CS(AR)-18/96-97

DEVELOPMENT OF OPERATION POLICY FOR TAWA DAM

NATIONAL INSTITUTE OF HYDROLOGY
JAL VIGYAN BHAWAN
ROORKEE - 247 667

ABSTRACT

Reservoirs are one of the most important elements of water resource systems. They are used for spatial and temporal redistribution of water in accordance with requirement. Reservoir storage is necessary to use the highly variable water resources of a river basin for beneficial purposes such as municipal and industrial water supply, irrigation, hydroelectric power generation, and navigation. Under uncertain streamflows and multiobjective demands, water allocation process becomes more complex. The evaluation of current operating rules of existing reservoirs is very important to meet the changing demands according to the public needs and objectives. An operating plan or release is a set of rules for determining the quantity of water to be stored or released from a reservoir or a system of several reservoirs under various conditions. The operating rules provide guidance to the water managers who make the actual release decisions.

Simulation models are used to represent a system and to predict the behaviour of the system under given set of conditions. Simulation models are limited to predicting system performance for a user specified set of variable values. On the other hand, an optimization procedure may involve iterative executions of a simulation model, with the iterations being automated to various degrees.

In this report, rule curves based policy has been adopted for the conservation regulation of Tawa dam. Rule curves are developed for three levels such as upper rule level, middle rule level (critical for irrigation), lower rule level (critical for water supply and upstream use). The generalised simulation model developed by the Water Resources System Group at N.I.H. is used to simulate the system operation and to refine the rule curves. A number of simulation runs have been taken by adjusting the rule curves and the final rule levels have been arrived to satisfy the target demands to the maximum extent possible. The current operating policy of the reservoir is also simulated and the results are compared with the recommended rule curves based policy.

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CHAPTER 1
INTRODUCTION

Water has been recognised as a basic and crucial natural resource for economic development. With continuous increase in the demand for water in all regions, the need for planning for water resources development and management has become more important. The investments in water resources development are influenced by economic, social and political considerations along with the engineering aspects. Reservoirs are one of the most important elements of water resource systems. They are used for spatial and temporal redistribution of water according to prevalent demands. Reservoir storage is necessary to use the highly variable water resource of a river basin for beneficial purposes such as municipal and industrial water supply, irrigation, hydroelectric power generation, and navigation. Under uncertain streamflows and multiobjective demands, water allocation process becomes more complex.

Since more than 80% of the annual rainfall in India occurs in the four monsoon months from June to September, it is general tendency to fill up the reservoirs during the monsoon months and then to use this stored water for the remaining months of the water year. On the other hand, most of the flood situations also arise in the monsoon months and reservoirs should be kept empty so that they can effectively control any flood situation and prevent the downstream area from flooding. An optimum operation policy is derived keeping in view both these conflicting purposes to attain the maximum possible benefits from the reservoir. In India more than 3000 major and medium dams have already been completed and multipurpose reservoir projects are quite common among them.

The evaluation of current operating rules of existing reservoirs is very important to meet the changing demands according to the public needs and objectives. An operating plan or release is a set of rules for determining the quantity of water to be stored or released from a reservoir or system of several reservoirs under various conditions. Typically, a regulation plan includes a set of quantitative criteria within which significant flexibility exists for operator judgement. The operating rules provide guidance to the water managers who make the actual release decisions. Reservoir system analysis models are developed to support

* in sizing of reservoir storage capacities and establishing operating policies during preconstruction planning of new projects.
* in evaluation of the operating plans of existing reservoir systems.
* in administration of water allocation systems involving water rights and agreements between water suppliers and users.
* in operational planning for developing management strategies for the next year or season.
* in real time operations.

The reservoir system models are of two kinds: simulation and optimization. A simulation model, which is a representation of a system, is used to predict the behaviour of the system under a given set of conditions. Alternative executions of a simulation model are made to analyse the performance of the system under varying conditions, such as for alternative operating policies. Optimization models are used to compute a set of decision variable values that minimize or maximize an objective function subject to constraints. Simulation models are limited to predicting system performance for a user specified set of variable values whereas optimization models automatically search for an optimum solution. All optimization models simulate the system. An optimization procedure may involve iterative executions of a simulation model, with the iterations being automated to various degrees.

Tawa reservoir is a multipurpose reservoir located in the Hoshangabad District, Madhya Pradesh mainly to serve irrigation, water supply and upstream use. The upstream use demands are accounted in the months of July, August and September. There is no control on the water supply for upstream use demands from the dam site. The power generation of this reservoir is incidental. The monthly inflow series (in million cubic meter) at the Tawa reservoir for the period 1948 to 1971 is considered for the study. The Elevation-Area-Capacity table based on the 1990 survey has been used for the operation study.

In this report, rule curves based policy has been recommended for the conservation regulation of the Tawa dam. This reservoir is not operated for flood protection. Power transformation technique is applied to arrive different reliable inflow series using the available inflow data series. These reliable inflow series are used later in the trial rule curve derivation module of the SRA package to develop trial rule curve levels. Three rule curves are developed : upper rule level, middle rule level (critical for irrigation), lower rule level (critical for water supply and upstream use). The generalised simulation model developed by Water Resources System Group at NIH is used to simulate the system operation and to refine the rule curves. A number of simulation runs have been taken by adjusting the rule curves and the final recommended rule levels have been arrived by using the reliability analysis. In the simulation runs the upper and middle rule curves are adjusted to avoid the unnecessary spill so that the failures can be reduced. The rule curves are adjusted to avoid the critical failures (supply less than 0.75 times of the demand) at the maximum possible and thus the partial supply is maintained for longer period to avoid heavy damage of the crop. The current operating policy is also simulated. The results of both policies are compared. The final recommended rule curves policy for the reservoir gives better performance than the presently followed policy. Three rule curves have been recommended for different purposes for the conservation regulation of the reservoir and the operation procedure for the reservoir has been explained.

This report consists of five chapters. Chapter 2 contains the brief description of the basin and the general details of the reservoir. It also presents the different demands from the reservoir. Chapter 3 gives brief description about the capability of SRA (Software for Reservoir Analysis) package. It also explains briefly about the multireservoir simulation module. Chapter 4 details the data used for the study, the solution strategy of the study and the recommended procedure for the operation of the system. The conclusions drawn from the study are given in Chapter 5. The data used for the study and the recommended rule curves have been presented in tabular and graphical form. The detailed simulation tables for the current operating policy and the recommended rule curves based policy have also been presented.

CHAPTER 2

DESCRIPTION OF THE STUDY AREA

2.1 TAWA RIVER BASIN

The Tawa river is one of the major tributaries of the Narmada river. Rising on the south western end of the Mahadeo hills near the Mankhoi village (Latitude 22°7', Longitude 78°29') in the Chhindwara district, it cuts its course through the hills of the Satpura Range, flowing first westwards for about 64.4 kms up to the Golai reserve forest (Latitude 22°1', Longitude 77°49') and then northwards for about the same distance upto the G.I.P. Railway Bridge (Latitude 22°36½', Longitude 77°59') where it emerges from the Satpura hills into the alluvial plains of the Narmada valley. Emerging from plains, it turns north-westwards and, widening its bed to 1.61 km, runs for about 32.2 kms to meet the Narmada. About 6.44 kms upstream of the railway bridge, the Tawa is joined by its biggest tributary, the Denwa, which rises on the northern slopes of the Mahadeo hills. The Tawa basin showing the reservoir location and the main canal systems is presented in Fig. 1.

2.2 PHYSICAL CHARACTERISTICS OF THE TAWA DAM

The Tawa dam site across the Tawa river lies in the Hoshangabad District, Madhya Pradesh. It is situated 4.83 kms southwest of Bagra Tawa Railway Station (Latitude 22°35½', Longitude 77°59½') and about 1.61 km north of Ranipura (Latitude 22°34½', Longitude 78°59¾'). It is about 2.01 kms upstream of the railway bridge on the Tawa river. The hills on either side of the dam site rise to about 381 to 457.2 m while the river bed is about 307.85 m above MSL. The hilly region is overgrown with a fairly dense jungle while the alluvial plain in the north is a fertile wheat producing area.

Tawa masonry dam is a gravity structure with maximum height of 57.912 m above deepest foundation level. The masonry dam is 417.576 m long consisting of 237.744 m of spillway in the river portion. Road way of 6.706 m between the kerbs is provided for full length of the masonry dam. The spillway can pass a maximum moderated flood discharge of 21225 cumecs with 13.487 m depth of flow over the crest at RL 343.105 m. The spillway is controlled by 13 radial gates of size 15.240 m × 12.192 m. The concrete spillway piers are 3.048 m thick. The spillway is of Ogee type with Hydraulic jump type stilling basin with floor level at RL 303.276 m.

The masonry dam is flanked on either sides by earth dam 690.372 m long on left side and 521.208 m long on the right side in addition to 375.760 m of dykes in the two saddle portion. The maximum height of earth dam above the stripped level is 33.528 m. The top of the earth dam is at RL 359.664 m providing a free board of 2.972 m above the maximum reservoir level.

The catchment area at the dam site is 5982.90 sq kms. The gross, live and dead storage capacities of the reservoir are 2079.698 Mm^3, 1955.854 Mm^3 and 123.844 Mm^3 respectively. The maximum water level, full reservoir level, spillway crest level and dead storage level are 356.692 m, 355.397 m, 343.205 m and 334.243 m respectively. The average annual rainfall for this catchment area is 1546.13 mm. The maximum and minimum rainfall values are 2506.22 mm and 873.76 mm respectively. The average annual runoff is 3706.616 Mm^3. The maximum and minimum runoffs are 9400.373 Mm^3 and 1927.934 Mm^3 respectively. The peak of the design flood hydrograph is 30800 cumecs while the maximum observed flood is 24300 cumecs.

The project has been constructed to meet the irrigation and water supply demands. The power generation in this project is only incidental. The command area is irrigated by Left Bank and Right Bank Canal systems. The sill levels of sluices of Left Bank and Right Bank Canal systems are at 334.243 m and 338.328 m respectively. The Minimum Draw Down Levels for the Left Bank and Right Bank Canal are 336.804 m and 340.462 m respectively. The lengths of main canal, Bagra branch canal and Pipariya branch canal are 7.5 km, 24 km and 60 km respectively. The gross command area, culturable command area, irrigable command area under LBC are 288956 ha, 186162 ha and 186162 ha respectively. The gross command area, culturable command area, irrigable command area under RBC are 112729 ha, 98079 ha and 60702 ha respectively. The annual irrigation demands to be met by the LBC and the RBC are 1895.863 Mm^3 and 431.495 Mm^3 respectively. The annual water supply demand to be met by the system is 11.596 Mm^3. The upstream use accounted at reservoir site is 222.027 Mm^3. This demand is to be met in the months of July, August and September. The power plant is situated on the LBC and its power generating capacity is 13 MW (two units of 6.5 MW). The rainfall data for 4 stations Betul, Shahpur, Tamia and Pachmarhi in the catchment and of one station at Bagra Tawa is being used for average annual rainfall calculation. The average annual rainfall values are available from 1891 to 1971. The monthly inflow values are available from 1948 to 1971.

2.3 TARGET DEMANDS FROM THE DAM

The Tawa reservoir project is mainly operated to meet the irrigation demands of LBC and RBC, water supply demands for the Ordinance Factory, Itarsi and upstream use demands. This reservoir is not operated for flood control. The power production at the LBC is 13 MW and the power generation is incidental. Various demands which are met from the reservoir are detailed in the following section.

a) Water Supply Demands for Domestic Purposes

The agreement between the Government of Madhya Pradesh and the Ordinance Factory, Itarsi is to supply water for domestic purposes at the rate of 8.4 million gallons per day from the reservoir through a separate pipe. This amounts to 11.596 Mm^3 annually and has been considered for developing the operating policy of the reservoir.

b) Upstream Use Demands

The upstream use demands for the months of July, August and September are 88.811, 66.608 and 66.608 Mm^3 respectively. These values have been subtracted from the inflow series of corresponding months as there is no control on the water supply for these demands from the dam.

c) Irrigation Demands

The Tawa reservoir is constructed to provide irrigation through its Left Bank Canal and Right Bank Canal Systems. The gross command area and culturable command area under LBC are 288956 ha and 186162 ha respectively. The gross command area and culturable command area under RBC are 112729 ha and 98079 ha respectively. The cropping intensity under LBC for kharif, Rabi and summer crops are 67%, 67%, 4%. The cropping intensity under RBC for kharif, rabi and summer crop are 58%, 67%, 0%. The command area lies in the districts of Hoshangabad, Narasinghpur and Betul. The annual requirement of the irrigation system is estimated to be around 2327.358 Mm^3.

CHAPTER 3

GENERALISED MULTIRESERVOIR SIMULATION MODEL

A software package, named ***SOFTWARE FOR RESERVOIR ANALYSIS*** **(SRA)** has been developed by the water resources systems group of N.I.H. The software is capable of carrying out various kinds of analysis associated with the planning and design of reservoirs. The software is a menu-driven, interactive package. The various modules of this software are Reservoir Capacity Computation, Interpolation of Elevation-Area-Capacity Table, Hydropower Analysis (Firm Power Determination, Hydropower Simulation), Reservoir Inflow Estimation, Multireservoir Simulation, Reservoir Routing (Coefficient Method, Goodrich Method, Mass Curve Method, Modified Puls Method), Stretched Thread Method, Trial Rule Curve Derivation, Yield-Storage Analysis [(Storage known, Yield unknown),(Yield known, Storage unknown)]. Multireservoir Simulation and Trial Rule Curve Derivation are the important modules as per this study is concerned.

The module **MULTIRESERVOIR SIMULATION** consists of a model for simulating the operation of a multipurpose multireservoir system for conservation operation. The various conservation purposes considered in the model are water supply for domestic and industrial purposes, irrigation, hydropower generation and minimum flow requirements in the downstream river channel. In a multireservoir system, the model can help in finalizing the optimum rule levels for each storage location. The rule curves based policy has been adopted in this module.

For each storage location, the model operates the reservoir in accordance with the given trial rule curves (given for each reservoir) and carries out the reliability analysis. Correspondingly, it calculates the time and volume reliability of each reservoir for the given set of rule curve levels and for the given period of operation. Detailed simulation table is also prepared. Based on the observations from the simulation table, trial rule curves are modified till optimum results are achieved.

In the program, several checks have been introduced to detect the likely errors while preparing the input data. After reading a group of data items, the program displays a message on the screen showing that the corresponding data items have been read properly. This facility is very helpful in locating the possible error as the user knows that for which structure and at which group of data, the error is encountered. The program reads the entire data for a structure at a time. After reading the input data, the simulation of operation for each structure is performed.

The report on "Software for Reservoir Analysis (SRA)" of the N.I.H. can be consulted to know more about the rule curves, data requirement and output of this module.

CHAPTER - 4
DEVELOPMENT OF OPERATION POLICY FOR TAWA RESERVOIR

4.1 CURRENT OPERATING POLICY OF THE RESERVOIR

From the working table (1948-1971) of the reservoir, prepared by the reservoir operating authority, it is noted that top priority is given for meeting full water supply demand (11.596 Mm^3 annually) while next higher priority is given for meeting irrigation demand by Right Bank Canal (431.495 Mm^3 annually). The irrigation demand of Left Bank Canal is met from the water in excess of the above mentioned demands. If the water is in excess of all demands, the extra water is spilled after filling the reservoir upto the FRL. It is also mentioned that the requirement of June for RBC is neglected as the nursery crop of this period is grown by the tube well irrigation. Water is supplied to late variety of paddy in the middle or end of July for RBC. The failures for LBC, as noted from the working table and as given by the project authority, are for the years 51-52, 52-53, 54-55, 56-57, 57-58 i.e., 5 years in 23 years and it amounts to 22 percent. There is no control on the water supply for upstream use demands from the dam site.

4.2 ASPECTS CONSIDERED FOR POLICY DEVELOPMENT

In the present study, the reservoir operation policy for the Tawa reservoir has been developed for the conservation demands like water supply for domestic and industrial use, upstream use and irrigation. Hydropower generation is incidental. The policy development does not include flood protection as this reservoir is not operated for flood control.

4.3 DATA USED FOR THE STUDY

The monthly inflow series (in million cubic meter) at the Tawa reservoir for the period 1948 to 1971 has been considered for the policy development and is given in Table 1. The Elevation - Area - Capacity table based on the 1990 survey has been used for the operation study and the same is given in Table 2. It is noted from the survey that the reduction in storage capacity at DSL is 52.8 percent and at FRL is 10 percent of the storage capacity. The normal values of monthly evaporation for the reservoir are presented in Table 3. The Elevation - Area curve and the Elevation - Capacity curve for this reservoir have been plotted in Figure 2 and Figure 3 respectively. The average monthly irrigation demands have been calculated from the details collected from the project authority. The details about power plants have been obtained from the officials in charge of the reservoir. Various demands from the reservoir are given in Table 4.

