SIMULATION STUDY OF FLOOD DETENTION BASINS IN KASHMIR VALLEY

A DISSERTATION

submitted in partial fulfilment of the requirements
for the award of the degree
of
MASTER OF ENGINEERING
in
HYDROLOGY

By
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UNESCO SPONSORED
INTERNATIONAL HYDROLOGY COURSE
UNIVERSITY OF ROORKEE
ROORKEE (INDIA)
April, 1978

CERTIFICATE

Certified that the dissertation entitled "Simulation Study of Flood Detention Basins in Kashmir Valley" which is being submitted by Shri Z.A. Banday in partial fulfilment for the award of the degree of Master of Engineering in Hydrology of the University of Roorkee, is a record of candidate's own work carried out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other degree.

This is further to certify that he has worked for six and half months with effect from Ist October 1977 to 15 April 1978 for preparing his dissertation for Master of Engineering of this University.

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The author is also grateful to MR.G.R. MIR, State Chief Engineer, Irrigation and Flood Control Department, Jammu and Kashmir for his encouragement and suggesting this interesting topic for the study, and to Mr. Noor Hussian, Executive Engineer, Planning and Design (Flood's) Srinagar for providing the required data.

The Co-operation extended by his friends and colleagues is thankfully acknowledged.

(Z.A. BANDAY)

ROORKEE

April 21, 1978

ACKNOWLEDGEMENT

The author wishes to express his deep sense of gratitude and indebtness to Dr. D.K. SRIVASTAVA, Reader, School of Hydrology, University of Roorkee, Roorkee who provided inspirational guidence, encouragement and whole hearted cooperation in carrying out the study.

My sincere thanks are also due to Dr. Satish Chandra, Professor and Coordinator, School of Hydrology, University of Roorkee for his encouragement and providing the facilities.

I wish to record my deep sense of gratitudes to Dr. B.S. Mathur, Reader School of Hydrology for his valuable suggestions during this study.

The thanks are also extended to Structural Engineering Research Centre, Roorkee and Indian Metereological Department Delhi for their assistance rendering in Computer work.

It is also the pleasant duty of the author to express his sincere gratitude and thanks to Govt. of Jammu and Kashmir, for giving the rare opportunity to complete Master's course in Hydrology at University of Roorkee, Roorkee.

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S Y N O P S I S

The study deals with the development of a model for predicting the behaviour of detention basins during floods. The model is developed in the context of Jehlum River Basin in Kashmir Valley. The simulation technique is used as a tool in this model and a simulation programme has been prepared. The IBM 1620 and the IBM 360/44 computers were used for developing the above simulation programme.

It shows in this study that the flood detention period of basin varies with (i) flood peak ,(ii)elements of the flood hydrograph and its shape, and (iii)Finally the routing period. The levels of basins as proposed in the Jehlum River Basin project report are sufficient to accommodate the design flood of 90000 cusecs. For higher floods the flood spill channel capacity upstream of Srinagar City may be increased to save the city from desastrous floods.

CHAPTER - 1

CHAPTER-1

INTRODUCTION

1.1 INTRODUCTION

The fundamental idea the term "flood" carries is that it is an unlimited statistical variable. This was originally inunciated as such in 1905 by Western F. Fuller[1]. This definition amounts to saying that however large a flood may have been, there will come a day when this flood will be superceded in size. In the usual concept a flood exists when the gauge height of a stream exceeds a certain level and the flow threatens life and property. When the stream discharge spills its banks and inundates and destroys life and property of the adjoining area, the phenomenon is known as flood.

Flood control works like reservoirs, detention basins, levees and river channel improvements, and flood loss reduction measures like flood plain zoning, flood forecasting, evacuation, and flood insurance are the measures generally taken against the flood protection[2].

Very few examples are available of the detention basins, some of them are Miami flood control project[3] in U.S.A. which consists of five detention basins, channel improvements, and levees to provide protection to towns and cities on the Miami River from Piqua to Hamilton, another one is the Chin Kiang flood detention basin in China[4] which consists of fifty four entrance gates. The swamps and lakes found in alluvial lands, usually beyond the high banks, are used as detention basins which serve a purpose similar to that of reservoirs. As the depth available for flood moderation is normally only a few feet, the area of the basins has to be very large if it is to be effective. Embankments round these swamps and natural lakes prevent inundation of marginal lands and also permit fuller utilization of their capacity. Detention Basins receive silt laden waters which are clarified as a result of storage and the outflow will therefore be comparatively silt free and assist in river conservancy. The coarse and medium silt deposited in the basin gradually reduces the moderating capacity and ultimately the land so built up becomes available for cultivation. Detention basins, where practicable are about the cheepest Method of flood control, as the land requires a minimum of compensation and the low head control are relatively in expensive.

The studies carried out on the detention basins are also rare. In the Miami flood control project[3] the regulating effect of the four upstream detention basins on flows at downstream point was studied. The sole idea of the Chin Kiang flood detention basin[4] was to only protect the country site against the devasting floods.

Therefore, a proper methodology or technique has to be developed to predict the behaviour of detention basins during floods and to analyse the flood detention period and its variations with the sizes of basins and the elements of the hydrograph.

Among the various new techniques for planning a water resouces system, a technique that finds increased use is simulation. In general terms, simulation is a process which "duplicates the essence of a system or activity without actually attaining reality itself"[5].

Planners turn to simulation because it is often the only method for dealing effectively with large and complex problems that defy analytical solution or that cannot be reproduced by experiment on actual system

The design of water-resource system[5,6,7] supplies starting examples of such in tractable systems. The difficulties arise from the complex relationships and inter-dependencies among the design variables (dams, power plants, target outputs for water supply, Power, and flood control requirements and the like) and the hydrology.

The availability to day of high speed digital computers of large capacity makes it possible to simulate the performance of relatively complex river basin systems for periods of any desired length.

To analyze the behaviour of detention basins during floods a study may be under taken of routing floods through basins. This would require considering a reasonable number of cases representing various sizes of detention basins and related measures and routing various floods through these basins and finding a combination of basins for efficient control against floods. It would thus appear appropriate that a study is undertaken to simulate the behaviour of the detention basins, and the proper technique to use under these circumstances will be simulation.

1.2 THE STUDY

The study deals with the simulation of flood detention basins in the Jehlum River Basin in Kashmir Valley.

Every major flood jeopardized[8, 9] the safety of Srinagar city with its building, houses sprawling on both sides of River Jehlum. The river is its reach right form sangam down below does not have enough capacity to accomodate any major flood with the result that embankments get breached, besides posing threat for the safety of Srinagar city. Consequently the areas along the river get inundated thereby devasting crops and property.

To control the floods in the Valley two detention Basins A and B have been proposed[8] by H.F.L. Committee as an interim measure, especially to save Srinagar City. The simulation studies were carried out for these two Basins in order to Predict the behaviour of the basins during floods in the river Jehlum and to get the combination of sizes of detention basins, river channels, and inlets of basins and the sill levels of outlets so as to get the maximum level of flood protection under the physical limitations of the system.

The results show that the simulation study of detention basins can reveal many aspects regarding the detention period, its relationships (i) with flood peak, and (ii) with the shape of the flood hydrograph i.e. the flood peak, the flood volume, and the base period. Also this kind of study can help in determining the optimum level of flood control for designing a system of detention basins. The results are reasonable and according to expectation.

Before the analysis is carried out, Chapter 2, 'THE SYSTEM', gives a brief description of the Jehlum River Basin system and its proposed development measures. The Chapter also deals with the problem being investigated for the Jehlum basin.

The simulation model is described in Chapter 3, 'THEORY'. The model only plans for flood control, as it is the main function of the detention basins. The theory regarding stage-discharge relations, flood routing through channels and detention basins, and regression analysis which are needed to develop the basic data and for formulating operating procedures for the simulation study are also described in this chapter.

Chapter 4 is about 'COMPUTATION'. Simulation model is applied to the Jehlum river basin flood control design. For this purpose, operating procedures for detention basins are developed. Initially IBM 1620 computer was used for preparing the required computer programmes and then IBM 360 computer was used for the analysis.

