SCREEN (-1) DO NOT PRINT
C         (1) PRINT
C   IWEN1  = OPYION TO PRINT 'ENERGY RELATED WRITE STATEMENTS
C          (-1) DO NOT PRINT (1) PRINT
C   IWWT1  = OPTION TO PRINT WORKING TABLE (-1) DO NOT PRINT
C          (1) PRINT
C   IWAT   = OPTION TO PRINT STATEMENTS IN THE SUBROUTINE WATER
C         (-1) DO NOT PRINT (1) PRINT
C   ICOMT = OPTION TO PRINT STATEMENTS IN THE SUBROUTINE WRT
C       (-1) DO NOT PRINT (1) PRINT
C   IELEV = OPTION FOR WRITING,ELEVATION,AREA & EVAPORATION
C         LOSSES ETC.(-1) DO NOT PRINT (1) PRINT
C   USUAL CONVENTION
C   'I' SITE NO.
C   'JJ' NO. OF YEARS
C   'IT' NO. OF MONTHS
C   MSITE = TOTAL NUMBER OF PROJECT SITES IN THE RIVER NETWORK
C   NSITE = TOTAL NUMBER OF PROJECT SITES UNDER CONSIDERATION
C         FOR THE SIMULATION
C   NOUSI = NUMBER OF PROJECTS AT THE IMMEDIATE UPSTREAM OF GIVEN
C          PROJECT (ON MAIN & TRIBUTARY(S))
C   FLOW  = MONTHLY FLOW VALUE USED IN SIMULATION PROGARM
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C    NUSCO = PROJECT SITE INDEX UNDER CONSIDERATION (LAST IN SERIES)
C    NUSSI = INDEX OF THE UPSTREAM PROJECT SITE
C    ILOC =  LOCATION INDEX OF THE PROJECT SITE
C    F     = MONTHLY FLOW VALUE AS PER 'ALLFLOW.DAT'
C    DFLOW = NET MONTHLY FLOW AT THE SITE UNDER CONSIDERATION AFTER
C            DEDUCTING FLOWS AT THE IMMEDIATE UPSTREAM PROJECT SITES
C    SUM   = TEMPORARY VARIBLE FOR CALCULATING THE SUM OF THE MONTHLY
C            FLOWS AT THE UPSTREAM PROJECT SITES
C    SITENAMO = ORIGAINAL SITE NAME
C    SITENEW = TEMPORARY VARIABLE FOR STORING SITE NAME
C    IOPPN   = OPTION FOR READING PRECIPATION DATA
C              1 READ
C             -1 DO NOT READ
C    AVREL =AVERAGE RELEASE FOR GIVEN SITE (SUM OF ANNUAL RELEASES
C    DIVIDED BY NYEAR. MAY BE CONSIDERED FOR RESERVOIR YIELD CALCULATIONS
C    ISITE = SITE OR PROJECT INDEX
C    NFYRE = NUMBER OF FAILURE YEARS
C    RENE1 = REQUIREMENT
C    IPCON = OPTION FOR WRITING SUM1,SUM2,SUM3 RELATED TO
C    U/S , D/S USE AND SPILL CONTRIBUTIONS OF U/S PROJECTS, IF ANY.
C        ANDD1= ANNUAL DEFICIT FOR D/S REQUIREMENT
C        AADD1= AVERAGE ANNUAL DEFICIT FOR D/S
C        AAUD1= AVERAGE ANNUAL DEFICIT FOR U/S
C        AVANW=NET  WATER AVAILABLE
C        AVDDT= AVERAGE DEFICIT FOR DOWNSTREAM DEMAND IN TIME T
C        AVUDT= AVERAGE DEFICIT IN UPSTREAM DEMAND
C        AVSPT= AVERAGE SPILL IN TIME T
C        ANSPL= ANNUAL SPILL
C        AASPL= AVERAGE ANNUAL SPILL
C        ARD1 =TOTAL D/S RETURN FROM UNCLUBBED DEMANDS
C        AS   =WATER SPREAD AREA(MILLION SQURE METRE)
C        AREQ1=ANNUAL D/S REQUIREMENT (CLUBBED)
C        AREU1=ANNUAL U/S REQUIREMENT (CLUBBED)
C        AVANS=AVAILABLE NET SHARE
C        AWACS=AVAILABLE WATER ABOVE CONSERVATION STORAGE
C        AWWCS=AVAILABLE WATER WITHIN CONSERVATION STORAGE
C        AVDD1=AVERAGE DEFICIT IN D/S DEMAND (CLUBBED)
C        AVUD1=AVERAGE DEFICIT IN U/S DEMAND (CLUBBED)
C        ANUDI=ANNUAL DEFICIT U/S (CLUBBED)
C        ARU1 =ANNUAL U/S REQUIREMENT (UNCLUBBED)
C        AVD1 =AVERAGE  D/S DEFICIT FOR UNCLUBBED DEMAND
C        AVU1 =AVERAGE  U/S DEFICIT FOR UNCLUBBED DEMAND
C        AAD1 =AVERAGE ANNUAL D/S DEFICIT FOR UNCLUBBED DEMAND
C        AAU1 =AVERAGE ANNUAL U/S DEFICIT FOR UNCLUBBED DEMAND
C        AND1 =ANNUAL D/S DEFICIT FOR UNCLUBBED DEMAND
C        ANU1 =ANNUAL U/S DEFICIT FOR UNCLUBBED DEMAND
C        ADNLC=ADDITIONAL TURBINE CAPACITY AVAILABLE ABOVE REQV
C        ADNLV=ADDITIONAL VOLUME NEEDED FOR GENERATING REQUIRED ENERGY
C        ADNLD=ADDITIONAL VOLUME OF WATER REQUIRED TO MEET ENERGY DEMAND
C        AMDE1=AVERAGE MONTHLY ENERGY DEFICITS
C        AMDU1=AVERAGE MONTHLY DUMP ENERGY
C        AADU1=TOTAL ANNUAL DUMP ENERGY
C        AADE1=TOTAL ANNUAL ENERGY DEFICIT
C        ANLEN=ANNUAL GENERATED ENERGY
C        CUMP =CUMMULATIVE PRECIPITATION
C        CUMF =CUMMULATIVE INFLOW TO RESERVOIR
C        CUMEL=CUMMULATIVE EVAPORATION
C        CUSR1=TOTAL D/S RELEASES DEMANDWISE (CLUBBED)
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C       CUUS1=TOTAL U/S SUBTRACTION (CLUBBED)
C       CUR1 =TOTAL D/S RELEASES (UNCLUBBED)
C       CUS1 =TOTAL U/S SUBTRACTION (UNCLUBBED)
C       CCF  =CONVERSION FACTOR(MCM TO CUB.M = 10**6)
C       CF   =CONVERSION FACTOR(CUMEC TO MCM)
C       DDDT = DEFICIT FOR DOWNSTREAM DEMAND
C       DUDT = DEFICIT FOR U/S DEMAND
C       DSRFL=D/S RETURN FLOW IN PERCENTAGE RATIO
C       DUDT1=DEFICIT FOR U/S DEMAND FOR CLUBBED DEMAND
C       DDDT1=DEFICIT FOR D/S DEMAND FOR CLUBBED DEMAND
C       DSRFC=D/S RETURN FLOW CONTRIBUTION
C       DUD1 =DEFICIT IN U/S DEMAND FOR UNCLUBBED DEMAND
C       DDD1 =DEFICIT IN D/S DEMAND FOR UNCLUBBED DEMAND
C       DEFE1=ENERGY DEFFICIENCY
C       DUME1=DUMP ENERGY
C       EL   =EVAPORATION IN METRE
C       ELE  =ELEVATION IN METRE
C       EVAPO=MONTHLY EVAPORATION VALUES
C       ENERG=TOTAL ENERGY GENERATED
C       FLOW =INFLOW TO RESERVOIR IN  MILLION CUBIC METRE
C       FACTR=FACTOR(CUMEC*FACTOR=KW.HR/MONTH)
C       FRATN=FRACTION(FRACTION OF R.B. CANAL SUPPLY TO TOTAL)
C       HOURS=NO. OF HOURS CONSIDERED IN YEAR
C       HE   =EFFECTIVE TURBINE HEAD
C       IUMRE=OPTION-FOR UPPERMOST RESERVOIR(1) AND FOR OTHER (-1)
C       IWRT =OPTION FOR PRINT(1,1,1,1,1,1)
C             IWRT(1)=U/S DEMANDS AVERAGE DEFICITS
C             IWRT(2)=U/S DEMANDS ANNUAL DEFICITS
C             IWRT(3)=U/S DEMANDS NO. OF ANNUAL DEFICITS
C             IWRT(4)=D/S DEMANDS AVERAGE DEFICITS
C             IWRT(5)=D/S DEMANDS ANNUAL DEFICITS
C             IWRT(6)=D/S DEMANDS NO. OF ANNUAL DEFICITS
C       IPRT =OPTION FOR PRINT(1-UNIT 3,KUMA2.OUT, CALLING SUBROUTINE
C             WRTM)
C       IREQ1=OPTION FOR WATER RELEASE  USE
C               1-HYDROPOWER RELEASES
C               0-NON HYDROPOWER RELEASES
C       IENO1=OPTION FOR POWER GENERATION FROM RELEASES
C               1-IRRIGATION WATER(OTHER USES)ALSO CAN BE USED FOR
C                 HYDROPOWER
C               0-RELEASES OTHER THAN HYDROPOWER
C       ISPPO=OPTION FOR SPILL WATER FOR POWER GENERATION
C               1-SPILL WATER CAN BE USED FOR POWER
C       KYEAR=STARTING YEAR
C       NSITE=NUMBER OF SITES
C       NYEAR=NUMBER OF YEARS
C       NMONT=NUMBER OF MONTHS CONSIDERED IN A YEAR
C       NDDDT=NO. OF DEFICITS (REQUIREMENTS) FOR DOWNSTREAM DEMAND IN
C             TIME T
C       NDUDT=NO. OF DEFICIT ( REQUIREMENT)FOR UPSTREAM DEMAND IN
C             TIME T
C       NADD1=NO.OF DEFICIT FOR D/S REQUIREMENT
C       NAUD1=NO.OF DEFICIT FOR U/S REQUIREMENT
C       NREM1=NO.OF TIMES RESERVOIR EMPTY AT THE END IN TIME T
C       NRFUL=NO.OF TIMES RESERVOIR FULL/SPILL IN TIME T
C       NTREQ=NO.OF REQUIREMENT FOR D/S
C       NTREU=NO. OF REQUIREMENTS FOR U/S
C       NUSRE=NO. OF (UNCLUBBED) U/S REQUIREMENT
```

```
C        NDSRE=NO. OF (UNCLUBBED) D/S REQUIREMENT
C        NURCF=OPTION-HOW MANY U/S RESERVOIR CONTRIBUTE FLOW
C        NTRCF=OPTION-WHAT ARE THOSE NOS.
C        NREMT=NO.OF TIME RESERVOIR EMPTY AT THE END OF THE TIME
C        NRFUT=NO.OF TIME RESERVOIR FULL AT THE END OF THE TIME
C        NADD1=NO.OF D/S ANNUAL DEFICIT FOR CLUBBED DEMAND
C        NAUD1=NO.OF U/S ANNUAL DEFICIT FOR CLUBBED DEMAND
C        NDDD1=NO.OF DEFICIT OF D/S REQUIREMENT (CLUBBED)
C        NDUD1=NO.OF DEFICIT OF U/S REQUIREMENT (CLUBBED)
C        NAD1 =NO.OF ANNUAL D/S DEFICIT (UNCLUBBED)
C        NAU1 =NO.OF ANNUAL U/S DEFICIT (UNCLUBBED)
C        NDD1 =NO.OF  D/S DEFICIT (UNCLUBBED)
C        NDU1 =NO.OF U/S DEFICIT (UNCLUBBED)
C        NSTAT=NO.OF STATE
C        NSHRE=SHARE NUMBER
C        NMDE1=NUMBER OF MONTHLY ENERGY DEFICITS
C        NMDU1=NUMBER OF MONTHLY DUMP ENERGY
C        O    =OUTFLOW FROM RESERVOIR(MCM)
C        P    =PRECIPITATION IN RESERVOIR(IN M)
C        PREQ1=PERCENTAGE D/S REQUIREMENT FOR CLUBBED DEMANDS
C        PREU1=PERCENTAGE U/S REQUIREMENT FOR CLUBBED DEMANDS
C        PRU1 =PERCENTAGE U/S REQUIREMENT FOR UNCLUBBED DEMANDS
C        PRD1 =PERCENTAGE D/S REQUIREMENT FOR UNCLUBBED DEMANDS
C        PPEFF=POWER PLANT EFFICIENCY
C        PPC  =POWER PLANT CAPACITY
C        PHMIN=MINIMUM MONTHLY WATER LEVEL THAT POWER CAN BE GENERATED
C        QMAX =MAXIMUM TURBINE DISCHARGE
C        REGEN=WATER FOR ENERGY GENERATION AVAILABLE FROM D/S RELEASE
C        REQV =ACTUAL WATER NEEDED FOR REQUIRED ENERGY GENERATION
C        REQA =AVAILABLE WATER FOR GENERATING POWER
C        REQD1=MONTHLY D/S REQUIREMENT FOR CLUBBED DEMANDS
C        REQU1=MONTHLY U/S REQUIREMENT FOR CLUBBED DEMANDS
C        RED1 =D/S RETURN FLOW FROM UNCLUBBED DEMANDS
C        REU1 =MONTHLY U/S REQUIREMENT FOR UNCLUBBED DEMANDS
C        RLDT1=D/S RELEASE FOR CLUBBED DEMANDS
C        RLD1 =D/S RELEASE FOR UNCLUBBED DEMANDS
C        REQE1=ENERGY DEMAND
C        S    =INITIAL STORAGE IN RESERVOIR (MCUM)
C        SPILL=AMOUNT OF SPILL IN TIME T
C        SHARE=SHARE
C        SUPT1=U/S SUBTRACTION FOR CLUBBED DEMANDS
C        SUP1 =U/S SUBTRACTION FOR UNCLUBBED DEMANDS
C        SUM4 =AVERAGE ANNUAL DEFICIT IN ENERGY
C        SUM5 =AVERAGE ANNUAL DUMP ENERGY
C        SUM6 =AVERAGE ANNUAL GENERATED ENERGY
C        TUSUT= TOTAL U/S SUBSTRACTION IN TIME T
C        UPRFL=U/S RETURN FLOW IN PERCENTAGE RATIO
C        YMAX = MAXIMUM CAPACITY OF RESERVOIR(MCUM)
C        YMIN =MINIMUM CAPACITY OF RESERVOIR (MCUM)
C        SUM1 = RETURN FLOW FROM THE UPSTREAM USE OF THE
C               ITH RESERVOIR (i.e. RESERVOIR UNDER CONSIDERATION
C               FOR SIMULATION
C        SUM2 = RETURN FLOW FROM THE DOWNSTREAM USE OF THE RESERVOIRS
C               UPSTREAM OF THE Ith RESERVOIR
C        SUM3 = RETURN FLOW DUE TO SPILL FROM THE UPSTREAM RESERVOIR(S)
```

```
C       *****************************************************************
C       SUBPROGRAMS
C       *****************************************************************
C
C       SUBROUTINE SUBPROGRAMS
C       ----------------------
C       INTI1 -INITIALIZE THE STATISTICS TO ZERO FOR CLUBBED DEMANDS
C       INIL1 -INITIALIZE THE STATISTICS TO ZERO FOR UNCLUBBED DEMANDS
C       STAT1 -CALCULATE U/S SUBTRACTION & D/S RELEASES FROM SHARE 1 &
C              D/S RELEASES FROM SHARE 2
C       WATER -CALCULATE DEFICITS & D/S SUBTRACTION AFTER MEETING U/S &
C              D/S DEMANDS,ADDITIONAL POWER RELEASES,ENERGY GENERATE
C              FROM OTHER RELEASES
C       RELES -CALCULATE NET WATER AVAILABLE AND DEFICITS
C       CAL1  -CALCULATE STATISTICS FOR U/S & D/S DEMANDS
C       WRT1  -WRITE THE STATISTICS FOR SHARE U/S & D/S DEMANDS
C       WRT   -WRITE THE INTERMEDIATE CALCULATION GIVING SHARE U/S &
C              D/S DEFICITS FOR EACH MONTH
C       CALL11-CALCULATES STATISTICS FOR U/S & D/S DEMAND WHEN THEY
C              ARE UNCLUBBED
C       WRTM  -CALCULATE THE INTERMEDIATE RESULTS OF SHARE U/S & D/S
C              DEFICITS FOR EACH MONTH
C       WRT11 -FOR FORMATING OF RESULTS
C       DIST1 -DISTRIBUTE THE WATER DEFICITS OF THE CLUBBED ANNUAL
C              DEMANDS TO UNCLUBBED DEMANDS
C       WRT12 -WRITES THE ANNUAL REQUIREMENT & MONTHLY REQUIREMENT OF
C              VARIOUS DEMANDS IN CLUBBED & IN UNCLUBBED
C       POWER -CALCULATES STATISTICS OF POWER GENERATION
C       WRRS1 - WRITES IMPORTANT RESULTS IN FILE '*.OT2'
C       RTNFL - WRITES  CONTRIBUTIONS FROM UPSTREAM RESERVOIRS
C
C       FUNCTION SUBPROGRAMS
C       --------------------------------------
C       AREA  -TO COMPUTTE WATER SPREAD AREA CORRESPONDING TO WATER
C              CONTENT IN RESERVOIR
C       ELEVAT -TO COMPUTTE ELEVATION CORRESPONDING TO WATER CONTENT
C              IN RESERVOIR
C       --------------------------------------
C       UNIT NUMBERS OF INPUT AND OUTPUT FILES
C       --------------------------------------
C       UNIT 1=INPUT DATA
C       UNIT 12 - MAIN PROGRAMME, NAMES OF THE DATA FILES FOR
C                 WHICH SIMULATION PROGRAM IS TO BE RUN.
C       UNIT 2=MAIN PROGRAM & SUBROUTINES OF
C               STAT1,WATER,RELES,POWER,CAL1,INTI1,INIL1
C       UNIT 3=SUBROUTINES OF WRTM,WRT
C       UNIT 4=SUBROUTINE OF WRT1
C       UNIT 5=SUBROUTINE OF WRT11
C       UNIT 6=SUBROUTINE OF WRT12
C       UNIT 8 - SUBROUTINE OF WRRS1
C       UNIT 9-FLOW DATA AT ALL SITES IN THE RIVER NETWORK
C       UNIT 11 - SUBROUTINE RTNFL FOR WRITING CONTRIBUTIONS FROM
C                 UPSTREAM RESERVOIRS
C       --------------------------------------
```

```
C        *************************************************************
C        * PROGRAM FOR SEQUENCING OF MULTIRESERVOIR, MULTIPURPOSE *
C        *             WATER RESOURCES SYSTEM.                     *
C        *             PREPARED BY M.L.WAIKAR                      *
C        *           SUPERVISOR DR. D.K.SRIVASTAVA                 *
C        *************************************************************
C        TOTCA  = TOTAL TARGET SUPPLIED BY A STATE
C        TOTCO  = TOTAL USEWISE OMR COST OF A STATE
C        COSTMT = USEWISE TOTAL OMR COST OF A STATE
C        COSTMI = USEWISE OMR COST PER MCM
C        FXCOST = FIXED COST OF A PROJECT
C        RELES  = USEWISE RELEASE FROM A PROJECT
C        REYLD  = USEWISE TARGET THAT CAN BE SUPPLIED BY A PROJECT
C        PLSTI  = PERMISSIBLE LOWER LIMIT ON INITIAL STATE AT 'T'
C        PUSTI  = PERMISSIBLE UPPER LIMIT ON INITIAL STATE AT 'T'
C        PLSTF  = PERMISSIBLE LOWER LIMIT ON FINAL STATE AT 'T'
C        PUSTF  = PERMISSIBLE UPPER LIMIT ON FINAL STATE AT 'T'
C        PLSII  = PERMISSIBLE LOWER LIMIT ON INITIAL STATE FOR
C                'ISTGO' STAGES TO GO
C        PUSII  = PERMISSIBLE UPPER LIMIT ON INITIAL STATE FOR
C                'ISTGO' STAGES TO GO
C        PLSIF  = PERMISSIBLE LOWER LIMIT ON FINAL STATE FOR
C                'ISTGO' STAGES TO GO
C        PUSIF  = PERMISSIBLE UPPER LIMIT ON FINAL STATE FOR
C                'ISTGO' STAGES TO GO
C        GI     = COST FUNCTION IN TERMS OF COST OF THE STATES
C        ISTGO  =  STAGES TO GO
C        FOT    = FUNCTION VALUE AT THE END OF 'N'TH TIME PERIOD
C        FOI    = FUNCTION VALUE AT 0 STAGES TO GO
C        F      = OPTIMAL OBJECTIVE FUNCTION VALUE AT
C                 INITIAL STATE
C        FMIN   = MINIMUM VALUE OF OBJECTIVE FUNCTION
C        FIMI1  = MINIMUM OBJECTIVE FUNCTION VALUE AT PREVIOUS STAGE
C        OI     = CURRENT DECISION AT 'I'TH INITIAL STATE (IN TERMS
C           OF CONNECTION WITH FIANL RESULTING 'II'TH STATE)
C        OIMI   = OPTIMAL DECISIONS AT 'I'TH INITIAL STATE (IN TERMS
C           OF CONNECTION WITH FIANL RESULTING 'II'TH STATE)
C        NOI    = NUMBER OF DECISIONS
C        N      = NUMBER OF TIME PERIODS
C        IT     = NUMBER OF TIME PERIODS
C        OIMIN  = DECISION REGARDING STATE (RESULTING STATE)
C        COELE  = BINARY CODE OF A STATE (PROJECT COMBINATION)
C        COEFF  = CODE OF THE PROJECT COMBINATION
C        NP =     NUMBER OF THE PROJECTS
C        IOPT   = 1 FOR DESCENDING ORDER ARRANGEMENT
C                 2 FOR ASCENDING  ORDER ARRANGEMENT
C        IOPT2  = OPTION FOR USING DISCOUNT FACTORS ETC.
C                 -1 == NOT TO BE USED
C                  1 == TO BE USED
C        IGEN  -- OPTION FOR CODE GENERATION SUBROUTINE
C                 1 -- CALLS SUBROUTINE CODE1(NP)
C                 2 -- CALLS SUBROUTINE CODE(NP)
C        IARNG -- OPTION FOR ARRANGING (TO BE USED ONLY IF ARRANGING
C                 IN ANY ORDER IS USEFUL)
C                 1 -- ARRANGE AS PER IOPT
C                 2 -- SKIP ARRANGING
C        ISG   -- No. OF THE STARTING INITIAL STATES CONSIDERED
C                 FOR EXPANSION PLANNING
```