4.4 THE SOLUTION STRATEGY ADOPTED

The rule curves based policy has been adopted for the conservation regulation of the Tawa reservoir. This policy tries to distribute the deficit equitably much in advance so that the reduced supply can be maintained throughout the demand period. Based on the number, nature and priority of demands, three initial trial rule curves have been derived for this reservoir.

The methodology of simulation has been adopted for refining the rule curves. Simulation, in essence, is to duplicate the system behaviour under given hydrologic conditions. Though this approach is not useful for deriving any operation policy directly, it helps in policy evaluation. Simulation is one of the important techniques which can represent the true behaviour of a system. The analysis has been carried out for the monthly time interval. The results of simulation have been used for refining the policy so as to achieve the maximum possible benefits from the available resources.

The module **MULTIRESERVOIR SIMULATION** of **SRA** package has been used to simulate the monthly operation of this reservoir for conservation regulation. For each time step, the module calculates the release to be made for each demand in accordance with the trial policy, spill (if any) and the actual evaporation losses at the prevailing water spread area etc. In the end, the module calculates the number of months when the release is less than the demand and thus calculates the monthly time reliability of the reservoir for the trial policy. It also calculates the volumetric reliability. In addition, it also calculates the number of months of critical failure when the release is less than 75% of the target demand.

Initially, three trial rule curve levels have been derived for the reservoir using various scenarios of reservoir inflows and level of demands. Upper rule curve provides empty storage space in the reservoir for flood absorption. The middle rule curve is critical for irrigation demands and the lower rule curve is critical for water supply demands and upstream use demands. An exhaustive reservoir operation simulation study has been undertaken using these rule curves. The rule curves have been refined as long as the monthly time reliability of the reservoir could be increased without increasing the number of critical failure (supply less than 75 percentage of the demand) months. The detailed operation table of simulation has been utilised for this purpose. The operation policy which has met the objectives of the conservation storage regulation has finally been recommended for adoption. Monthly reservoir inflows of different probabilities have been considered in deriving different rule levels. The derivation of inflows of different probability is explained in the following section.

4.5 MONTHLY DEPENDABLE INFLOW

The monthly inflow series for the reservoir has been analyzed using the statistical approach. For Tawa reservoir, inflow data are available for 23 years of historical record and the different reliable inflows have been arrived at the dam site using the available inflow data series. The power transformation approach has been used for this purpose. This approach is a standard technique and is being extensively used in the hydrological analysis. The monthly inflows for the reservoir have been estimated for 50%, 60%, 70%, 75%, 80% and 90% probabilities using this approach. The results of this analysis for the 12 months have been presented in Table 5. The report on "Software for Reservoir Analysis (SRA)" can be consulted to know more about the power transformation approach.

4.6 DERIVATION OF INITIAL TRIAL RULE CURVE LEVELS

The computations for deriving various rule curve levels have been made using the monthly inflow series for different probability levels along with the average monthly demands. Using the monthly dependable inflow series, the water availability has been assumed as corresponding to particular monthly inflow series. Computations of end-of-month reservoir levels have been made for 12 months after allowing for water demands in full or partial and the evaporation losses from the reservoir surface. The Elevation-Area-Capacity table has been used and the intermediate values have been linearly interpolated whenever required. The evaporation losses have been considered at normal monthly rate over the surface area of the reservoir corresponding to a particular elevation.

The module **TRIAL RULE CURVE DERIVATION** of **SRA** package has been used to derive the initial trial rule curves. Since the Tawa reservoir is meant to serve for irrigation, upstream use and water supply demands, it has been considered appropriate to decide three rule levels for this reservoir. First, the upper rule level up to which the reservoir should be filled if there is sufficient inflow in the reservoir and all the demands are met in full. Second, the irrigation rule level, below which the supply for irrigation demands should be curtailed so that the reduced supply can be maintained for a longer duration. Third, the water supply level, below which, the supply will be made to meet domestic and industrial water supply demand and upstream use demand. The report on "Software for Reservoir Analysis (SRA)" can be consulted to know the procedure adopted to derive the trial rule curves. The initial trial rule curves are presented in Table 6.

4.7 SIMULATION OF MONTHLY OPERATION OF THE RESERVOIR

The module **MULTIRESERVOIR SIMULATION** of the **SRA** package has been used to simulate the monthly operation of the reservoir. The monthly inflow data, target monthly domestic and industrial water supply demand (M Cum), upstream use demand (M Cum), irrigation demand (M Cum), storage details and the normal values of monthly evaporation are input to the program. Various trial rule curve levels, derived earlier, are also input to the program. The module simulates the operation of the reservoir in accordance with the policy. Detailed working table for the reservoir operation is prepared. The following quantities are computed monthly:

1. Initial storage (M Cum) in the reservoir at the start of each time step (monthly in the present case).
2. Actual evaporation losses (M Cum) from the reservoir based on the initial and final water spread area. This is calculated iteratively till sufficient accuracy is achieved.
3. The total demand in the month (M Cum) for all the purposes.
4. Release of water from the reservoir for different purposes like domestic & industrial demand, upstream use demand and irrigation demand, based on the policy.
5. The amount of incidental power produced (M Kwh) in different months.
6. The spill (M Cum) from the reservoir, if any.
7. End level (m) in the reservoir after each time step.

In addition, some ratios are also calculated and if a ratio is less than a specified target, letters signifying different failures are indicated. These are indicated below:

1. Total release for irrigation/Total irrigation demand. If this ratio is less than 1.00, "I" appears after the Tot_Rel column indicating that it is a failure month for irrigation.

2. Total Release for water supply and upstream use/Total domestic & industrial water demand and upstream use demand. If this ratio is less than 1.00, "W" appears after the Tot_Rel column indicating that it is a water supply and upstream use failure month.

3. Total release for all demands/Total of all demands. If this ratio is less than 0.75. "C" appears in the column instead of "I" indicating that it is a critical failure month.

In the end, the module calculates the total number of failure months when the supply is less than the total of target demand for all purposes and hence, calculates the monthly time reliability of the reservoir for the test policy. It also calculates the total number of critical failure months when the supply is less than 75% of the demand and hence, the monthly time reliability for critical failure. The module also calculates the total volumetric demand and supply from the reservoir and hence, the volumetric reliability of the reservoir.

An exhaustive operation simulation study for the Tawa reservoir has been undertaken using the initial trial rule curve levels. The results of the simulation analysis have been intercompared using above performance indices. The policy has been refined using the detailed operation simulation table of the reservoir. The operation policy which has best met the objectives of the conservation storage regulation has finally been recommended for adoption.

For refining the initial rule curve levels (those giving the highest monthly time reliability with the least number of critical failure months), the detailed operation table has been utilised. Initially, the upper rule curve levels were changed to store spilled water to increase the time reliability and volume reliability of the reservoir. Then based on the observations from the simulated operation table, the rule curves for irrigation were adjusted till the number of failure months could be reduced without increasing the number of critical failure months. The rule level for water supply demand and the upstream use was not modified as the failure for the same was zero at the initial run of the module. A number of simulation runs have been taken in the process and the various rule curve levels have been finalised. In the next step, the final rule curves for irrigation, water supply demands and upstream use demands were kept unchanged and the initial upper rule curve levels were lowered till there is any increase in the number of critical failure months. In this way, the various rule curves have been finalised.

4.8 RESULTS OF SIMULATION RUNS FOR THE TAWA RESERVOIR

Simulation runs for the Tawa reservoir with the present policy (SLOP) and the recommended policy have been presented in Table 8 and Table 9. The abstract of the simulation runs for the present policy and for the recommended policy is presented as follows.

Sl.no	Items	Present policy	Recommended policy
1	Number of failures for water supply	0	0
2	Time reliability for water supply	1	1
3	Number of failures for irrigation	32	45
4	Time reliability for irrigation	0.886	0.84
5	Number of critical failures	27	4
6	Volume reliability for irrigation and water supply	0.94	0.95

The results are discussed as follows.

In the present operating policy (SLOP), the demand for the water supply and industrial use and upstream use is met fully in all the periods. The demand for RBC and LBC is met to the possible extent. The month in which the release for the irrigation is less than 75% of the total demand is treated as critical failure month. From the simulation table it is observed that the monthly time reliability for water supply and upstream use and irrigation comes out to be 100% and 88.6% respectively. The volume reliability comes out to be 94%. Out of the 281 months, there are 27 critical failure months (when the total release is less than 75% of the total demand). The reliability of the reservoir for meeting partial demands is also carried out. With this policy, the reliability for supplying 75% assured supply for irrigation comes out to be 100%. For calculating the average annual values, three drought years, i.e. 1951-52, 1952-53 and 1957-58 have been discarded. From the simulation table using the current operating policy, the average annual release for irrigation is 2254.91 M Cum while average annual incidental hydropower production is 92.15 M kwh.

At the beginning the simulation run has been carried out with initial trial rule curve levels. From the simulation table it is observed for this run that there are so many periods with unnecessary spills. The critical failures observed are 4. The number of irrigation failures are 78 with the time reliability for the irrigation is 72.2%. The volume reliability for the irrigation and water supply is 92%.

Later number of simulation runs have been taken considering various rule curve levels and the refinement has been made till the reliability of the reservoir for various demands could be improved and the unnecessary spill water could be reduced. In the recommended policy, it has been assumed that for the reservoir level above the irrigation rule level, all the demands will be satisfied in full. If the water level falls below the irrigation rule level then the water supply demand and upstream use demand will be satisfied in full while the irrigation demand will be curtailed to 75%. If the reservoir level falls below the water supply rule level, only water supply demands and upstream use demands will be met for as longer the duration as possible. Based on this policy, the monthly time reliability for water supply and upstream use and irrigation comes out to be 100% and 84% respectively. The volume reliability comes out to be 95%. Out of the 281 months, there are 4 critical failure months (when the total release is less than 75% of the total demand). The reliability of the reservoir for meeting partial demands is also carried out. With the recommended policy, the reliability for supplying 75% assured supply for irrigation comes out to be 99.3%. From the simulation table using the recommended rule curve policy, the average annual release for irrigation is 2500.39 M Cum while average annual incidental hydropower production is 95.70 M kwh.

From the operation table, water lost through evaporation per year is around 223.53 M Cum. Thus, roughly 2750 M Cum of water is required annually. From the inflow data, it is observed that the years 1951-52, 1952-53, and 1957-58 are drought years with annual inflow less than 2088 M Cum. From the operation table, it can be seen the most of the irrigation failure months happen to fall in these drought years.

From the above analysis, it is observed that the presently followed policy gives higher reliability than the recommended policy for meeting the full as well as partial demands. However the presently followed policy gives more critical failures than the recommended policy. So the recommended policy tries to distribute the deficit equitably in all the months. As soon as shortage of water is anticipated, the supply is curtailed much in advance so that reduced supply can be maintained throughout the year. The recommended operating policy improves the volume reliability for irrigation and water supply by 1% over the current operating policy. The recommended operating policy improves the average annual release and also the incidental power generation. By comparing the two simulation tables, it is observed that the recommended operating policy reduces the spill considerably over the current operating policy. So the recommended policy gives the optimum upper rule level which gives the storage space for flood absorption without affecting conservation demands.

Three rule curves have been provided in the recommended policy. The upper rule curve has been termed as Curve A, irrigation rule curve as Curve B and water supply and upstream use rule curve as Curve C. These have been presented in Table 7 and have been plotted in Figure 4.

4.9 RECOMMENDED CONSERVATION OPERATION PROCEDURE FOR THE TAWA RESERVOIR

The recommended procedure for conservation operation of the Tawa reservoir using the three rule curves A, B and C is as follows:

For a particular month:

1. Try to maintain the reservoir at rule level A while meeting all the demands in full. If the reservoir level overtops the rule level A, spill the excess water and bring the reservoir level back to level A.

2. If it is not possible to maintain the reservoir level at A, meet all the demands as long as the reservoir is at or above level B.
3. If it is likely that the reservoir level will go below level B, meet 75% of target irrigation demands.
4. If the reservoir is at or below rule level C, make release to meet only full water supply demand and upstream use demand for as longer the duration as possible. In this case, stop supply for irrigation demands completely.
5. It is advisable to periodically review the situation within a month and modify the previous decision (for the remaining duration of that month) and follow steps (1) to (4) to operate the reservoir.

CHAPTER - 5
CONCLUSIONS

To overcome the uncertain nature of monsoon, it is imperative to use our available water resources efficiently. Reservoir operation is an important aspect of water resources management. In the present study, a policy to optimally utilise the conservation storage of Tawa reservoir has been developed. The operation of the reservoir with the recommended policy has been simulated using 23 years of inflow data series. Some of important conclusions from the simulation study are as follows:

1. The presently followed operating policy (SLOP) gives more critical failures than recommended rule curve policy. The recommended policy gives the irrigation rule curve to distribute the deficit equitably much in advance.

2. The average annual incidental hydropower and the average annual release are improved by the recommended operating policy. In the months of August and September, the reservoir is filled to its capacity in number of years.

3. The volume reliability for irrigation and water supply is improved by the recommended operating policy. The value is improved by 1% over the current operating policy.

4. The present study has been carried out based on the water supply demands and upstream use demands and the irrigation demands from the left bank canal and right bank canal . From the analysis, it appears that the demands can be satisfied almost in all the months except for the drought years 1951-52, 1952-53 and 1957-58.

This reservoir is not operated for flood protection. Eventhough The upper rule levels in all the months have been lowered below the FRL, to the extent possible, as long as the conservation requirement of the reservoir is not affected. It is required to maintain the reservoir at the upper rule level and spill the additional water at the rate of inflow so that the reservoir can be kept at this level.

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SALIENT FEATURES OF TAWA RESERVOIR

LOCATION	Village - Tawa Nagar, Ranipura Distt. - Hoshangabad State - Madhya Pradesh
River	Tawa
Latitude	22° 33′ 40"
Longitude	77° 58′ 30"
Toposheet No.	55 F/14
HYDROLOGY	
Catchment Area	5982.90 sq. km
Maximum Rainfall in the catchment	2506.22 mm
Minimum Rainfall in the catchment	873.76 mm
Average Rainfall in the catchment	1546.13 mm
Maximum Annual yield	9400.373 M Cum
Minimum Annual yield	1927.934 M Cum
Average Annual yield	3706.616 M Cum
50% dependable yield	4086.529 M Cum
75% dependable yield	3076.306 M Cum
90% dependable yield	2142.560 M Cum
Maximum designed flood	30800 Cumecs
Moderated flood	20500 Cumecs
RESERVOIR DATA	
River Bed level	RL 309.677 m
Minimum draw down level (MDDL)	RL 334.243 m
Spillway Crest level	RL 343.205 m
Full Reservoir level (FRL)	RL 355.397 m
Maximum Reservoir level (MWL)	RL 356.692 m
Top of Bund Level (TBL)	RL 359.664 m
Sill level (LBC)	RL 334.243 m
Sill level (RBC)	RL 338.328 m
Tail water level	RL 316.992 m
Dead Storage Capacity at MDDL	123.844 Mm^3
Gross Storage Capacity at FRL	2079.698 Mm^3
Live Storage Capacity at FRL	1955.854 Mm^3
Area under Submergence	15506 ha
DAM DATA	
Type of Dam	Composite earthen & masonry
Length of masonry Dam	417.576 m
Length of earthen Dam	1587.340 m
Maximum height of masonry Dam	57.912 m
Maximum height of earthen Dam	33.528 m
Free Board above MWL	2.972 m

SPILLWAY

Length of Spillway	237.744 m
Number of Gates	13 Nos.
Size of Gates	15.240 m x 12.192 m
Type of Gates	Radial

OUTLETS

Length of LBC	131 km
Handia Branch Canal	56 km
Maximum discharge capacity of LBC	94.76 cumecs
Length of RBC	7.5 km
Bagra Branch Canal	24 km
Pipariya Branch Canal	60 km
Maximum discharge capacity of LBC	26.77 cumecs