CHAPTER - 2

THE SYSTEM

2.1 THE RIVER SYSTEM

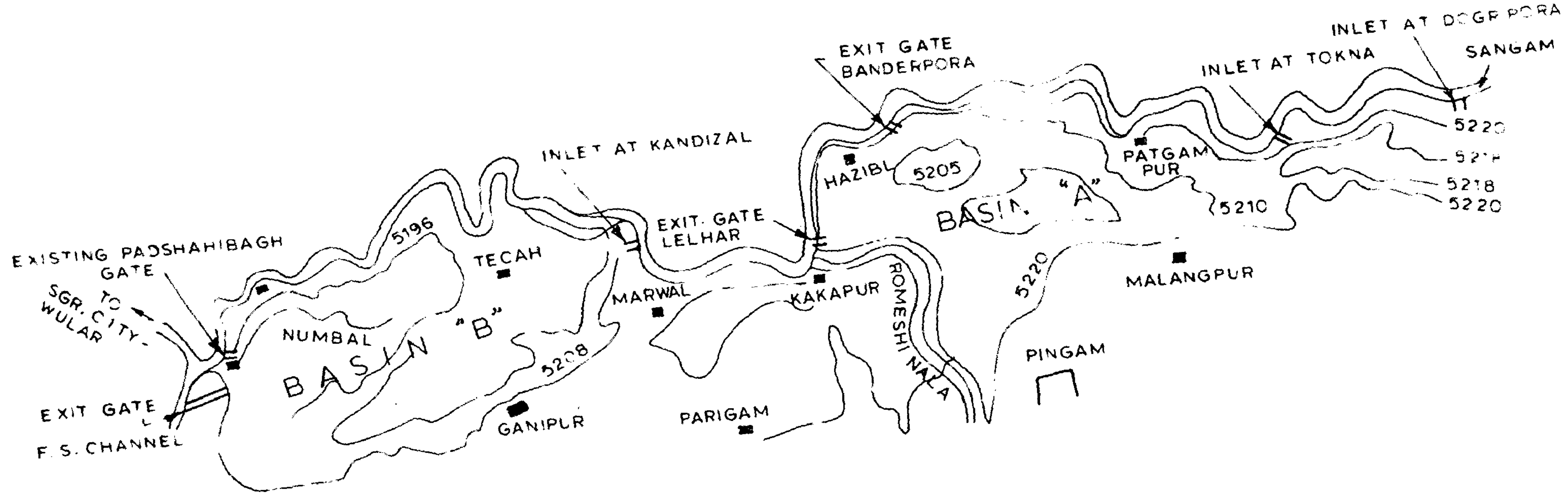
2.11 General

The valley of Kashmir[29] is a fertile plain oval in form, and surrounded by unbroken mountains. It is like a saucer shaped bowl surrounded by hills on all the sides with a single drainage outlet, the River Jehlum, which actually originates from a spring at verinagh. The river is joined above sangam by Tributories namely Lidder the Bringi, the Sandran the Aripath, the Vishaw and the Rambiara, From Sangam down to Banyari the River is joined by, Aripal, Watalara and Sindh on its right bank while, Romshi joins its on its left side just above Srinagar, Flood Spill channel takes off from the River at Padshahi-Bagh, which is joined enroute by Doodganga, the Sukhnagh, the Ferozpore nallah and ultimately joins the Wullar lake. The length of the River from Sangam to Banyari is 72 miles.

From wullar below, Jehlum is known as outfall channel and is joined by Ningly immediately after its take off from wullar on its left bank, and the major tributory, the Pohru on its right bank at Doabgah. Besides some small torrential Nallah's also join the outfall channel along its course upto Baramulla. The length of the outfall channel from Wullar Lake to Khandanyar is 18 miles. After Khandanyar the river further flows for a length of about 28 miles when it crosses into Pakistan. The total catchment area of the River upto Wullar Lake is 3708.65 sq.ml. and upto Indo-Pakistan border 5069.12 sq.miles.

The Jehlum system is unique and does not exhibits the characteristics of other Himalayan Rivers. It has well stabilished meandering from, and is sluggish in its course. Its course has not changed during the past several decades. At Khanabal, it becames navigable and continues to be so in its course upto Baramulla.

From Khannabal to Srinagar, the river Jealum, Fig(2.1) flows in a single channel between earthen banks constructed by Zamindar's since ancient times and improved and raised by the government, from time to time. The level of the banks is higher than the land on its left side where the lowest land forms the Swamps beings surrounded by cultivated area. A long series of depressions, lakes and feeds are extended along the course of the river and are mostly on its left bank. These are connected to river at same places by outfall. During the floods, the spills from the river enter the depression and relieve the pressure to the main river.



PLAN OF THE VALLEY ON THE LEFT OF RIVER JEHLUM FROM DOGRIPORA
TO FLOODSPILL CHANNEL

FIG. 2.1

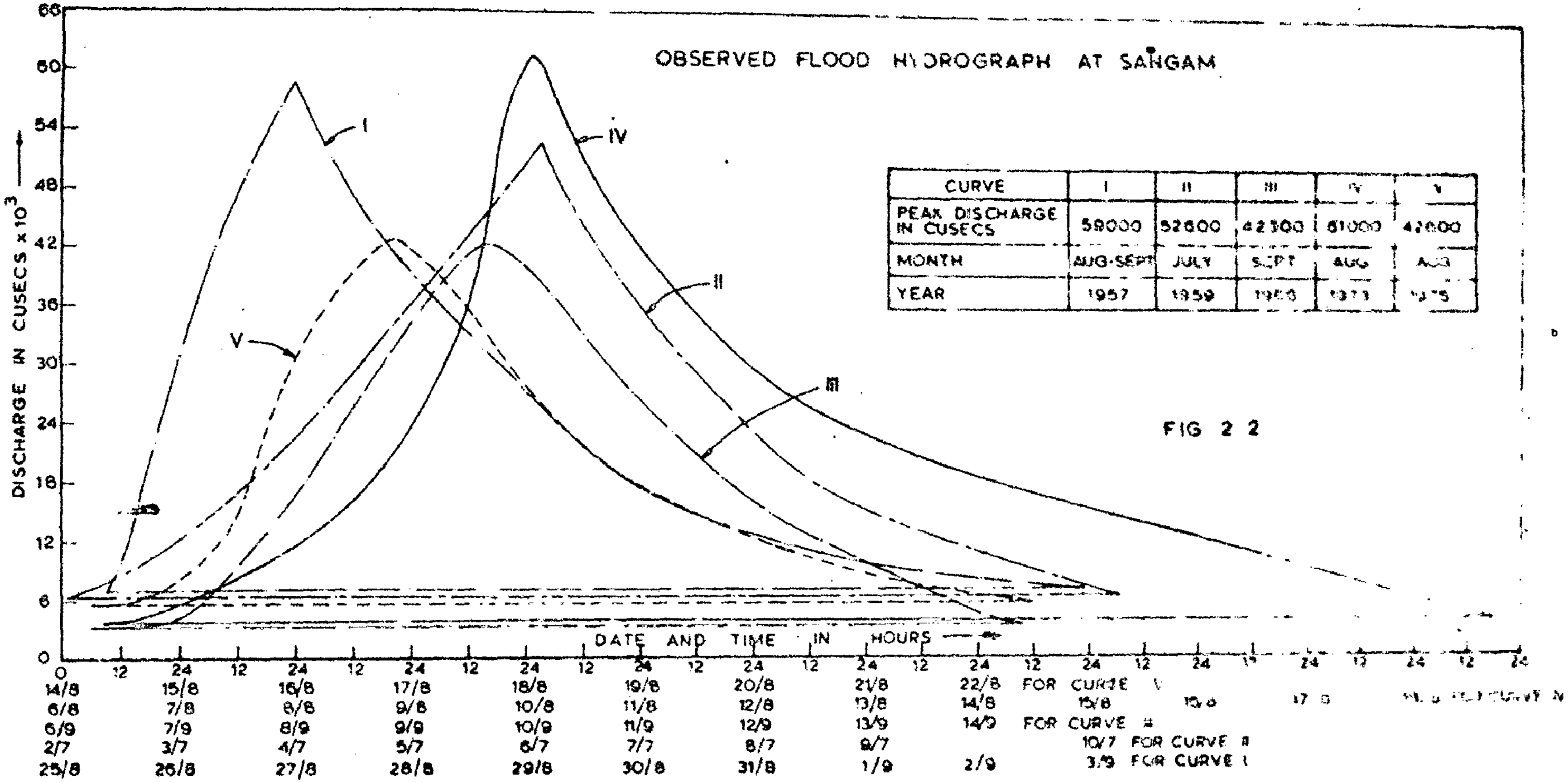
The valley of Kashmir has superabundance of water flowing in it and provides a rich scope for the cultivation of rice, since times immemorial. Rice is the staple food of the population. Besides Rice, maize and water nuts are also produced in the country. Saffron is the famous produce of Kashmir. The mountain slopes, where cultivation has not been carried out, are covered with magnificent coniferous forests. Above the forests where trees do not grow rich alpine pastures extend upto the Snow line.

It is seen that yearly Rainfall in the valley is not so heavy as it is generally on the mountains or in the foot of hills. Since it is on the lee side of the mountains facisng the monsoons. In fact there is no rainy season in Kashmir. The maximum rainfall occurs during the month of August and September and in early spring which leads to high floods on the Jehlum River. The annual normal rainfall of the valley varies from 35" to 50". But the maximum rainfall at certain stations ranges from 60" to 80" annual.

2.12 History of Floods

The history of the valley is full of Woeful accounts of loss of life and property caused by floods. The miseries get aggrevated due to the famine caused at times immediately the floods.

The valley has witnessed many disastrous 8 floods



CURVE	I	II	III	IV	V
PEAK DISCHARGE IN CUSECS	58000	52600	42300	61000	42600
MONTH	AUG-SEPT	JULY	SEPT	AUG	AUG
YEAR	1957	1959	1958	1971	1975

FIG 2 2

and to name some these are the floods of 1893,1903,1905, 1908,1909,1948,1950,1954,1956,1957,1959,1973 and 1976. Hydrograph of same floods are shown in fig.(2.2).

2.13 Flood Problem

Every major flood jeopardizes the safety of Srinagar city with its building houses sprawling on both sides of River Jehlum. The River in its reach right from Sangam down below does not have enough capacity to accomodate any major flood with the result that the embankments get breached, besides Posing threat for the safety of Srinagar city. Consequently the areas along the river get inundated thereby devastating crops. The existing flood control measures are some flood control works such as Diversion of some part of flood water into existing flood spill channel, river training works to provide local protection against erosion, Scour or flooding by spurs, re-vetments. Rai-sing of embankments, desiltiong of flood spill channel and dredging of River Jehlum below Wular lake are also a measure for flood control.

2.2 THE PROBLEM

The capacity of River Jehlum through Srinagar is limited to about 33000 cusecs, and 17000 cusecs are proposed to be diverted from the flood discharge of River Jehlum at Padshahibagh to spill channel. Thus a total capacity above Srinagar should be 17000+33000=50000 cusecs.

In the year 1975 the Govt, of constituted a H.L.F, Committee[8] to recommend measures to be adopted for the flood control of the valley after examining the earlier proposals and work done and the benefits thereof.