```
C       STATG -- INDEX OF THOSE STARTING STATES
C       DR     =  DISCOUNT RATE
C       IPL    =  PLANNING PERIOD IN YEARS (STAGE LENGTH)
C       PF     =  PRESENT WORTH FACTOR (DISCOUNT FACTOR) i.e. P/F
C       PA     =  ANNUITY PRESENT WORTH FACTOR i.e. A/P
C       DEMDI,DEMDT = USEWISE DEMAND ON THE SYSTEM
C       NOPNT,NOPNI = NUMBER OF PENALTY RANGES
C       ASHOI,ASHOT = ALLOWABLE SHORTAGES IN MEETING THE DEMAND
C       PNLTI,PNLTT = PENALTY COSTS FOR NOT MEETING THE DEMAND
C       UPLMI,UPLMT = UPPER LIMIT ON TARGET
C       AEXEI,AEXET = ALLOWABLE EXCESS BEYOND UPPER LIMIT ON TARGET
C       PXLTI,PXLTT = PENALTY FOR ALLOWABLE EXCESS BEYOND
C                     UPPER LIMIT ON TARGET
C       ISG    = POSSIBLE NUMBER OF STARTING STATES AT 'T=0'
C       STATG = INDICES OF THOSE POSSIBLE STARTING STATES
C               AT 'T=0'
C       STATI = INITIAL STARTING STATE AT 'ISTGO=N'
C       STATF = OPTIMAL RESULTING STATE FOR 'ISTGO=N'
C       NOINS = NUMBER OF DECISION FOR 'ISTGO'
C       NOFLS = NUMBER OF OPTIMAL RESULTING STATES
C       NCCUI = NUMBER OF CONNECTING CUMULATIVE INITIAL STATE
C       NCCUF = NUMBER OF CONNECTING CUMULATIVE FINAL STATE
C       PROJT = PROJCT NAME (A CHARACTER VARIABLE)
        CHARACTER*20 FN1,FN2,FN3
        CHARACTER*5 PROJT
        INTEGER COUSE,COEFF,COELE,PLSTI,PUSTI,PLSTF,PUSTF
        INTEGER STATG,STATI,STATF
        DIMENSION SUMCA(1024),SUMCO(1024)
        DIMENSION PROJT(10),NOPNT(10),NOPNI(10)
        DIMENSION COUSE(1024),COEFF(1024,10),COELE(1024,10)
        DIMENSION REYLD(1024,10,2),TOTCA(1024,2),TOTCO(1024,2)
        DIMENSION FOT(1024),FOI(1024),OIMI(16,1024,1024)
        DIMENSION F(16,1024),STATG(1024)
        DIMENSION PLSTI(16),PUSTI(16),PLSTF(16),
     1  PUSTF(16),NOI(16,1024),COSTMI(10,2),FXCOST(10)
        DIMENSION DEMDI(16,2),DEMDT(16,2)
        DIMENSION ASHOI(16,10,2),ASHOT(16,10,2)
        DIMENSION PNLTI(16,10,2),PNLTT(16,10,2)
        DIMENSION RELES(1024,10,2),COSTMT(1524,10,2)
        DIMENSION UPLMT(16,2),PXLTT(16,10,2),AEXET(16,10,2)
        DIMENSION UPLMI(16,2),PXLTI(16,10,2),AEXEI(16,10,2)
        DIMENSION NCCUI(10,1024,1024),NCCUF(10,1024,1024)
        DIMENSION STATI(16,16),STATF(16,16)
        COMMON/BLK1/NOPNT,NOPNI
        COMMON/BLK33/NCCUI,NCCUF
        COMMON/BLK34/STATI,STATF
        COMMON/BLK3/COUSE
        COMMON/BLK4/GI
        COMMON/BLK5/COELE
        COMMON/BLK6/COEFF
        COMMON/BLK7/F
        COMMON/BLK8/NOI,OIMI
        COMMON/BLK9/STATG
        COMMON/BLK12/REYLD
        COMMON/BLK14/SUMCA,SUMCO
        COMMON/BLK14/TOTCA,TOTCO
        COMMON/BLK16/DEMDI
        COMMON/BLK17/PNLTI,PXLTI
```

```
      COMMON/BLK18/ASHOI,AEXEI
      COMMON/BLK19/FOT
      COMMON/BLK20/PLSTI,PUSTI,PLSTF,PUSTF
      COMMON/BLK21/PROJT
      COMMON/BLK22/RELES
      COMMON/BLK23/COSTMI
      COMMON/BLK24/COSTMT
      COMMON/BLK25/FXCOST
      COMMON/BLK27/UPLMI
      COMMON/BLK28/PF,PA
      COMMON/BLK29/IOPT2
      WRITE(*,*) 'ENTER THE INPUT fixed data FILENAME ='
      READ(*,100) FN1
      WRITE(*,*) 'ENTER THE INPUT variable data FILENAME ='
      READ(*,100) FN3
100   FORMAT (A20)
      WRITE(*,*) 'ENTER THE RESULT FILENAME ='
      READ(*,100) FN2
      OPEN (1, FILE=FN1, STATUS='OLD')
      OPEN (2, FILE=FN2, STATUS='NEW')
      OPEN (3, FILE=FN3, STATUS='OLD')
      READ(3,*)IOPT2
      IF (IOPT2.NE.1) GO TO 200
      READ(3,*)DR,IPL
      CALL FACTORS(DR,IPL)
200   READ(1,*)NP,NDEMD,IGEN,IARNG,IOPT
      READ(3,*)N
      DO 11 J=1,NP
      READ(1,*)FXCOST(J),(COSTMI(J,ID),ID=1,NDEMD)
 11   CONTINUE
      NCODE=2**NP
      INP=1
  1   MCOMB=2**(INP-1)
      DO 10 ID=1,NDEMD
      READ(1,*)(REYLD(I,INP,ID),I=1,MCOMB)
      READ(1,*)(RELES(I,INP,ID),I=1,MCOMB)
 10   CONTINUE
      INP=INP+1
      IF(INP.LE.NP) GO TO 1
      DO 97 IT=1,N
      READ(3,*)(DEMDT(IT,ID),ID=1,NDEMD)
      READ(3,*)(UPLMT(IT,ID),ID=1,NDEMD)
 97   CONTINUE
      READ(3,*)(NOPNT(IT),IT=1,N)
      DO 98 IT=1,N
      DO 99 KK=1,NOPNT(IT)
      READ(3,*)(ASHOT(IT,KK,ID),ID=1,NDEMD)
      READ(3,*)(PNLTT(IT,KK,ID),ID=1,NDEMD)
      READ(3,*)(AEXET(IT,KK,ID),ID=1,NDEMD)
      READ(3,*)(PXLTT(IT,KK,ID),ID=1,NDEMD)
 99   CONTINUE
 98   CONTINUE
      IF(NDEMD.GT.2) GO TO 667
      DO 332 IJ1=1,N
      IF(NOPNT(IJ1).GT.1) GO TO 667
332   CONTINUE
      WRITE(2,555)
 555  FORMAT(1X,'PERIOD',2X,'IRR DM/ULT',2X,'POW DM/ULT',
```

```
     1  2X,'IRR DF/EX',2X,'POW DF/EX',3X,'IRPNLT',5X,'POWPNLT')
        DO 556 IT=1,N
        WRITE(2,557)'DEM',IT,DEMDT(IT,1),DEMDT(IT,2),ASHOT(IT,1,1),
     1  ASHOT(IT,1,2),PNLTT(IT,1,1),PNLTT(IT,1,2)
        WRITE(2,557)'ULT',IT,UPLMT(IT,1),UPLMT(IT,2),AEXET(IT,1,1),
     1  AEXET(IT,1,2),PXLTT(IT,1,1),PXLTT(IT,1,2)
 556    CONTINUE
 557    FORMAT(A3,1X,I2,4X,4(F8.2,3X),F8.4,3X,F8.4)
         GO TO 668
 667     DO 666 IT=1,N
        WRITE(2,*)IT,'  DEMANDS:',(DEMDT(IT,ID),ID=1,NDEMD)
         DO 558 ID=1,NDEMD
        WRITE(2,889)'SHTs US No.',ID,(ASHOT(IT,KK,ID),KK=1,NOPNT(IT))
        WRITE(2,888)'PNTs US No.',ID,(PNLTT(IT,KK,ID),KK=1,NOPNT(IT))
 558    CONTINUE
        WRITE(2,*)IT,'  UPLMTS :',(UPLMT(IT,ID),ID=1,NDEMD)
         DO 559 ID=1,NDEMD
        WRITE(2,889)'EXSs US No.',ID,(AEXET(IT,KK,ID),KK=1,NOPNT(IT))
        WRITE(2,888)'PXTs US No.',ID,(PXLTT(IT,KK,ID),KK=1,NOPNT(IT))
 559    CONTINUE
        WRITE(2,*)
 888    FORMAT(A11,I1,1X,6(F7.4,2X))
 889    FORMAT(A11,I1,1X,3(F7.1,2X),3(F5.1,3X))
 666    CONTINUE
 668    ISTGO=N
        DO 401 IT=1,N
        NOPNI(ISTGO)=NOPNT(IT)
        DO 402 ID=1,NDEMD
        DEMDI(ISTGO,ID)=DEMDT(IT,ID)
        UPLMI(ISTGO,ID)=UPLMT(IT,ID)
c   variable penalty costs
        DO 403 MM=1,NOPNT(IT)
        ASHOI(ISTGO,MM,ID)=ASHOT(IT,MM,ID)
        PNLTI(ISTGO,MM,ID)=PNLTT(IT,MM,ID)
        AEXEI(ISTGO,MM,ID)=AEXET(IT,MM,ID)
        PXLTI(ISTGO,MM,ID)=PXLTT(IT,MM,ID)
 403    CONTINUE
 402    CONTINUE
        ISTGO=ISTGO-1
 401    CONTINUE
        READ(3,*)PLSTI(1),PUSTI(1)
        READ(3,*)(PLSTF(IT),IT=1,N)
        READ(3,*)(PUSTF(IT),IT=1,N)
        MAXNS=NCODE
        READ (1,*) (FOT(I),I=1,MAXNS)
        READ(1,444)(PROJT(KK),KK=1,NP)
 444    FORMAT(10(A5,1X))
        READ(1,*)ISG
        READ(1,*)(STATG(IL),IL=1,ISG)
        IF(IGEN.EQ.1)CALL CODE1(NP)
        IF(IGEN.EQ.2)CALL CODE(NP)
        CALL STYLD(NP,NDEMD)
        IF(IARNG.EQ.1) CALL ARRNG(NP,NDEMD,IOPT)
        IF(IARNG.EQ.1) GO TO 4
        DO 2 I=1,NCODE
        COUSE(I)=1
        DO 3 KK=1 ,NP
        COELE(I,KK)=COEFF(I,KK)
```

```
    3   CONTINUE
    2   CONTINUE
    4   CALL DPALG(ISG,NP,N,NDEMD)
        STOP
        END
C       end of main program
C************************************************************************
C       SUBROUTINE CODE1(NP)
C***********************************************************************
C This subroutine of code generation can be used with
C         pc as well as mainframe.
C******************************************************************
        SUBROUTINE CODE1(NP)
        INTEGER COEFF
        DIMENSION COEFF(1024,10)
        COMMON/BLK6/COEFF
        NCODE=2**NP
        DO 1 I=1,NCODE
        DO 1 J=1,NP
        COEFF(I,J)=0
    1   CONTINUE
        INP=1
        NCOMB=2**INP
        COEFF(2,1)=1
    5   MCOMB=NCOMB
        INP=INP+1
        NCOMB=2**INP
        I=MCOMB
        DO 3 K=1,MCOMB
        I=I+1
        DO 4 J=1,NP
        COEFF(I,J)=COEFF(K,J)
    4   CONTINUE
        COEFF(I,INP)=1
    3   CONTINUE
        IF (INP.LT.NP) GO TO 5
        RETURN
        END
C************************************************************************
C USE THIS SUBROUTINE IN CASE THE COMPUTER SUPPORTS BIT MANIPULATION
C       SUBROUTINE CODE(NP)
C************************************************************************
        SUBROUTINE CODE(NP)
        INTEGER B(1024),COEFF(1024,10)
        COMMON/BLK6/COEFF
        NBITS=NP
        NCODE=2**NP
        M=LSHIFT(1,NBITS-1)
        DO 10 I=1,NCODE
        MASK=M
        DO 20 J=1,NBITS
        B(J)=0
        IF(AND(I-1,MASK)) B(J)=1
        COEFF(I,J)=B(J)
        MASK=RSHIFT(MASK,1)
   20   CONTINUE
   10   CONTINUE
        RETURN
```

```
      END
C*****************************************************************
C SUBROUTINE FOR CALCULATING THE YIELD OF A STATE
C       SUBROUTINE STYLD(NP,NDEMD)
C*****************************************************************
      SUBROUTINE STYLD(NP,NDEMD)
      INTEGER COEFF
      DIMENSION COEFF(1024,10),TOTCA(1024,2),REYLD(1024,10,2)
      DIMENSION TOTCO(1024,2),COSTMI(10,2)
      DIMENSION RELES(1024,10,2),COSTMT(1524,10,2)
      COMMON/BLK6/COEFF
      COMMON/BLK12/REYLD
      COMMON/BLK14/TOTCA,TOTCO
      COMMON/BLK22/RELES
      COMMON/BLK23/COSTMI
      COMMON/BLK24/COSTMT
      NCODE=2**NP
      DO 1 I=1,NCODE
      DO 2 ID=1,NDEMD
      TOTCA(I,ID)=0
      TOTCO(I,ID)=0
      DO 3 J=1,NP
      COSTMT(I,J,ID)=0
    3 CONTINUE
    2 CONTINUE
    1 CONTINUE
      DO 91 ID=1,NDEMD
      DO 31 I=1,NCODE
      DO 41 J=1,NP
      IF(COEFF(I,J).EQ.0) GO TO 41
      NCOMB=2**J
      MCOMB=2**(J-1)
      DO 51 KK1=MCOMB+1,NCOMB
      DO 61 KK2=1,J
      IF(COEFF(I,KK2).EQ.COEFF(KK1,KK2)) GO TO 61
      GO TO 51
   61 CONTINUE
      IYES=KK1
   51 CONTINUE
      L=IYES-MCOMB
      COSTMT(L,J,ID)=COSTMI(J,ID)*RELES(L,J,ID)
      TOTCA(I,ID)=TOTCA(I,ID)+REYLD(L,J,ID)
      TOTCO(I,ID)=TOTCO(I,ID)+COSTMT(L,J,ID)
   41 CONTINUE
   31 CONTINUE
   91 CONTINUE
      RETURN
      END
C**********************************************************************
C    SUBROUTINE DPALG(ISG,NP,N,NDEMD)
C   SUBROUTINE FOR FINDING OPTIMAL PATH (DYNAMIC PROGRAMMING)
C**********************************************************************
      SUBROUTINE DPALG(ISG,NP,N,NDEMD)
      CHARACTER*5 PROJT
      INTEGER COELE,SI,PLSTI,PLSII,PUSTI,PUSII,PLSIF,PLSTF,PUSIF,
     1 PUSTF,OIMI,OIMIN,OI,O,SIMI1,STATG,COUSE,STATI,STATF
      DIMENSION COELE(1024,10),FOT(1024),FOI(1024)
      DIMENSION F(16,1024),STATG(1024)
```

```
      DIMENSION OIMI(16,1024,1024),DEMDT(16,2)
      DIMENSION PLSTI(16),PLSII(16),PUSTI(16),PUSII(16),PLSTF(16),
     1 PLSIF(16),PUSTF(16),PUSIF(16),NOI(16,1024),COUSE(1024)
      DIMENSION TOTCA(1024,2),DEMDI(16,2),TOTCO(1024,2)
      DIMENSION ASHOI(16,10,2),ASHOT(16,10,2),PNLTI(16,10,2),
     1 PNLTT(16,10,2),NOPNT(10),NOPNI(10)
      DIMENSION REYLD(1024,10,2),PROJT(10),FXCOST(10)
      DIMENSION UPLMT(16,2),PXLTT(16,10,2),AEXET(16,10,2)
      DIMENSION UPLMI(16,2),PXLTI(16,10,2),AEXEI(16,10,2)
      DIMENSION NCCUI(10,1024,1024),NCCUF(10,1024,1024)
      DIMENSION STATI(16,16),STATF(16,16)
      COMMON/BLK1/NOPNT,NOPNI
      COMMON/BLK33/NCCUI,NCCUF
      COMMON/BLK34/STATI,STATF
      COMMON/BLK3/COUSE
      COMMON/BLK4/GI
      COMMON/BLK5/COELE
      COMMON/BLK7/F
      COMMON/BLK8/NOI,OIMI
      COMMON/BLK9/STATG
      COMMON/BLK12/REYLD
      COMMON/BLK14/TOTCA,TOTCO
      COMMON/BLK16/DEMDI
      COMMON/BLK17/PNLTI,PXLTI
      COMMON/BLK18/ASHOI,AEXEI
      COMMON/BLK19/FOT
      COMMON/BLK20/PLSTI,PUSTI,PLSTF,PUSTF
      COMMON/BLK21/PROJT
      COMMON/BLK25/FXCOST
      COMMON/BLK27/UPLMI
      COMMON/BLK28/PF,PA
      COMMON/BLK29/IOPT2
      NCODE=2**NP
      MAXNS=NCODE
      IF(N.EQ.1)GO TO 510
      DO 502 IT=2,N
      PLSTI(IT)=PLSTF(IT-1)
      PUSTI(IT)=PUSTF(IT-1)
502   CONTINUE
510   WRITE(2,126)
126   FORMAT(2X,'THE PERMISSIBLE STATES ARE')
      DO 100 I=1,MAXNS
      FOI (I)=FOT(I)
100   CONTINUE
      IT=N
      ISTGO=1
5     DO 400 I=1,MAXNS
      F(ISTGO,I)=-1
      DO 4 K=1,MAXNS
      OIMI(ISTGO,I,K)=-1
4     CONTINUE
400   CONTINUE
      PLSII(ISTGO)=PLSTI(IT)
      PUSII(ISTGO)=PUSTI(IT)
      PLSIF(ISTGO)=PLSTF(IT)
      PUSIF(ISTGO)=PUSTF(IT)
      SI=PLSII(ISTGO)
      I=SI
```