POWER HOUSE

Location	Left Bank Canal
Installed Capacity	2 x 6.5 MW

Table 1
Monthly Inflow (M Cum) Series at the Tawa Reservoir for the Period (1948-71)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.
1948	-	-	-	-	-	-	1449.342	2647.054	1800.885	246.697	222.027	50.573
1949	33.304	12.335	8.634	6.167	3.700	27.137	564.935	648.812	2362.120	424.318	99.912	30.837
1950	19.736	23.436	9.868	4.934	3.700	4.934	1434.541	474.891	643.878	22.203	18.502	16.035
1951	17.269	7.401	4.934	3.700	3.700	82.643	213.393	1038.593	515.596	94.978	12.335	7.401
1952	8.630	11.101	3.700	2.467	2.467	57.974	736.389	1087.932	155.419	18.502	7.401	6.167
1953	4.930	4.934	3.700	2.467	2.467	16.035	548.900	1883.528	314.538	80.176	14.802	9.868
1954	8.630	7.401	3.700	2.467	1.233	18.502	532.865	588.371	890.575	130.749	28.370	14.802
1955	11.100	7.401	3.700	2.467	2.467	102.379	125.815	1124.936	1300.091	869.605	41.938	24.670
1956	14.800	7.401	6.167	2.467	2.467	65.375	801.764	590.838	421.851	74.009	150.485	27.137
1957	30.840	3.700	17.269	13.568	3.700	24.670	145.551	1150.840	478.591	34.538	11.101	7.401
1958	4.930	3.700	3.700	2.467	2.467	25.903	421.851	1224.849	1586.259	241.763	102.379	27.137
1959	8.630	6.167	3.700	2.467	2.467	72.775	2249.873	1807.052	3220.624	398.415	119.648	88.811
1960	99.910	24.670	20.969	0.000	0.000	59.207	445.287	1874.894	356.477	275.067	60.441	45.639
1961	19.740	9.868	0.000	0.000	0.000	18.502	1064.496	2138.859	5442.127	540.266	94.978	71.542
1962	55.510	28.370	18.502	19.736	9.868	28.370	522.997	1145.906	2299.212	130.749	12.335	46.872
1963	9.870	8.634	33.304	3.700	3.700	27.137	164.053	1873.661	1762.647	130.749	86.344	81.410
1964	62.908	51.806	37.004	23.436	18.502	97.445	896.742	3332.871	418.151	974.452	49.339	44.405
1965	40.705	28.370	28.370	25.903	18.502	65.375	485.992	294.802	1425.906	91.278	38.238	29.604
1966	17.269	9.868	9.868	4.934	3.700	2.467	1662.735	1173.042	218.326	25.903	6.167	6.167
1967	4.934	3.700	4.934	2.467	2.467	111.013	1349.430	1010.223	1045.994	74.009	4.934	53.040
1968	18.502	9.868	18.502	4.934	2.467	4.934	965.817	964.584	569.869	54.273	27.137	17.269
1969	16.035	11.101	9.868	6.167	4.934	9.868	869.605	1614.629	859.738	44.405	18.502	11.101
1970	8.634	4.934	12.335	4.934	3.700	69.075	551.367	1427.140	2302.913	43.172	16.035	11.101
1971	7.401	4.934	3.700	2.467	1.233	88.811	1174.276	209.692	1633.131	128.282	-	-

Table 2
Elevation-Area-Capacity table for Tawa Reservoir
(Based on 1990 Survey)

Elevation m	Area M Sq.m	Capacity M Cu.m
326.140	13.796	33.057
327.664	15.941	42.925
329.188	18.089	55.753
330.712	22.962	70.802
332.236	27.834	90.168
333.760	32.707	114.344
335.284	37.579	144.318
336.808	44.252	183.172
338.332	51.411	233.745
339.856	58.331	296.653
341.380	65.248	375.596
342.904	75.713	471.067
344.428	86.186	581.587
345.952	96.651	713.447
347.476	107.124	867.138
349.000	120.010	1044.760
350.524	132.891	1245.694
352.048	154.100	1470.188
353.572	175.342	1717.748
355.097	196.346	2028.586
356.621	217.373	2288.234
358.145	233.896	2602.032

Table 3
Normal Monthly Evaporation Depths (m)
for Tawa Reservoir

Month	Evaporation	Month	Evaporation
Jan	0.121	Jul	0.091
Feb	0.121	Aug	0.091
Mar	0.152	Sep	0.121
Apr	0.213	Oct	0.121
May	0.304	Nov	0.121
Jun	0.243	Dec	0.121

Table 4
Target Monthly Demands from the Tawa Reservoir

Month	Irrigation Demands (M Cum) LBC	Irrigation Demands (M Cum) RBC	Upstream use Demands (M Cum)	Water Supply Demands (M Cum)
Jan	224.658	60.825	0.000	0.985
Feb	153.528	39.419	0.000	0.889
Mar	143.669	33.485	0.000	0.985
Apr	57.045	0.000	0.000	0.953
May	79.581	0.000	0.000	0.985
Jun	205.643	38.148	0.000	0.953
Jul	88.737	26.704	88.811	0.985
Aug	84.511	25.432	66.608	0.985
Sep	219.024	59.129	66.608	0.953
Oct	252.829	45.566	0.000	0.985
Nov	216.912	58.493	0.000	0.953
Dec	169.726	44.294	0.000	0.985

Table 5
Monthly Yield Estimation for Tawa Reservoir

Month	Monthly Yield (M Cum)					
	Probability Level for Value to be Equalled or Exceeded 50%	60%	70%	75%	80%	90%
Jan	14.249	11.760	9.706	8.750	7.846	5.985
Feb	8.452	7.230	6.202	5.715	5.248	4.260
Mar	7.545	6.321	5.323	4.860	4.423	3.518
Apr	3.480	3.146	2.870	2.740	2.615	2.346
May	3.174	2.741	2.371	2.194	2.023	1.657
Jun	31.357	23.916	17.917	15.209	12.720	7.929
Jul	701.127	580.966	467.807	410.206	352.599	225.151
Aug	1189.448	1015.313	846.378	758.104	667.941	459.655
Sep	949.810	755.282	589.391	511.172	437.001	286.530
Oct	109.893	83.472	62.858	53.740	45.443	29.620
Nov	31.392	23.831	17.804	15.105	12.636	7.914
Dec	23.801	19.181	15.168	13.247	11.407	7.605

Table 6
Initial Rule Curve Levels (m) for Tawa Reservoir

Month	Upper Rule Curve	Irrigation Rule Curve	Water Supply & Upstream use Rule Curve
Jan	349.40	348.30	335.80
Feb	347.80	345.50	335.80
Mar	346.00	342.90	335.80
Apr	345.10	339.70	335.60
May	343.80	338.10	335.40
Jun	355.40	349.20	335.80
Jul	355.40	346.90	335.80
Aug	355.40	348.70	335.80
Sep	355.40	352.70	335.80
Oct	354.30	353.60	335.80
Nov	352.90	351.90	335.80
Dec	351.50	350.00	335.80

Table 7
Recommended Rule Curve Levels (m) for Tawa Reservoir

Month	Upper Rule Curve	Irrigation Rule Curve	Water Supply & Upstream use Rule Curve
Jan	352.55	347.60	335.80
Feb	351.30	342.20	335.80
Mar	350.05	339.60	335.80
Apr	349.40	336.60	335.60
May	348.45	335.90	335.40
Jun	353.40	337.00	335.80
Jul	354.90	339.60	335.80
Aug	355.40	348.00	335.80
Sep	355.40	352.40	335.80
Oct	355.40	353.00	335.80
Nov	354.60	351.60	335.80
Dec	353.75	349.10	335.80

Table 8
Simulation of Tawa Reservoir with Current Operation Policy

YYYY-Mn-D	Ini_Sto m m3	Loc_Flo m m3	Evapr m m3	Tir Dem m m3	Pw_Dem M kwh	Ws_Dem m m3	Tds_Dem m m3	Releas m m3	Pw_Gen M kwh	Spill m m3	End_Lev m	Dal m	Frl m
1948-06-0	678.8	.0	19.9	243.8	.0	1.0	.0	244.7	9.4	.0	342.00	334.24	354.39
1948-07-0	414.2	1449.3	10.9	115.4	.0	89.8	.0	205.2	7.6	.0	353.14	334.24	354.39
1948-08-0	1647.4	2647.1	16.2	109.9	.0	67.6	.0	177.5	7.1	2216.3	354.39	334.24	354.39
1948-09-0	1884.5	1800.9	22.6	278.2	.0	67.6	.0	345.7	9.4	1432.6	354.39	334.24	354.39
1948-10-0	1884.5	246.7	22.3	298.4	.0	1.0	.0	299.4	9.4	.0	354.02	334.24	354.39
1948-11-0	1809.5	222.0	21.7	275.4	.0	1.0	.0	276.4	9.4	.0	353.65	334.24	354.39
1948-12-0	1733.5	50.6	20.4	214.0	.0	1.0	.0	215.0	9.4	.0	352.53	334.24	354.39
1949-01-0	1548.7	33.3	18.0	285.5	.0	1.0	.0	286.5	9.4	.0	350.74	334.24	354.39
1949-02-0	1277.6	12.3	15.6	192.9	.0	.9	.0	193.8	9.4	.0	349.27	334.24	354.39
1949-03-0	1080.5	8.6	17.6	177.2	.0	1.0	.0	178.1	9.4	.0	347.70	334.24	354.39
1949-04-0	893.4	6.2	22.7	57.0	.0	1.0	.0	58.0	3.7	.0	347.08	334.24	354.39
1949-05-0	818.9	3.7	33.5	79.6	.0	1.0	.0	80.6	5.1	.0	345.93	334.24	354.39
1949-06-0	711.6	27.1	20.9	243.8	.0	1.0	.0	244.7	9.4	.0	342.93	334.24	354.39
1949-07-0	473.0	564.9	8.2	115.4	.0	89.8	.0	205.2	7.0	.0	347.05	334.24	354.39
1949-08-0	824.5	648.8	11.0	109.9	.0	67.6	.0	177.5	5.8	.0	350.79	334.24	354.39
1949-09-0	1284.8	2362.1	19.6	278.2	.0	67.6	.0	345.7	9.4	1397.2	354.39	334.24	354.39
1949-10-0	1884.5	424.3	22.6	298.4	.0	1.0	.0	299.4	9.4	102.4	354.39	334.24	354.39
1949-11-0	1884.5	99.9	21.7	275.4	.0	1.0	.0	276.4	9.4	.0	353.38	334.24	354.39
1949-12-0	1686.3	30.8	19.8	214.0	.0	1.0	.0	215.0	9.4	.0	352.12	334.24	354.39
1950-01-0	1482.3	19.7	17.2	285.5	.0	1.0	.0	286.5	9.4	.0	350.16	334.24	354.39
1950-02-0	1198.3	23.4	15.8	192.9	.0	.9	.0	193.8	9.4	.0	348.73	334.24	354.39
1950-03-0	1013.0	3.9	16.9	177.2	.0	1.0	.0	178.1	9.4	.0	347.09	334.24	354.39
1950-04-0	827.8	4.9	21.7	57.0	.0	1.0	.0	58.0	3.7	.0	346.34	334.24	354.39
1950-05-0	753.0	3.7	29.0	79.6	.0	1.0	.0	80.6	4.9	.0	345.19	334.24	354.39
1950-06-0	647.2	4.9	19.2	243.8	.0	1.0	.0	244.7	9.4	.0	341.58	334.24	354.39
1950-07-0	388.2	1434.5	10.6	115.4	.0	89.8	.0	205.2	7.5	.0	352.89	334.24	354.39
1950-08-0	1606.9	474.9	16.6	109.9	.0	67.6	.0	177.5	6.7	3.7	354.39	334.24	354.39
1950-09-0	1884.5	643.9	22.6	278.2	.0	67.6	.0	345.7	9.4	275.6	354.39	334.24	354.39
1950-10-0	1884.5	23.2	21.2	298.4	.0	1.0	.0	299.4	9.4	.0	352.76	334.24	354.39
1950-11-0	1586.1	18.5	18.9	275.4	.0	1.0	.0	276.4	9.4	.0	350.96	334.24	354.39
1950-12-0	1309.9	16.3	15.9	214.0	.0	1.0	.0	215.0	9.4	.0	349.38	334.24	354.39
1951-01-0	1095.1	17.3	13.7	285.5	.0	1.0	.0	286.5	9.4	.0	346.93	334.24	354.39
1951-02-0	812.2	7.4	11.6	192.9	.0	.9	.0	193.8	9.4	.0	344.80	334.24	354.39
1951-03-0	614.1	4.9	12.1	177.2	.0	1.0	.0	178.1	9.4	.0	342.23	334.24	354.39
1951-04-0	428.8	3.7	14.4	57.0	.0	1.0	.0	58.0	3.0	.0	341.08	334.24	354.39
1951-05-0	360.1	3.7	14.1	79.6	.0	1.0	.0	80.6	4.0	.0	339.09	334.24	354.39
1951-06-0	265.2	82.6	18.8	243.8	.0	1.0	.0	213.11	8.6	.0	334.24	334.24	354.39
1951-07-0	124.8	213.4	4.2	115.4	.0	89.8	.0	205.2	4.3	.0	334.50	334.24	354.39
1951-08-0	128.8	1038.6	6.9	109.9	.0	67.6	.0	177.5	4.5	.0	348.47	334.24	354.39
1951-09-0	983.1	515.6	14.6	278.2	.0	67.6	.0	345.7	9.4	.0	349.71	334.24	354.39
1951-10-0	1138.3	95.0	14.3	298.4	.0	1.0	.0	299.4	9.4	.0	347.93	334.24	354.39
1951-11-0	919.6	12.3	12.2	275.4	.0	1.0	.0	276.4	9.4	.0	345.14	334.24	354.39
1951-12-0	643.3	7.4	9.8	214.0	.0	1.0	.0	215.0	9.4	.0	342.18	334.24	354.39
1952-01-0	425.9	8.6	6.5	285.5	.0	1.0	.0	286.5	9.4	.0	335.14	334.24	354.39
1952-02-0	141.6	11.1	4.3	192.5	.0	.9	.0	34.50	.7	.0	334.24	334.24	354.39
1952-03-0	125.8	3.7	5.2	177.2	.0	1.0	.0	1.00	.0	.0	334.12	334.24	354.39
1952-04-0	121.4	2.5	7.1	57.0	.0	1.0	.0	1.00	.0	.0	333.83	334.24	354.39
1952-05-0	115.8	2.5	9.8	79.6	.0	1.0	.0	1.00	.0	.0	333.33	334.24	354.39
1952-06-0	107.5	58.0	6.0	243.8	.0	1.0	.0	33.70	.5	.0	334.24	334.24	354.39
1952-07-0	123.8	736.4	5.7	115.4	.0	89.8	.0	205.2	5.7	.0	345.21	334.24	354.39
1952-08-0	649.3	1087.9	11.5	109.9	.0	67.6	.0	177.5	5.9	.0	352.53	334.24	354.39
1952-09-0	1548.2	155.4	18.3	278.2	.0	67.6	.0	345.7	9.4	.0	351.16	334.24	354.39
1952-10-0	1339.6	18.5	15.8	298.4	.0	1.0	.0	299.4	9.4	.0	348.98	334.24	354.39
1952-11-0	1042.9	7.4	13.3	275.4	.0	1.0	.0	276.4	9.4	.0	346.42	334.24	354.39
1952-12-0	760.6	6.2	11.0	214.0	.0	1.0	.0	215.0	9.4	.0	343.87	334.24	354.39
1953-01-0	540.8	4.9	8.2	285.5	.0	1.0	.0	286.5	9.4	.0	338.75	334.24	354.39
1953-02-0	251.0	4.9	5.3	192.9	.0	.9	.0	126.80	4.6	.0	334.24	334.24	354.39
1953-03-0	123.8	3.7	5.2	177.2	.0	1.0	.0	1.00	.0	.0	334.12	334.24	354.39
1953-04-0	121.4	2.5	7.1	57.0	.0	1.0	.0	1.00	.0	.0	333.83	334.24	354.39
1953-05-0	115.8	2.5	9.8	79.6	.0	1.0	.0	1.00	.0	.0	333.33	334.24	354.39
1953-06-0	107.5	16.0	7.8	243.8	.0	1.0	.0	1.00	.0	.0	333.78	334.24	354.39
1953-07-0	114.8	548.9	4.8	115.4	.0	89.8	.0	205.2	5.3	.0	342.63	334.24	354.39
1953-08-0	453.6	1883.5	11.8	109.9	.0	67.6	.0	177.5	5.9	263.3	354.39	334.24	354.39
1953-09-0	1884.5	314.5	22.4	278.2	.0	67.6	.0	345.7	9.4	.0	354.13	334.24	354.39
1953-10-0	1830.9	80.2	21.0	298.4	.0	1.0	.0	299.4	9.4	.0	352.79	334.24	354.39
1953-11-0	1590.7	14.8	18.4	275.4	.0	1.0	.0	276.4	9.4	.0	350.97	334.24	354.39
1953-12-0	1310.8	9.9	15.8	214.0	.0	1.0	.0	215.0	9.4	.0	349.34	334.24	354.39
1954-01-0	1089.8	8.6	13.6	285.5	.0	1.0	.0	286.5	9.4	.0	346.79	334.24	354.39
1954-02-0	794.4	7.4	11.5	192.9	.0	.9	.0	193.8	9.4	.0	344.65	334.24	354.39
1954-03-0	608.4	3.7	11.9	177.2	.0	1.0	.0	178.1	9.4	.0	341.99	334.24	354.39
1954-04-0	414.0	2.5	14.1	57.0	.0	1.0	.0	58.0	3.3	.0	340.78	334.24	354.39
1954-05-0	344.4	1.2	17.5	79.6	.0	1.0	.0	80.6	3.9	.0	338.67	334.24	354.39
1954-06-0	247.6	13.5	18.6	243.8	.0	1.0	.0	151.00	4.3	.0	334.24	334.24	354.39
1954-07-0	121.8	532.9	4.9	115.4	.0	89.8	.0	205.2	5.3	.0	342.51	334.24	354.39
1954-08-0	446.6	588.4	8.1	109.9	.0	67.6	.0	177.5	5.1	.0	347.38	334.24	354.39
1954-09-0	849.5	298.6	15.2	278.2	.0	67.6	.0	345.7	9.4	.0	351.43	334.24	354.39
1954-10-0	1378.3	130.7	16.6	298.4	.0	1.0	.0	299.4	9.4	.0	350.13	334.24	354.39
1954-11-0	1193.7	28.4	14.6	275.4	.0	1.0	.0	276.4	9.4	.0	348.82	334.24	354.39
1954-12-0	931.1	14.0	12.8	214.0	.0	1.0	.0	215.0	9.4	.0	346.00	334.24	354.39
1955-01-0	718.2	11.1	10.2	285.5	.0	1.0	.0	286.5	9.4	.0	342.29	334.24	354.39
1955-02-0	432.7	7.4	7.5	192.9	.0	.9	.0	193.8	9.4	.0	338.45	334.24	354.39
1955-03-0	238.8	5.7	6.6	177.2	.0	1.0	.0	112.10	4.1	.0	334.24	334.24	354.39
1955-04-0	123.8	2.5	7.2	57.0	.0	1.0	.0	1.00	.0	.0	333.95	334.24	354.39
1955-05-0	114.2	2.5	9.9	79.6	.0	1.0	.0	1.00	.0	.0	333.47	334.24	354.39