Based on the recommendations given by the Committee, it has been decided that flood control project above Wullar will comprise of the following works:-

1. Construction of flood detention Basins.
2. Works for improvement to River Jehlum above Srinagar.
3. Works for improvement to River Jehlum through Srinagar City.
4. Works for imrpovement to River Jehlum below Srinagar.

These are only two possible alternatives to take care of the excessive channel discharge during floods.

Proposal 1

Construction of a supply channel from Sangam to Padshahibagh for 40,000 cusecs and consequently increase the capacity of spill channel to 40000+17000 = 57000 cusecs below Srinagar.

Proposal 2

Utilization of the existing low lying depression on the left bank of River as Detention Basins, see fig.2.1.

The proposal 1 through promising is not practicable at this time and the following are some of the main reasons against it

(i) Construction of the channel through low lying numbals will pose considerable difficulties.

(ii) These will be pre-mature reclaiminations of the numbals of the channel

(iii) The flood spill channel from Padshahibagh to down below upto Wullar shall lake to be improved for additional discharge of 40000 cusecs.

(iv) Keeping in view, the deterioration that has been caused to present spill channel in the long run is doubtful.

(v) Quite a large cultivated area has to be acquired.

(vi) Lastly, the proposal will be costly.

In view of the above the proposal 2 i.e. the construction of flood detention basins has been proposed..

There is no alternative, but to provide detention basins as a purely interim measure for flood control especially to save Srinagar city. Two Basins have been proposed, they are Basin "A" and Basins "B". The decision taken by committee that the inlet to Basin "A" should be so located as to fit in with the ultimate proposal. The inlets should be designed as to take maximum amount of silt. The Basin "B" should have its outfall into F.S. Channel and the existing outlet at Padshahibagh will also continue with suitable modifications.

The Detention Basin "A" is proposed to have two inlets one at Dogripora and another at Tokna. Two outlets one at Banderpora and another at Lelhar.

The detention Basin "B" will have one inlet at Kandizal and two outlets one existing padshahibagh outlet flowing into the river jehlum and another discharging into F.S. channel Keeping in view the topography of the area the second outlet has been fixed at RD7000 of F.S. Channel.

The embankments around detention basins A and B have to be constructed in a manner so that they may ultimately fit in with the alignment of supplementry channel.

Simulation study of these detention basins should be carried out to see the behaviour regarding their ability to absorb the floods. Also, it would be necessary to find out the sizes of the detention basins for optimum flood Protection of Srinagar City.

CHAPTER - 3

CHAPTER-3

T H E O R Y

The simulation model of the detention Basin is presented in this Chapter in sec. 3.1. Stage-discharge relationships, storage elevation curves of basins, routing of flood flows through channels, and through detention Basins are needed in the simulation study. The first two relations were not available readily, therefore these were developed for the study as given in the Chapter 4. The theory needed to develop these relations are given here in sec. 3.2, and 3.4. Theory of flood routing through channel and detention Basins are given in sec.3.3.

3.1 Simulation Model

In general terms simulation is a process which "duplicates the essence of a system or activity without actually attainting reality itself"[5]. Simulation often the only method for dealing effectively with large and complex problems that defy analytical solution or that can not be reproduced by experiment on actual system.

3.1.1 Design Variables, inputs, Constants in Simulation:

For every simulation problem there are design variables, inputs, and constants of the system.[5,6] These are defined below for the simulation study undertaken of the detention Basins in Jehlum River System.

(1) Design Variables

(i) River Channel Capacities for various reaches.

(ii) Detention basin capacities

(iii) Inlet capacities of detention basins, and

(iv) Sill levels of the detention basin out lets

(2) Input

(i) Flood hydrograph at Sangam

(3) Constants

(i) Constants for the channel routing for various reaches between inlets and outlets

(ii) Constants used in the outflow equations of the detention basin outlets.

(4) Others

(i) Stage-Discharge relations at the various inlets and outlets of the basins

(ii) Elevation-capacity relations of the detention Basins.

3.1.2 Data Required

The river flows values are needed, for this stage discharge relations should be known. The relationship for storage elevation curve, the inlet capacities of detention basins, sill level of detention basin outlets are needed. The constants for channel routing for various reaches and constants for outflow equation of the detention basins are required.

3.1.3 Simulation Problem

The simulation problem of the detention basins of the river Jehlum is (1) to know the combination of the sizes of detention basins, river channel, and inlets of detention basins and the sill levels of outlets so as to get the maximum level of flood protection under the physical limitations of the system. (2) Given the inputs of the system.

3.2 STAGE DISCHARGE RELATION

The term stage[10], is used in stream flow measurement, refers to the water surface elevation at a point along a stream, measured above an arbitrary datum. Stage is determined by indicators of various types, the readings of which are either taken at intervals by an observer or are contineously by automatic instruments. Measurements by custormery methods[11] provide only occasional determinations of discharge, which must be correlated with stage in order that a continuous discharge record may be computed. This correlation is customarily expressed in the form of a curve or table called a stage-discharge relation or rating. It is an important phenomenon for evaluation of flood protection works. Rating curve developed from discharge measurements during the course of a flood wave is of the form of a loop and hence called loop rating.

Extension of Rating Curve-

For river forecasting or design problems, it is frequently necessary to have stage-discharge relations extended above the limit of the highest previous measurement. Several techniques have been developed as the result of Experience and study of a large number of stage-discharge relations. In many cases, these procedures will lead to a reasonably adequate estimate of the extensions.

The following two methods are generally used for extension of a rating curve.

1. Logarithmic Method Of Extension

A study of numerous rating curves indicates that, in general, they conform to the equation.

$$Q = C(s-a)^n \qquad (3.1a)$$

Similarly $$s = a + (Q/C)^{1/n} \qquad (3.1b)$$

Where Q = discharge at stage s.

C, and n = constants for the station.

a = Zero Elevation of Zero flow (approx.)

Taking Logarithm , we have

$$\log Q = \text{Log } C + n \log (s-a) \qquad (3.2)$$

This is the equation of a straight line whose slope is n and whose intercept on discharge axis is C. This can be easily extended. It is often difficult to determine "a" for stations lacking a clearly define control, and in this case Q VS s may be plotted. If the resulting curve is concave upward, "a" is positive. If it is concave downward, "a" is negative. Having determined the sign of "a", successive assumptions may be made until a value which results in a straight line plotting is determined. The value of "a" can also be determined by plotting Q Vs s. Select three values of discharges a, b and c, one near the lower segment of curve, and last near the upper segment and such that they are in geometric progression. Suppose these points are a, b and c. Draw verticals and horizontals through these lines to intersect at d and e. If line ed intersects the line ba at f, then it can be proved that f is the elevation of zero point, if the points c, b, and a lie on parabola shown in Fig.3.1).

2. <u>Steven's Method of Extension</u>

(i) Use Chezy's formula[12] and plot $A\sqrt{R}$ as a function of stage for all stages (including the highest ones).

(ii) Plot Q versus $A\sqrt{R}$ for observed value of stages and discharges extend this curve to determine Q at higher stage.

3.3 FLOOD ROUTING

3.3.1 General

The purpose of flood Routing in most engineering works is to determine what stages or rates of flow occur, without actually measuring them, at Specific location in streams or structures during the Passage of floods. Flood routing may be defined as the procedure whereby the time and magnitude of a flood wave at a point on a stream is determined from the known or assumed data at one or more points upstream. The channel routing problem is to determine the effect of channel storage on the flood wave, that to determine the flood hydrograph at a point downstream for the given inflow hydrograph upstream in the river reach.

The solution of the basic equation, "inflow equals outflow plus change in storage for a unit time" is involved in the channel routing i.e.

$$I = O + \Delta S$$

Where for a given time period, T

I = total inflow

O = total outflow

ΔS= change in storage.

The swamps and lakes found in alluvial lands, usually beyond the high banks, are used as detension basins which serve a purpose similar to that of reserviors. Flood water enters the basin through inlets provided in the upstream reaches of the basins. Outlets at the downstream reaches are generally used to route the flood through detention basins. An outlet generally consists of a weir controlled by a sluice gate. The weir works under submerged conditions.

3.3.2 Channel Routing

Routing in natural river channels is complicated by the fact that the channel, or valley storage which is not the volume of water in temporary storage at any instant in that reach of the channel is not a function of outflow alone as in the case of reservoir routing. When the storage computed from the inflow and outflow hydrographs for a reach of the river is plotted against simultaneous outflow, the resulting curve usually a wide loop indicating greater storage for a given outflow during rising stages then during falling. This is because during the advance of a wave, inflow always exceeds outflow thus producing a wedge of storage called 'Wedge storage' and during the recession outflow exceeds inflow resulting in a negative wedge storage. The storage beneath a line parallel to the stream bed is called 'Prism storage', between this line and the actual profile, 'wedge storage'. During rising stages a considerable volume of wedge storage may exist before any large increase in outflow occurs. During falling stages inflow drops more rapidly than outflow and the wedge-storage volume becomes negative. Routing in streams requires a storage relationship which adequately represents the wedge storage. This is usually done by including inflow as a parameter in the storage equation.

The Muskingum Method

This method involves the concept of wedge and prism storages, Fig.3.2.

The Prism storage is represented as KO, where K known as the storage constant' is the ratio of storage to discharge and has the dimension of time. The wedge storage is represented as KX(I-O) where X is a parameter, which expresses the relative importance (weightage) of inflow and outflow in determining storage. The total storage is

$$S = KO + KX(I-O)$$
$$= K\left[XI + (1-X)\,O\right] \qquad (3.3)$$

which is known as the Muskingun equation.