```
    3   IF(COUSE(I).EQ.0) GO TO 1000
        II=PLSIF(ISTGO)
        NOI(ISTGO,I)=0
        FMIN=100000.
        IF(II.LT.I) GO TO 19
    2   IF(COUSE(II).EQ.0) GO TO 19
        IF(PLSIF(ISTGO).NE.PUSIF(ISTGO))GO TO 20
        CALL CONNECT(ISTGO,NP,ICONT,MATCH,I,II,NDEMD,NOFEA)
        IF(NOFEA.EQ.-1)GO TO 19
        SIMI1=PUSIF(ISTGO)
        IMI1=II
        OI=II
        CALL FUNCT(I,IT,ISTGO,NP,II,NDEMD)
        IF(ISTGO.EQ.1)FIMI1=FOI(IMI1)
        IF(ISTGO.GT.1)FIMI1=F(ISTGO-1,IMI1)
        IF(IOPT2.NE.1)X=GI+FIMI1
        IF(IOPT2.EQ.1)X=GI*PA+FIMI1*PF
        NOI(ISTGO,I)=1
        FMIN=X
        OIMI(ISTGO,I,NOI(ISTGO,I))=OI
        GO TO 1
   20   CALL CONNECT(ISTGO,NP,ICONT,MATCH,I,II,NDEMD,NOFEA)
        IF(NOFEA.EQ.-1)GO TO 19
        SIMI1=II
        IMI1=II
        OI=II
        CALL FUNCT(I,IT,ISTGO,NP,II,NDEMD)
        IF(ISTGO.EQ.1)FIMI1=FOI(IMI1)
        IF(ISTGO.GT.1)FIMI1=F(ISTGO-1,IMI1)
        IF(IOPT2.NE.1)X=GI+FIMI1
        IF(IOPT2.EQ.1)X=GI*PA+FIMI1*PF
        IF(X.LT.FMIN)GO TO 16
        IF(X.EQ.FMIN)GO TO 17
        GO TO 19
   16   NN=NOI(ISTGO,I)
        NOI(ISTGO,I)=0
        FMIN=X
        OIMIN=OI
        NOI(ISTGO,I)=NOI(ISTGO,I)+1
        DO 18 N1=1,NN
        OIMI(ISTGO,I,N1)=0
   18   CONTINUE
        OIMI(ISTGO,I,NOI(ISTGO,I))=OIMIN
        GO TO 19
   17   NOI(ISTGO,I)=NOI(ISTGO,I)+1
        OIMI(ISTGO,I,NOI(ISTGO,I))=OI
   19   II=II+1
        OI=II
        IF(II.LE.PUSIF(ISTGO))GO TO 2
    1   F(ISTGO,I)=FMIN
 1000   I=I+1
        SI=SI+1
        IF(I.LE.PUSII(ISTGO))GO TO 3
        IT=IT-1
        ISTGO=ISTGO+1
        IF(ISTGO.LE.N)GO TO 5
C         ISTGO=0
C         WRITE(2,103)
```

```
C  103    FORMAT(4X,70('=')/,10X,'ISTGO',9X,'I',8X,
C      1   'F',17X,'NOI',9X,'OIMI'/,4X,70('-')///)
C         DO 40 KJ=1,N
C         ISTGO=ISTGO+1
C          write(*,*) 'ISTGO=',ISTGO
c         SI=PLSII(ISTGO)
C         I=SI
C   41    IF(NOI(ISTGO,I).EQ.0)WRITE(2,*)'ISTGO=',ISTGO,'I=',I,
C      1  'INFEASIBLE'
C         IF(NOI(ISTGO,I).NE.0)WRITE(2,*)ISTGO,I,
C      1   F(ISTGO,I),NOI(ISTGO,I),
C      2   (OIMI(ISTGO,I,KKK),KKK=1,NOI(ISTGO,I))
C          SI=SI+1
C          I=SI
C          IF(I.LE.PUSII(ISTGO))GO TO 41
C   40    CONTINUE
C          WRITE(2,135)
C  135    FORMAT(2X,'STARTING INITIAL STATES TO BE CONSIDERED AT T=0 FOR
C      1   OPTIMAL DECISIONS'/)
          CALL OPTPA(ISG,N,MAXNS,NP,NDEMD)
          RETURN
          END
C *************************************************************
C   SUBROUTINE FUNCT(I,IT,ISTGO,NP,II,NDEMD)
C ******:******************************************************
          SUBROUTINE FUNCT(I,IT,ISTGO,NP,II,NDEMD)
          INTEGER COELE(1024,10)
          DIMENSION FXCOST(10),NOPNT(10),NOPNI(10)
          DIMENSION TOTCA(1024,2),DEMDI(16,2),TOTCO(1024,2)
          DIMENSION PNLTI(16,10,2),PXLTI(16,10,2),UPLMI(16,2)
          DIMENSION ASHOI(16,10,2),AEXEI(16,10,2)
          COMMON/BLK1/NOPNT,NOPNI
          COMMON/BLK4/GI
          COMMON/BLK5/COELE
          COMMON/BLK14/TOTCA,TOTCO
          COMMON/BLK16/DEMDI
          COMMON/BLK17/PNLTI,PXLTI
          COMMON/BLK25/FXCOST
          COMMON/BLK18/ASHOI,AEXEI
          COMMON/BLK27/UPLMI
          GI=0.
          DO 402 ID=1,NDEMD
          IF(TOTCA(II,ID).GT.DEMDI(ISTGO,ID)) THEN
          IF(TOTCA(II,ID).LE.UPLMI(ISTGO,ID)) GO TO 403
          EX=TOTCA(II,ID)-UPLMI(ISTGO,ID)
           DO 405 MM=1,NOPNI(ISTGO)
          IF(EX.GT.AEXEI(ISTGO,MM,ID)) GO TO 405
          GI=GI+TOTCO(II,ID)+EX*PXLTI(ISTGO,MM,ID)
  405     CONTINUE
          GO TO 402
          ENDIF
          X=DEMDI(ISTGO,ID)-TOTCA(II,ID)
           DO 406 MM1=1,NOPNI(ISTGO)
          IF(X.GT.ASHOI(ISTGO,MM1,ID)) GO TO 406
          GI=GI+TOTCO(II,ID)+X*PNLTI(ISTGO,MM1,ID)
  406     CONTINUE
          GO TO 402
  403     GI=GI+TOTCO(II,ID)
```

```
  402   CONTINUE
        DO 404 J=1,NP
        IF (COELE(II,J).NE.0) GI=GI+FXCOST(J)
  404   CONTINUE
        RETURN
        END
C***********************************************************
C  SUBROUTINE CONNECT(ISTGO,NP,ICONT,MATCH,I,II,NDEMD,NOFEA)
C***********************************************************
C SUBROUTINE CONNECT FOR FINDING CONNECTED STATES
        SUBROUTINE CONNECT(ISTGO,NP,ICONT,MATCH,I,II,NDEMD,NOFEA)
        INTEGER COELE(1024,10)
        DIMENSION TOTCA(1024,2),DEMDI(16,2),TOTCO(1024,2)
        DIMENSION ASHOI(16,10,2),UPLMI(16,2),AEXEI(16,10,2)
        DIMENSION NOPNT(10),NOPNI(10)
        COMMON/BLK1/NOPNT,NOPNI
        COMMON/BLK5/COELE
        COMMON/BLK14/TOTCA,TOTCO
        COMMON/BLK16/DEMDI
        COMMON/BLK18/ASHOI,AEXEI
        COMMON/BLK27/UPLMI
        MATCH=0
        ICONT=0
        DO 32 KL=1,NP
        IF(COELE(I,KL).EQ.1)ICONT=ICONT+1
   32   CONTINUE
        DO 30 KL=1,NP
        IF(COELE(I,KL).EQ.0)GO TO 30
        IF(COELE(I,KL).NE.COELE(II,KL))GO TO 30
        MATCH=MATCH+1
   30   CONTINUE
        IF(ICONT.NE.MATCH)NOFEA=-1
        IF(ICONT.NE.MATCH) RETURN
        DO 401 ID=1,NDEMD
        IF((DEMDI(ISTGO,ID)-TOTCA(II,ID)).GT.
     1  ASHOI(ISTGO,NOPNI(ISTGO),ID))GO TO 1
        IF(TOTCA(II,ID).GT.UPLMI(ISTGO,ID)) THEN
        IF((TOTCA(II,ID)-UPLMI(ISTGO,ID)).GT.
     1  AEXEI(ISTGO,NOPNI(ISTGO),ID)) GO TO 1
        ENDIF
  401   CONTINUE
        NOFEA=1
        RETURN
    1   NOFEA=-1
        RETURN
        END
C*****************************************************************
C         SUBROUTINE OPTPA(ISG,N,MAXNS,NP,NDEMD)
C*****************************************************************
C       SUBROUTINE FOR FINDING THE OPTIMAL PATH
        SUBROUTINE OPTPA(ISG,N,MAXNS,NP,NDEMD)
        CHARACTER*5 PROJT
        INTEGER STATG,STATI,STATF,OIMI
        DIMENSION COELE(1024,10),PROJT(10)
        DIMENSION F(16,1024),NOI(16,1024),OIMI(16,1024,1024)
        DIMENSION STATG(1024),STATI(16,16),STATF(16,16)
        DIMENSION NOINS(16)
        DIMENSION NOFLS(16),TOTCO(1024,2),TOTCA(1024,2)
```

```
      DIMENSION NCCUI(10,1024,1024),NCCUF(10,1024,1024)
      COMMON/BLK33/NCCUI,NCCUF
      COMMON/BLK34/STATI,STATF
      COMMON/BLK5/COELE
      COMMON/BLK7/F
      COMMON/BLK8/NOI,OIMI
      COMMON/BLK9/STATG
      COMMON/BLK14/TOTCA,TOTCO
      COMMON/BLK21/PROJT
      DO 33 IL=1,ISG
      IT=1
      ISTGO=N
      K2=0
      STATI(ISTGO,1)=STATG(IL)
      I=STATI(ISTGO,1)
      FMIN=F(ISTGO,I)
      WRITE(2,*)'FMIN=',FMIN
      IF(NOI(ISTGO,I).NE.0) NOINS(ISTGO)=1
      IF(NOI(ISTGO,I).EQ.0) NOINS(ISTGO)=0
 25   IF(NOINS(ISTGO).EQ.0) GO TO 33
      DO 22 K1=1,NOINS(ISTGO)
      I=STATI(ISTGO,K1)
      DO 21 N1=1,NOI(ISTGO,I)
      K2=K2+1
      STATF(ISTGO,K2)=OIMI(ISTGO,I,N1)
      NOFLS(ISTGO)=K2
 21   CONTINUE
 22   CONTINUE
      NOINS(ISTGO-1)=NOFLS(ISTGO)
      DO 23 K1=1,NOFLS(ISTGO)
      STATI(ISTGO-1,K1)=STATF(ISTGO,K1)
 23   CONTINUE
      IT=IT+1
      ISTGO=ISTGO-1
      K2=0
      IF(ISTGO.NE.1)GO TO 25
      IT=1
      ISTGO=N
      WRITE(2,410)
410   FORMAT(1X,70('=')/,8X,'IT',5X,'ISTGO',5X,'STATI',
     1 2X,'NCCUI',6X,'OIMI',5X,'STATF',2X,'NCCUF'/,1X,
     2 70('-')//)
      K5=0
      K6=MAXNS
      K55=K5
      K66=K6
      DO 42 IJ=1,N
      DO 50 K1=1,NOINS(ISTGO)
      I=STATI(ISTGO,K1)
      K5=K5+I
      DO 51 N1=1,NOI(ISTGO,I)
      STATF(ISTGO,N1)=OIMI(ISTGO,I,N1)
      II=STATF(ISTGO,N1)
      K6=K6+II
      NCCUI(ISTGO,I,II)=K5
      NCCUF(ISTGO,I,II)=K6
      WRITE(2,600)IT,ISTGO,STATI(ISTGO,K1),NCCUI(ISTGO,I,II),
     1 OIMI(ISTGO,I,N1), STATF(ISTGO,N1),NCCUF(ISTGO,I,II)
```

```
  600   FORMAT(2X,7(I7,2X))
        CALL SERCH(I,II,IADD,NP,ISTGO,NDEMD)
        K6=K66
   51   CONTINUE
        K5=K55
   50   CONTINUE
        K5=IT*MAXNS
        K6=(IT+1)*MAXNS
        K55=K5
        K66=K6
        IT=IT+1
        ISTGO=ISTGO-1
   42   CONTINUE
   33   CONTINUE
        RETURN
        END
C*********************************************************************
C       SUBROUTINE SERCH(I,II,IADD,NP,ISTGO,NDEMD)
C    SUBROUTINE WRITES INITIAL & FINAL STATES IN THE EXPANSION
C    & ALSO THE NAMES OF PROJECTS ADDED.
C*********************************************************************
        SUBROUTINE SERCH(I,II,IADD,NP,ISTGO,NDEMD)
        INTEGER COELE
        CHARACTER*5 PROAD,PROJT
        DIMENSION COELE(1024,10),IADDL(10)
        DIMENSION PROAD(10),PROJT(10),F(16,1024)
        DIMENSION TOTCA(1024,2),TOTCO(1024,2)
        COMMON/BLK5/COELE
        COMMON/BLK7/F
        COMMON/BLK14/TOTCA,TOTCO
        COMMON/BLK21/PROJT
        IADD=0
        WRITE(2,50)'INITI STATE',(COELE(I,L),L=1,NP)
        WRITE(2,50)'FINAL STATE',(COELE(II,L),L=1,NP)
   50   FORMAT(A11,2X,22(I1,1X))
        DO 5 KL=1,NP
        IADDL(KL)=0
    5   CONTINUE
        DO 1 KL=1,NP
        IF(COELE(II,KL).EQ.0) GO TO 1
        IF(COELE(II,KL).NE.COELE(I,KL)) GO TO 2
        GO TO 1
    2   IADD=IADD+1
        IADDL(IADD)=KL
    1   CONTINUE
        IF(IADD.EQ.0) WRITE(2,*)'NO PROJECT IS ADDED'
        IF(IADD.EQ.0)WRITE(2,*)(TOTCA(II,ID),ID=1,NDEMD)
        IF(IADD.EQ.0) RETURN
        DO 3 KL1=1,IADD
        DO 4 KL =1,NP
        IF(IADDL(KL1).NE.KL) GO TO 4
        PROAD(KL1)=PROJT(KL)
        GO TO 3
    4   CONTINUE
    3   CONTINUE
        WRITE(2,444)(PROAD(KL1),KL1=1,IADD)
  444   FORMAT('PROJECTS ADDED ARE',5X,9(A5,1X))
        WRITE(2,*)(TOTCA(II,ID),ID=1,NDEMD)
```

```
      RETURN
      END
C******SUBROUTINE FACTORS(DR,IPL)********************
      SUBROUTINE FACTORS(DR,IPL)
      COMMON/BLK28/PF,PA
      Z1=(1+DR)**IPL
      PF=1/Z1
      PA=(Z1-1)/(DR*Z1)
C       PF=1/((1+DR)**IPL)
C       PA=(((1+DR)**IPL)-1)/(DR*((1+DR)**IPL))
      WRITE(2,*)'PF, PA ARE',PF,PA
      RETURN
      END
C*********************************************************************
C     TO BE USED ONLY WHEN ARRANGEMENT (RANKING)OF STATES IS
C     FEASIBLE AND USEFUL FOR SEQUENCING WITH SLIGHT MODIFICATION
C     IN THE SUBROUTINE STYLD AND MAIN PROGRAM.
C********************************************************************
C     SUBROUTINE ARRNG(NP,NDEMD,IOPT)
C     SUBROUTINE FOR ARRANGINING THE STATES
C********************************************************************
      SUBROUTINE ARRNG(NP,NDEMD,IOPT)
C     SUMCA(I) = SUM OF CAPACITIES FOR ITH COMBINATION
C     SUMCO(I) = SUM OF COSTS FOR ITH PROJECT COMBINATION
C     NNBIG = RANK OF THE VALUE OF CAPACITY
C     BIGN = VALUE OF THAT CAPACITY
C     NBINE = NUMBER OF CODES HAVING SINGLE UNEQUAL CAPACITY
C     VBINE = VALUE OF THAT SINGLE UNEQUAL CAPACITY
C     NBIEQ = NUMBER OF SETS OF CODES HAVING EQUAL CAPACITY
C     NOBEQ = NUMBERS OF CODES IN A PARTICULAR SET OF
C             EQUAL CAPACITY
C     VBIEQ = VALUE OF THAT PARTICULAR EQUAL CAPACITY
C     XMIN = MINIMUM COST EQUAL CAPACITY IN A SET
C     IMIN = RANK OF THE CODE OF THAT MINIMUM COST EQUAL
C            CAPACITY IN THAT SET
C     CONOT = CODES NOT TO BE USED (WITH EQUAL CAPACITY)
C     COUSE = CODES TO BE USED (WITH SINGLE CAPACITY)
C             HAVING RANK (I-1)
C     CODEU = CODES TO BE USED (WITH SINGLE CAPACITY)
C             HAVING RANK (NBINE)
C     COELE(I,KL) = NEW REARRANGED BINARY CODE OF PROJECT
C                   COMBINATION
C      (AFTER ARRANGEMENT IN DESCENDING OR ASCENDING ORDER)
      INTEGER COUSE,CONOT,COELE,COEFF,CODEU,COUS1,COEL1
      DIMENSION SUMCA(1024),SUMCO(1024),CAP(10),COST(10),NNBIG(1024)
     1 ,BIGN(1024),NOBEQ(1024),VBIEQ(1024),COUSE(1024),CONOT(1024,50),
     2 COELE(1024,10),COEFF(1024,10),CODEU(1024),VBINE(1024),KBIG(1024)
     3 ,XMIN(1024),IMIN(1024),BIGK(1024),SUCA1(1024),SUCO1(1024),
     4 COEL1(1024,10),NNBI1(1024),ISCOE(1024,50),COUS1(1024)
       DIMENSION RYILD(1024,10),TYILD(1024),S1(1024),S2(1024)
       DIMENSION REYLD(1024,10,2),TOTCA(1024,2),TOTCO(1024,2)
       DIMENSION DCOST(10,2)
       DIMENSION S3(1024,2),S4(1024,2)
C      COMMON/BL1/COST
C      COMMON/BL2/CAP
       COMMON/BLK3/COUSE
       COMMON/BLK5/COELE
       COMMON/BLK6/COEFF
```

```
C         COMMON/BL12/RYILD,REYLD
         COMMON/BLK12/REYLD
         COMMON/BLK13/SUMCA,SUMCO
         COMMON/BLK14/TOTCA,TOTCO
C         COMMON/BL15/DCOST
C       FINDING TOTAL CAPACITY & TOTAL COST OF A CODE
        NCODE = 2 ** NP
C        WRITE(2,200)
C 200    FORMAT(5X,'ORIGINAL CODE NO.',5X,'CAPACITY',10X,'COST')
        DO 1 I=1,NCODE
C        WRITE(2,304) I , SUMCA(I), SUMCO(I)
C 304    FORMAT(10X,I4,12X,F12.3,5X,F12.3)
    1   CONTINUE
        WRITE(2,*)
C       ARRANGING CODES IN DESCENDING OR ASCENDING  ORDER OF
C       CAPACITY
        LARGE=NCODE
        IP1=2
        J=0
        NBIG=1
        BIG=SUMCA(1)
    6   DO 3 I=IP1,NCODE
        IF(J.EQ.0)GO TO 7
        DO 4 K=1,J
        IF(I.EQ.NNBIG(K))GO TO 3
    4   CONTINUE
    7   IF((IOPT.EQ.1).AND.(SUMCA(I).LT.BIG))GO TO 3
        IF((IOPT.EQ.2).AND.(SUMCA(I).GT.BIG))GO TO 3
        NBIG=I
        BIG=SUMCA(I)
    3   CONTINUE
        J=J+1
        NNBIG(J)=NBIG
        BIGN(J)=BIG
C        WRITE(2,700) J,LARGE,NNBIG(J),BIGN(J)
C  700   FORMAT(2X,'J=',I3,3X,'LARGE=',I3,3X,'NNBIG=',I3
C     1  ,3X,'BIGN=',F12.3)
        LARGE=LARGE-1
        IF(J.LT.NCODE)GO TO 8
    8   DO 5 I=1,NCODE
        DO 601 K=1,J
        IF(I.EQ.NNBIG(K))GO TO 5
  601   CONTINUE
        NBIG=I
        BIG=SUMCA(I)
        IP1=I+1
        GO TO 6
    5   CONTINUE
C       SORTING EQUAL CAPACITY CODES COMBINATION & MAKING THEM
C       INFEASIBLE INITIALLY
C       MAKING SINGLE CAPACITY CODES FEASIBLE
C       STORING OF SUMCA, SUMCO, TOTCA, TOTCO IN TEMPORARY ARRAYS
C       S1,S2,S3,S4
        DO 606 ID=1,NDEMD
        DO 602 I=1,NCODE
        IF(ID.EQ.1)S1(I)=SUMCA(NNBIG(I))
        IF(ID.EQ.1)S2(I)=SUMCO(NNBIG(I))
        S3(I,ID)=TOTCA(NNBIG(I),ID)
```

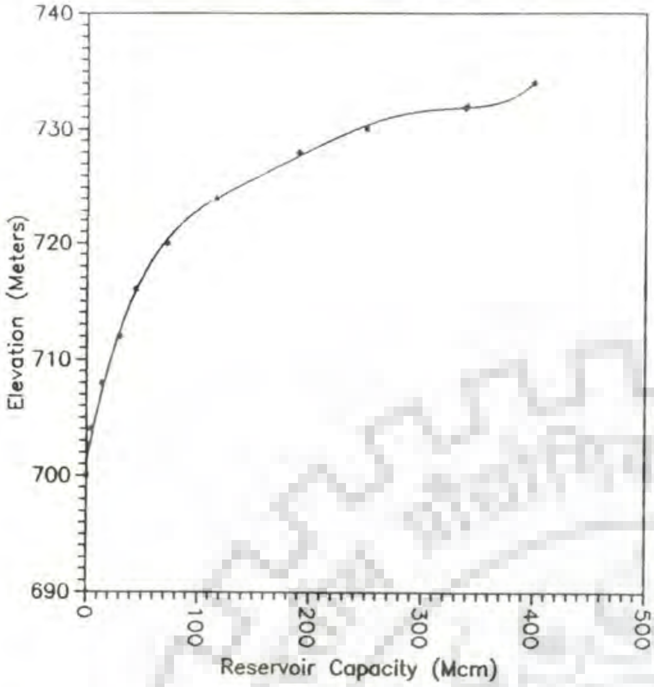
```
      S4(I,ID)=TOTCO(NNBIG(I),ID)
      DO 602 KL=1,NP
      IF(ID.EQ.1)COELE(I,KL)=COEFF(NNBIG(I),KL)
  602 CONTINUE
  606 CONTINUE
C     BINARY CODES AFTER REARRANGEMENT
C     REPLACING OF ARRAY ELEMENTS OF S1,S2,S3 & S4 INTO
C     SUMCA, SUMCO, TOTCA, TOTCO
      DO 607 ID=1,NDEMD
      DO 603 I=1,NCODE
      IF(ID.EQ.1)SUMCA(I)=S1(I)
      IF(ID.EQ.1)SUMCO(I)=S2(I)
      TOTCA(I,ID)=S3(I,ID)
      TOTCO(I,ID)=S4(I,ID)
  603 CONTINUE
  607 CONTINUE
      X=SUMCA(1)
      COUSE(1)=0
      KL=-1
      NBINE=0
      NBIEQ=0
      DO 16 I=2,NCODE
      IF(X.EQ.SUMCA(I))GO TO 20
      IF(KL.EQ.-1) NBINE=NBINE+1
      IF(KL.EQ.-1) COUSE(I-1)=1
      IF(KL.EQ.-1) VBINE(NBINE)=X
      IF(KL.EQ.-1) CODEU(NBINE)=I-1
      X=SUMCA(I)
      COUSE(I)=0
      KL=-1
      IF(I.EQ.NCODE) THEN
      NBINE=NBINE+1
      VBINE(NBINE)=X
      CODEU(NBINE)=I
      COUSE(I)=1
      ENDIF
      GO TO 16
   20 IF(KL.EQ.1)GO TO 21
      NBIEQ=NBIEQ+1
      VBIEQ(NBIEQ)=X
      NOBEQ(NBIEQ)=2
      COUSE(I)=0
      CONOT(NBIEQ,1)=I-1
      CONOT(NBIEQ,2)=I
      KL=1
      ISCOE(NBIEQ,1)=0
      ISCOE(NBIEQ,2)=0
      DO 800 KK=1,NP
      IF(COELE(I-1,KK).EQ.1)ISCOE(NBIEQ,1)=ISCOE(NBIEQ,1)+1
      IF(COELE(I,KK).EQ.1)ISCOE(NBIEQ,2)=ISCOE(NBIEQ,2)+1
  800 CONTINUE
      GO TO 16
   21 NOBEQ(NBIEQ)=NOBEQ(NBIEQ)+1
      CONOT(NBIEQ,NOBEQ(NBIEQ))=I
      COUSE(I)=0
      ISCOE(NBIEQ,NOBEQ(NBIEQ))=0
      DO 801 KK=1,NP
      IF(COELE(I,KK).EQ.1)ISCOE(NBIEQ,NOBEQ(NBIEQ))=
```