YYYY Mn D	Ini_Sto m m3	Loc_Flo m m3	Evapr m m3	Tir_Dem m m3	Pw_Dem M kwh	Ws_Dem m m3	Tds_Dem m m3	Releas m m3	Pw_Gen M kwh	Split m m3	End_Lev m	Dal m	Fri m
1955-06-0	109.7	102.4	8.0	243.8	.0	1.0	.0	80.30	2.2	.0	334.24	334.24	354.39
1955-07-0	123.8	125.8	3.1	115.4	.0	89.8	.0	122.70	1.6	.0	334.24	334.24	354.39
1955-08-0	123.8	1124.9	7.1	109.9	.0	67.6	.0	177.5	4.5	.0	349.15	334.24	354.39
1955-09-0	1064.2	1300.1	18.6	278.2	.0	67.6	.0	345.7	9.4	115.4	354.39	334.24	354.39
1955-10-0	1884.5	869.6	22.6	298.4	.0	1.0	.0	299.4	9.4	547.6	354.39	334.24	354.39
1955-11-0	1884.5	41.9	21.4	275.4	.0	1.0	.0	276.4	9.4	.0	353.02	334.24	354.39
1955-12-0	1628.6	24.7	19.2	214.0	.0	1.0	.0	215.0	9.4	.0	351.70	334.24	354.39
1956-01-0	1419.1	14.8	16.6	285.5	.0	1.0	.0	286.5	9.4	.0	349.65	334.24	354.39
1956-02-0	1130.8	7.4	14.4	192.9	.0	.9	.0	193.8	9.4	.0	348.02	334.24	354.39
1956-03-0	930.0	6.2	16.0	177.2	.0	1.0	.0	178.1	9.4	.0	346.24	334.24	354.39
1956-04-0	742.1	2.5	20.4	57.0	.0	1.0	.0	58.0	3.6	.0	345.41	334.24	354.39
1956-05-0	666.2	2.5	26.9	79.6	.0	1.0	.0	80.6	4.8	.0	344.15	334.24	354.39
1956-06-0	561.1	65.4	18.0	243.8	.0	1.0	.0	244.7	9.4	.0	341.15	334.24	354.39
1956-07-0	363.7	801.8	8.1	115.4	.0	89.8	.0	205.2	6.9	.0	348.21	334.24	354.39
1956-08-0	952.2	590.8	11.7	109.9	.0	67.6	.0	177.5	6.0	.0	351.26	334.24	354.39
1956-09-0	1353.8	421.9	17.7	278.2	.0	67.6	.0	345.7	9.4	.0	351.66	334.24	354.39
1956-10-0	1412.3	74.0	16.7	298.4	.0	1.0	.0	299.4	9.4	.0	349.95	334.24	354.39
1956-11-0	1170.2	150.5	14.9	275.4	.0	1.0	.0	276.4	9.4	.0	348.87	334.24	354.39
1956-12-0	1029.4	27.1	13.5	214.0	.0	1.0	.0	215.0	9.4	.0	347.09	334.24	354.39
1957-01-0	828.0	30.8	11.4	285.5	.0	1.0	.0	286.5	9.4	.0	344.14	334.24	354.39
1957-02-0	561.0	3.7	9.0	192.9	.0	.9	.0	193.8	9.4	.0	341.11	334.24	354.39
1957-03-0	361.8	17.3	8.3	177.2	.0	1.0	.0	178.1	8.5	.0	337.09	334.24	354.39
1957-04-0	192.6	13.6	8.8	57.0	.0	1.0	.0	58.0	2.9	.0	335.04	334.24	354.39
1957-05-0	139.4	3.7	10.8	79.6	.0	1.0	.0	8.50	.2	.0	334.24	334.24	354.39
1957-06-0	123.8	24.7	8.3	243.8	.0	1.0	.0	16.30	.4	.0	334.24	334.24	354.39
1957-07-0	123.8	145.6	3.1	115.4	.0	89.8	.0	142.40	1.7	.0	334.24	334.24	354.39
1957-08-0	123.8	1150.8	7.2	109.9	.0	67.6	.0	177.5	4.5	.0	349.34	334.24	354.39
1957-09-0	1090.0	478.6	15.3	278.2	.0	67.6	.0	345.7	9.4	.0	350.29	334.24	354.39
1957-10-0	1207.5	34.5	14.6	298.4	.0	1.0	.0	299.4	9.4	.0	348.00	334.24	354.39
1957-11-0	928.1	11.1	12.3	275.4	.0	1.0	.0	276.4	9.4	.0	345.22	334.24	354.39
1957-12-0	650.5	7.4	9.9	214.0	.0	1.0	.0	215.0	9.4	.0	342.30	334.24	354.39
1958-01-0	433.0	4.9	6.5	285.5	.0	1.0	.0	286.5	9.4	.0	335.31	334.24	354.39
1958-02-0	144.9	3.7	4.4	192.9	.0	.9	.0	20.40	.6	.0	334.24	334.24	354.39
1958-03-0	123.8	3.7	5.2	177.2	.0	1.0	.0	1.00	.0	.0	334.12	334.24	354.39
1958-04-0	121.4	2.5	7.1	57.0	.0	1.0	.0	1.00	.0	.0	333.83	334.24	354.39
1958-05-0	115.8	2.5	9.8	79.6	.0	1.0	.0	1.00	.0	.0	333.33	334.24	354.39
1958-06-0	107.5	25.9	6.8	243.8	.0	1.0	.0	1.60	.0	.0	334.24	334.24	354.39
1958-07-0	123.8	421.9	4.6	115.4	.0	89.8	.0	205.2	5.1	.0	348.62	334.24	354.39
1958-08-0	336.1	1224.8	5.4	109.9	.0	67.6	.0	177.5	5.3	.0	351.39	334.24	354.39
1958-09-0	1374.0	1586.3	20.1	278.2	.0	67.6	.0	345.7	9.4	710.0	354.39	334.24	354.39
1958-10-0	1884.5	241.8	22.9	298.4	.0	1.0	.0	299.4	9.4	.0	354.00	334.24	354.39
1958-11-0	1834.6	102.4	21.0	275.4	.0	1.0	.0	276.4	9.4	.0	352.91	334.24	354.39
1958-12-0	1609.6	27.1	19.0	214.0	.0	1.0	.0	215.0	9.4	.0	351.59	334.24	354.39
1959-01-0	1402.8	8.6	16.4	285.5	.0	1.0	.0	286.5	9.4	.0	349.48	334.24	354.39
1959-02-0	1108.5	6.2	14.2	192.9	.0	.9	.0	193.8	9.4	.0	347.82	334.24	354.39
1959-03-0	906.7	3.7	15.7	177.2	.0	1.0	.0	178.1	9.4	.0	345.98	334.24	354.39
1959-04-0	716.5	2.5	20.0	57.0	.0	1.0	.0	58.0	3.5	.0	345.11	334.24	354.39
1959-05-0	641.0	2.5	26.3	79.6	.0	1.0	.0	80.6	4.7	.0	343.81	334.24	354.39
1959-06-0	536.6	72.8	17.6	243.8	.0	1.0	.0	244.7	9.4	.0	340.83	334.24	354.39
1959-07-0	347.1	2243.9	11.3	115.4	.0	89.8	.0	205.2	8.0	495.9	354.39	334.24	354.39
1959-08-0	1884.5	1807.1	17.0	109.9	.0	67.6	.0	177.5	7.2	1612.5	354.39	334.24	354.39
1959-09-0	1884.5	3220.6	22.6	278.2	.0	67.6	.0	345.7	9.4	2852.3	354.39	334.24	354.39
1959-10-0	1884.5	398.4	22.6	298.4	.0	1.0	.0	299.4	9.4	76.5	354.39	334.24	354.39
1959-11-0	1884.5	119.6	21.8	275.4	.0	1.0	.0	276.4	9.4	.0	353.58	334.24	354.39
1959-12-0	1765.3	88.8	20.3	214.0	.0	1.0	.0	215.0	9.4	.0	352.60	334.24	354.39
1960-01-0	1559.4	99.5	18.4	285.5	.0	1.0	.0	286.5	9.4	.0	351.26	334.24	354.39
1960-02-0	1354.4	24.7	16.4	192.9	.0	.9	.0	193.8	9.4	.0	349.94	334.24	354.39
1960-03-0	1168.8	21.0	18.6	177.2	.0	1.0	.0	178.1	9.4	.0	348.56	334.24	354.39
1960-04-0	993.1	.0	24.1	57.0	.0	1.0	.0	58.0	3.8	.0	347.85	334.24	354.39
1960-05-0	911.0	.0	32.3	79.6	.0	1.0	.0	80.6	5.2	.0	346.79	334.24	354.39
1960-06-0	798.1	59.2	23.0	243.8	.0	1.0	.0	244.7	9.4	.0	344.52	334.24	354.39
1960-07-0	589.5	445.3	8.7	115.4	.0	89.8	.0	205.2	7.2	.0	347.02	334.24	354.39
1960-08-0	820.9	1874.9	13.2	109.9	.0	67.6	.0	177.5	6.5	620.6	354.39	334.24	354.39
1960-09-0	1884.5	356.5	22.5	278.2	.0	67.6	.0	345.7	9.4	.0	354.33	334.24	354.39
1960-10-0	1872.7	275.1	22.3	298.4	.0	1.0	.0	299.4	9.4	.0	354.10	334.24	354.39
1960-11-0	1826.1	60.4	21.0	275.4	.0	1.0	.0	276.4	9.4	.0	352.78	334.24	354.39
1960-12-0	1589.2	45.6	18.9	214.0	.0	1.0	.0	215.0	9.4	.0	351.58	334.24	354.39
1961-01-0	1401.0	19.7	16.5	285.5	.0	1.0	.0	286.5	9.4	.0	349.55	334.24	354.39
1961-02-0	1117.8	9.5	14.3	192.9	.0	.9	.0	193.8	9.4	.0	347.93	334.24	354.39
1961-03-0	919.5	.0	15.8	177.2	.0	1.0	.0	178.1	9.4	.0	346.07	334.24	354.39
1961-04-0	725.6	.0	20.1	57.0	.0	1.0	.0	58.0	3.5	.0	345.19	334.24	354.39
1961-05-0	647.5	.0	26.4	79.6	.0	1.0	.0	80.6	4.7	.0	343.86	334.24	354.39
1961-06-0	540.5	16.5	17.1	243.8	.0	1.0	.0	244.7	9.4	.0	339.87	334.24	354.39
1961-07-0	297.2	1064.5	8.4	115.4	.0	89.8	.0	205.2	6.9	.0	349.78	334.24	354.39
1961-08-0	1148.0	2138.9	14.3	109.9	.0	67.6	.0	177.5	6.7	1210.6	354.39	334.24	354.39
1961-09-0	1884.5	5442.1	22.6	278.2	.0	67.6	.0	345.7	9.4	5073.8	354.39	334.24	354.39
1961-10-0	1884.5	540.3	22.6	298.4	.0	1.0	.0	299.4	9.4	218.3	354.39	334.24	354.39
1961-11-0	1884.5	95.0	21.7	275.4	.0	1.0	.0	276.4	9.4	.0	353.35	334.24	354.39
1961-12-0	1681.4	71.5	20.0	214.0	.0	1.0	.0	215.0	9.4	.0	352.34	334.24	354.39
1962-01-0	1517.5	55.5	17.7	285.5	.0	1.0	.0	286.5	9.4	.0	350.68	334.24	354.39
1962-02-0	1269.2	28.4	15.6	192.9	.0	.9	.0	193.8	9.4	.0	349.33	334.24	354.39
1962-03-0	1088.2	18.5	17.7	177.2	.0	1.0	.0	178.1	9.4	.0	347.85	334.24	354.39
1962-04-0	910.8	19.7	23.0	57.0	.0	1.0	.0	58.0	3.8	.0	347.30	334.24	354.39
1962-05-0	849.5	9.3	31.1	79.6	.0	1.0	.0	80.6	5.1	.0	346.27	334.24	354.39