The constant X expresses the relative importance of inflow and outflow in determining storage. If storage is entirely a function of outflow, as in a reservoir, then X = 0; but if the wedge storage is significant, then X will be greater than zero with a limiting value of 0.5 when inflow and outflow have equal weight as in uniform channels. For most streams, X is between 0 and 0.3 with mean value near 0.2.

The storage constant K which expresses the ratio between storage and discharge, infact is a measure of the lag or travel time through the reach and is the slope of the storage discharge curve. K may be determined by finding the lag, or time interval, between the occurances of the centre of mass of inflow and centre of mass of outflow over the reach. It may also be approximated by determining the time of travel of critical points on the hydrograph, such as the peak.. The Muskingum equation (3.3) may be rewritten as

$$S_2-S_1 = K\left[X(I_2-I_1)+(1-X)(O_2-O_1)\right] \qquad \ldots(3.4)$$

where subscripts 1,2 indicate the routing periods and I, O and S are instantaneous values of inflow, outflow and storage respectively at the begining of the routing periods indicated. The basic equation for change in storage in a time interval is

$$S_2-S_1 = 1/2(I_1+I_2)t - 1/2(O_1+O_2)\ t \qquad \ldots(3.5)$$

Combining the equations and simplifying we get

$$O_2 = C_1I_2 + C_2I_1 + C_3O_1 \qquad \ldots(3.6)$$

where $C_1 = \frac{t-2KX}{2K(1-X)+t}$; $C_2 = \frac{t+2KX}{2K(1-X)+t}$;

$$C_3 = \frac{2K(1-X)-t}{2K(1-X)+t}$$

and $C_1 + C_2 + C_3 = 1$

By an algebric modification, this equation can be written as

$$O_2 = O_1 + C_1(I_1 - O_1) + C_2(I_2 - I_1) \quad \ldots. \quad (3.7)$$

Where $C_1 = \frac{t}{K(1 - X) + 1/2\, t}$ and

$$C_2 = \frac{1/2\, t - KX}{K(1-X)+1/2t}$$

In these equations it is important that the routing period t is in the same time units as K. The routing period t is selected to fit the needs of the problem; it must be sufficiently short that points t-hour apart adequately define the hydrograph shape. This means t must be equal to or shorter than the time of travel through the reach since if it were longer then the travel time a major change in the flow could traverse the reach within a routing period.

For convience t is usually taken as some even fraction or multiple of a day, for flashy tributaries it may be taken as 1/4 day or its sub multiple and 1/2 to 1 day or more for large and slowly rising stream.

The values of K and X are simultaneously determined as follows. Combining equations (3.3) and (4.5) solving for K, $K = \frac{1/2\, t\left[(I_2+I_1) - (O_2+O_1)\right]}{X(I_2-I_1)+(1-X)(O_2-O_1)}$ ..(3.8)

Successive values of the numerator (representing storage increment) and the denominator (representing weighted flow increments) are computed for a flood with known values of inflow and outflow and assuming various parametric values (0.1 to 0.5) of X. The computed values of the accumulated numerator and denominator are then plotted, usually producing curves in the form of loops. The assumed value of X that resulted in a loop closest to a single line is accepted as the correct value. The reciprocal of the slope of the single line gives the value of K. The units of K depend on the units of flow and storage. If the storage is in Cumec days and flow in cumec, K is in days. With K,X, and t established, values of the coefficients can be computed. The routing operation is a solution of equation (3.7). Since O_1, I_1 and I_2 are known at the begining of the routing from equation (3.7). The values of O_2 for one period is the O_1 value for the subsequent routing period, and the solution can be repeated indefinitely to compute successive values of O at intervals of time t. The solution is simplest when K is a constant i.e. the storage-discharge function is a straight line. If the relation is not linar it must be approximated by a series of straight lines and values of the coefficients changed the conform to varying values of K as bouting progresses through successive ranges in stage.

3.3.3 Detention Basin Routing

The discharge through outlets have been worked

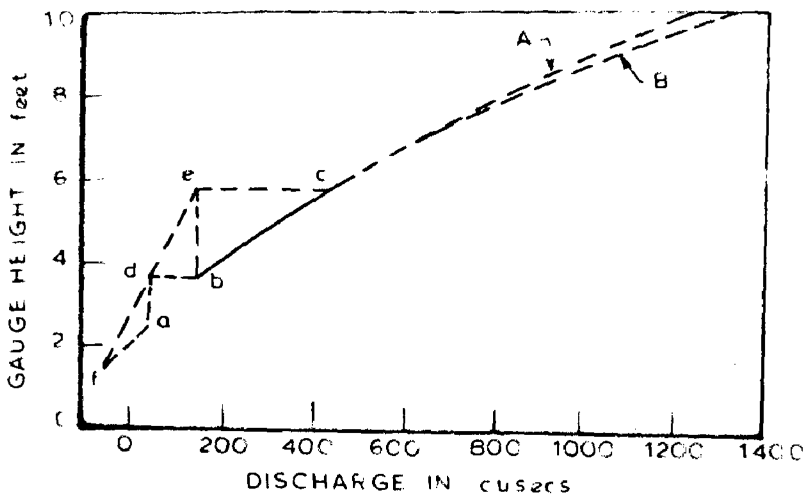


FIG. 3.1 _ DETERMINATION OF ZERO ELEVATION OF STAGE

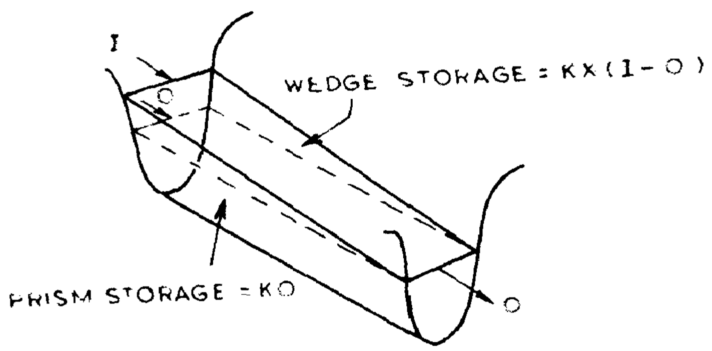


FIG. 3.2 . PRISM AND WEDGE STORAGES IN A RIVER CHANNEL

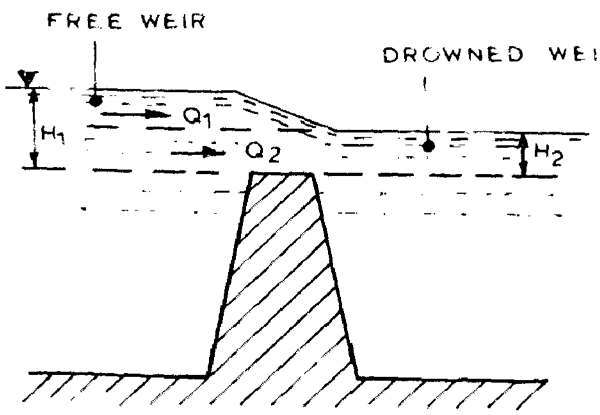


FIG. 3.3 _ DROWNED OR SUBMERGED-WEIR

out, assuming the weir to work under submerged condition[14] Fig.3.3 In the submerged weir, the downstream water level of weir nappe is higher than the crest, the weir is said to be submerged. Such a weir may be a dam drowned during the floods. Such weirs have great discharge capacity and thus flooding can be prevented. The sluice gates in a river control are installed on low concrete structure. The latter acts as a submerged weir when the gates are raised and the water flows through the opening.

The discharge over a submerged their is calculated by dividing the nappe into two parts shown in the Fig. The upper part acts as a free weir with a head (H_1-H_2) the difference between the upstream and downstream water level. The lower part acts as a drowned weir under a head H_2, the height of downstream water level above crest.

In fig.3.3 Q_1 and Q_2 be discharge through upper and lower parts respectively, then

$$Q_1 = 2/3\ Cd_1 . \sqrt{2g}\ \ L(H_1-H_2)^{3/2}$$ ....(free weir Equation)

and $Q_2 = C_{d2}\ (L.H_2)\ \sqrt{2g}(H_1-H_2)$

......(drowned weir equation)

Total discharge $Q = Q_1+Q_2$ ... (3.9)

Where $c_1 = 2/3\ cd_1 \cdot L \cdot \sqrt{2g}$; $c_2 = cd_2 \cdot L \cdot \sqrt{2g}$

L = is the width of weir

H_1= is the upstream water level in the detention basin above crest of weir H_2 = is downstream conditions respectively. c_{d_1} and c_{d_2} are the coefficient of discharge.

3.4 REGRESSION ANALYSIS

3.4.1 Definition of Regression

If a plot between two variables X and Y is made (independent variable on X-axis and dependent on Y-axis) and if data cluster about a straight line, a linear regression is indicated. If the points have a tendency to fall in a curved band, a non linear regression" is apparent. "Regression or curve fitting is a procedure for estimations of the average values of X_1 corresponding to a given value of X. " Method of least Squares" powerful tool of regression. Depending on the scatter of points, several regressions i.e. straight line, Parabola or lograthmic or exponential curve can be fitted.

3.4.2 Simple Linear Regression

The straight line regression for variable Y[10,12] versus variable X is defined by a straight line which gives the best estimate of Y for a given value of X.

$$Y = A_y + B_Y X \qquad .....(3.10)$$

where B_Y is the regression coefficient of Y versus X.