```
     1  ISCOE(NBIEQ,NOBEQ(NBIEQ))+1
  801   CONTINUE
        KL=1
   16   CONTINUE
        ISUM=NBINE
        DO 14 K=1,NBIEQ
        ISUM=ISUM+NOBEQ(K)
   14   CONTINUE
        IF(ISUM.EQ.NCODE)GO TO 15
        WRITE(2,701)
  701   FORMAT(2X,'ISUM NOT EQUAL TO NCODE')
        STOP
C     ARRANGING EQUAL CAPACITY CODES IN DESCENDING ORDER IN TERMS
C     OF TOTAL NUMBER OF PROJECTS IN A CODE
   15   DO 802 I=1,NBIEQ
C     ARRANGING IN DESCENDING ORDER
        LARGE=NOBEQ(I)
        IP1=2
        JJ=0
        NBIG=1
        BIG=ISCOE(I,1)
  906   DO 903 IL=IP1,NOBEQ(I)
        IF(JJ.EQ.0) GO TO 907
        DO 904 K=1,JJ
        IF(IL.EQ.KBIG(K)) GO TO 903
  904   CONTINUE
  907   IF(ISCOE(I,IL).LT.BIG) GO TO 903
        NBIG=IL
        BIG=ISCOE(I,IL)
  903   CONTINUE
        JJ=JJ+1
        KBIG(JJ)=NBIG
        BIGK(JJ)=BIG
        LARGE=LARGE-1
        IF(JJ.LT.NOBEQ(I)) GO TO 908
  908   DO 905 IL=1,NOBEQ(I)
        DO 920 K=1,JJ
        IF(IL.EQ.KBIG(K)) GO TO 905
  920   CONTINUE
        NBIG=IL
        BIG=ISCOE(I,IL)
        IP1=IL+1
        GO TO 906
  905   CONTINUE
  802   CONTINUE
C         SOLVING THIS NEW SEQUENCE IN A NEW SET OF VARIABLES
        DO 810 I=1,NBIEQ
        DO 803 J=1,NOBEQ(I)
        KL=CONOT(I,KBIG(J))
        SUCA1(J)=SUMCA(KL)
        SUCO1(J)=SUMCO(KL)
        COUS1(J)=COUSE(KL)
        DO 804 KK=1,NP
        COEL1(J,KK)=COELE(KL,KK)
  804   CONTINUE
        NNBI1(J)=NNBIG(KL)
  803   CONTINUE
C     REPLACING THIS NEW SEQUENCE FOR USE IN ORIGINAL ARRAY
```

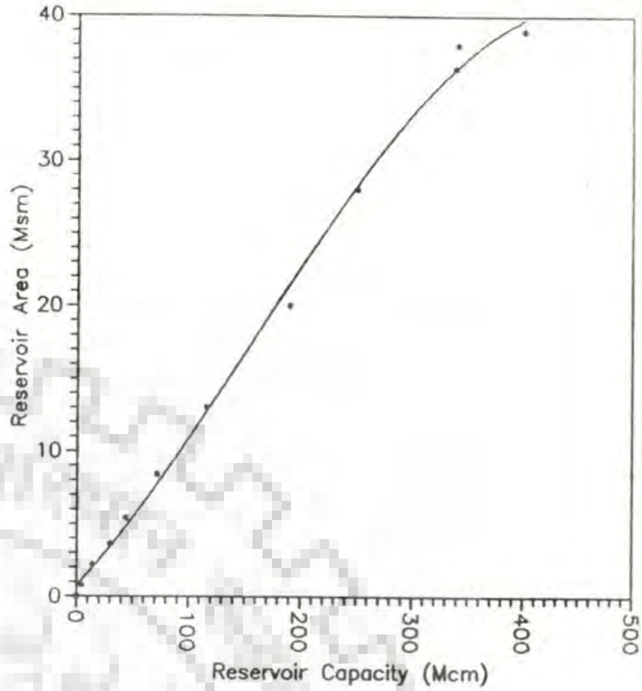
```
      JJ=NOBEQ(I)
      DO 805 J=1,NOBEQ(I)
      KL=CONOT(I,J)
      SUMCA(KL)=SUCA1(JJ)
      SUMCO(KL)=SUCO1(JJ)
      COUSE(KL)=COUS1(JJ)
      DO 806 KK=1,NP
      COELE(KL,KK)=COEL1(JJ,KK)
806   CONTINUE
      NNBIG(CONOT(I,J))=NNBI1(JJ)
      JJ=JJ-1
805   CONTINUE
810   CONTINUE
C     SORTING MINIMUM COST-CAPCITY FOR ABOVE EQUAL CAPACITY
C     COMBINATION AND MAKING THE LOWEST COST CODE AS
C     FEASIBLE FINALLY
      DO 22 I=1,NBIEQ
      XMIN(I)=SUMCO(CONOT(I,1))
      IMIN(I)=1
      DO 23 J=2,NOBEQ(I)
      IF(XMIN(I).LE.SUMCO(CONOT(I,J)))GO TO 23
      XMIN(I)=SUMCO(CONOT(I,J))
      IMIN(I)=J
 23   CONTINUE
      COUSE(CONOT(I,IMIN(I)))=1
 22   CONTINUE
C     MAKING THE REMAINING EQUAL CAPACITY EQUAL COST
C     CODES  FEASIBLE
      DO 24 I=1,NBIEQ
      DO 25 J=1,NOBEQ(I)
      IF (XMIN(I).NE.SUMCO(CONOT(I,J))) GO TO 25
      COUSE(CONOT(I,J))=1
 25   CONTINUE
 24   CONTINUE
      WRITE(2,201)
201   FORMAT(1X,'REARRANGED',5X,'CAPACITY',5X,'COST',5X
     1 ,'ORIGINAL',5X,'COUSE',3X,'BINARY CODE'/2X,'CODE NO.'
     2 ,28X,'CODE NO.')
      DO 26 I=1,NCODE
      WRITE(2,202)I,SUMCA(I),SUMCO(I),NNBIG(I),COUSE(I),
     1 (COELE(I,J),J=1,NP)
202   FORMAT(3X,I4,4X,F12.3,4X,F12.3,2X,I4,4X,I4,2X,
     1 10(I1))
 26   CONTINUE
      RETURN
      END
C*************************************************************
C MODIFIED SUBROUTINE FOR CALCULATING THE YIELD OF A STATE
C    TO BE USED WHEN SUBROUTINE FOR RANKING THE STATES IS
C    PROPOSED TO BE USED.
C     SUBROUTINE STYLD(NP,NDEMD)
C*************************************************************
      SUBROUTINE STYLD(NP,NDEMD)
      INTEGER COEFF
      DIMENSION COEFF(1024,10),TOTCA(1024,2),REYLD(1024,10,2)
      DIMENSION TOTCO(1024,2),COSTMI(10,2)
      DIMENSION RELES(1024,10,2),COSTMT(1524,10,2)
      COMMON/BLK6/COEFF
```