YYYY-Mn-D	Ini_Sto m m3	Loc Flo m m3	Evapr m m3	Tir_Dem m m3	Pw_Dem M kwh	Ws_Dem m m3	Tds_Dem m m3	Releas m m3	Pw_Gen M kwh	Spill m m3	End_Lev m	Dsl m	Frl m
1962-06-0	747.7	28.4	21.7	243.8	.0	1.0	.0	244.7	9.4	.0	343.44	334.24	354.39
1962-07-0	509.6	525.9	8.3	115.4	.0	89.8	.0	205.2	7.0	.0	347.00	334.24	354.39
1962-08-0	819.1	3145.7	12.9	109.9	.0	67.6	.0	177.5	6.1	.0	353.85	334.24	354.39
1962-09-0	1774.6	2299.2	22.1	278.2	.0	67.6	.0	345.7	9.4	1821.4	354.39	334.24	354.39
1962-10-0	1884.5	130.7	21.8	298.4	.0	1.0	.0	299.4	9.4	.0	353.43	334.24	354.39
1962-11-0	1694.1	12.3	19.5	275.4	.0	1.0	.0	276.4	9.4	.0	351.64	334.24	354.39
1962-12-0	1410.6	46.9	16.9	214.0	.0	1.0	.0	215.0	9.4	.0	350.37	334.24	354.39
1963-01-0	1225.5	9.9	14.7	285.5	.0	1.0	.0	286.5	9.4	.0	348.05	334.24	354.39
1963-02-0	934.2	8.6	12.7	192.9	.0	.9	.0	193.8	9.4	.0	346.18	334.24	354.39
1963-03-0	736.3	53.3	14.0	177.2	.0	1.0	.0	178.1	9.4	.0	344.37	334.24	354.39
1963-04-0	577.4	3.7	17.5	57.0	.0	1.0	.0	58.0	3.3	.0	343.38	334.24	354.39
1963-05-0	505.5	3.7	22.4	79.6	.0	1.0	.0	80.6	4.4	.0	341.87	334.24	354.39
1963-06-0	400.3	27.1	13.5	243.8	.0	1.0	.0	244.7	9.4	.0	336.49	334.24	354.39
1963-07-0	175.1	164.1	3.6	115.4	.0	89.8	.0	205.2	4.6	.0	334.58	334.24	354.39
1963-08-0	130.4	1873.7	9.9	109.9	.0	67.6	.0	177.5	5.0	.0	354.06	334.24	354.39
1963-09-0	1816.6	1762.6	22.5	278.2	.0	67.6	.0	345.7	9.4	1326.8	354.39	334.24	354.39
1963-10-0	1884.5	130.7	21.8	298.4	.0	1.0	.0	299.4	9.4	.0	353.43	334.24	354.39
1963-11-0	1694.1	35.5	19.9	275.4	.0	1.0	.0	276.4	9.4	.0	352.13	334.24	354.39
1963-12-0	1464.2	81.4	17.9	214.0	.0	1.0	.0	215.0	9.4	.0	351.11	334.24	354.39
1964-01-0	1332.7	62.9	16.0	285.5	.0	1.0	.0	286.5	9.4	.0	349.37	334.24	354.39
1964-02-0	1093.1	51.8	14.2	192.9	.0	.9	.0	193.8	9.4	.0	348.07	334.24	354.39
1964-03-0	936.8	37.0	16.2	177.2	.0	1.0	.0	178.1	9.4	.0	346.61	334.24	354.39
1964-04-0	779.5	23.4	21.1	57.0	.0	1.0	.0	58.0	3.2	.0	346.05	334.24	354.39
1964-05-0	725.8	18.5	28.5	79.6	.0	1.0	.0	80.6	4.9	.0	345.02	334.24	354.39
1964-06-0	633.2	97.4	20.1	243.8	.0	1.0	.0	244.7	9.4	.0	342.82	334.24	354.39
1964-07-0	465.8	896.7	9.2	115.4	.0	89.8	.0	205.2	7.3	.0	349.78	334.24	354.39
1964-08-0	1148.1	3332.9	14.3	109.9	.0	67.6	.0	177.5	6.7	2484.7	354.39	334.24	354.39
1964-09-0	1884.5	416.2	22.6	278.2	.0	67.6	.0	345.7	9.4	49.9	354.39	334.24	354.39
1964-10-0	1884.5	974.5	22.6	298.4	.0	1.0	.0	299.4	9.4	652.5	354.39	334.24	354.39
1964-11-0	1884.5	49.5	21.5	275.4	.0	1.0	.0	276.4	9.4	.0	353.07	334.24	354.39
1964-12-0	1636.8	44.4	19.4	214.0	.0	1.0	.0	215.0	9.4	.0	351.88	334.24	354.39
1965-01-0	1446.0	40.7	17.8	285.5	.0	1.0	.0	286.5	9.4	.0	350.05	334.24	354.39
1965-02-0	1183.3	28.4	14.9	192.9	.0	.9	.0	193.8	9.4	.0	348.64	334.24	354.39
1965-03-0	1002.9	28.4	16.9	177.2	.0	1.0	.0	178.1	9.4	.0	347.17	334.24	354.39
1965-04-0	836.3	25.9	22.8	57.0	.0	1.0	.0	58.0	3.7	.0	346.63	334.24	354.39
1965-05-0	782.2	18.5	29.8	79.6	.0	1.0	.0	80.6	5.0	.0	345.68	334.24	354.39
1965-06-0	690.3	65.4	20.9	243.8	.0	1.0	.0	244.7	9.4	.0	343.17	334.24	354.39
1965-07-0	490.0	486.0	8.1	115.4	.0	89.8	.0	205.2	6.9	.0	346.44	334.24	354.39
1965-08-0	762.7	294.8	9.4	109.9	.0	67.6	.0	177.5	5.5	.0	347.51	334.24	354.39
1965-09-0	870.5	1425.9	17.8	278.2	.0	67.6	.0	345.7	9.4	48.5	354.39	334.24	354.39
1965-10-0	1884.5	91.3	21.6	298.4	.0	1.0	.0	299.4	9.4	.0	353.18	334.24	354.39
1965-11-0	1654.8	38.2	19.2	275.4	.0	1.0	.0	276.4	9.4	.0	351.55	334.24	354.39
1965-12-0	1397.5	29.6	16.8	214.0	.0	1.0	.0	215.0	9.4	.0	350.14	334.24	354.39
1966-01-0	1195.3	17.3	14.5	285.5	.0	1.0	.0	286.5	9.4	.0	347.86	334.24	354.39
1966-02-0	911.6	9.0	12.5	192.9	.0	.9	.0	193.8	9.4	.0	345.97	334.24	354.39
1966-03-0	715.1	9.3	13.6	177.2	.0	1.0	.0	178.1	9.4	.0	343.76	334.24	354.39
1966-04-0	533.3	4.9	16.7	57.0	.0	1.0	.0	58.0	3.2	.0	342.78	334.24	354.39
1966-05-0	463.6	3.7	21.2	79.6	.0	1.0	.0	80.6	4.3	.0	341.19	334.24	354.39
1966-06-0	365.5	2.5	12.0	243.8	.0	1.0	.0	232.21	9.4	.0	334.24	334.24	354.39
1966-07-0	123.8	1612.7	9.0	115.4	.0	89.8	.0	205.2	6.6	.0	352.68	334.24	354.39
1966-08-0	1572.4	1173.0	15.5	109.9	.0	67.6	.0	177.5	7.0	667.5	354.39	334.24	354.39
1966-09-0	1884.5	218.3	22.0	278.2	.0	67.6	.0	345.7	9.4	.0	353.66	334.24	354.39
1966-10-0	1735.1	25.9	19.8	298.4	.0	1.0	.0	299.4	9.4	.0	351.86	334.24	354.39
1966-11-0	1441.8	6.2	16.8	275.4	.0	1.0	.0	276.4	9.4	.0	349.83	334.24	354.39
1966-12-0	1154.8	6.2	14.5	214.0	.0	1.0	.0	215.0	9.4	.0	348.03	334.24	354.39
1967-01-0	931.5	4.9	12.2	285.5	.0	1.0	.0	286.5	9.4	.0	345.08	334.24	354.39
1967-02-0	637.7	3.7	9.8	192.9	.0	.9	.0	193.8	9.4	.0	342.57	334.24	354.39
1967-03-0	437.7	4.9	5.6	177.2	.0	1.0	.0	178.1	5.0	.0	338.85	334.24	354.39
1967-04-0	255.0	2.5	10.5	57.0	.0	1.0	.0	58.0	2.6	.0	336.98	334.24	354.39
1967-05-0	188.9	2.5	12.1	79.6	.0	1.0	.0	55.50	2.1	.0	334.24	334.24	354.39
1967-06-0	125.8	111.0	8.3	243.8	.0	1.0	.0	102.70	2.5	.0	334.24	334.24	354.39
1967-07-0	125.8	1349.4	7.7	115.4	.0	89.8	.0	205.2	6.3	.0	350.62	334.24	354.39
1967-08-0	1260.4	1010.2	14.6	109.9	.0	67.6	.0	177.5	6.6	194.0	354.39	334.24	354.39
1967-09-0	1884.5	1046.3	22.6	278.2	.0	67.6	.0	345.7	9.4	677.7	354.39	334.24	354.39
1967-10-0	1884.5	74.0	23.5	298.4	.0	1.0	.0	299.4	9.4	.0	353.08	334.24	354.39
1967-11-0	1637.6	4.1	18.8	275.4	.0	1.0	.0	276.4	9.4	.0	351.21	334.24	354.39
1967-12-0	1347.4	35.0	16.4	214.0	.0	1.0	.0	215.0	9.4	.0	349.94	334.24	354.39
1968-01-0	1152.1	18.5	14.3	285.5	.0	1.0	.0	286.5	9.4	.0	347.64	334.24	354.39
1968-02-0	865.8	9.9	12.5	192.9	.0	.9	.0	193.8	9.4	.0	345.69	334.24	354.39
1968-03-0	650.5	16.5	13.3	177.2	.0	1.0	.0	178.1	9.4	.0	343.55	334.24	354.39
1968-04-0	517.6	4.1	16.3	57.0	.0	1.0	.0	58.0	3.2	.0	342.54	334.24	354.39
1968-05-0	444.2	3.5	20.7	79.6	.0	1.0	.0	80.6	4.2	.0	340.87	334.24	354.39
1968-06-0	340.4	4.9	11.8	243.8	.0	1.0	.0	218.71	9.5	.0	334.24	334.24	354.39
1968-07-0	123.8	961.5	6.5	115.4	.0	89.8	.0	205.2	5.8	.0	347.57	334.24	354.39
1968-08-0	878.0	554.6	12.6	109.9	.0	67.6	.0	177.5	6.1	.0	351.17	334.24	354.39
1968-09-0	1652.4	569.9	21.4	278.2	.0	67.6	.0	345.7	9.4	.0	354.25	334.24	354.39
1968-10-0	1859.1	54.9	21.1	298.4	.0	1.0	.0	299.4	9.4	.0	352.78	334.24	354.39
1968-11-0	1548.9	27.1	18.4	275.4	.0	1.0	.0	276.4	9.4	.0	351.84	334.24	354.39
1968-12-0	1321.2	17.3	16.0	214.0	.0	1.0	.0	215.0	9.4	.0	349.68	334.24	354.39
1969-01-0	1107.5	16.0	13.8	285.5	.0	1.0	.0	286.5	9.4	.0	347.84	334.24	354.39
1969-02-0	823.3	11.1	11.7	192.9	.0	.9	.0	193.8	9.4	.0	344.77	334.24	354.39
1969-03-0	628.8	9.9	12.4	177.2	.0	1.0	.0	178.1	9.4	.0	342.54	334.24	354.39
1969-04-0	448.1	6.2	14.8	57.0	.0	1.0	.0	58.0	3.1	.0	341.67	334.24	354.39
1969-05-0	581.5	4.9	16.7	79.6	.0	1.0	.0	80.6	4.0	.0	339.63	334.24	354.39

YYYY Mn-D	Ini_Sto m m3	Loc_Flo m m3	Evapr m m3	Tir_Dem m m3	Pw_Dem M kwh	Ws_Dem m m3	Tds_Dem m m3	Releas m m3	Pw_Gen M kwh	Spill m m3	End_Lev m	Del m	Fri m
1969-06-0	287.1	9.9	11.1	243.8	.0	1.0	.0	162.00	5.7	.0	334.24	334.24	354.39
1969-07-0	123.8	869.6	6.2	115.4	.0	89.8	.0	205.2	5.8	.0	346.69	334.24	354.39
1969-08-0	782.0	1614.6	13.1	109.9	.0	67.6	.0	177.5	6.3	321.6	354.39	334.24	354.39
1969-09-0	1884.5	859.7	22.6	278.2	.0	67.6	.0	345.7	9.4	491.4	354.39	334.24	354.39
1969-10-0	1884.5	44.4	21.3	298.4	.0	1.0	.0	299.4	9.4	.0	352.90	334.24	354.39
1969-11-0	1688.2	18.5	18.6	275.4	.0	1.0	.0	276.4	9.4	.0	351.11	334.24	354.39
1969-12-0	1331.8	11.1	16.1	214.0	.0	1.0	.0	215.0	9.4	.0	349.51	334.24	354.39
1970-01-0	1111.8	8.6	13.8	285.5	.0	1.0	.0	286.5	9.4	.0	347.01	334.24	354.39
1970-02-0	820.2	4.9	11.7	192.9	.0	.9	.0	193.8	9.4	.0	344.87	334.24	354.39
1970-03-0	619.6	12.5	12.3	177.2	.0	1.0	.0	178.1	9.4	.0	342.43	334.24	354.39
1970-04-0	441.5	4.9	14.6	57.0	.0	1.0	.0	58.0	3.1	.0	341.54	334.24	354.39
1970-05-0	373.8	3.7	18.5	79.6	.0	1.0	.0	80.6	4.0	.0	339.41	334.24	354.39
1970-06-0	278.4	65.1	11.0	243.8	.0	1.0	.0	212.71	6.6	.0	334.24	334.24	354.39
1970-07-0	123.8	551.4	5.0	115.4	.0	89.8	.0	205.2	5.4	.0	342.81	334.24	354.39
1970-08-0	465.0	1427.1	11.3	109.9	.0	67.6	.0	177.5	5.7	.0	353.49	334.24	354.39
1970-09-0	1703.3	2302.9	21.8	278.2	.0	67.6	.0	345.7	9.4	1754.2	354.39	334.24	354.39
1970-10-0	1884.5	43.2	21.3	298.4	.0	1.0	.0	293.4	9.4	.0	352.89	334.24	354.39
1970-11-0	1607.0	16.0	18.5	275.4	.0	1.0	.0	276.4	9.4	.0	351.08	334.24	354.39
1970-12-0	1328.1	11.1	16.0	214.0	.0	1.0	.0	215.0	9.4	.0	349.48	334.24	354.39
1971-01-0	1108.2	7.4	13.8	285.5	.0	1.0	.0	286.5	9.4	.0	346.96	334.24	354.39
1971-02-0	815.3	4.9	11.6	192.9	.0	.9	.0	193.8	9.4	.0	344.81	334.24	354.39
1971-03-0	614.8	3.7	12.1	177.2	.0	1.0	.0	178.1	9.4	.0	342.22	334.24	354.39
1971-04-0	428.2	2.5	14.4	57.0	.0	1.0	.0	58.0	3.0	.0	341.05	334.24	354.39
1971-05-0	358.3	1.2	18.0	79.6	.0	1.0	.0	80.6	4.0	.0	338.99	334.24	354.39
1971-06-0	261.0	88.8	10.8	243.8	.0	1.0	.0	215.21	6.7	.0	334.24	334.24	354.39
1971-07-0	123.8	1174.3	7.1	115.4	.0	89.8	.0	205.2	6.2	.0	349.31	334.24	354.39
1971-08-0	1085.7	209.7	11.2	109.9	.0	67.6	.0	177.5	5.9	.0	349.47	334.24	354.39
1971-09-0	1165.7	1033.1	18.8	278.2	.0	67.6	.0	345.7	9.4	490.8	354.39	334.24	354.39
1971-10-0	1884.5	128.3	21.8	298.4	.0	1.0	.0	299.4	9.4	.0	353.41	334.24	354.39

Number of Failures for WS. = 0, Time Reliability = 1.00

Number of Failures for IRR. = 32, Time Reliability = .886

Number of Critical Failures = 27
(Release < .75 * Total Demand)