The sum of $(\Delta Y_i)^2 = (Y_i - Y)^2$ is minimised where Y_i is the observed value and Y is the value from the straight regression line for a given X_i. If $\bar{X}$ and $\bar{Y}$ are the mean values of X and Y for the sample size N,

$$\text{then } B_Y = \frac{\sum X_i Y_i - N\bar{X}\ \bar{Y}}{\sum X_i^2 - N\bar{X}^2} = \frac{\sum \Delta X_i\ \Delta Y_i}{\sum (\Delta X_i)^2} \quad \ldots.(3.11)$$

Where the summutations are taken from 1 to N, with

$\Delta X_i = X_i - \bar{X}$ and

$\Delta Y_i = Y_i - \bar{Y}$

The intercept is $A_Y = \bar{Y} - B_Y$, $\bar{X} = \bar{Y}$ -

$$\bar{X}\ ,\ \frac{\sum \Delta X_i\ \Delta Y_i}{\sum (\Delta X_i)^2} \quad \ldots\ldots.(3.12)$$

For higher orders of polynomial refer.

3.4.3 Multiple Regression

10,12

The multiple regression and correlation analysis is used vastly in hydrologic analysis because such complicated analysis can be made practicable through numerical computions and thus can be economically executed with the aid of Electronic digital computers.

Multiple regression is normally adopted to tell, without bias, what value can usually be expected with a given set of variables.

The method of multiple regression combines least-square fitting of the best equation to the data and gives a measure of the significance of each of the effects the probable range of error in Evaluation of the individual effects,. and the error in the total effect.

The tests of significance provide a criterian to judge whether a given variable should be retained or dropped form the analysis. The individual effects obtained are true partial effects, and may be used to estimate the effect of changing a single variable. The overall results are expressed in the form of an equation. The association of three or more variables can be investigated by the multiple regression and correlation analysis. The multiple regression relation may be expressed in the form

$$X_1 = f\,(X_2, X_3, \ldots\ldots\ldots\ldots\; X_m) \qquad \ldots(3.13)$$

Where X_1, X_2, ...X_m are m variables. This equation gives are estimate of X_1 for given values of all other variables.

If equation (3.13) is linear the regression is referred to as multiple linear regression and the association is multiple linear correlation.

Because linear Equations are easier to treat than non-linear multiple relations, variables of non-linear relations in hydrology are often transformed to linear relation for multiple regression analysis.

Linear Regression with Several Variables

If there are m variables to correlate, including one dependent and m-1 externally independent, the general equation for Multiple linear regression is

$$X_1 = B_1 + B_2\, X_2 + \ldots, +B_i X_i +, . . +B_m X_m \qquad ..(3.14)$$

Where B_1 is the intercept and B_i is the multiple regression coefficient of the dependent variable X, on the independent variable X_i, with all other variables kept constant.

Applying the least square, method for the sum of residuals as in section 3.4.2

$$\Delta_1 = X_1 - B_1 - B_2X_2 - B_3X_3 \ldots\ldots - B_mX_m,$$

m partial differential equations in $B_1, B_2, \ldots\ldots, B_m$ give m linear equations

$$B_2\sum(\Delta X_2)^2 + B_3\sum(\Delta X_2\ \Delta X_3) + \ldots + B_n\sum(\Delta X_2\ \Delta X_m)\ \sum(\Delta X_1\Delta X_2)$$

$$B_2\sum(\Delta X_2\Delta X_3) + B_3\sum(\Delta X_3)^2 + \ldots\ldots + B_m\sum(\Delta X_3\Delta X_m)$$

$$= \sum(\Delta X_1\Delta X_3)$$

$$B_2\sum(\Delta X_2\Delta X_m) + B_3\sum(\Delta X_3\Delta X_m) + \ldots\ldots + B_m\sum(\Delta X_m)^2$$

$$= \sum(\Delta X_1\ \Delta X_m)$$

Where $\Delta X_i = X_i - \bar{X}_i = \bar{X}_i$, with i = 1 to m.

These equations enable the determination of m parameters. The computational work increases with the increase of either the number m of variables or the sample size N,

CHAPTER - 4

CHAPTER-4

COMPUTATIONS

Computations were carried out for the simulation study of the detention basins on the basis of theory given in Chapter 3. In this Chapter sec.4.1 deals with storage Elevation computation for Basin A and Basin B and sec. 4.2, 4.2.2 deals with stage-discharge computations at Sangam, and at basin inlets and outlets respectively. The computation of relationships among flood hydrograph elements at Sangam are given is sec 4.3, channel routing computations in sec.4.4 and simulation computations in sec.4.5.For computation IBM 1620 and IBM 360/44 computer were used.

4.1 Storage-elevation computation

The capacity elevation curves for detention Basin A and B for given data were fitted by using computer programme lthese are shown in fig.4.1(a) and 4.1(b).

The final expressions obtained were as:-

For Basin A:

$$Y = 5.208029*10^3+2.416*10^{-4}* X - 1.123*10^{-9}* X^2 \qquad 4.1(a)$$

with correlation Index = 0.9977

For Basin B:

$$Y = 5.195638*10^3+3.21*10^{-4}*X -1.983*10^{-9}*X^2 \qquad 4.1(b)$$

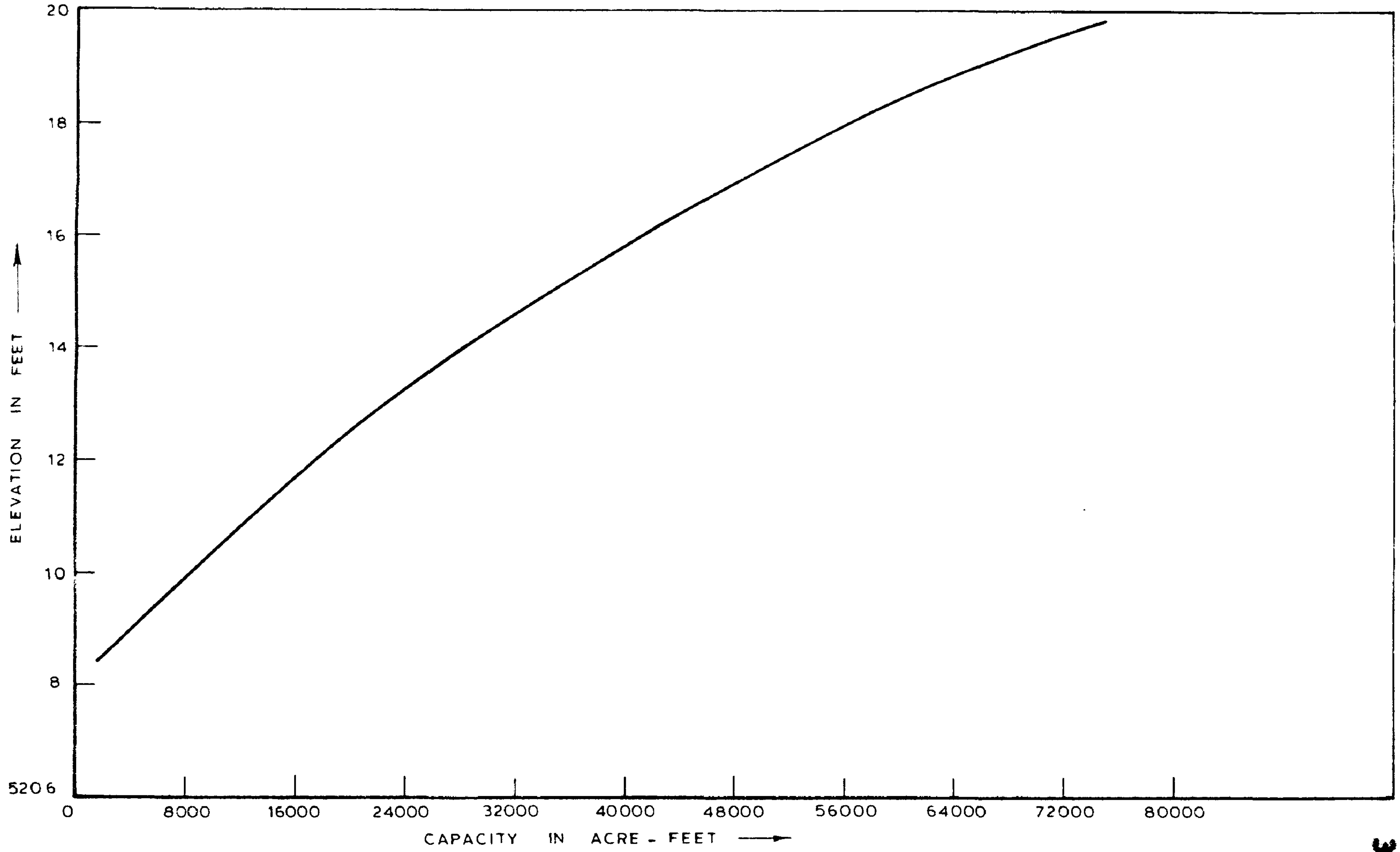


FIG. 4·1 a _ELEVATION CAPACITY CURVE FOR BASIN 'A'