```
      COMMON/BLK12/REYLD
      COMMON/BLK13/SUMCA,SUMCO
      COMMON/BLK14/TOTCA,TOTCO
      COMMON/BLK22/RELES
      COMMON/BLK23/COSTMI
      COMMON/BLK24/COSTMT
      NCODE=2**NP
      DO 1 I=1,NCODE
      DO 2 ID=1,NDEMD
      TOTCA(I,ID)=0
      TOTCO(I,ID)=0
      DO 3 J=1,NP
      COSTMT(I,J,ID)=0
 3    CONTINUE
 2    CONTINUE
 1    CONTINUE
      DO 91 ID=1,NDEMD
      DO 31 I=1,NCODE
      DO 41 J=1,NP
      IF(COEFF(I,J).EQ.0) GO TO 41
      NCOMB=2**J
      MCOMB=2**(J-1)
      DO 51 KK1=MCOMB+1,NCOMB
      DO 61 KK2=1,J
      IF(COEFF(I,KK2).EQ.COEFF(KK1,KK2)) GO TO 61
      GO TO 51
61    CONTINUE
      IYES=KK1
51    CONTINUE
      L=IYES-MCOMB
      COSTMT(L,J,ID)=COSTMI(J,ID)*RELES(L,J,ID)
      IF(ID.EQ.1)SUMCA(I,ID)=SUMCA(I,ID)+REYLD(L,J,ID)
      IF(ID.EQ.1)SUMCO(I,ID)=SUMCO(I,ID)+COSTMT(L,J,ID)
      TOTCA(I,ID)=TOTCA(I,ID)+REYLD(L,J,ID)
      TOTCO(I,ID)=TOTCO(I,ID)+COSTMT(L,J,ID)
41    CONTINUE
31    CONTINUE
91    CONTINUE
      RETURN
      END
```

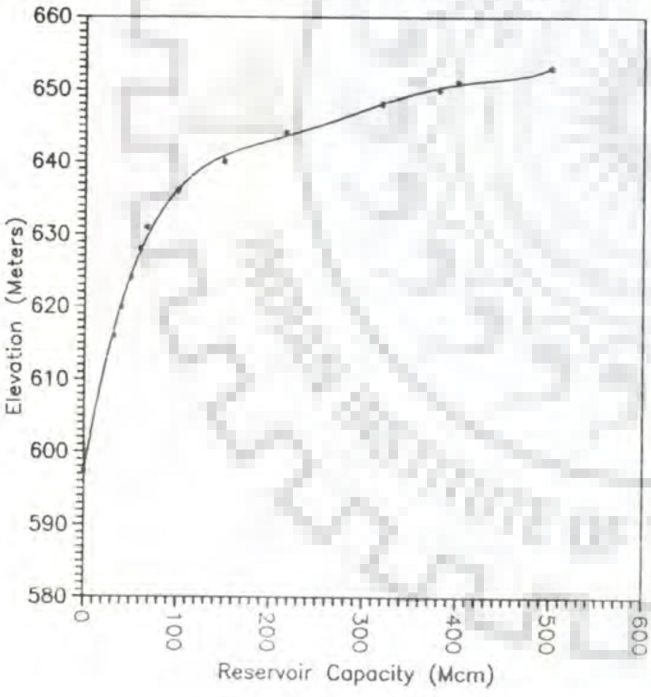
UPPER NARMADA: $ELEVAT=701.28+0.471X-0.004X^2+1.7E-05X^3-3.57E-08X^4+2.85E-11X^5$



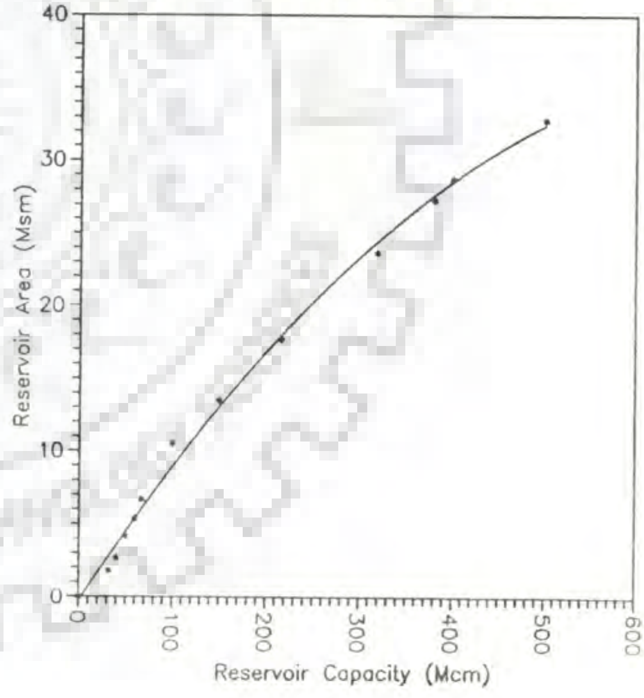
UPPER NARMADA: $AREA=.1698+0.1298X-0.0002X^2+4.62E-07X^3$

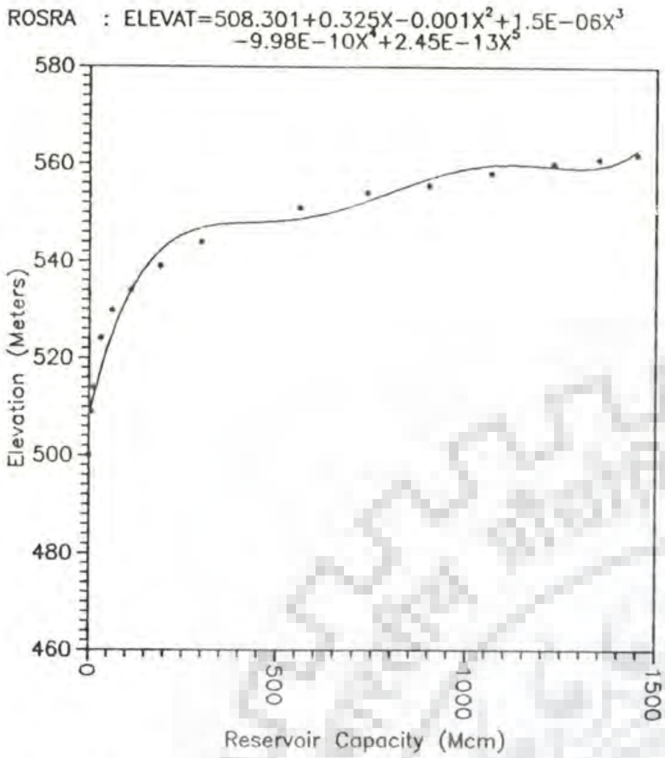


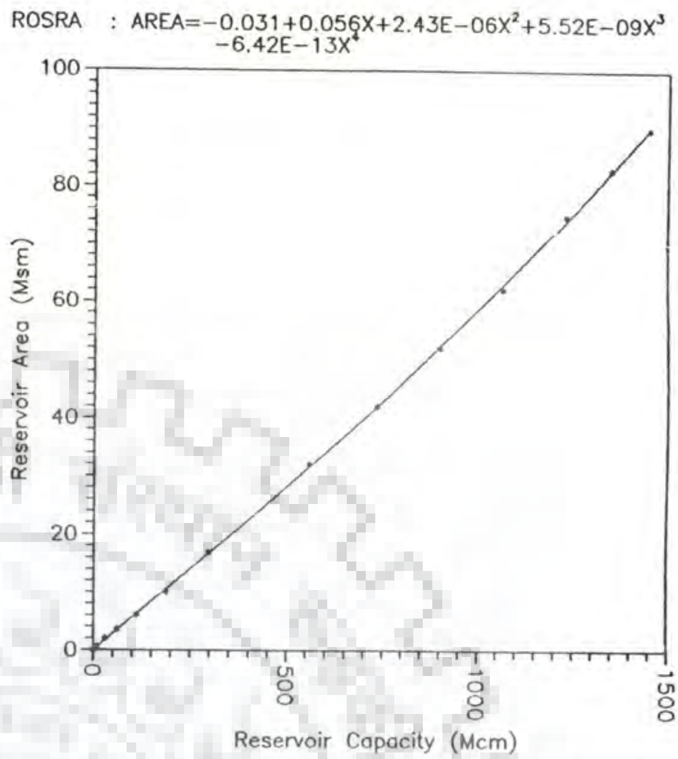
RAGHAVPUR: $ELEVAT=597.07+0.78X-0.0057X^2+2.25E-05X^3-4.68E-08X^4+4.9E-11X^5-2.05E-14X^6$

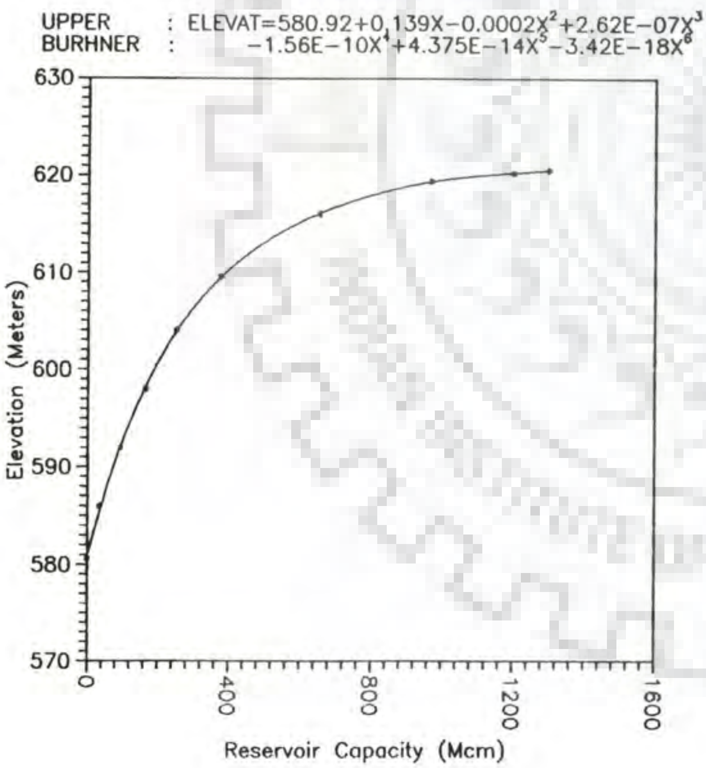


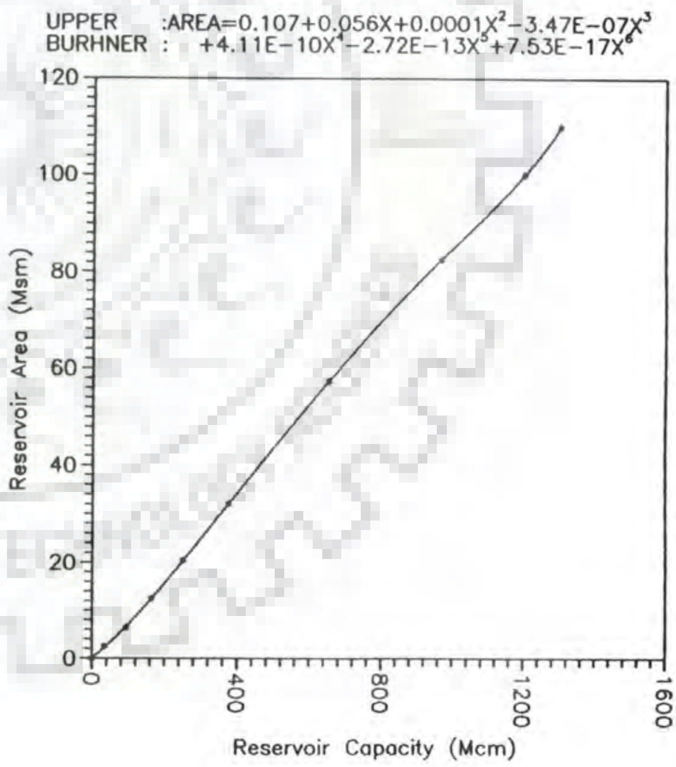
RAGHAVPUR: $AREA=0.29+0.0985X-6.47E-05X^2$



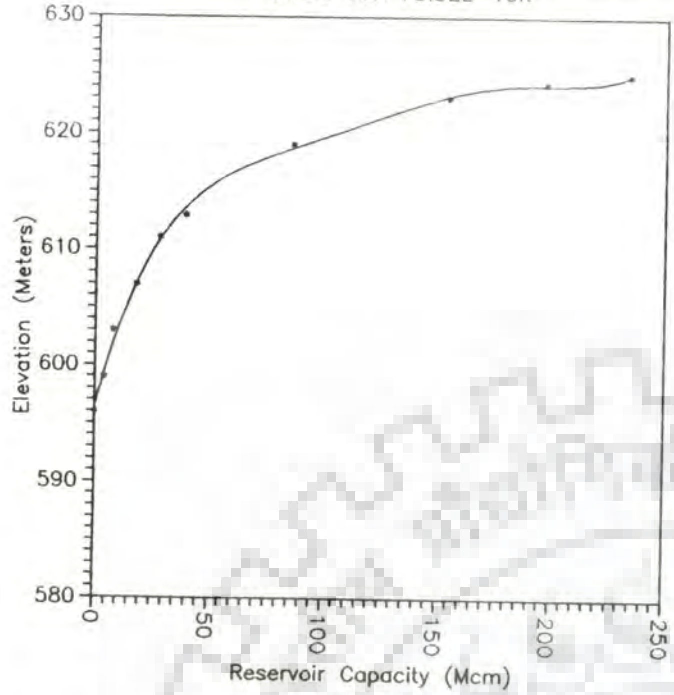

ROSRA : ELEVAT=508.301+0.325X−0.001X²+1.5E−06X³
−9.98E−10X⁴+2.45E−13X⁵
Elevation (Meters)
Reservoir Capacity (Mcm)
580
560
540
520
500
480
460
0
500
1000
1500


ROSRA : AREA=−0.031+0.056X+2.43E−06X²+5.52E−09X³
−6.42E−13X⁴
Reservoir Area (Msm)
Reservoir Capacity (Mcm)
100
80
60
40
20
0
500
1000
1500

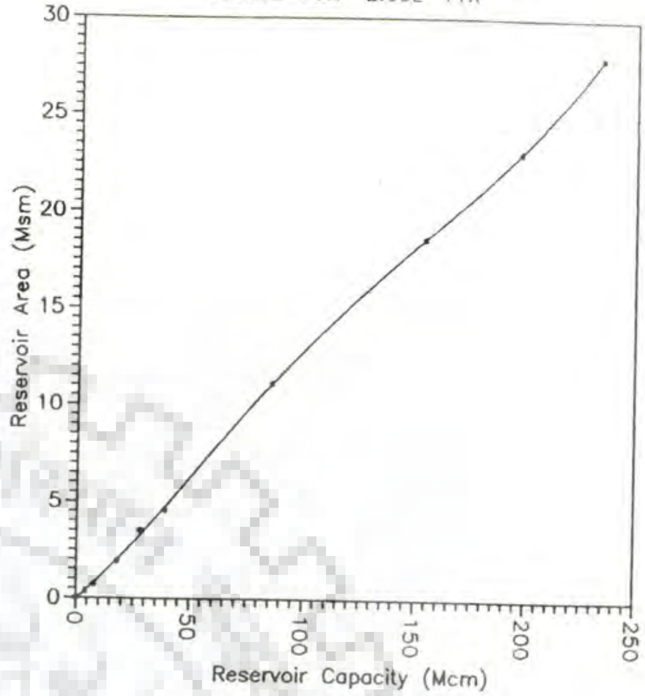

UPPER BURHNER : ELEVAT=580.92+0.139X−0.0002X²+2.62E−07X³
−1.56E−10X⁴+4.375E−14X⁵−3.42E−18X⁶
Elevation (Meters)
Reservoir Capacity (Mcm)
630
620
610
600
590
580
570
0
400
800
1200
1600


UPPER BURHNER : AREA=0.107+0.056X+0.0001X²−3.47E−07X³
+4.11E−10X⁴−2.72E−13X⁵+7.53E−17X⁶
Reservoir Area (Msm)
Reservoir Capacity (Mcm)
120
100
80