Volume Reliability for IRR. & WS. = .94

Table 9
Simulation of Tawa Reservoir with Recommended Operation Policy

YYYY Mn-D	Ini_Sto m m3	Loc_Flo m m3	Evapr m m3	Tir_Dem m m3	Pw_Dem M kwh	Ws_Dem m m3	Tds_Dem m m3	Releas m m3	Pw_Gen M kwh	Spill m m3	End_lev m	Mdl_Rul m	Upr_Rul m
1948-06-0	1008.0	.0	26.1	243.8	.0	1.0	.0	244.7	9.4	.0	346.11	337.00	353.40
1948-07-0	723.2	1449.3	13.2	115.4	.0	89.8	.0	205.2	8.3	.0	354.76	339.60	354.90
1948-08-0	1960.1	2047.1	17.8	109.9	.0	67.6	.0	177.5	7.2	2332.1	355.40	348.00	355.40
1948-09-0	2079.7	1800.9	24.3	278.2	.0	67.6	.0	345.7	9.4	1439.9	355.40	352.40	355.40
1948-10-0	2079.7	246.7	25.9	298.4	.0	1.0	.0	299.4	9.4	.0	354.97	353.00	355.40
1948-11-0	2003.1	222.0	23.2	275.4	.0	1.0	.0	276.4	9.4	.0	354.59	351.60	354.60
1948-12-0	1925.5	50.6	22.2	214.0	.0	1.0	.0	215.0	9.4	.0	353.68	349.10	353.75
1949-01-0	1739.8	35.3	20.0	285.5	.0	1.0	.0	286.5	9.4	.0	352.02	347.60	352.55
1949-02-0	1465.4	12.3	17.5	192.9	.0	.9	.0	193.8	9.4	.0	350.67	342.20	351.30
1949-03-0	1266.8	8.6	19.5	177.2	.0	1.0	.0	178.1	9.4	.0	349.25	339.60	350.05
1949-04-0	1077.8	6.2	25.4	57.0	.0	1.0	.0	58.0	3.9	.0	348.62	336.60	349.40
1949-05-0	1000.5	3.7	34.3	79.6	.0	1.0	.0	80.6	5.4	.0	347.67	335.90	348.45
1949-06-0	849.4	27.1	24.3	243.8	.0	1.0	.0	244.7	9.4	.0	345.19	337.00	353.40
1949-07-0	647.5	564.9	9.5	115.4	.0	89.8	.0	205.2	7.5	.0	348.60	339.60	354.90
1949-08-0	957.7	648.8	12.3	109.9	.0	67.6	.0	177.5	6.1	.0	351.96	348.00	355.40
1949-09-0	1455.7	2362.1	21.4	278.2	.0	67.6	.0	345.7	9.4	1372.9	355.40	352.40	355.40
1949-10-0	2079.7	424.3	24.3	298.4	.0	1.0	.0	299.4	9.4	100.7	355.40	353.00	355.40
1949-11-0	2079.7	21.9	23.4	275.4	.0	1.0	.0	276.4	9.4	.0	354.37	351.60	354.60
1949-12-0	1875.5	30.8	21.7	214.0	.0	1.0	.0	215.0	9.4	.0	353.30	349.10	353.75
1950-01-0	1674.8	19.7	19.2	285.5	.0	1.0	.0	286.5	9.4	.0	351.49	347.60	352.55
1950-02-0	1580.1	23.4	16.7	192.9	.0	.9	.0	193.8	9.4	.0	350.18	342.20	351.30
1950-03-0	1200.9	5.9	18.8	177.2	.0	1.0	.0	178.1	9.4	.0	348.79	339.60	350.05
1950-04-0	1013.8	4.9	24.5	57.0	.0	1.0	.0	58.0	3.9	.0	348.07	336.60	349.40
1950-05-0	936.3	3.7	32.9	79.6	.0	1.0	.0	80.6	5.3	.0	347.07	335.90	348.45
1950-06-0	826.5	4.9	22.9	243.8	.0	1.0	.0	244.7	9.4	.0	344.18	337.00	353.40
1950-07-0	563.9	1434.5	12.0	115.4	.0	89.8	.0	205.2	8.0	.0	353.68	339.60	354.90
1950-08-0	1781.1	474.9	17.2	109.9	.0	67.6	.0	177.5	6.9	.0	355.29	348.00	355.40
1950-09-0	2061.2	643.9	24.2	278.2	.0	67.6	.0	345.7	9.4	255.5	355.40	352.40	355.40
1950-10-0	2077.7	22.2	23.0	298.4	.0	1.0	.0	299.4	9.4	.0	353.88	353.00	355.40
1950-11-0	1779.5	18.5	20.3	275.4	.0	1.0	.0	276.4	9.4	.0	352.24	351.60	354.60
1950-12-0	1501.3	16.0	17.7	214.0	.0	1.0	.0	215.0	9.4	.0	350.79	349.10	353.75
1951-01-0	1264.6	17.3	15.5	285.5	.0	1.0	.0	286.5	9.4	.0	348.62	347.60	352.55
1951-02-0	1060.1	7.4	13.3	192.9	.0	.9	.0	193.8	9.4	.0	346.61	342.20	351.30
1951-03-0	830.4	4.9	14.5	177.2	.0	1.0	.0	178.1	9.4	.0	344.79	339.60	350.05
1951-04-0	612.6	3.7	18.2	57.0	.0	1.0	.0	58.0	3.4	.0	343.66	336.60	349.40
1951-05-0	540.1	3.7	23.5	79.6	.0	1.0	.0	80.6	4.5	.0	342.40	335.90	348.45
1951-06-0	459.8	82.6	15.4	243.8	.0	1.0	.0	244.7	9.4	.0	339.92	337.00	353.40
1951-07-0	262.3	213.4	5.1	115.4	.0	89.8	.0	184.57	4.6	.0	339.60	339.60	354.90
1951-08-0	286.1	1038.6	8.3	109.9	.0	67.6	.0	177.5	5.0	.0	349.71	348.00	355.40
1951-09-0	1198.8	517.6	16.3	278.2	.0	67.6	.0	276.21	9.4	.0	351.31	352.40	355.40
1951-10-0	1361.9	94.0	16.3	298.4	.0	1.0	.0	224.81	9.4	.0	350.29	353.00	355.40
1951-11-0	1275.5	13.3	15.0	275.4	.0	1.0	.0	207.51	9.4	.0	348.66	351.60	354.60
1951-12-0	1065.3	7.4	13.4	214.0	.0	1.0	.0	161.51	8.5	.0	347.18	349.10	353.75
1952-01-0	837.7	6.6	11.8	285.5	.0	1.0	.0	215.11	9.4	.0	344.87	347.60	352.55
1952-02-0	619.5	11.1	9.7	192.9	.0	.9	.0	193.8	9.4	.0	342.20	342.20	351.30
1952-03-0	427.1	3.7	9.7	177.2	.0	1.0	.0	135.01	6.9	.0	339.60	339.60	350.05
1952-04-0	246.1	2.5	12.3	57.0	.0	1.0	.0	58.0	2.7	.0	337.89	336.60	349.40
1952-05-0	219.2	2.5	13.3	79.6	.0	1.0	.0	60.71	2.5	.0	335.42	335.90	348.45
1952-06-0	147.7	58.0	9.5	243.8	.0	1.0	.0	38.72	1.1	.0	335.90	337.00	353.40
1952-07-0	157.5	756.4	6.1	115.4	.0	89.8	.0	205.2	5.9	.0	345.53	339.60	354.90
1952-08-0	682.5	1047.9	11.7	109.9	.0	67.6	.0	177.5	5.9	.0	352.73	348.00	355.40
1952-09-0	1561.2	155.4	19.1	278.2	.0	67.6	.0	276.21	9.4	.0	351.85	352.40	355.40
1952-10-0	1441.4	18.5	17.1	298.4	.0	1.0	.0	224.81	9.4	.0	350.31	353.00	355.40
1952-11-0	1218.0	7.4	15.0	275.4	.0	1.0	.0	207.51	9.4	.0	348.64	351.60	354.60
1952-12-0	1002.9	6.2	13.4	214.0	.0	1.0	.0	161.51	8.5	.0	347.15	349.10	353.75
1953-01-0	814.1	4.9	11.7	285.5	.0	1.0	.0	215.11	9.4	.0	344.78	347.60	352.55
1953-02-0	612.3	4.9	9.6	192.9	.0	.9	.0	180.61	9.4	.0	342.20	342.20	351.30
1953-03-0	427.0	3.7	9.7	177.2	.0	1.0	.0	134.81	6.9	.0	339.60	339.60	350.05
1953-04-0	286.1	2.5	11.5	57.0	.0	1.0	.0	58.0	2.7	.0	337.89	336.60	349.40
1953-05-0	219.2	2.5	13.3	79.6	.0	1.0	.0	60.71	2.5	.0	335.42	335.90	348.45
1953-06-0	147.7	11.0	9.4	243.8	.0	1.0	.0	1.00	.0	.0	335.64	337.00	353.40
1953-07-0	153.4	546.9	5.3	115.4	.0	89.8	.0	205.2	5.6	.0	343.19	339.60	354.90
1953-08-0	451.7	1861.5	12.7	109.9	.0	67.6	.0	177.5	6.0	105.4	355.40	348.00	355.40
1953-09-0	2079.7	314.5	24.6	278.2	.0	67.6	.0	345.7	9.4	.0	355.08	352.40	355.40
1953-10-0	2024.5	80.2	22.7	298.4	.0	1.0	.0	299.4	9.4	.0	353.89	353.00	355.40
1953-11-0	1782.6	14.8	20.4	275.4	.0	1.0	.0	276.4	9.4	.0	352.24	351.60	354.60
1953-12-0	1500.7	9.3	17.7	214.0	.0	1.0	.0	215.0	9.4	.0	350.74	349.10	353.75
1954-01-0	1277.9	8.6	15.2	285.5	.0	1.0	.0	286.5	9.4	.0	348.49	347.60	352.55
1954-02-0	984.8	7.4	13.1	192.9	.0	.9	.0	193.8	9.4	.0	346.66	342.20	351.30
1954-03-0	745.2	3.7	14.4	177.2	.0	1.0	.0	178.1	9.4	.0	344.60	339.60	350.05
1954-04-0	596.4	2.5	17.1	57.0	.0	1.0	.0	58.0	3.3	.0	343.62	336.60	349.40
1954-05-0	523.0	1.2	22.9	79.6	.0	1.0	.0	80.6	4.4	.0	342.10	335.90	348.45
1954-06-0	420.7	18.5	14.0	243.8	.0	1.0	.0	235.71	9.4	.0	337.00	337.00	353.40
1954-07-0	189.5	532.9	5.7	115.4	.0	89.8	.0	205.2	5.8	.0	343.46	339.60	354.90
1954-08-0	511.5	580.4	8.7	109.9	.0	67.6	.0	163.01	5.9	.0	348.00	348.00	355.40
1954-09-0	928.2	390.6	16.4	278.2	.0	67.6	.0	276.21	9.4	.0	352.39	352.40	355.40
1954-10-0	1526.2	190.7	18.6	298.4	.0	1.0	.0	224.81	9.4	.0	351.56	353.00	355.40
1954-11-0	1413.6	28.4	16.9	275.4	.0	1.0	.0	207.51	9.4	.0	350.31	351.60	354.60
1954-12-0	1217.5	14.8	15.2	214.0	.0	1.0	.0	161.51	9.0	.0	349.08	349.10	353.75
1955-01-0	1055.8	11.1	13.7	285.5	.0	1.0	.0	215.11	9.4	.0	347.19	347.60	352.55
1955-02-0	837.1	7.4	11.9	192.9	.0	.9	.0	193.8	9.4	.0	345.10	342.20	351.30
1955-03-0	659.7	3.7	12.5	177.2	.0	1.0	.0	178.1	9.4	.0	342.61	339.60	350.05
1955-04-0	452.7	2.5	14.9	57.0	.0	1.0	.0	58.0	3.1	.0	341.49	336.60	349.40
1955-05-0	382.3	2.5	18.7	79.6	.0	1.0	.0	80.6	4.0	.0	339.59	335.90	348.45

YYYY-Mo-D	Ini_Sto m m3	Loc_Flo m m3	Evapr m m3	Tir_Dem m m3	Pw_Dem M kwh	Ws_Dem m m3	Tds_Dem m m3	Releas m m3	Pw_Gen M kwh	Spill m m3	End_Lev m	Mdl_Rul m	Upr_Rul m
1955-06-0	285.5	102.4	12.4	243.8	.0	1.0	.0	185.91	8.5	.0	337.00	337.00	353.40
1955-07-0	189.5	125.8	3.9	115.4	.0	89.8	.0	154.01	2.6	.0	335.80	339.60	354.90
1955-08-0	157.5	1124.9	7.4	109.9	.0	67.6	.0	177.5	4.7	.0	349.40	348.00	355.40
1955-09-0	1097.4	1300.1	19.4	278.2	.0	67.6	.0	345.7	9.4	.0	355.12	352.40	355.40
1955-10-0	2032.5	869.6	24.0	298.4	.0	1.0	.0	299.4	9.4	499.0	355.40	353.00	355.40
1955-11-0	2079.7	41.9	23.2	275.4	.0	1.0	.0	275.4	9.4	.0	354.08	351.60	354.60
1955-12-0	1822.1	24.7	21.1	214.0	.0	1.0	.0	215.0	9.4	.0	352.91	349.10	353.75
1956-01-0	1610.7	14.8	18.5	285.5	.0	1.0	.0	286.5	9.4	.0	351.03	347.60	352.55
1956-02-0	1320.5	7.4	16.0	192.9	.0	.9	.0	193.8	9.4	.0	349.56	342.20	351.30
1956-03-0	1118.1	6.2	18.0	177.2	.0	1.0	.0	178.1	9.4	.0	348.00	339.60	350.05
1956-04-0	928.1	2.5	23.2	57.0	.0	1.0	.0	58.0	3.8	.0	347.30	336.60	349.40
1956-05-0	849.4	2.5	31.1	79.6	.0	1.0	.0	80.6	5.1	.0	346.22	335.90	348.45
1956-06-0	740.3	65.4	21.9	243.8	.0	1.0	.0	244.7	9.4	.0	343.84	337.00	353.40
1956-07-0	539.0	801.8	9.4	115.4	.0	89.8	.0	205.2	7.4	.0	349.62	339.60	354.90
1956-08-0	1126.0	590.8	12.9	109.9	.0	67.6	.0	177.5	6.2	.0	352.39	348.00	355.40
1956-09-0	1526.4	421.9	19.5	278.2	.0	67.6	.0	345.7	9.4	.0	352.74	352.40	355.40
1956-10-0	1583.0	74.0	18.9	298.4	.0	1.0	.0	224.81	9.4	.0	351.66	353.00	355.40
1956-11-0	1413.4	150.5	17.6	275.4	.0	1.0	.0	207.51	9.4	.0	351.16	351.60	354.60
1956-12-0	1338.8	27.1	16.2	214.0	.0	1.0	.0	215.0	9.4	.0	349.68	349.10	353.75
1957-01-0	1134.7	30.8	14.2	285.5	.0	1.0	.0	269.81	9.4	.0	347.60	347.60	352.55
1957-02-0	881.6	3.7	12.2	192.9	.0	.9	.0	193.8	9.4	.0	345.56	342.20	351.30
1957-03-0	679.2	17.3	13.1	177.2	.0	1.0	.0	178.1	9.4	.0	343.37	339.60	350.05
1957-04-0	505.2	13.6	16.2	57.0	.0	1.0	.0	58.0	3.2	.0	342.48	336.60	349.40
1957-05-0	444.6	3.7	20.6	79.6	.0	1.0	.0	80.6	4.2	.0	340.83	335.90	348.45
1957-06-0	347.2	24.7	12.8	243.8	.0	1.0	.0	183.81	7.2	.0	336.49	337.00	353.40
1957-07-0	175.2	145.6	3.8	115.4	.0	89.8	.0	159.51	2.8	.0	335.80	339.60	354.90
1957-06-0	157.5	1150.8	7.5	109.9	.0	67.6	.0	177.5	4.7	.0	349.00	348.00	355.40
1957-09-0	1123.3	478.6	16.0	278.2	.0	67.6	.0	276.21	9.4	.0	350.96	352.40	355.40
1957-10-0	1309.7	34.5	15.9	298.4	.0	1.0	.0	224.81	9.4	.0	349.45	353.00	355.40
1957-11-0	1103.6	11.1	14.1	275.4	.0	1.0	.0	207.51	9.4	.0	347.70	351.60	354.60
1957-12-0	893.1	7.4	12.5	214.0	.0	1.0	.0	161.51	8.2	.0	346.08	349.10	353.75
1958-01-0	726.5	4.9	10.7	285.5	.0	1.0	.0	215.10	9.4	.0	343.38	347.60	352.55
1958-02-0	505.6	3.7	8.6	192.9	.0	.9	.0	145.60	7.9	.0	340.98	342.20	351.30
1958-03-0	355.1	3.7	8.5	177.2	.0	1.0	.0	133.91	5.2	.0	337.81	339.60	350.05
1958-04-0	216.4	2.5	9.6	57.0	.0	1.0	.0	43.71	1.8	.0	336.12	336.60	349.40
1958-05-0	165.6	2.5	12.1	79.6	.0	1.0	.0	8.70	.3	.0	335.40	335.90	348.45
1958-06-0	147.3	25.9	9.5	243.8	.0	1.0	.0	6.20	.2	.0	335.80	337.00	353.40
1958-07-0	157.5	421.9	4.8	115.4	.0	89.8	.0	205.2	5.4	.0	341.26	339.60	354.90
1958-08-0	369.3	1224.8	9.7	109.9	.0	67.6	.0	177.5	5.4	.0	351.62	348.00	355.40
1958-09-0	1407.0	1586.3	21.1	278.2	.0	67.6	.0	345.7	9.4	546.7	355.40	352.40	355.40
1958-10-0	2079.7	241.8	23.9	298.4	.0	1.0	.0	299.4	9.4	.0	354.95	353.00	355.40
1958-11-0	1998.2	102.4	22.7	275.4	.0	1.0	.0	276.4	9.4	.0	353.98	351.60	354.60
1958-12-0	1801.5	27.1	20.9	214.0	.0	1.0	.0	215.0	9.4	.0	352.80	349.10	353.75
1959-01-0	1592.7	8.6	18.3	285.5	.0	1.0	.0	286.5	9.4	.0	350.87	347.60	352.55
1959-02-0	1296.6	6.2	15.8	192.9	.0	.9	.0	193.8	9.4	.0	349.37	342.20	351.30
1959-03-0	1093.2	3.7	17.7	177.2	.0	1.0	.0	178.1	9.4	.0	347.77	339.60	350.05
1959-04-0	901.0	2.5	22.8	57.0	.0	1.0	.0	58.0	3.7	.0	347.04	336.60	349.40
1959-05-0	822.7	2.5	30.5	79.6	.0	1.0	.0	80.6	5.1	.0	345.96	335.90	348.45
1959-06-0	714.1	72.8	21.5	243.8	.0	1.0	.0	244.7	9.4	.0	343.59	337.00	353.40
1959-07-0	520.6	2249.3	12.5	115.4	.0	89.8	.0	205.2	8.4	564.4	354.90	339.60	354.90
1959-08-0	1988.4	1807.1	17.9	109.9	.0	67.6	.0	177.5	7.2	1520.3	355.40	348.00	355.40
1959-09-0	2079.7	3220.6	24.3	278.2	.0	67.6	.0	345.7	9.4	2850.7	355.40	352.40	355.40
1959-10-0	2079.7	398.4	24.3	298.4	.0	1.0	.0	299.4	9.4	74.8	355.40	353.00	355.40
1959-11-0	2079.7	119.6	23.5	275.4	.0	1.0	.0	276.4	9.4	.0	354.46	351.60	354.60
1959-12-0	1899.5	88.8	22.1	214.0	.0	1.0	.0	215.0	9.4	.0	353.74	349.10	353.75
1960-01-0	1751.2	99.9	20.5	285.5	.0	1.0	.0	286.5	9.4	.0	352.50	347.60	352.55
1960-02-0	1544.2	24.7	18.4	192.9	.0	.9	.0	193.8	9.4	.0	351.28	342.20	351.30
1960-03-0	1356.7	21.0	20.7	177.2	.0	1.0	.0	178.1	9.4	.0	350.02	339.60	350.05
1960-04-0	1178.8	.0	26.8	57.0	.0	1.0	.0	58.0	4.0	.0	349.37	336.60	349.40
1960-05-0	1034.0	.0	36.2	79.6	.0	1.0	.0	80.6	5.5	.0	348.42	335.90	348.45
1960-06-0	977.2	59.2	26.2	243.8	.0	1.0	.0	244.7	9.4	.0	346.47	337.00	353.40
1960-07-0	765.5	445.3	9.9	115.4	.0	89.8	.0	205.2	7.6	.0	348.58	339.60	354.90
1960-08-0	995.7	1874.9	14.4	109.9	.0	67.6	.0	177.5	6.6	599.0	355.40	348.00	355.40
1960-09-0	2079.7	356.5	24.2	278.2	.0	67.6	.0	345.7	9.4	.0	355.32	352.40	355.40
1960-10-0	2066.3	275.1	23.3	298.4	.0	1.0	.0	299.4	9.4	.0	355.05	353.00	355.40
1960-11-0	2018.1	60.4	22.7	275.4	.0	1.0	.0	276.4	9.4	.0	353.87	351.60	354.60
1960-12-0	1779.4	45.6	20.8	214.0	.0	1.0	.0	215.0	9.4	.0	352.78	349.10	353.75
1961-01-0	1589.3	19.7	14.3	285.5	.0	1.0	.0	286.5	9.4	.0	350.92	347.60	352.55
1961-02-0	1304.2	9.9	15.9	192.9	.0	.9	.0	193.8	9.4	.0	349.45	342.20	351.30
1961-03-0	1104.4	.0	17.8	177.2	.0	1.0	.0	178.1	9.4	.0	347.83	339.60	350.05
1961-04-0	908.5	.0	22.9	57.0	.0	1.0	.0	58.0	3.8	.0	347.08	336.60	349.40
1961-05-0	827.8	.0	30.6	79.6	.0	1.0	.0	80.6	5.1	.0	345.98	335.90	348.45
1961-06-0	716.5	18.5	20.9	243.8	.0	1.0	.0	244.7	9.4	.0	342.88	337.00	353.40
1961-07-0	469.3	1064.5	9.8	115.4	.0	89.8	.0	205.2	7.5	.0	351.02	339.60	354.90
1961-08-0	1318.7	2138.9	15.5	109.9	.0	67.6	.0	177.5	6.9	1184.9	355.40	348.00	355.40
1961-09-0	2079.7	5442.1	24.3	278.2	.0	67.6	.0	345.7	9.4	5072.2	355.40	352.40	355.40
1961-10-0	2079.7	540.3	24.3	298.4	.0	1.0	.0	299.4	9.4	216.6	355.40	353.00	355.40
1961-11-0	2079.7	95.0	23.4	275.4	.0	1.0	.0	276.4	9.4	.0	354.34	351.60	354.60
1961-12-0	1874.9	71.5	21.8	214.0	.0	1.0	.0	215.0	9.4	.0	353.52	349.10	353.75
1962-01-0	1709.7	55.5	19.8	285.5	.0	1.0	.0	286.5	9.4	.0	351.97	347.60	352.55
1962-02-0	1458.9	28.4	17.5	192.9	.0	.9	.0	193.8	9.4	.0	350.73	342.20	351.30
1962-03-0	1275.9	18.5	19.7	177.2	.0	1.0	.0	178.1	9.4	.0	349.39	339.60	350.05
1962-04-0	1096.6	19.7	25.8	57.0	.0	1.0	.0	58.0	4.0	.0	348.90	336.60	349.40
1962-05-0	1032.5	9.9	35.0	79.6	.0	1.0	.0	80.6	5.4	.0	347.99	335.90	348.45