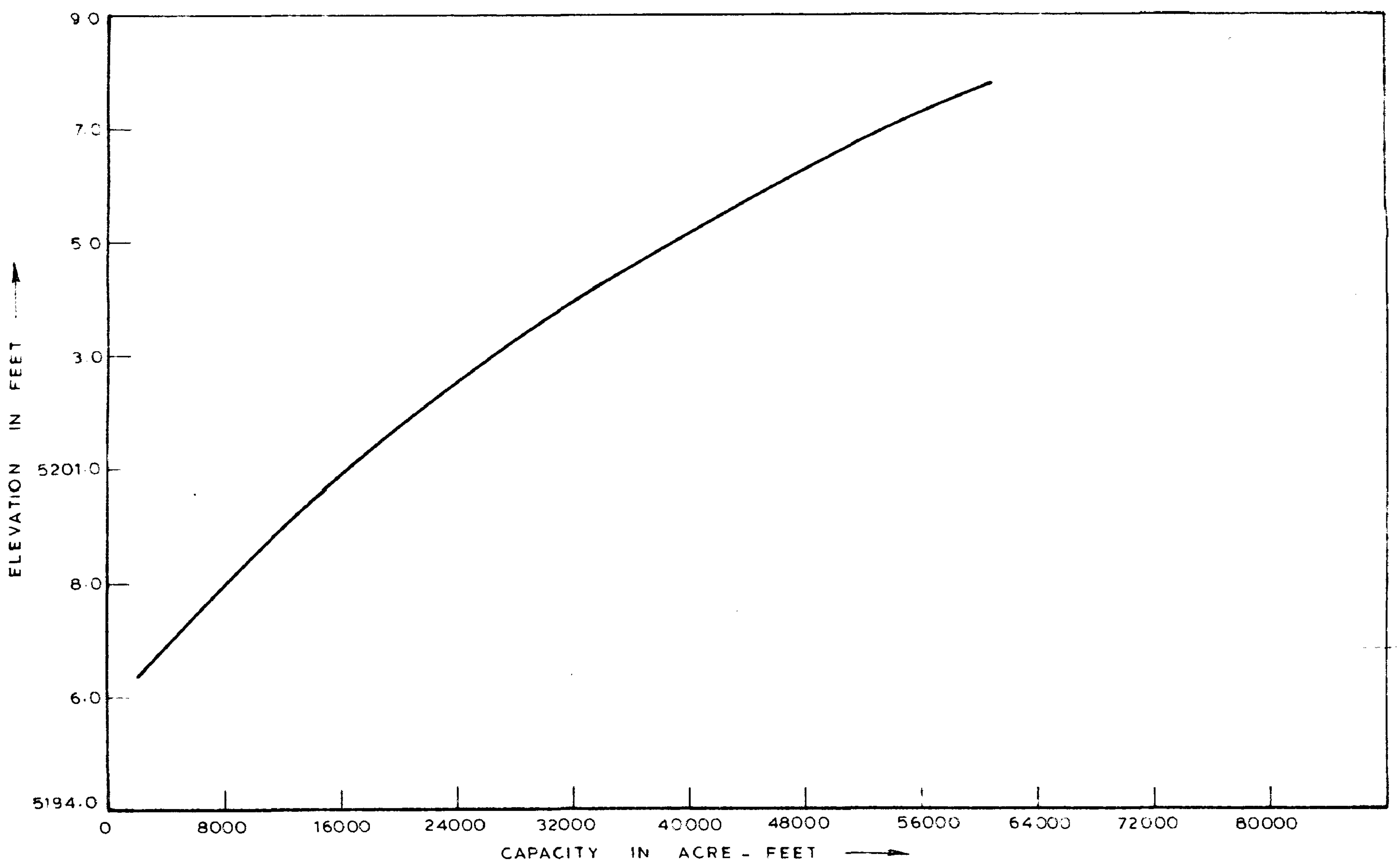


FIG. 4.1 b _ ELEVATION CAPACITY CURVE FOR BASIN 'B'

With correlation Index = 0.9931

where Y is R.L. in the Basins in feet and

X is storage or volume in the Basin in Acre-feet.

4.2 Stage-Discharge Computation

4.2.1 At Sangam

The stage-discharge relationship for the Sangam site was developed from the observed river flows at the site. It was found suitable to fit a polynomial[15] instead of a logarithmic extension. For the various flood years the measured gauge and discharge data were available as presented in Fig.4.2(a) Table 4.1. A mean curve has been used for fitting the gauge discharge curve for actual data observed. The mean curve data was used and the best fit polynomial was selected refer sec.4.4.2, using computer program (1). The gauge discharge curve was fitted in two portions Fig.4.2(b). One for the depth of flow less than 28 ft. gauge and another for flow depth equal and greater than 28 ft. gauge. The following 4rth degree relationships were finally obtained:-

For Stage < 28 ft.

$$= 1.2452\times10^{3} - 1.3513\times10^{3} * Q + 2.3049\times10^{2} * Q^{2} - 8.3958 * Q^{3} + 0.122961 * Q^{4} \qquad 4.1(a)$$

With the correlation Index = 0.9998

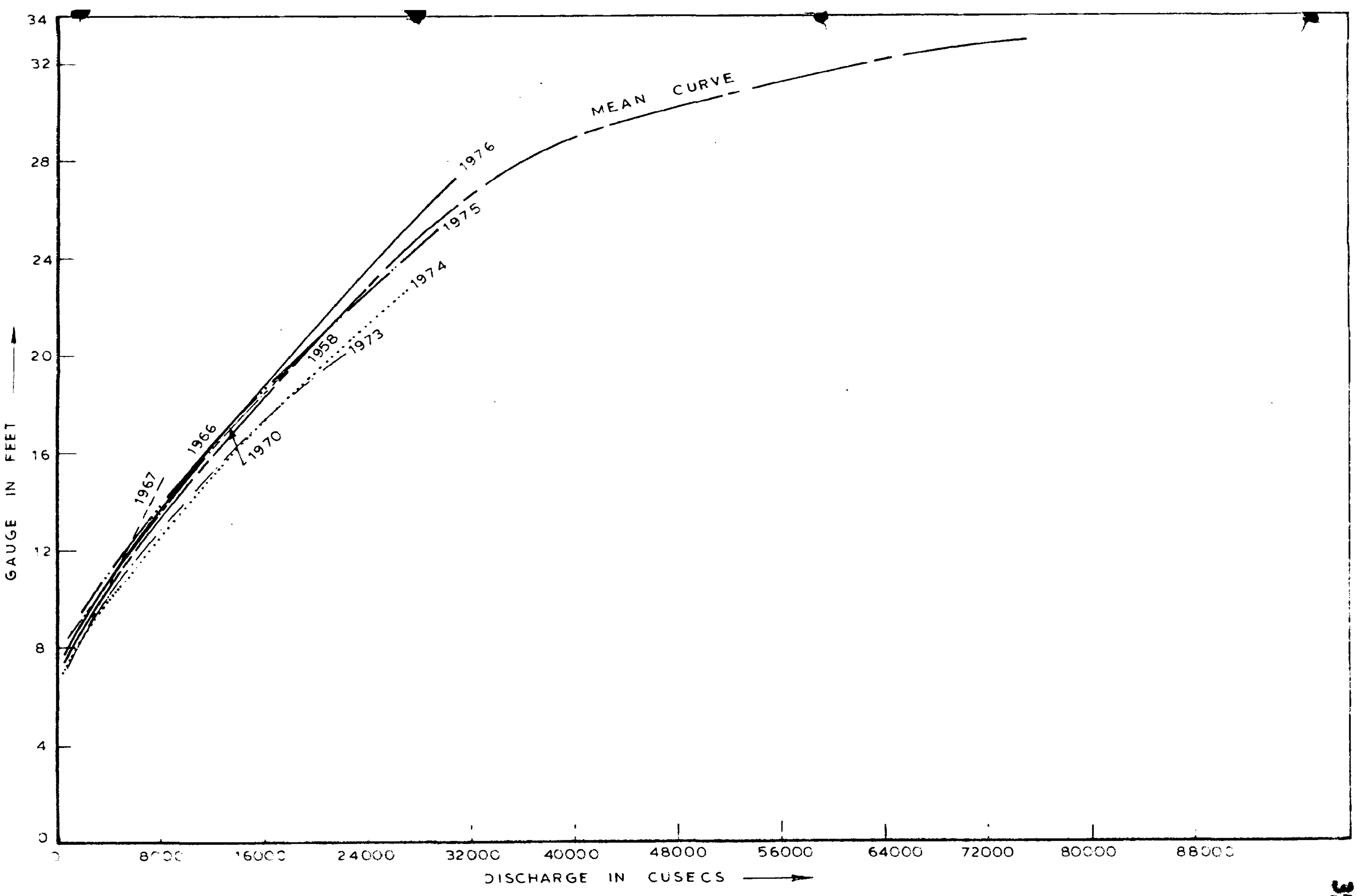


FIG 4 2 a_AVAILABLE GAUGE DISCHARGE VALUES AT SANGAM

TABLE 4.1

OBSERVED GAUGE DISCHARGE DATA AT SANGAM

R L of Gauge Zero at Sangam = 5199.48

Date	Gauge reading	Discharge in Cusecs	Date	Gauge reading	Discharge in Cusecs
1	2	3	1	2	3
22-5-58	9.5	3683.86	25-6-66	14.70	9699.0
22-6-58	11.8	6474.88	21-7-66	10.70	3551.0
26-6-58	12.8	8405.37	25-7-66	11.40	4367.0
16-7-58	15.0	9488.38	21-8-66	11.60	4770.0
17-7-58	21.7	24561.20	25-8-66	9.90	2680.0
22-7-58	10.6	4966.77	21-9-66	11.1	4580.0
26-7-58	10.2	4450.26	25-9-66	10.25	3537.0
22-8-58	8.9	2759.4	21-10-66	11.90	5369.0
26-8-58	9.0	2844.58	25-10-66	9.70	2675.0
23-9-58	8.7	2571.75	21-11-66	8.30	1520.0
26-9-58	8.35	2260.27	25-11-66	8.10	1358.0
22-10-58	7.7	1604.06	21-12-66	7.65	963.0
26-10-58	8.0	1969.99	25-12-66	7.60	914.0
22-11-58	7.3	1286.04	22-2-67	9.20	2170.0
26-11-58	7.25	1153.33	3-3-67	8.25	1394.0
			23-3-67	8.55	1725.0
15-2 -66	9.10	2718.0	21-4-67	11.20	4839.0
4-3 -66	9.70	3018.0	25-4-67	12.20	6359.0
18-3 -66	15.80	11645.0	21-5-67	12.40	6470.0
21-4 -66	12.80	6320.0	25-5-67	14.00	9355.0
25-4 -66	10.60	3731.0	21-6-67	10.40	3450.0
21-5 -66	11.85	5650.0	25-6-67	11.80	4936.0
25-5 -66	12.05	5820.0	21-7-67	10.20	3348.0
21-6 -66	14.80	9846.0	25-7-67	10.50	3918.0

Table 4.1 (Contd.)