60
40
20
0
400
800
1200
1600

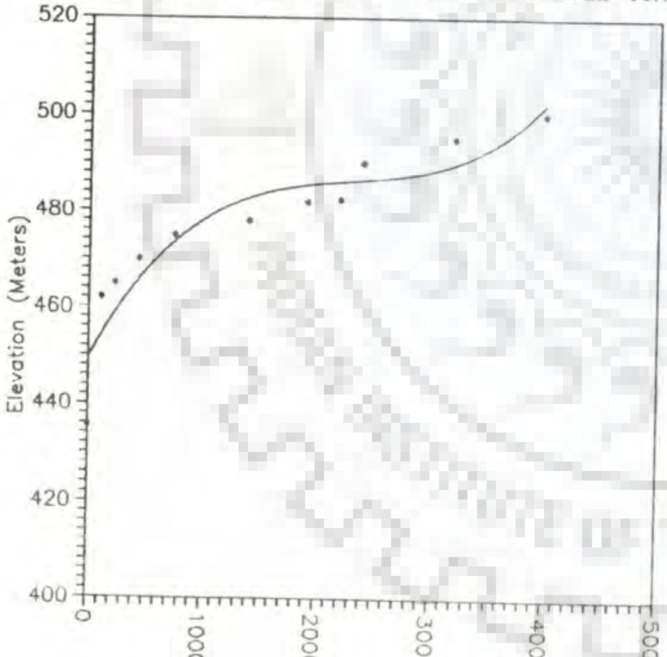
HALON : $ELEVAT=596.38+0.78X-0.012X^2+9.77E-05X^3-3.78E-07X^4+5.52E-10X^5$



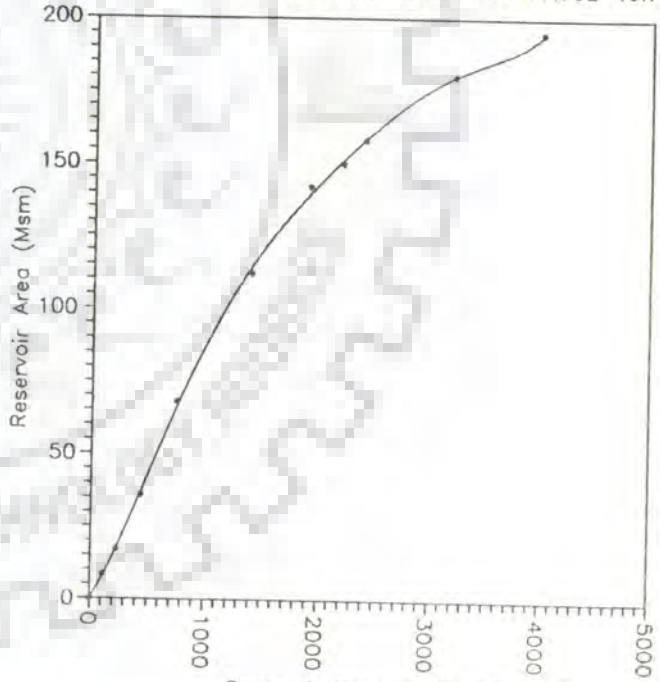
HALON : $AREA= -0.048+0.097X+0.00097X^2-9.27E-06X^3+3.05E-08X^4-2.88E-11X^5$

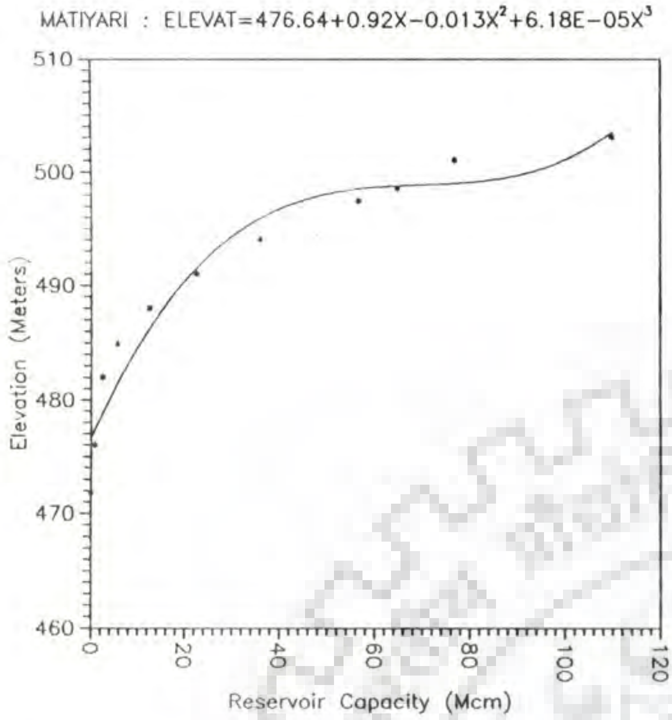


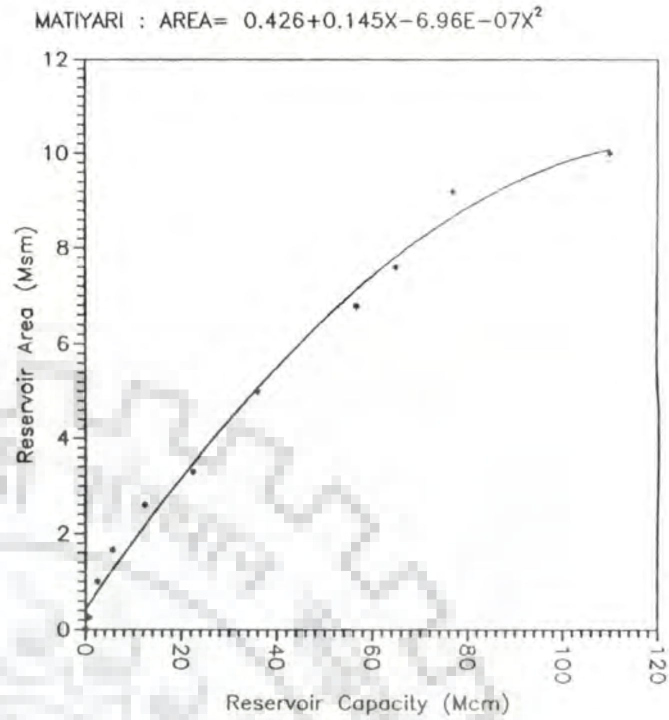
BASANIA : $ELEVAT=445.9+0.85X-6.84E-05X^2+1.72E-08X^3$

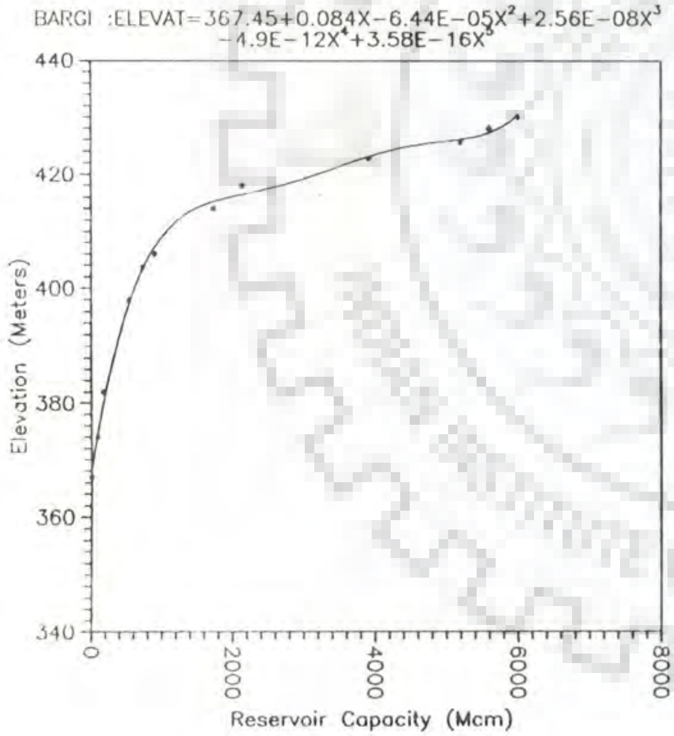


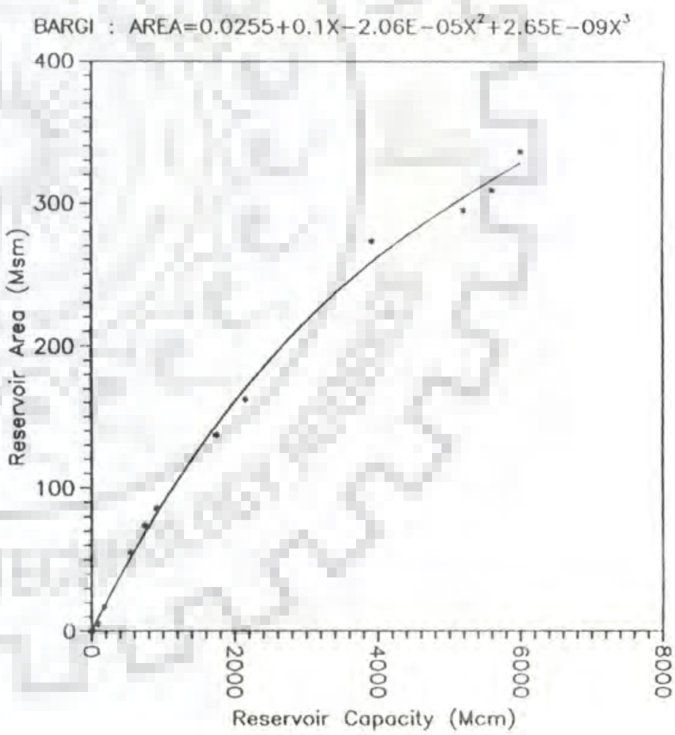
BASANIA : $AREA= -0.14+0.075X+4.59E-05X^2-6.79E-08X^3+3.63E-11X^4-8.73E-15X^5+7.73E-19X^6$

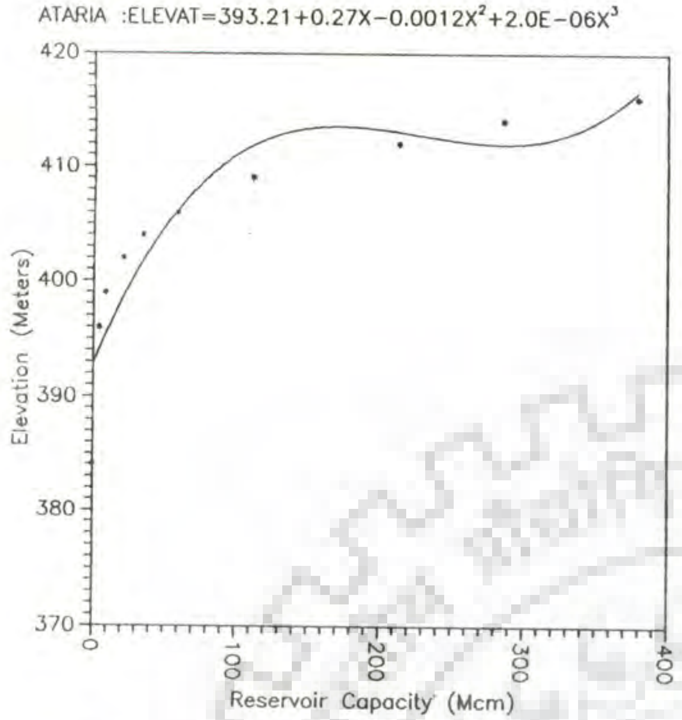


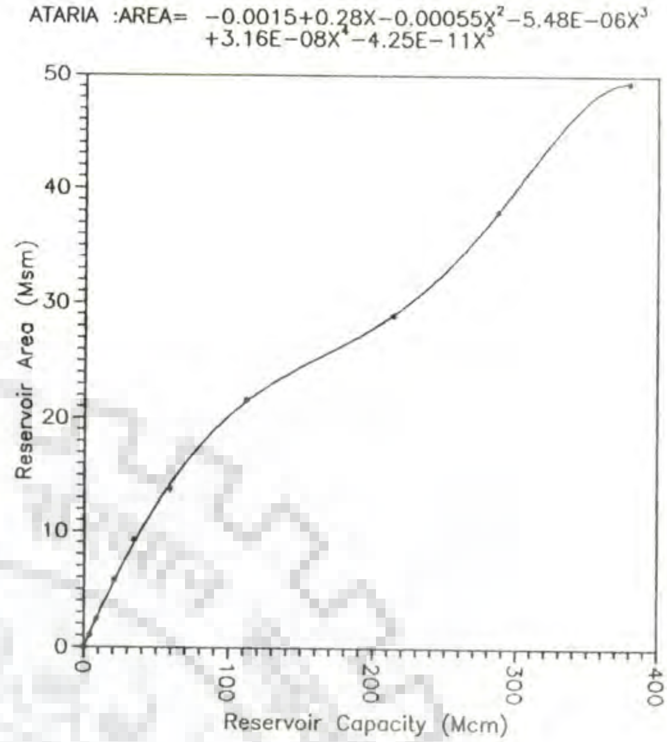

MATIYARI : ELEVAT=476.64+0.92X−0.013X²+6.18E−05X³
Elevation (Meters)
Reservoir Capacity (Mcm)
510
500
490
480
470
460
0
20
40
60
80
100
120

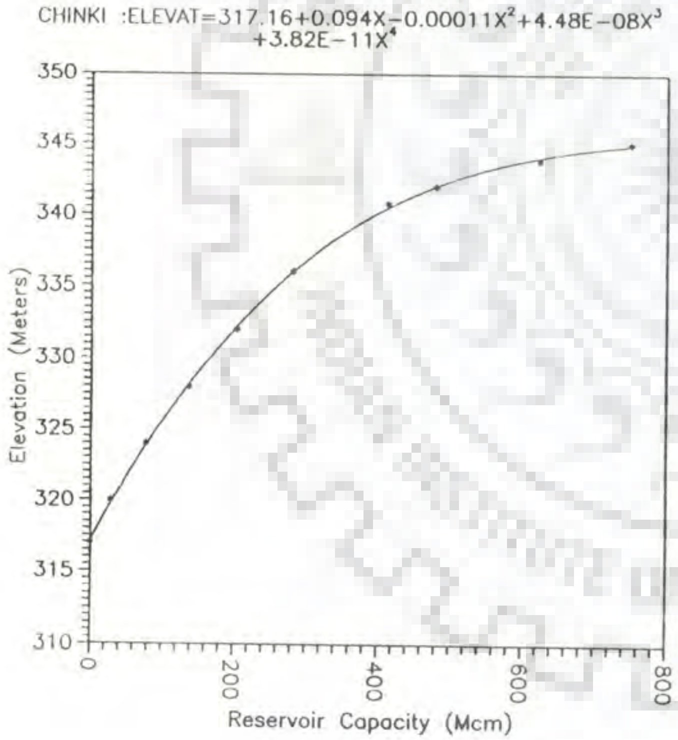

MATIYARI : AREA= 0.426+0.145X−6.96E−07X²
Reservoir Area (Msm)
Reservoir Capacity (Mcm)
12
10
8
6
4
2
0
0
20
40
60
80
100
120

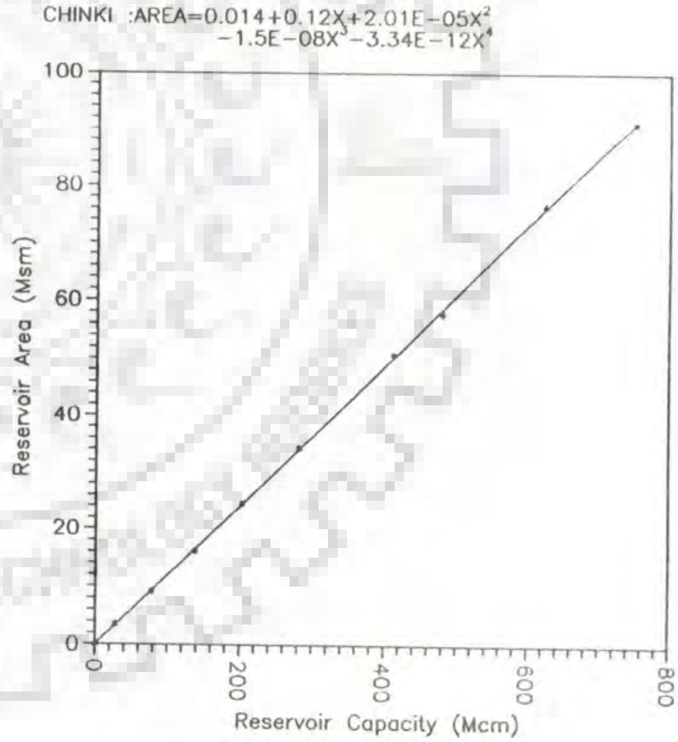

BARGI :ELEVAT=367.45+0.084X−6.44E−05X²+2.56E−08X³
−4.9E−12X⁴+3.58E−16X⁵
Elevation (Meters)
Reservoir Capacity (Mcm)
440
420
400
380
360
340
0
2000
4000
6000
8000


BARGI : AREA=0.0255+0.1X−2.06E−05X²+2.65E−09X³
Reservoir Area (Msm)
Reservoir Capacity (Mcm)
400
300
200
100
0
0
2000
4000
6000
8000

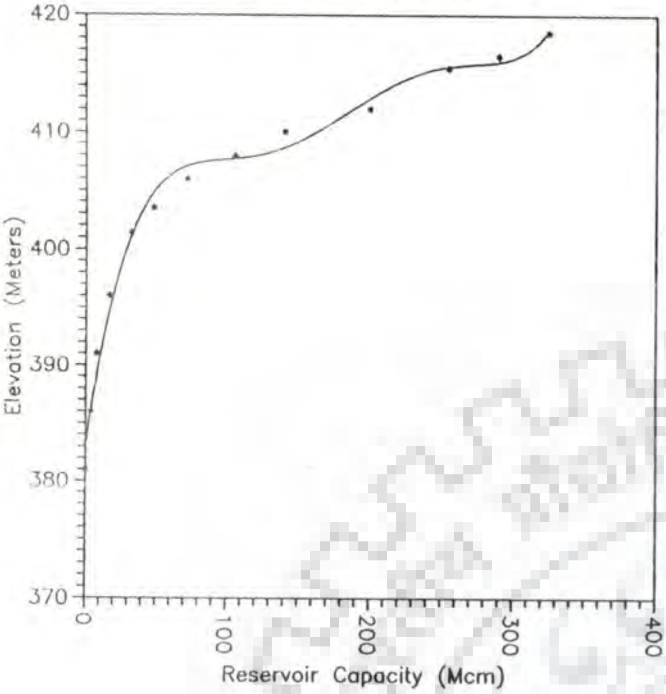

ATARIA :ELEVAT=393.21+0.27X-0.0012X²+2.0E-06X³
Elevation (Meters)
Reservoir Capacity (Mcm)
420
410
400
390
380
370
0
100
200
300
400


ATARIA :AREA= -0.0015+0.28X-0.00055X²-5.48E-06X³
+3.16E-08X⁴-4.25E-11X⁵
Reservoir Area (Msm)
Reservoir Capacity (Mcm)
50
40
30
20
10
0
0
100
200
300
400

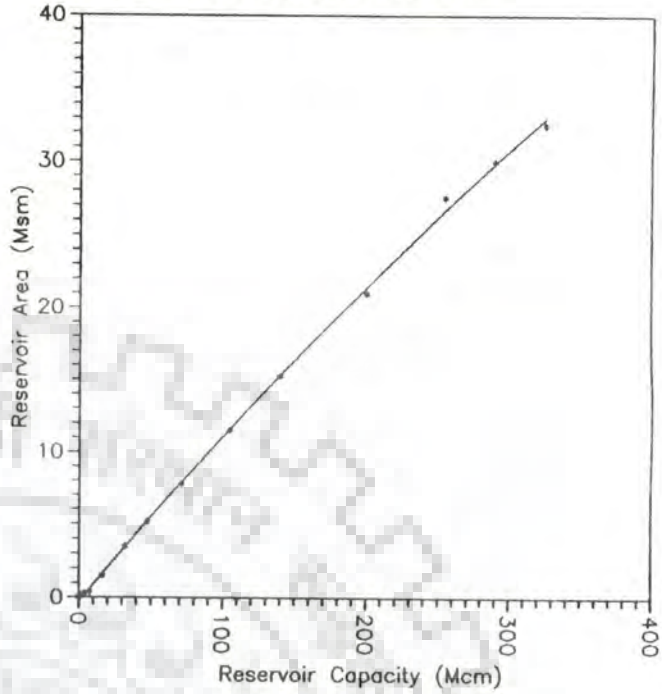

CHINKI :ELEVAT=317.16+0.094X-0.00011X²+4.48E-08X³
+3.82E-11X⁴
Elevation (Meters)
Reservoir Capacity (Mcm)
350
345
340
335
330
325
320
315
310
0
200
400
600
800


CHINKI :AREA=0.014+0.12X+2.01E-05X²
-1.5E-08X³-3.34E-12X⁴
Reservoir Area (Msm)
Reservoir Capacity (Mcm)
100
80
60
40
20
0
0
200
400
600
800

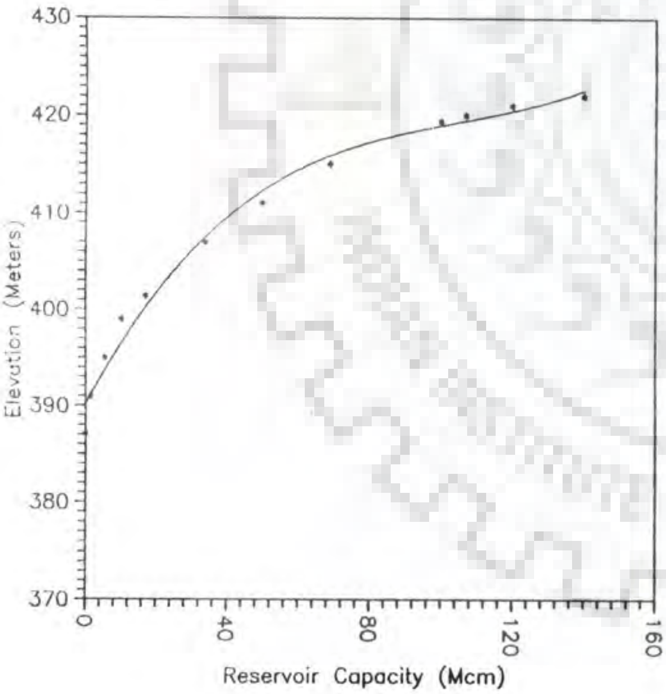
SHER :ELEVAT=$383.44+0.808X-0.01X^2+5.77E-05X^3-1.49E-07X^4+1.42E-10X^5$



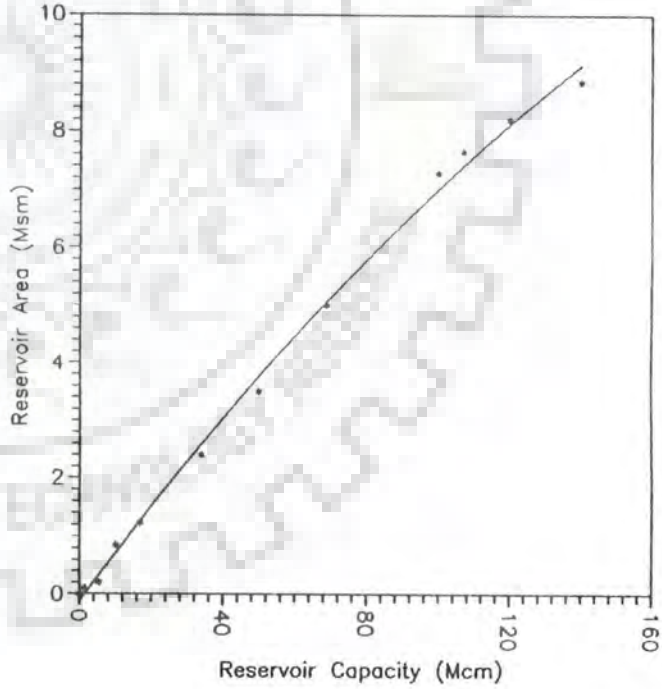
SHER :AREA= $-0.37+0.122X-5.91E-05X^2$



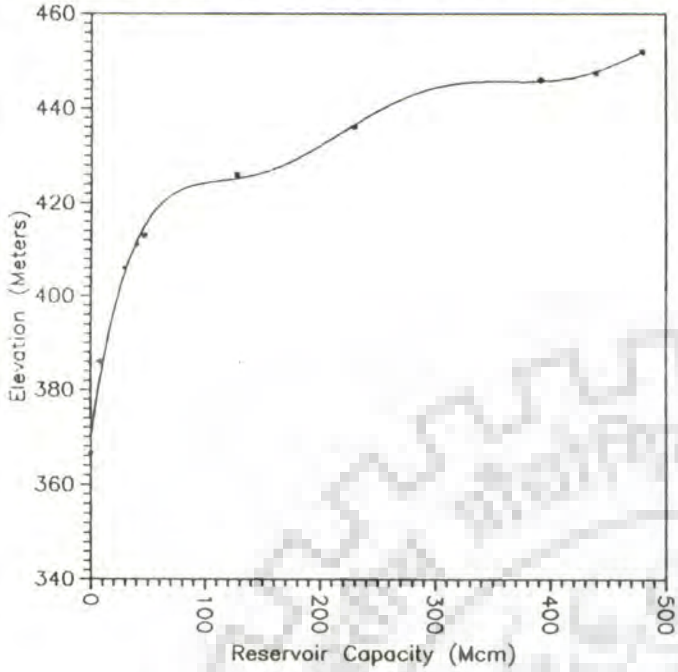