YYYY-Mo-D	Ini_Sto m m3	Loc_Flo m m3	Evapr m m3	Tir_Dem m m3	Pw_Dem M kwh	Wa_Dem m m3	Tds_Dem m m3	Release m m3	Pw_Gen M kwh	Spill m m3	End_Lev m	Mil_Rul m	Upr_Rul m
1962-06-0	926.8	20.4	25.0	243.8	.0	1.0	.0	244.7	9.4	.0	345.63	337.00	353.40
1962-07-0	685.4	523.0	9.6	115.4	.0	89.8	.0	205.2	7.5	.0	348.56	339.60	354.90
1962-08-0	993.6	1145.9	14.0	109.9	.0	67.6	.0	177.5	6.9	.0	354.70	348.00	355.40
1962-09-0	1948.0	2239.2	23.7	278.2	.0	67.6	.0	345.7	9.4	1798.1	355.40	352.40	355.40
1962-10-0	2079.7	130.7	23.4	298.4	.0	1.0	.0	299.4	9.4	.0	354.41	353.00	355.40
1962-11-0	1887.6	12.3	21.5	275.4	.0	1.0	.0	276.4	9.4	.0	352.86	351.60	354.60
1962-12-0	1602.3	46.9	19.0	214.0	.0	1.0	.0	215.0	9.4	.0	351.67	349.10	353.75
1963-01-0	1415.2	9.9	16.6	285.5	.0	1.0	.0	286.5	9.4	.0	349.59	347.60	352.55
1963-02-0	1122.0	8.6	14.5	192.9	.0	.9	.0	193.8	9.4	.0	347.95	342.20	351.30
1963-03-0	922.5	33.3	16.0	177.2	.0	1.0	.0	178.1	9.4	.0	346.43	339.60	350.05
1963-04-0	761.6	3.7	20.7	57.0	.0	1.0	.0	58.0	3.6	.0	345.64	336.60	349.40
1963-05-0	686.6	3.7	27.5	79.6	.0	1.0	.0	80.6	4.8	.0	344.44	335.90	348.45
1963-06-0	582.9	27.1	18.1	243.8	.0	1.0	.0	244.7	9.4	.0	340.82	337.00	353.40
1963-07-0	346.5	364.1	5.5	115.4	.0	89.8	.0	205.2	5.8	.0	339.92	339.60	354.90
1963-08-0	[illegible]	1873.7	11.5	109.9	.0	67.6	.0	177.5	[illegible]	.0	354.88	348.00	355.40
1963-09-0	1984.5	1762.6	23.8	278.2	.0	67.6	.0	345.7	9.4	1297.9	355.40	352.40	355.40
1963-10-0	2079.7	130.7	25.4	298.4	.0	1.0	.0	299.4	9.4	.0	354.41	353.00	355.40
1963-11-0	1887.6	86.3	21.7	275.4	.0	1.0	.0	276.4	9.4	.0	353.31	351.60	354.60
1963-12-0	1675.9	81.4	20.0	214.0	.0	1.0	.0	215.0	9.4	.0	352.37	349.10	353.75
1964-01-0	1522.3	62.9	17.8	285.5	.0	1.0	.0	286.5	9.4	.0	350.76	347.60	352.55
1964-02-0	1281.0	51.6	15.8	192.9	.0	.9	.0	193.8	9.4	.0	349.59	342.20	351.30
1964-03-0	1123.1	37.0	18.2	177.2	.0	1.0	.0	178.1	9.4	.0	348.31	339.60	350.05
1964-04-0	963.8	23.4	23.9	57.0	.0	1.0	.0	58.0	3.8	.0	347.80	336.60	349.40
1964-05-0	905.4	18.5	32.4	79.6	.0	1.0	.0	80.6	5.2	.0	346.92	335.90	348.45
1964-06-0	810.9	97.4	23.6	243.8	.0	1.0	.0	244.7	9.4	.0	345.10	337.00	353.40
1964-07-0	640.0	896.7	10.5	115.4	.0	89.8	.0	205.2	7.7	.0	351.04	339.60	354.90
1964-08-0	1321.0	3332.9	15.5	109.9	.0	67.6	.0	177.5	6.9	2381.2	355.40	348.00	355.40
1964-09-0	2079.7	418.2	24.3	278.2	.0	67.6	.0	345.7	9.4	48.2	355.40	352.40	355.40
1964-10-0	2079.7	974.5	24.3	298.4	.0	1.0	.0	299.4	9.4	650.8	355.40	353.00	355.40
1964-11-0	2079.7	49.3	23.2	275.4	.0	1.0	.0	276.4	9.4	.0	354.12	351.60	354.60
1964-12-0	1829.5	44.4	21.3	214.0	.0	1.0	.0	215.0	9.4	.0	353.08	349.10	353.75
1965-01-0	1637.6	40.7	19.0	285.5	.0	1.0	.0	286.5	9.4	.0	351.39	347.60	352.55
1965-02-0	1372.9	28.4	16.6	192.9	.0	.9	.0	193.8	9.4	.0	350.11	342.20	351.30
1965-03-0	1190.8	28.4	18.8	177.2	.0	1.0	.0	178.1	9.4	.0	348.81	339.60	350.05
1965-04-0	1022.2	25.9	24.8	57.0	.0	1.0	.0	58.0	3.9	.0	348.32	336.60	349.40
1965-05-0	965.4	18.5	33.7	79.6	.0	1.0	.0	80.6	5.3	.0	347.50	335.90	348.45
1965-06-0	869.6	65.4	24.3	243.8	.0	1.0	.0	244.7	9.4	.0	345.40	337.00	353.40
1965-07-0	665.9	486.0	9.3	115.4	.0	89.8	.0	205.2	7.4	.0	348.08	339.60	354.90
1965-08-0	937.4	294.8	10.6	109.9	.0	67.6	.0	177.5	5.8	.0	348.99	348.00	355.40
1965-09-0	1044.1	1425.9	19.4	278.2	.0	67.6	.0	345.7	9.4	25.2	355.40	352.40	355.40
1965-10-0	2079.7	91.3	23.3	298.4	.0	1.0	.0	299.4	9.4	.0	354.21	353.00	355.40
1965-11-0	1848.3	38.2	21.1	275.4	.0	1.0	.0	276.4	9.4	.0	352.78	351.60	354.60
1965-12-0	1589.1	29.6	18.8	214.0	.0	1.0	.0	215.0	9.4	.0	351.47	349.10	353.75
1966-01-0	1384.9	17.3	16.3	285.5	.0	1.0	.0	286.5	9.4	.0	349.41	347.60	352.55
1966-02-0	1092.4	9.9	14.1	192.9	.0	.9	.0	193.8	9.4	.0	347.77	342.20	351.30
1966-03-0	901.4	9.9	15.7	177.2	.0	1.0	.0	178.1	9.4	.0	345.90	339.60	350.05
1966-04-0	717.4	4.9	20.8	57.0	.0	1.0	.0	58.0	3.5	.0	345.15	336.60	349.40
1966-05-0	644.3	3.7	26.4	79.6	.0	1.0	.0	80.6	4.7	.0	343.87	335.90	348.45
1966-06-0	541.1	2.5	16.9	243.8	.0	1.0	.0	244.7	9.4	.0	339.50	337.00	353.40
1966-07-0	281.9	1662.7	10.6	115.4	.0	89.8	.0	205.2	7.4	.0	353.63	339.60	354.90
1966-08-0	1728.8	1273.0	17.1	109.9	.0	67.6	.0	177.5	7.1	627.5	355.40	348.00	355.40
1966-09-0	2079.7	218.3	23.6	278.2	.0	67.6	.0	345.7	9.4	.0	354.61	352.40	355.40
1966-10-0	1928.7	25.9	21.6	298.4	.0	1.0	.0	299.4	9.4	.0	353.05	353.00	355.40
1966-11-0	1633.6	6.2	19.1	275.4	.0	1.0	.0	216.41	9.4	.0	351.60	351.60	354.60
1966-12-0	1404.2	6.2	16.7	214.0	.0	1.0	.0	215.0	9.4	.0	350.02	349.10	353.75
1967-01-0	1178.6	4.9	14.3	285.5	.0	1.0	.0	286.5	9.4	.0	347.61	347.60	352.55
1967-02-0	882.8	3.7	12.2	192.9	.0	.9	.0	193.8	9.4	.0	345.57	342.20	351.30
1967-03-0	688.4	4.9	13.1	177.2	.0	1.0	.0	178.1	9.4	.0	343.22	339.60	350.05
1967-04-0	494.1	2.5	15.8	57.0	.0	1.0	.0	58.0	3.2	.0	342.15	336.60	349.40
1967-05-0	422.8	2.5	19.9	79.6	.0	1.0	.0	80.6	4.2	.0	340.40	335.90	348.45
1967-06-0	324.8	111.0	12.9	243.8	.0	1.0	.0	213.41	9.4	.0	337.00	337.00	353.40
1967-07-0	189.5	1349.4	8.4	115.4	.0	89.8	.0	205.2	6.7	.0	351.06	339.60	354.90
1967-08-0	1325.3	1018.2	15.5	109.9	.0	67.6	.0	177.5	6.6	62.8	[illegible]	348.00	355.40
1967-09-0	2079.7	1046.0	24.3	278.2	.0	67.6	.0	345.7	9.4	676.8	355.40	352.40	355.40
1967-10-0	2079.7	74.0	23.2	298.4	.0	1.0	.0	299.4	9.4	.0	354.15	353.00	355.40
1967-11-0	1831.1	4.9	20.8	275.4	.0	1.0	.0	276.4	9.4	.0	352.47	351.60	354.60
1967-12-0	1539.8	53.0	18.4	214.0	.0	1.0	.0	215.0	9.4	.0	351.29	349.10	353.75
1968-01-0	1359.6	10.5	16.1	285.5	.0	1.0	.0	286.5	9.4	.0	349.23	347.60	352.55
1968-02-0	1074.6	9.9	13.9	192.9	.0	.9	.0	193.8	9.4	.0	347.56	342.20	351.30
1968-03-0	876.7	18.5	15.5	177.2	.0	1.0	.0	178.1	9.4	.0	345.62	339.60	350.05
1968-04-0	701.6	4.9	19.8	57.0	.0	1.0	.0	58.0	3.5	.0	344.97	336.60	349.40
1968-05-0	628.8	2.5	26.0	79.6	.0	1.0	.0	80.6	4.7	.0	343.64	335.90	348.45
1968-06-0	524.7	4.9	16.5	243.8	.0	1.0	.0	244.7	9.4	.0	339.17	337.00	353.40
1968-07-0	268.4	965.8	7.9	115.4	.0	89.8	.0	205.2	6.7	.0	348.80	339.60	354.90
1968-08-0	1021.1	964.6	13.6	109.9	.0	67.6	.0	177.5	6.9	.0	353.95	348.00	355.40
1968-09-0	1794.5	569.9	22.7	278.2	.0	67.6	.0	345.7	9.4	.0	354.94	352.40	355.40
1968-10-0	1996.0	54.3	22.4	298.4	.0	1.0	.0	299.4	9.4	.0	353.62	353.00	355.40
1968-11-0	1728.5	27.1	19.9	275.4	.0	1.0	.0	276.4	9.4	.0	351.97	351.60	354.60
1968-12-0	1459.4	17.3	17.3	214.0	.0	1.0	.0	215.0	9.4	.0	350.51	349.10	353.75
1969-01-0	1244.4	16.0	14.9	285.5	.0	1.0	.0	286.5	9.4	.0	348.26	347.60	352.55
1969-02-0	959.0	11.1	12.9	192.9	.0	.9	.0	193.8	9.4	.0	346.45	342.20	351.30
1969-03-0	763.3	9.9	14.1	177.2	.0	1.0	.0	178.1	9.4	.0	344.42	339.60	350.05
1969-04-0	580.9	6.2	17.6	57.0	.0	1.0	.0	58.0	3.3	.0	343.46	336.60	349.40
1969-05-0	511.4	4.9	22.6	79.6	.0	1.0	.0	80.6	4.4	.0	341.98	335.50	348.45