1	2	3	1	2	3
21-8-67	10.05	3163.0	23-12-70	7.05	672.0
21-9-67	8.70	1798.0	28-12-70	7.0	630.0
25-9-67	8.30	1690.0			
21-10-67	7.45	1182.0	21-1-73	10.80	4550.0
25-10-67	7.80	1300.0	26-1-73	9.05	2185.0
21-11-67	7.50	1210.0	21-2-73	9.65	3156.0
25-11-67	7.45	1190.0	26-2-73	12.30	6702.0
21-12-67	7.50	1210.0	21-3-73	10.75	4524.0
25-12-67	7.90	1350.0	26-3-73	12.50	7100.0
			2-4-73	12.40	7100.0
23-1-70	7.05	570.0	14-4-73	13.15	8500.0
29-1-70	7.15	645.0	21-4-73	15.05	11024.0
23-2-70	7.00	553.0	26-4-73	13.75	9400.0
28-2-70	7.20	665.0	2-5-73	15.00	11310.0
23-3-70	7.70	1230.0	14-5-73	12.10	6899.0
28-3-70	8.90	2370.0	21-5-73	11.35	6096.0
23-4-70	10.55	4267.0	27-5-73	14.30	10680.0
28-4-70	8.85	2250.0	21-6-73	13.0	8160.0
23-5-70	11.60	5754.0	27-6-73	12.20	6580.0
28-5-70	8.50	1961.0	21-7-73	11.20	5060.0
22-6-70	8.45	1935.0	27-7-73	12.85	7360.0
27-6-70	8.75	2175.0	8-8-73	19.60	2070.0
22-7-70	8.00	1406.0	21-8-73	12.30	6700.0
27-7-70	8.00	1392.0	27-8-73	10.85	4850.0
23-8-70	10.15	3729.0	21-9-73	10.50	4300.0
28-8-70	11.80	5137.0	27-9-73	9.15	2380.0
23-9-70	9.30	2940.0	21-10-73	7.87	1570.0
28-9-70	8.60	2180.0	26-10-73	7.71	1560.0
23-10-70	8.60	2180.0	21-11-73	7.38	1300.0
28-10-70	7.80	1320.0	26-11-73	7.31	1280.0
23-11-70	7.30	850.0	21-12-73	7.25	1120.0
28-11-70	7.25	805.0	26-12-73	7.12	920.0

Table 4.1 (Contd.)

1	2	3	1	2	3
21-1-74	7.18	1050.0	22-3-75	13.09	9050.0
26-1-74	7.12	950.0	28-3-75	11.22	5320.0
21-2-74	7.9	1610.0	22-4-75	12.37	6910.0
26-2-74	9.05	2710.0	27-4-75	21.42	17500.0
21-3-74	9.35	3230.0	17-5-75	24.28	26800.0
26-3-74	10.46	4400.0	22-5-75	13.22	7550.0
21-4-74	10.59	4512.0	27-5-75	12.99	7510.0
26-4-74	10.07	4090.0	22-6-75	12.89	7200.0
21-5-74	10.27	4320.0	27-6-75	13.09	7740.0
26-5-74	9.58	3370.0	16-7-75	27.69	7900.0
21-6-74	10.07	4250.0	22-7-75	13.51	9010.0
24-6-74	20.99	23350.0	27-7-75	12.99	7750.0
25-6-74	21.58	21040.0	22-8-75	14.79	10200.0
26-6-74	15.78	11229.0	26-8-75	15.61	5500.0
21-7-74	13.19	7560.0	22-9-75	9.54	3100.0
26-7-74	11.81	4700.0	27-9-75	9.12	3070.0
21-8-74	8.69	1850.0	22-10-75	8.07	1650.0
26-8-74	8.27	1840.0	27-10-75	7.97	1580.0
21-9-74	7.71	820.0	21-11-75	7.80	1380.0
26-9-74	7.71	810.0	26-11-75	7.67	1240.0
21-10-74	7.18	711.0	21-12-75	7.54	1120.0
26-10-74	7.12	710.0	26-12-75	7.48	1100.0
21-11-74	7.15	735.0			
26-11-74	7-15	732.0	21-1-76	7.31	1041.0
21-12-74	7.22	722.0	26-1-76	7.31	1035.0
26-12-74	7.28	710.0	21-2-76	9.68	3153.0
			26-2-76	9.38	2867.0
21-1-75	7.15	730.0	21-3-76	10.15	3880.0
26-1-75	7.15	735.0	26-3-76	9.70	3157.0
22-2-75	8.46	1822.0	15-4-76	11.02	5168.0
27-2-75	8.53	1830.0	20-4-76	12.70	7460.0

Table 4.1 (Contd.)

1	2	3	1	2	3
21-5-76	13.0	7682.0			
26-5-76	13.25	7957.0			
21-6-76	10.37	4248.0			
25-6-76	10.0	3950.0			
21-7-76	11.20	4796.0			
26-7-76	10.0	3632.0			
1-8-76	28.55	44230.0			
2-8-76	31.50	50958.0			
3-8-76	30.20	42536.0			
4-8-76	25.25	27051.0			
5-8-76	25.30	27416.0			
6-8-76	25.50	28462.0			
7-8-76	24.7	26343.0			
8-8-76	24.90	26565.0			
9-8-76	21.10	20839.0			
10-8-76	18.30	16794.0			
21-9-76	8.85	2415.0			
25-9-76	8.50	2035.0			
21-10-76	7.95	1670.0			
26-10-76	8.17	1719.0			
21-11-76	7.60	1278.0			
26-11-76	7.50	1251.0			
20-12-76	7.25	943.0			
26-12-76	7.35	984.0			

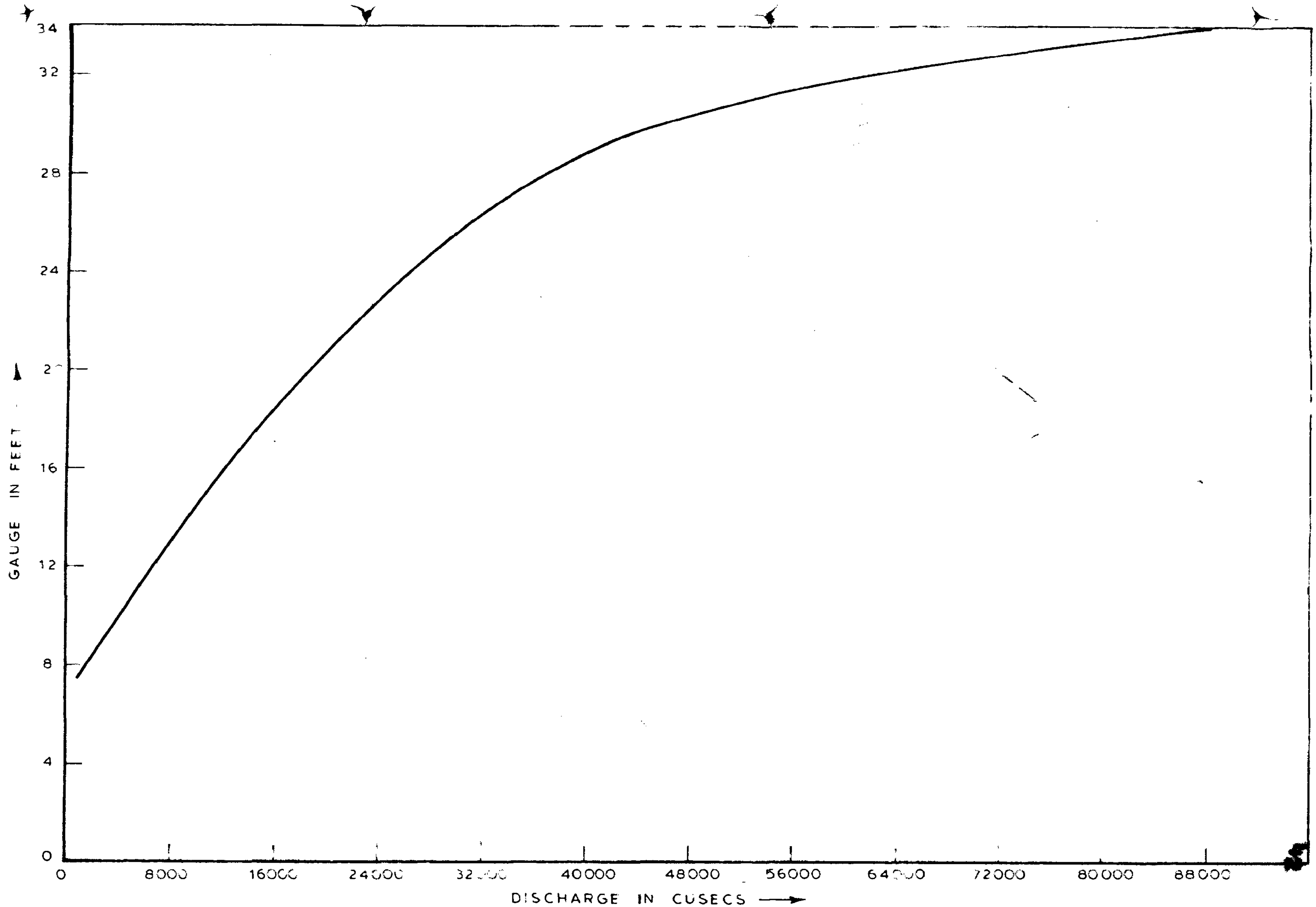


FIG 4.2 b_FITTED GAUGE DISCHARGE CURVE AT SANGAM

For Stage $\geqslant$ 28 ft.

$$= 1.178724 \times 10^6 - 7.7957 \times 10^4 * Q$$
$$+1.280897 \times 10^3 * Q^2 - 4.455\times10^{-2} * Q^3$$
$$+6.3733 \times 10^{-2} * Q^4 \qquad \ldots\ldots \quad 4.1(d)$$

With the correlation Index = 0.9908

Where s = stage (Gauge) in feet.

and Q= Discharge in cusecs.