MACHREWA :ELEVAT=$390.14+0.69X-0.006X^2+1.86E-05X^3$



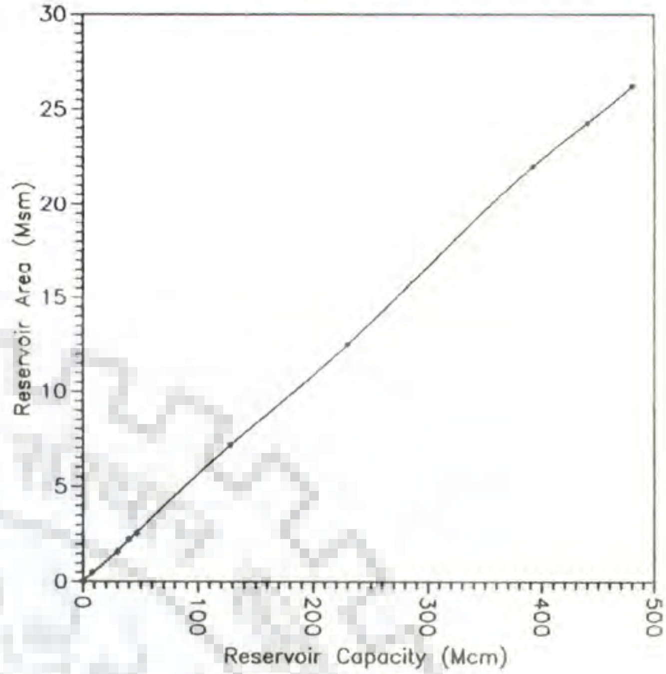
MACHREWA :AREA= $-0.127+0.084X-0.00012X^2$



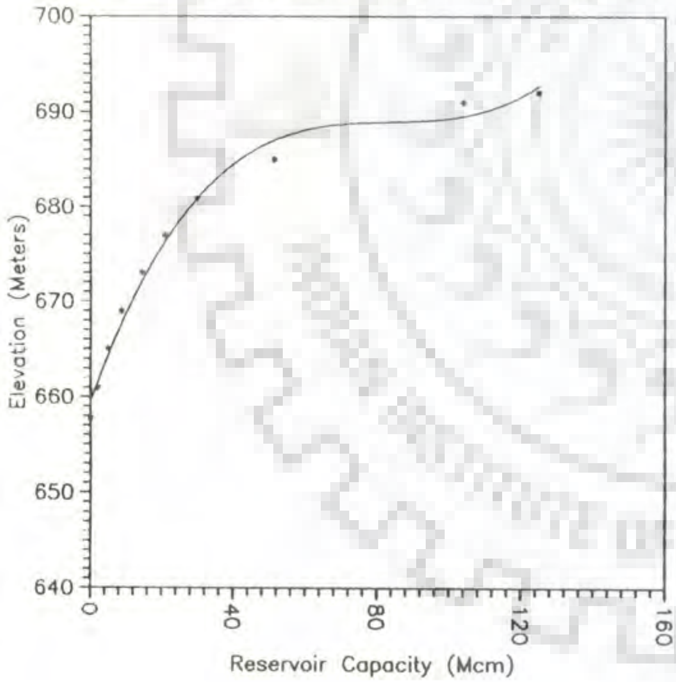
SHAKKER : $ELEVAT=369.4+1.79X-0.024X^2+0.00017X^3-6.31E-07X^4+1.3E-09X^5-1.35E-12X^6+5.73E-16X^7$



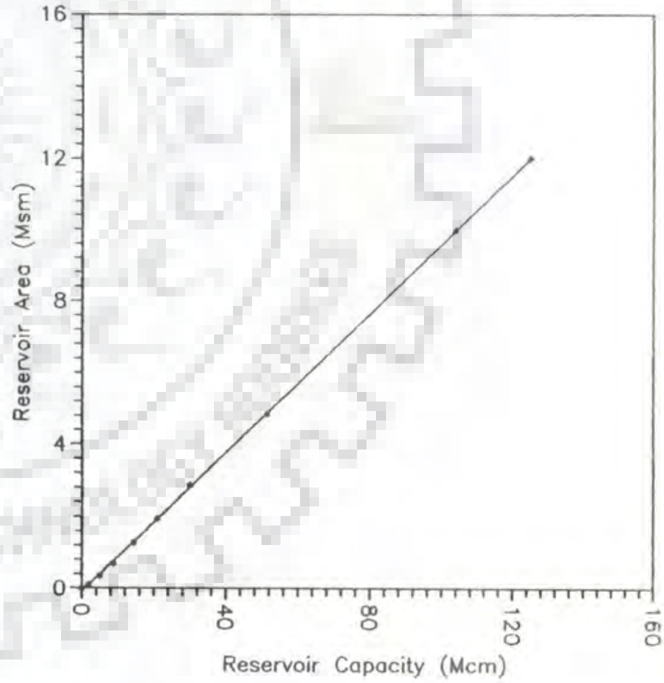
SHAKKER : $AREA=0.041+0.05X+0.00026X^2-2.85E-06X^3+1.28E-08X^4-2.49E-11X^5+1.77E-14X^6$



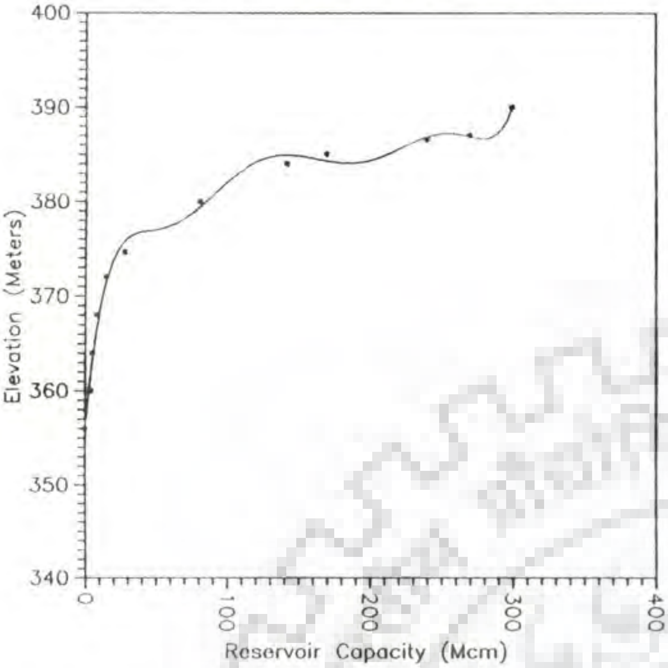
SITAREWA : $ELEVAT=659.498+1.036X-0.012X^2+4.87E-05X^3$



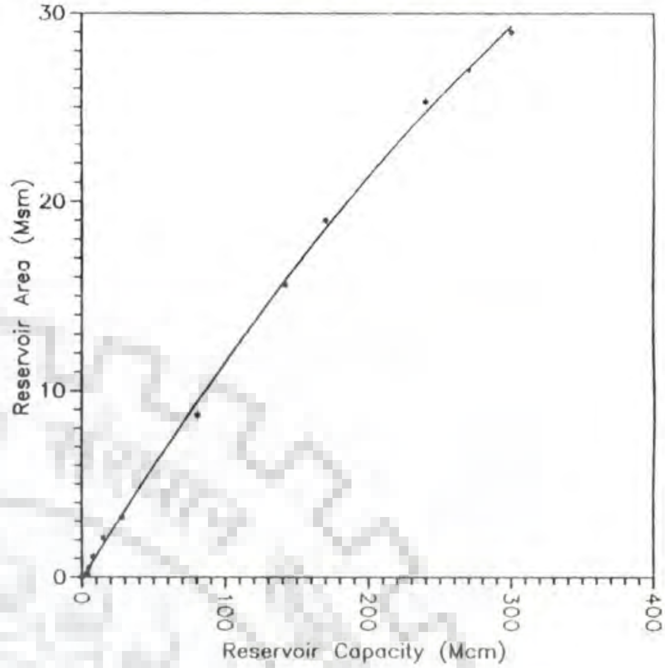
SITAREWA : $AREA= -0.085+0.096X-5.34E-06X^2$



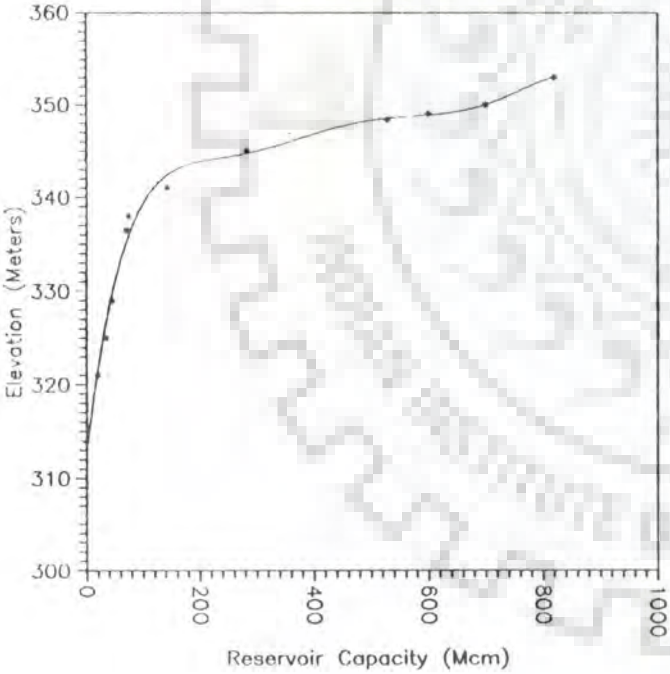
DUDHI :ELEVAT=$356.01+1.42X-0.036X^2+0.00047X^3-3.3E-06X^4+1.25E-08X^5-2.43E-11X^6+1.899E-14X^7$



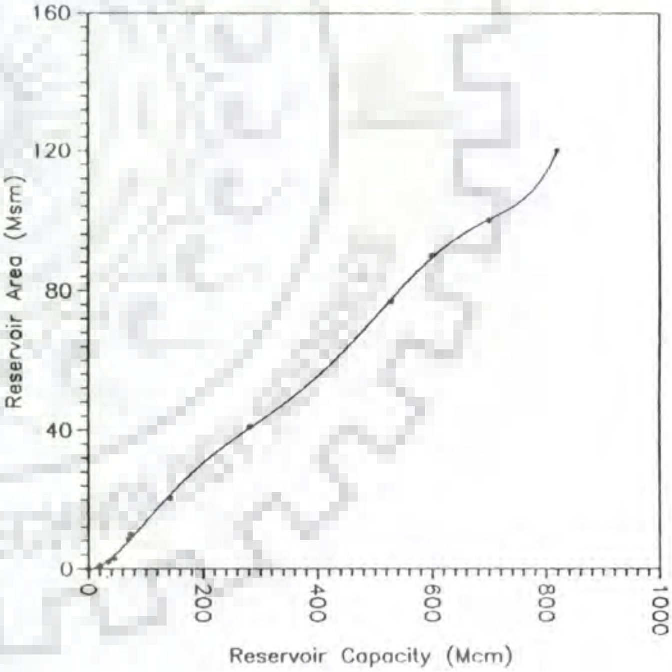
DUDHI : AREA= $-0.0168+0.13X-8.82E-05X^2$



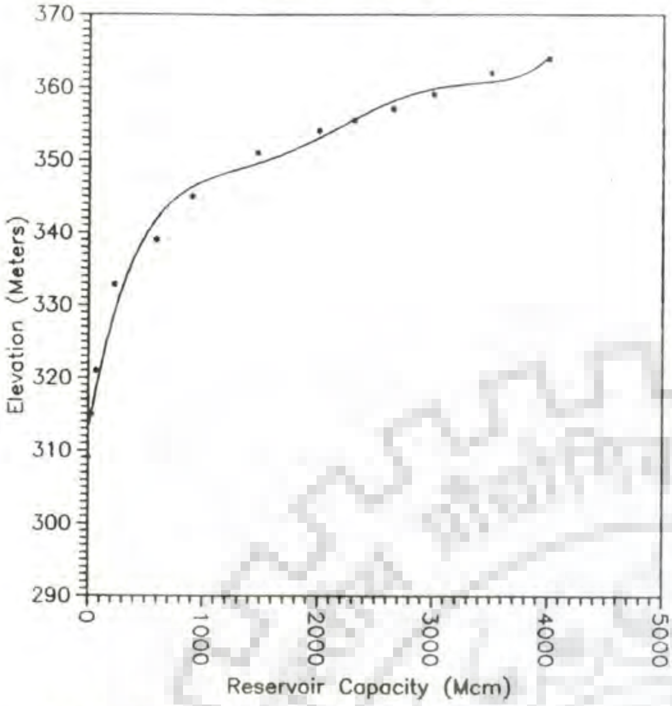
BARNA :ELEVAT=$312.915+0.5X-0.0033X^2+1.1E-05X^3-1.91E-08X^4+1.67E-11X^5-5.71E-15X^6$



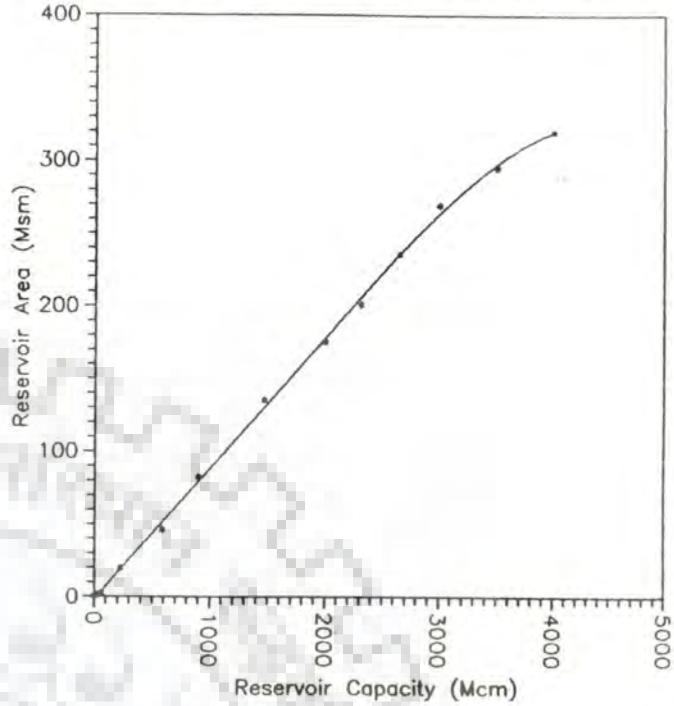
BARNA :AREA= $-0.13+0.0089X+0.0023X^2-1.3E-05X^3+3.22E-08X^4-3.63E-11X^5+1.52E-14X^6$



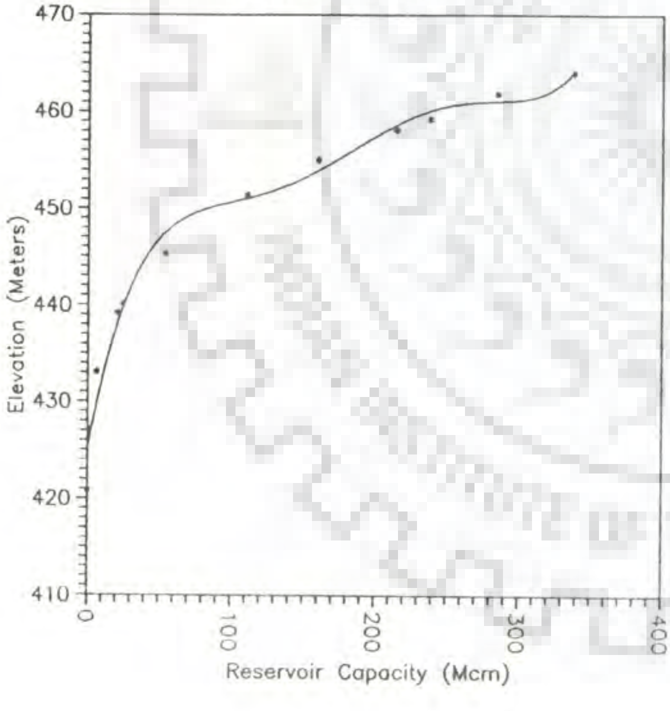
TAWA: ELEVAT=312.965+0.088X−9.01E−05X²+4.56E−08X³ −1.06E−11X⁴+9.34E−16X⁵



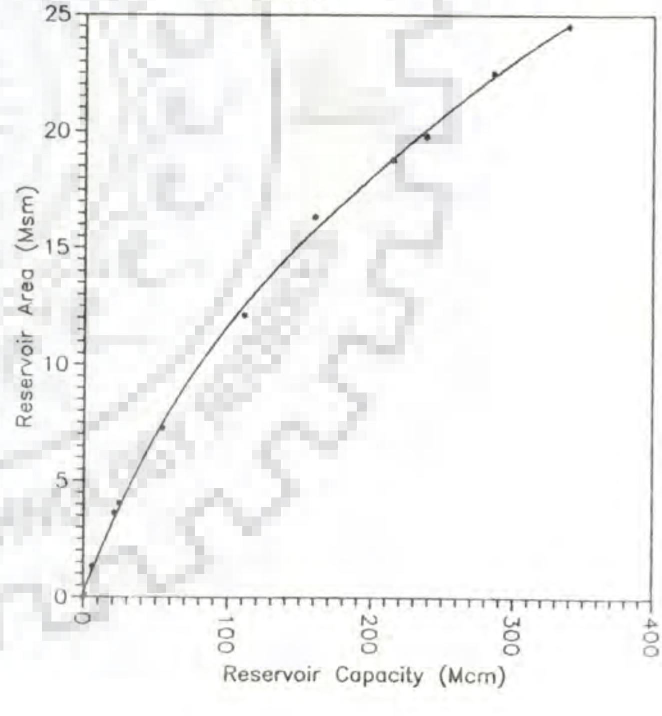
TAWA :AREA=.049+.054X+7.4E−5X²−4.6E−8X³+8.65E−12X⁴



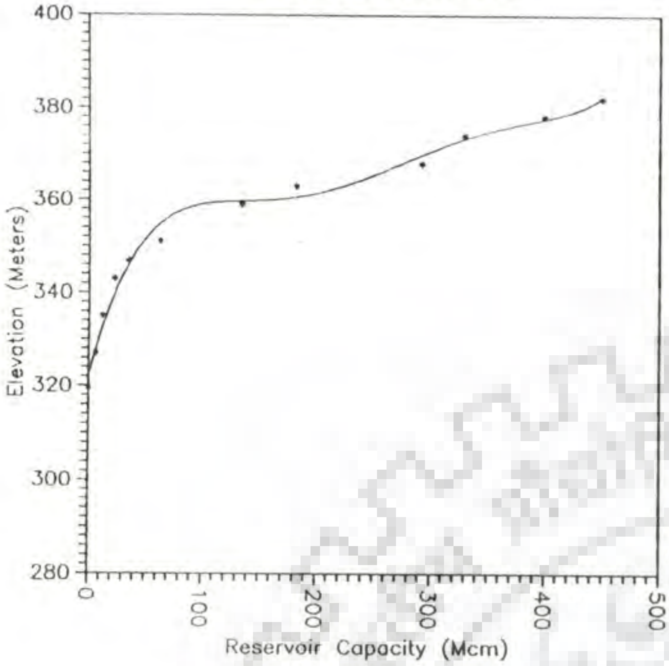
KOLAR :ELEVAT=425+0.82X−0.01X²+6.6E−05X³ −1.89E−07X⁴+1.99E−10X⁵



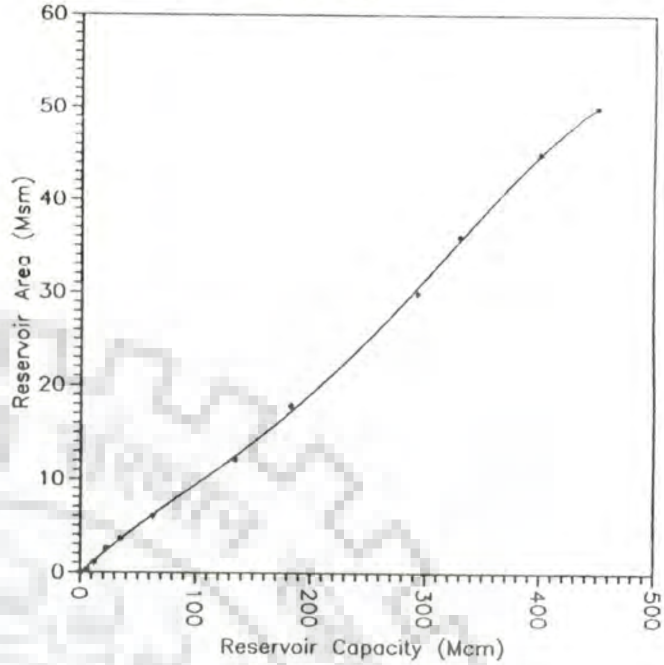
KOLAR :AREA=0.14+0.165X−0.00066X²+1.78E−06X³ −1.91E−09X⁴



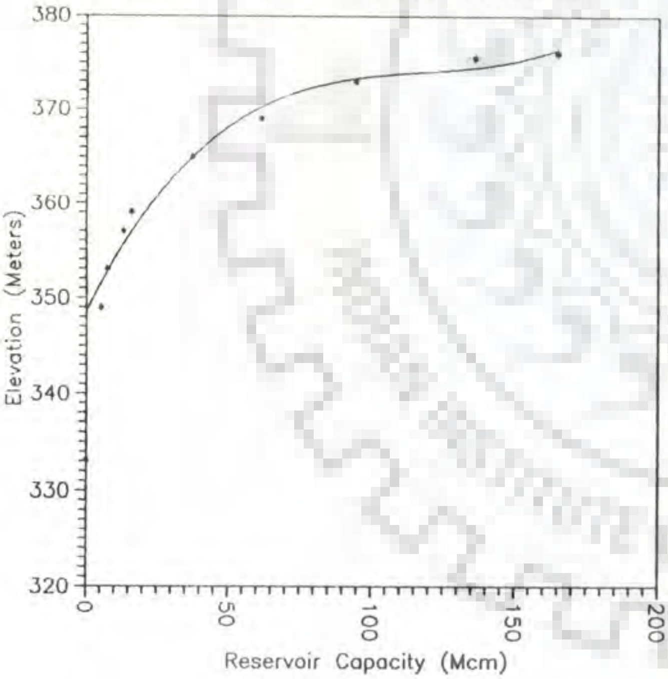
MORAND :ELEVAT=$322.74+0.91X-0.0088X^2+4.01E-05X^3$
$-8.31E-08X^4+6.36E-11X^5$



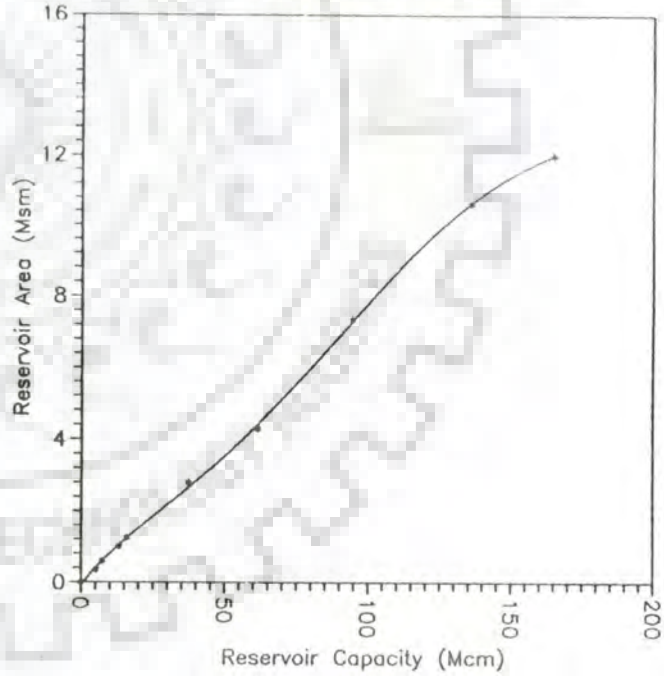
MORAND :AREA= $-0.027+0.0999X-6.52E-05X^2+1.05E-07X^3$
$+5.277E-10X^4$



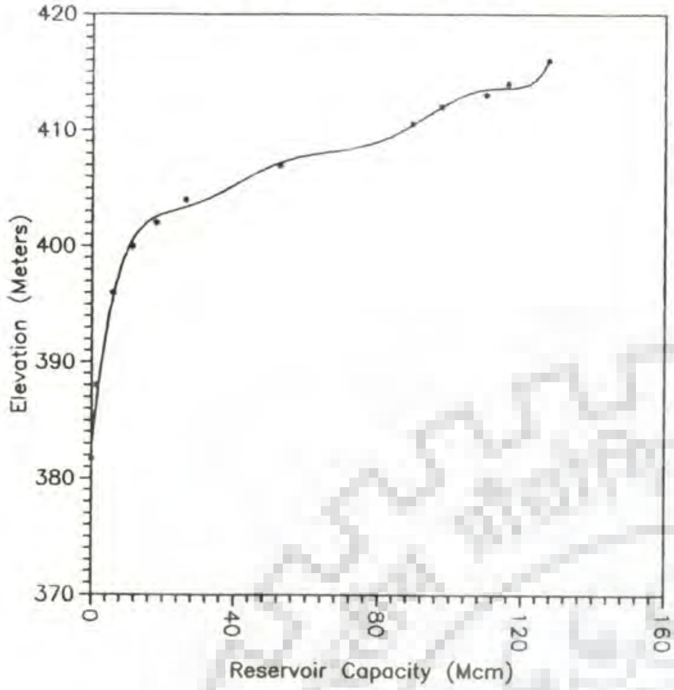
GANJAL :ELEVAT=$348.59+0.6X-0.005X^2+1.38E-05X^3$



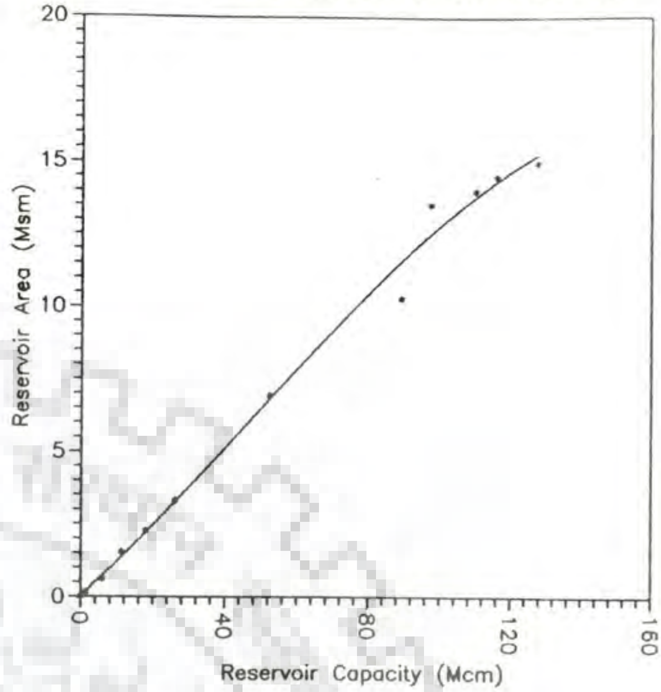
GANJAL :AREA= $-0.06+0.098X-0.001X^2+2.23E-05X^3$
$-1.37E-07X^4+2.76E-10X^5$



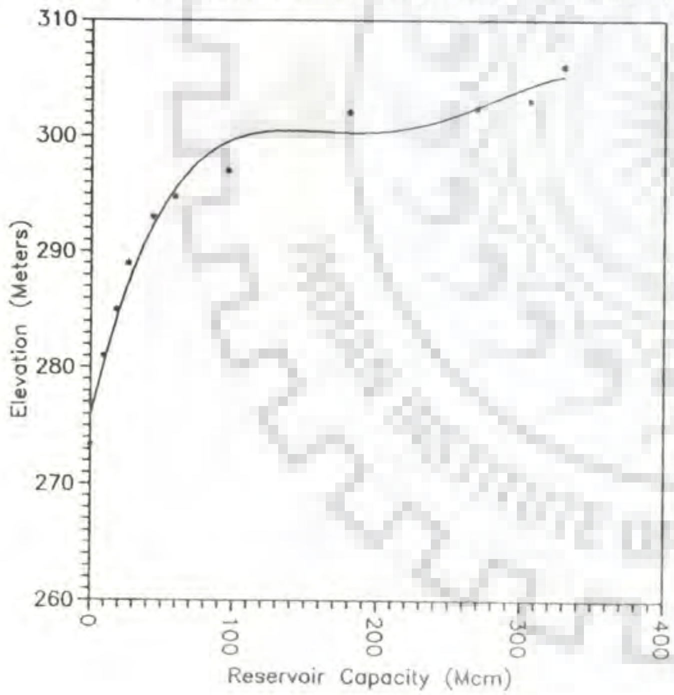
SUKTA: $ELEVAT=382.8+2.89X-0.16X^2+0.004X^3-5.33E-5X^4+3.38E-07X^5-8.31E-10X^6$



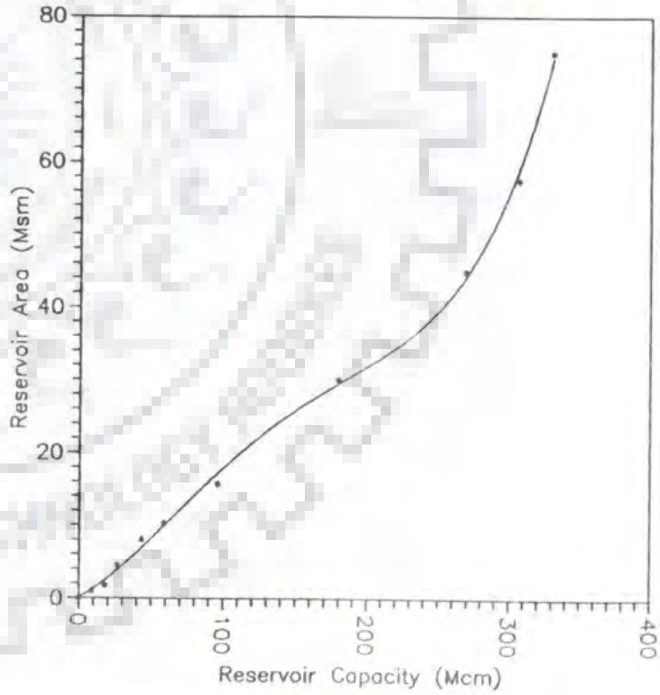
SUKTA: $AREA=-0.02+0.12X-0.0010X^2+0.00011X^3-3.42E-06X$ $+4.36E-08X^5-2.49E-10X^6+5.29E-13X^7$