YYYY-Mn-D	Ini_Sto m m3	Loc_Flo m m3	Evapr m m3	Tir_Dem m m3	Pw_Dem M kwh	Ws_Dem m m3	Tds_Dem m m3	Releas m m3	Pw_Gen M kwh	Spill m m3	End_Lev m	Mdl_Rul m	Upr_Rul m
1969-06-0	413.2	9.9	13.9	243.8	.0	1.0	.0	219.6	9.4	.0	337.00	337.00	353.40
1969-07-0	189.5	869.6	6.9	115.4	.0	89.8	.0	205.2	6.3	.0	347.28	339.60	354.90
1969-08-0	847.0	1614.6	13.9	109.9	.0	67.6	.0	177.5	6.4	190.5	355.40	348.00	355.40
1969-09-0	2079.7	859.7	24.3	278.2	.0	67.6	.0	345.7	9.4	489.8	355.40	352.40	355.40
1969-10-0	2079.7	44.4	23.1	298.4	.0	1.0	.0	299.4	9.4	.0	353.98	353.00	355.40
1969-11-0	1801.6	18.5	20.5	275.4	.0	1.0	.0	276.4	9.4	.0	352.37	351.60	354.60
1969-12-0	1523.2	11.1	18.0	214.0	.0	1.0	.0	215.0	9.4	.0	350.90	349.10	353.75
1970-01-0	1301.4	8.6	15.5	285.5	.0	1.0	.0	286.5	9.4	.0	348.69	347.60	352.55
1970-02-0	1008.1	4.9	13.3	192.9	.0	.9	.0	193.8	9.4	.0	346.87	342.20	351.30
1970-03-0	805.9	12.3	14.6	177.2	.0	1.0	.0	178.1	9.4	.0	344.93	339.60	350.05
1970-04-0	625.4	4.9	18.4	57.0	.0	1.0	.0	58.0	3.4	.0	344.05	336.60	349.40
1970-05-0	553.9	3.7	23.9	79.6	.0	1.0	.0	80.6	4.5	.0	342.62	335.90	348.45
1970-06-0	453.1	69.1	15.6	243.8	.0	1.0	.0	244.7	9.4	.0	339.01	337.00	353.40
1970-07-0	261.9	551.4	6.5	115.4	.0	89.8	.0	205.2	6.2	.0	344.66	339.60	354.90
1970-08-0	601.5	1427.1	12.3	109.9	.0	67.6	.0	177.5	5.9	.0	354.17	348.00	355.40
1970-09-0	1838.8	2302.9	23.2	278.2	.0	67.6	.0	345.7	9.4	1693.1	355.40	352.40	355.40
1970-10-0	2079.7	43.2	23.1	298.4	.0	1.0	.0	299.4	9.4	.0	353.98	353.00	355.40
1970-11-0	1800.4	16.0	20.5	275.4	.0	1.0	.0	276.4	9.4	.0	352.35	351.60	354.60
1970-12-0	1519.6	11.1	17.9	214.0	.0	1.0	.0	215.0	9.4	.0	350.88	349.10	353.75
1971-01-0	1297.7	7.4	15.4	285.5	.0	1.0	.0	286.5	9.4	.0	348.64	347.60	352.55
1971-02-0	1003.3	4.9	13.3	192.9	.0	.9	.0	193.8	9.4	.0	346.82	342.20	351.30
1971-03-0	801.1	3.7	14.5	177.2	.0	1.0	.0	178.1	9.4	.0	344.78	339.60	350.05
1971-04-0	612.1	2.5	18.2	57.0	.0	1.0	.0	58.0	3.4	.0	343.83	336.60	349.40
1971-05-0	538.4	1.2	25.4	79.6	.0	1.0	.0	80.6	4.5	.0	342.34	335.90	348.45
1971-06-0	435.7	88.8	15.4	243.8	.0	1.0	.0	244.7	9.4	.0	339.07	337.00	353.40
1971-07-0	264.3	1174.3	8.5	115.4	.0	89.8	.0	205.2	6.9	.0	350.37	339.60	354.90
1971-08-0	1224.9	209.7	12.0	109.9	.0	67.6	.0	177.5	6.1	.0	350.52	348.00	355.40
1971-09-0	1245.0	1633.1	20.2	278.2	.0	67.6	.0	345.7	9.4	432.6	355.40	352.40	355.40
1971-10-0	2079.7	128.3	23.4	298.4	.0	1.0	.0	299.4	9.4	.0	354.39	353.00	355.40

Number of Failures for WS. = 0, Time Reliability = 1.00

Number of Failures for IRR. = 45, Time Reliability = .840

Number of Critical Failures = 4
(Release < .75 * Total Demand)

Volume Reliability for IRR. & WS. = .95

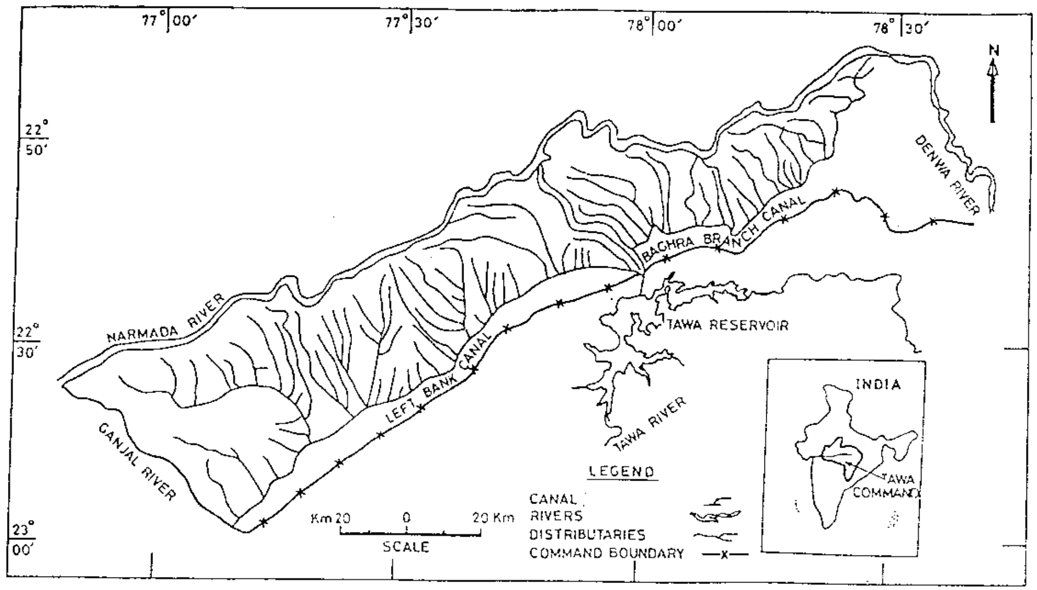

FIG 1 MAP OF TAWA BASIN SHOWING RESERVOIR LOCATION AND MAIN CANAL SYSTEMS

STUDY GROUP

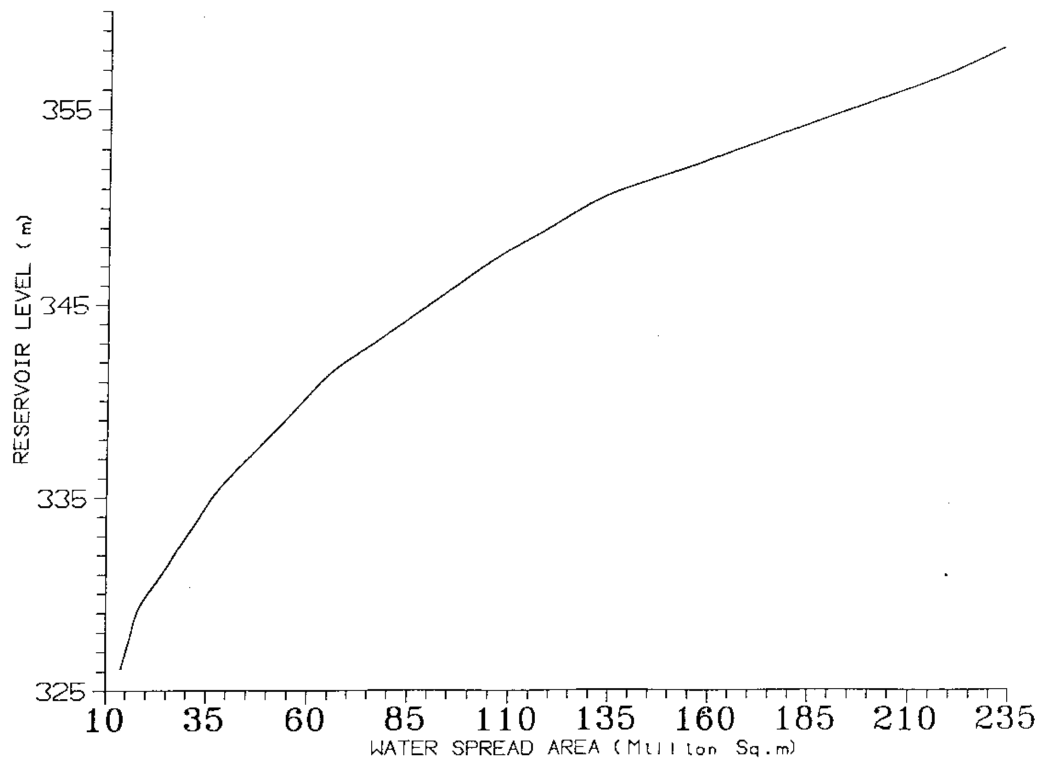

FIG 2 ELEVATION-WATER SPREAD AREA CURVE FOR TAWA RESERVOIR

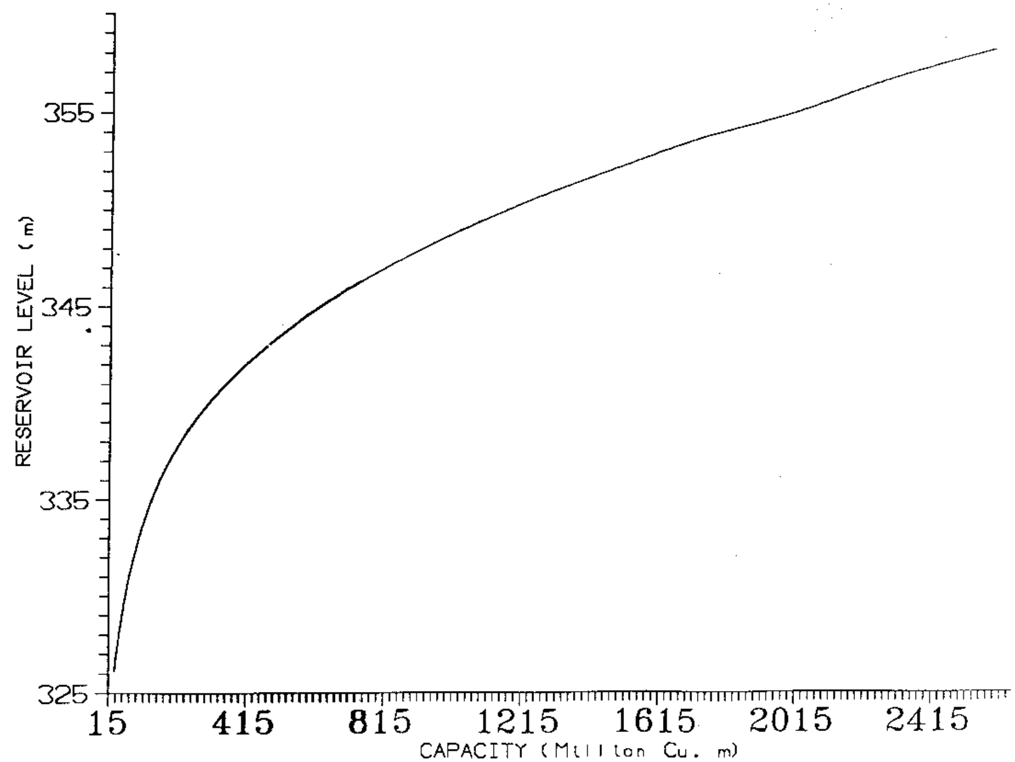

FIG 3 ELEVATION-CAPACITY CURVE FOR TAWA RESERVOIR

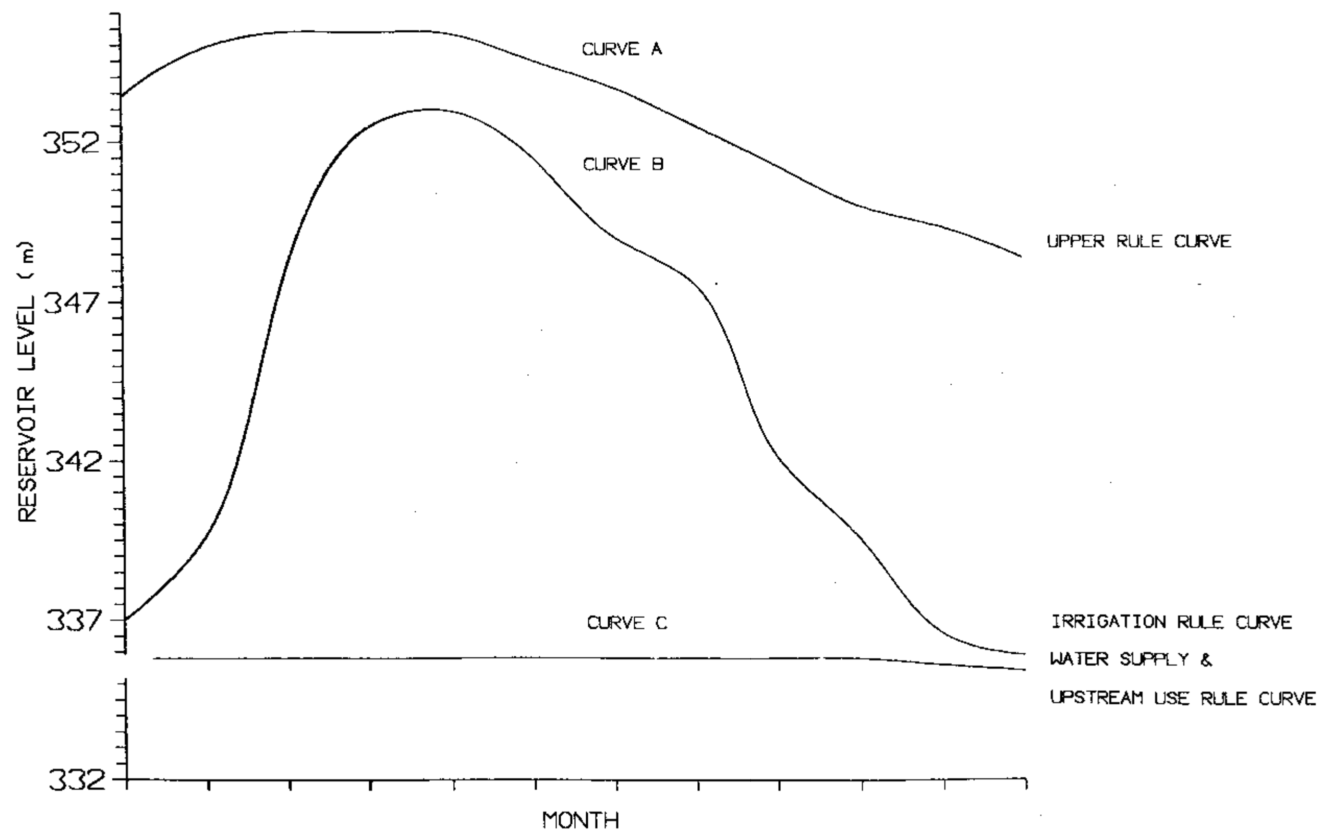

FIG 4 RECOMMENDED RULE CURVES FOR TAWA RESERVOIR

STUDY GROUP

Director	:	Dr S M Seth
Scientists		Sh A R Senthil Kumar
		Dr S K Jain
		Sh M K Goel
Scientific Staff	:	Sh R K Neema