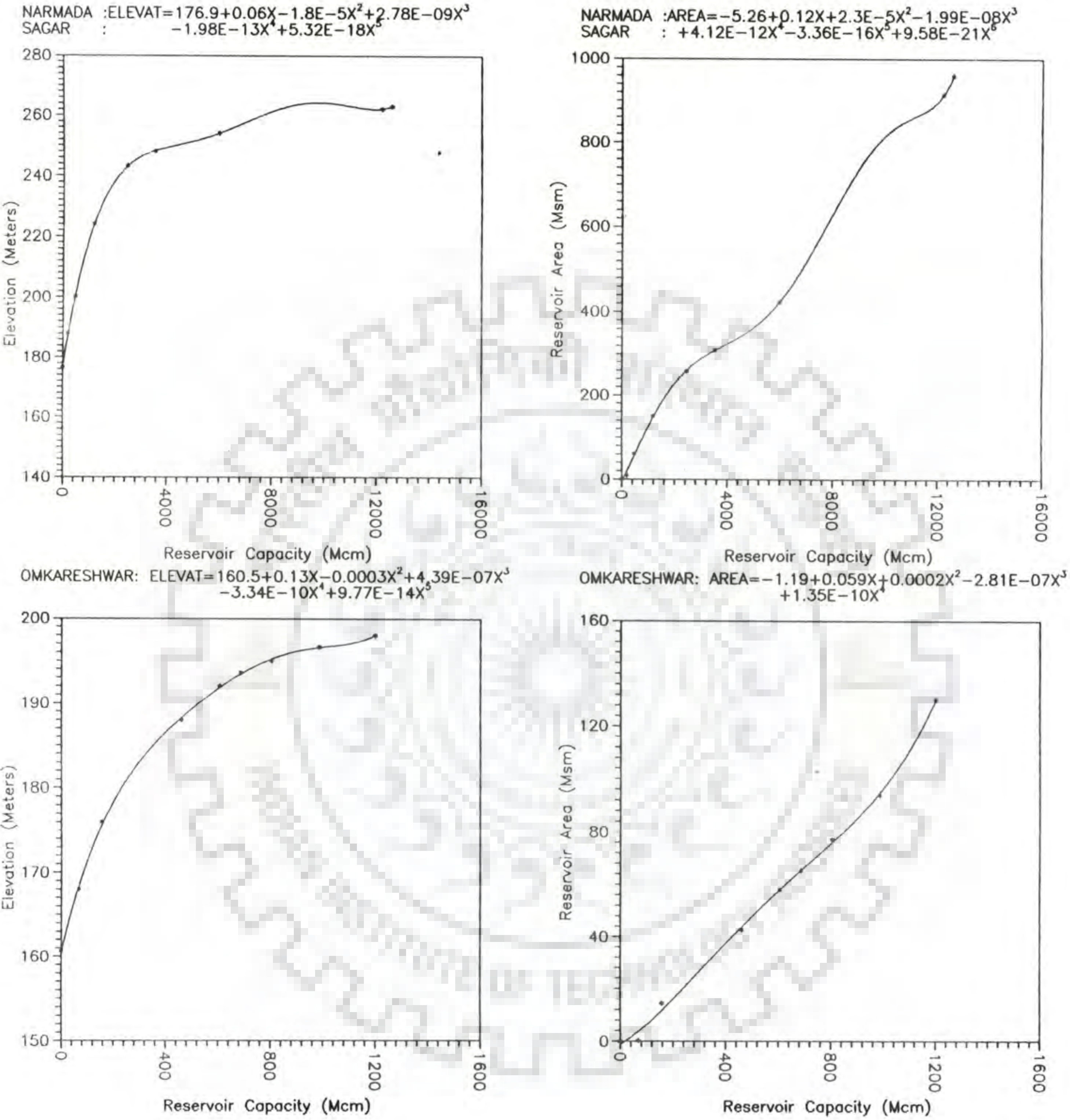


CHOTTA TAWA : $ELEVAT=276.76+0.43X-0.0024X^2+4.16E-06X^3$

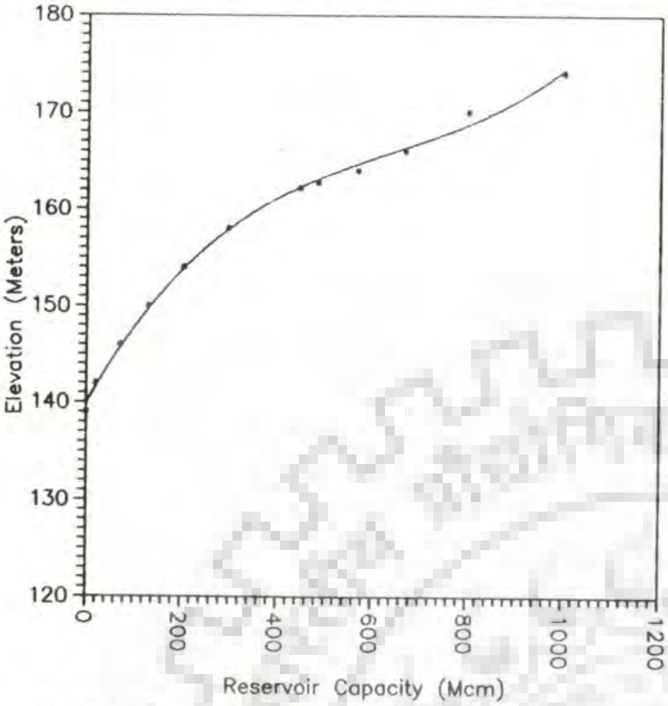


CHOTTA TAWA : $AREA=-0.15+0.15X+0.0003X^2-6.37E-07X^3+2.31E-10X^4$

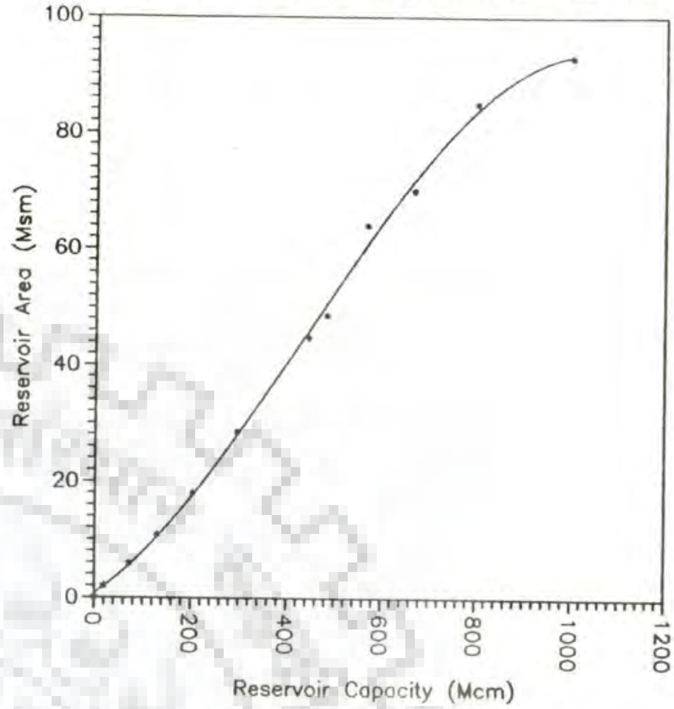



NARMADA :ELEVAT=176.9+0.06X-1.8E-5X²+2.78E-09X³
SAGAR : -1.98E-13X⁴+5.32E-18X⁵
Elevation (Meters)
Reservoir Capacity (Mcm)
NARMADA :AREA=-5.26+0.12X+2.3E-5X²-1.99E-08X³
SAGAR : +4.12E-12X⁴-3.36E-16X⁵+9.58E-21X⁶
Reservoir Area (Msm)
Reservoir Capacity (Mcm)
OMKARESHWAR: ELEVAT=160.5+0.13X-0.0003X²+4.39E-07X³
-3.34E-10X⁴+9.77E-14X⁵
Elevation (Meters)
Reservoir Capacity (Mcm)
OMKARESHWAR: AREA=-1.19+0.059X+0.0002X²-2.81E-07X³
+1.35E-10X⁴
Reservoir Area (Msm)
Reservoir Capacity (Mcm)

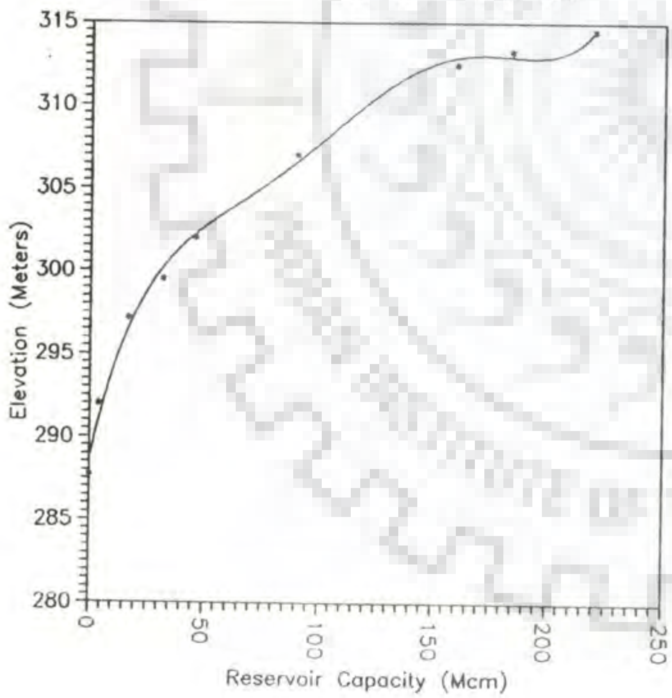
MAHESHWAR :ELEVAT$=139.85+0.09X-0.0001X^2+5.9E-08X^3$



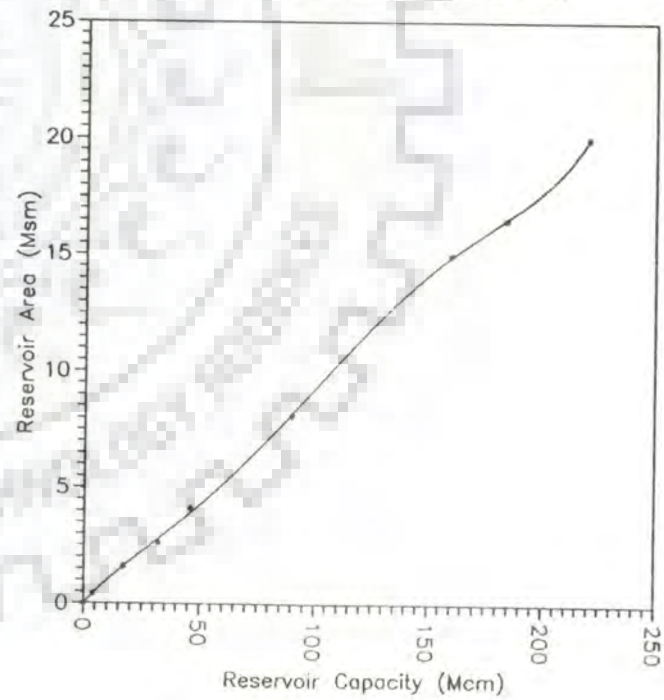
MAHESHWAR :AREA$=0.65+0.058X+0.00015X-1.15E-07X^3$

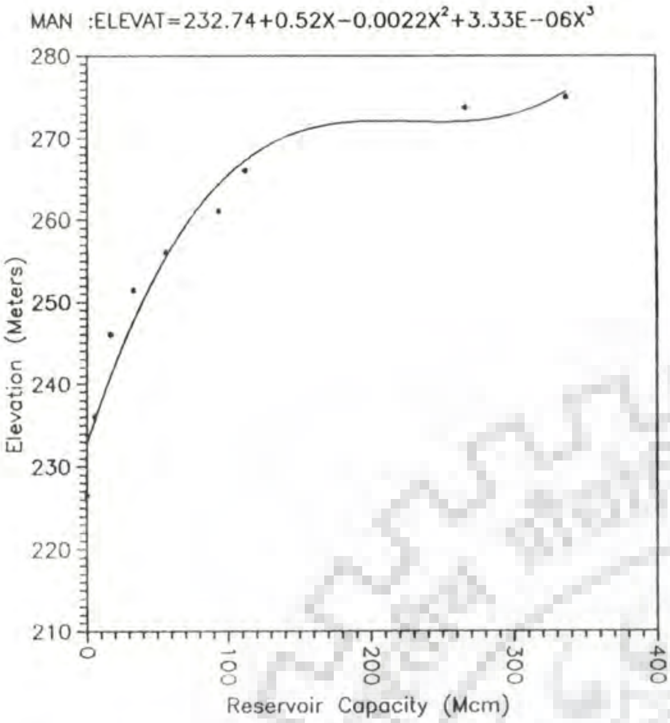


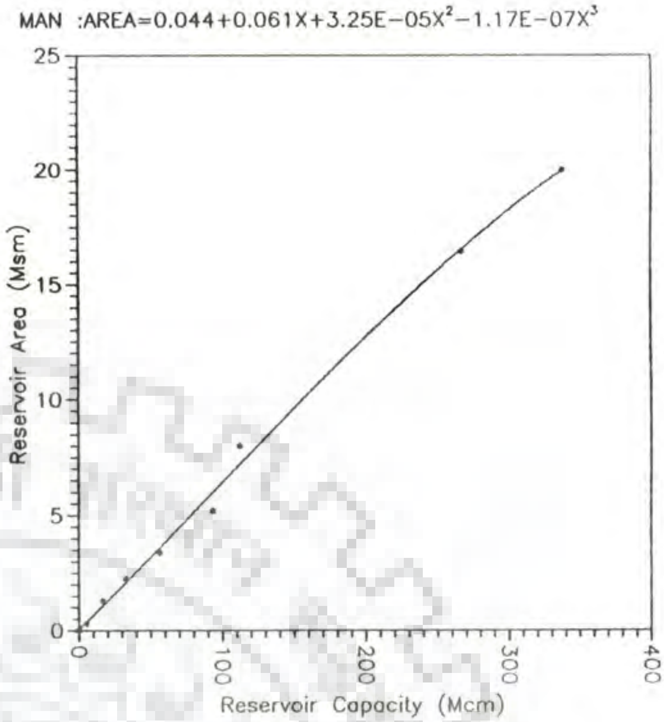
UPPER BEDA :ELEVAT$=288.69+0.63X-0.012X^2+0.00012X^3$
$-5.59E-07X^4+9.53E-10X^5$

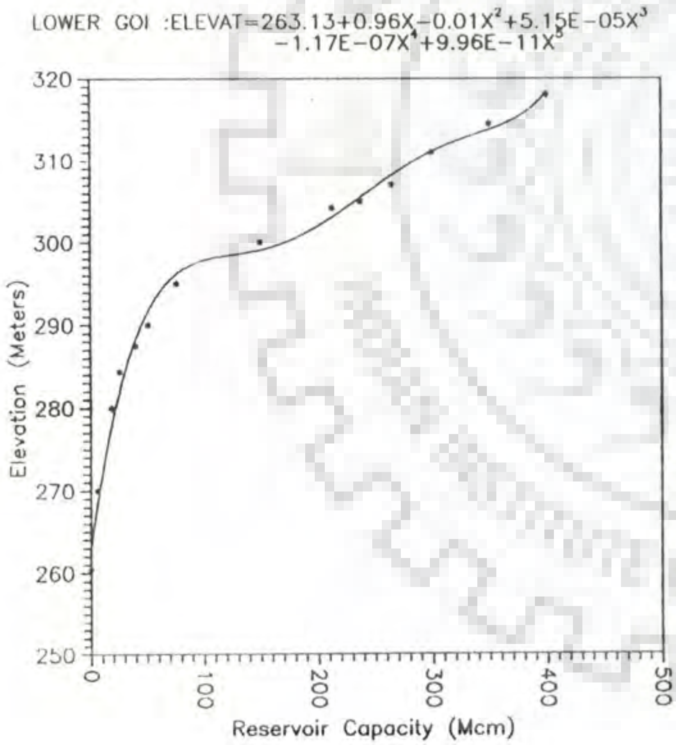


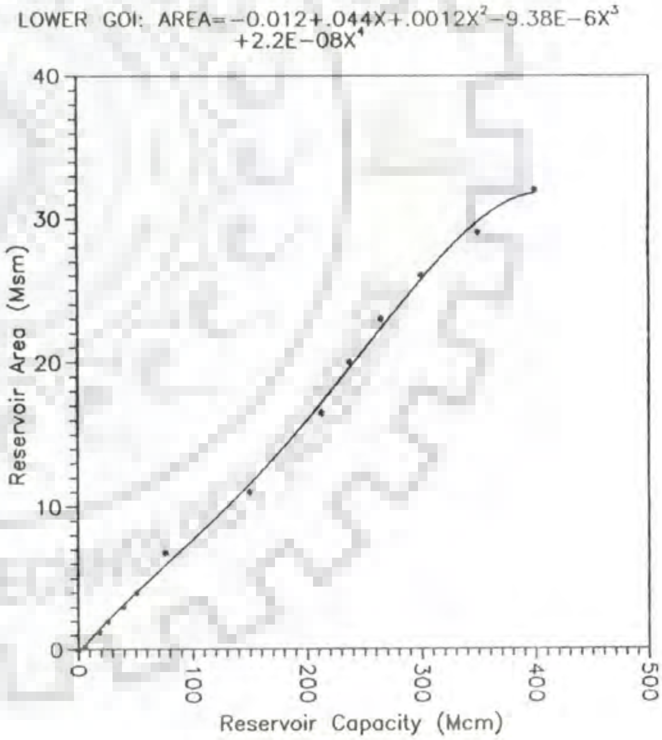
UPPER BEDA :AREA$=-0.016+0.11X-0.001X^2+2.0E-05X^3$
$-1.21E-07X^4+2.38E-10X^5$



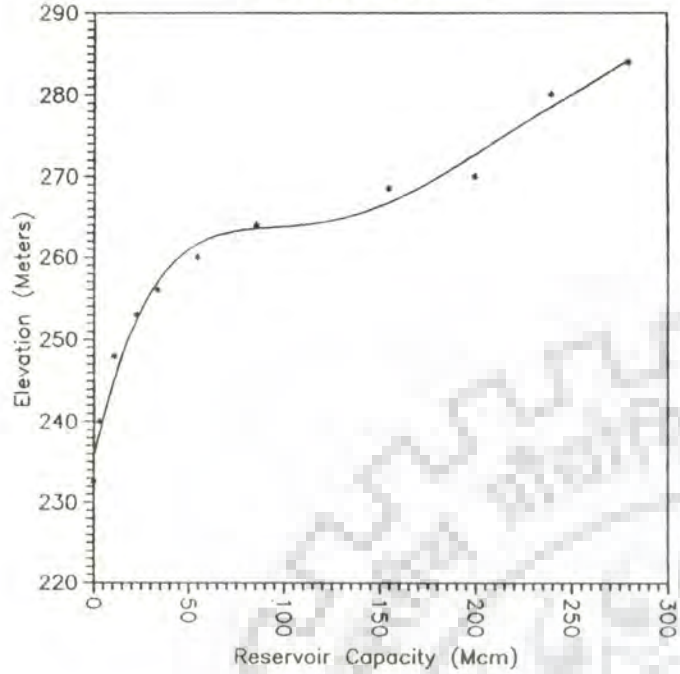

MAN :ELEVAT=232.74+0.52X-0.0022X²+3.33E-06X³
Elevation (Meters)
280
270
260
250
240
230
220
210
0
100
200
300
400
Reservoir Capacity (Mcm)


MAN :AREA=0.044+0.061X+3.25E-05X²-1.17E-07X³
Reservoir Area (Msm)
25
20
15
10
5
0
0
100
200
300
400
Reservoir Capacity (Mcm)

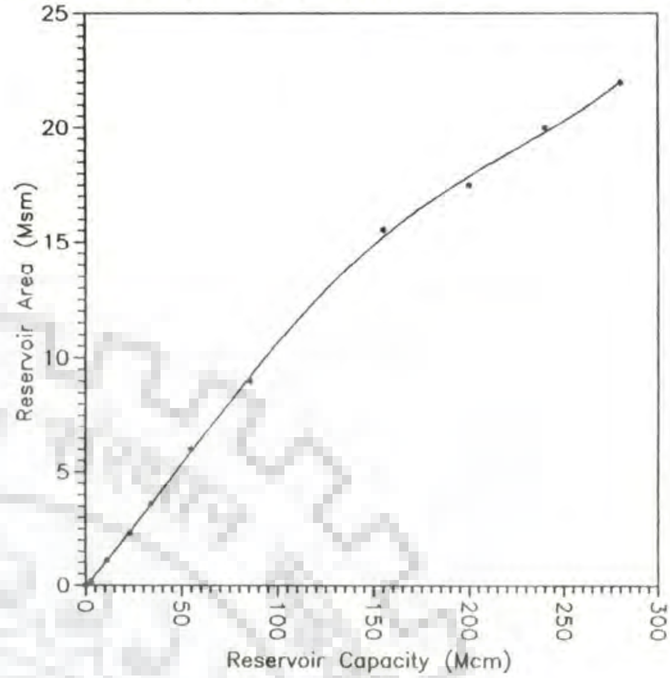

LOWER GOI :ELEVAT=263.13+0.96X-0.01X²+5.15E-05X³
-1.17E-07X⁴+9.96E-11X⁵
Elevation (Meters)
320
310
300
290
280
270
260
250
0
100
200
300
400
500
Reservoir Capacity (Mcm)


LOWER GOI: AREA=-0.012+.044X+.0012X²-9.38E-6X³
+2.2E-08X⁴
Reservoir Area (Msm)
40
30
20
10
0
0
100
200
300
400
500
Reservoir Capacity (Mcm)

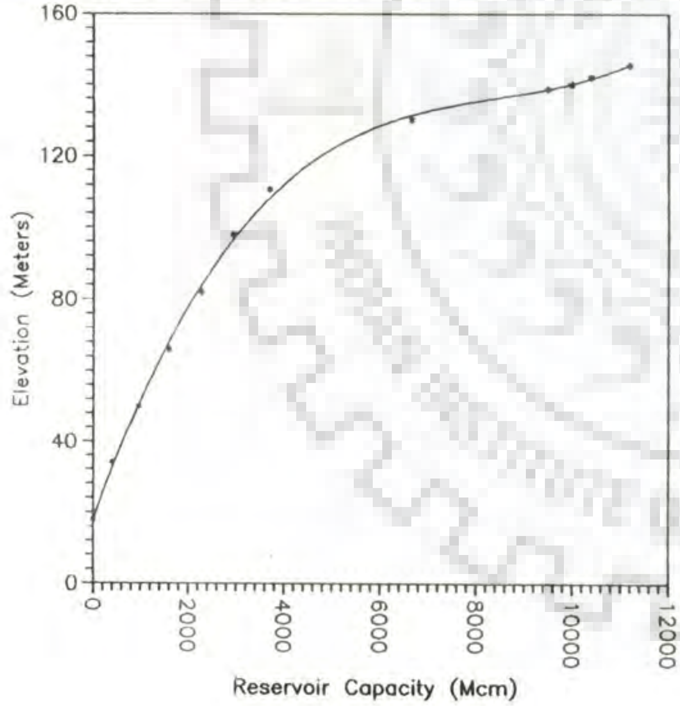
JOBAT :ELEVAT=239.25+0.75X−0.009X^2+5.75E−05X^3 −1.72E−07X^4+1.96E−10X^5



JOBAT :AREA=.029+.087X+.00039X^2−2.99E−6X^3+5.12E−9X^4



SARDAR SAROVAR :ELEVAT=18.01+0.038X−4.2E−06X^2+1.65E−10X^3



SARDAR SAROVAR: AREA=3.23−0.014X+4.03E−05X^2 −1.17E−08X^3+1.58E−12X^4−1.E−16X^5+2.44E−21X^6