4.2.2 At Basin Inlets and Outlets

The stage-discharge relations at the inlets and outlets were developed for the proposed designed channel sections at these sites. Stage-discharge values are given in Table 4.2. The developed stage-discharge relations are given in Table 4.3. Refer Sec 3.4.2 and computer programme (1).

4.3 "Computation of Relationships among Flood hydrograph elements at Sangam".

It was necessary to obtain correlations among various flood hydrograph elements to derive a flood hydrograph for a given flood peak, therefore the following relations were obtained:

From the given gauge-time hydrograph, at Sangam for various flood years, sec.2.12, hydrographs for these floods were computed (Fig.4.3) by using the developed mean discharge curves equations 4.1(c) and

TABLE 4.2

STAGE DISCHARGE DATA AT INLETS AND OUTLETS FOR THE DESIGNED SECTION

SITE	Gauge height feet	Discharge in Cusecs	SITE	Gauge height feet	Discharge in Cusecs
DOGRIPORA	4	4182.4	BANDERPORA	18.89	40800.0
	8	13000.0		19.75	44000.0
	12	26000.0		21.55	50800.0
	16	42000.0		24.00	60000.0
	20	59400.0		23.46	58200.0
	21	66000.0		22.46	54200.0
	25.75	90000.0		21.46	49400.0
				20.05	45200.0
				19.20	42000.0
TOKNA	4	3100.0			
	8	9620.0			
	12	19100.0	LELHAR	18.7	40800.0
	16	30800.0		19.6	44000.0
	19	41100.0		21.4	50800.0
	20	45000.0		24.0	60000.0
	24	60000.0		23.31	58200.0
				22.31	54200.0
KANDIZAL	4	2879.0		21.06	49400.0
	8	9676.0		19.9	45200.0
	12	19184.0		19.05	42000.0
	16	30831.0			
	17	33991.0	PADSHAHI-BAGH	18.65	40800.0
	21	50000.0		19.55	44000.0
				21.00	50000.0
				20.90	49400.0
				19.85	45200.0
				19.00	42000.0
				17.65	36800.0

Table 4.2 (Contd.)

	1	2			
	16.40	32000.0			
	15.30	28400.0			
	14.30	25200.0			
	13.20	22200.0			
	12.15	19400.0			
	11.20	16800.0			
	10.30	14600.0			
FLOOD SPILL CHANNEL (HEAD)	12.55	7800.0			
	13.45	11000.0			
	14.90	17000.0			
	14.8	16400.0			
	13.75	12200.0			
	12.90	9000.0			
	11.55	3800.0			

TABLE 4.3

DEVELOPED STAGE DISCHARGE RELATIONS AT INLETS AND OUTLETS

Name of site	Stage-discharge Relations	Correlation Index
1. DOGRIPORA	$s = 0.026037(Q)^{0.60384}$	0.99994579
2. TOKNA	$s = 0.031719(Q)^{0.602165}$	0.99997909
3. KANDIZAL	$s = 0.037821(Q)^{0.584528}$	0.99993359
4. BANDERPORA	$s = 0.026266(Q)^{0.6197}$	0.99892862
5. LELHAR	$s = 0.022315(Q)^{0.634}$	0.99938576
6. PADSHAHIBAGH AND FLOOD SPILL R.D. 7000.	$s = 0.040889(Q)^{0.57714}$	0.99984538

TABLE 4.4

VALUES OF K AND X

Reach	"K"	"X"
1. Sangam(Dogripora) to Tokna	1.17	0.3
2. Tokna to Banderpora	1.71	0.15
3. Banderpora to Lelhar	0.57	0.15
4. Lelhar to Kandizal	1.7	0.15
5. Kandizal to Padshahi Bagh	0.50	0.15

and 4.1(d) at Sangam. The hydrographs were plotted and the Base flow was separated by straight line method.

The volume of these hydrographs were computed by using Trapazoidal Rule. A relationship was developed between these flood volumes and for the corresponding values of flood peaks by plotting them on log-log paper and fitting a best fit straight line, refer sec.3.4.2.

The relationship obtained by using the computer programme (1) was

$$V = 0.33266(Q)^{1.2752} \quad \ldots. \quad (4.2)$$

Where Q is flood peak in cusecs, and V is flood volume in Acre-feet.

The correlation Index obtained was equal to 0.91933.

In order to develop flood hydrographs for other flood peaks, the relationships were developed among various hydrograph elements with the help of Multiple linear Regression Analysis, Sec.3.4.3 and computer programme (2).

(i) Relationship between given flood peaks, volumes and time bases was established and the relationship obtained was

$$T_b = 93.85908 - 9.52688 \times 10^{-4} * Q + 5.838894 \times 10^{-4} * V \quad \ldots. \quad (4.3)$$

Where T_b is time base in Hours.

Q is peak in cusecs.

V is volume in Acre-feet.

Multiple correlation coefficient obtained was 0.9502

(ii) Similarly for the given flood peaks, volumes and time peaks the relationship obtained was

$$T_p = 127.84442 - 5.0370266 \times 10^{-3} * Q + 6.0048158 \times 10^{-4} * V \quad \ldots. \quad (4.4)$$

Where

T_p is Time peak in Hours.

Q is peak in cusecs.

V is volume in Acre feet.

Multiple correlation coefficient obtained was 0.9337.

The above equations 4.1 to 4.4 can be used to develop a flood hydrograph for a given flood peak at Sangam.

4.4 CHANNEL ROUTING COMPUTATION

For routing floods through detention basins it is necessary to know the stages for given discharges in the river at various inlets and outlets of the detention basins. Therefore, flood flows were routed through river as given in sec 4.5, using Muskinghum method, refer sec.3.2.2. A computer programme CHROUT was developed for this purpose as given in Appendix-I.

From the given data for various sites the storage constant "K" and "X"(used in channel routing) a parameter which expresses the relative importance (weightage) of inflow and outflow in determining storage were found out for varius reaches. The assumed value of "X" that resulted in a loop closest to a single line was accepted and adopted. The reciprocal of the slope of the single lime gives the value of "K".

4.5 SIMULATION COMPUTATION

4.5.1 Development of Computer Programme

Based on the operation of the detention Basins as described in sec.2.3 computer programmes (3 and 4) were developed for Basins A and B for simulation. Each Computer Programme includes on Main Programme, four subroutine and function sub-programmes (CHROUT, OUTFL. GDIS and FRLB. Subroutine CHROUT is defined in Sec.4.4, subroutine OUTFL uses equation 3.9, to calculate the discharge through outlets of the basins. The function subaprogramme FRLB calculates the basin elevation for a given basin contents, and the other function subprogramme GDIS is used to obtain stage for a corresponding discharge in the river at inlets and outlets of the basins. The main routine does all the necessary calculations for the basin operation studies as described below;

4.5.1.1. <u>Basin A Operation</u>

(1) The flood hydrograph at Dogripora inlet is taken as given at Sangam which is the inflow hydrograph for the river reach 1, between Dogripora and Tokna inlets. This hydrograph is routed through the reach 1 to obtain the flood hydrograph at Tokna.

(2) The mean of Dogripora and Tokna discharge is calculated. If this mean discharge exceeds the channel capacity (CHCAPA) for the reach the excess flow enters into the basin. The water enters into the Tokna inlet first and then the remaining from the Dogripora inlet. The capacities of these inlets are defined as CINLD and CINLT.

(3) The cumulative (+ve) basin storage is known from the step and the water level in the basin is determined.

(4) The steps (2) and (3) are repeated till the water level in the basin does not exceed the maximum basin level (ALEVMA).

(5) The flows which do not enter the basin through the two inlets are routed through the river reach 2 between the Tokna inlet and the Banderpora outlet for each time t to get river flows at the later site. Similarly, the river flows available at the Banderpora outlet are routed through the river reach 3, between Banderpora and Lalhar outlet to get the river

flows at the later site for each time t.

(6) The river stages are calculated for the corresponding discharges at the two outlets. The outflows from the basin through these outlets take place when the river stages these outlets are lower than the water level in the basin. After the outflow(-ve), basin storage is known and the corresponding basin level is determined.

(7) Step 6 is repeated till the water level in the basin is lowered to its minimum value (ALEVMI).

(8) The total river flow in the downstream of Lelhar is the summation of actual flow, as calculated in step 5 and the sum of the outflows from the two outlets at any time t.

This will be the inflow flood hydrograph for the reach 1 between Lelhar and the inlet at Kandizal of Basin B.

(9) The flood detention period in the basin is measured from the time water starts entering into the basin, as in step 2, upto the time the water level in the basin is lowered to its minimum value, as in step 7.

4.5.1.2. <u>Basin B Operation</u>

(1) The inflow flood hydrograph at the downstream of Lelhar as obtained in step 8 above, is routed through

reach 1 of the river between Lelher and the Kandizel inlet to obtain the flood hydrograph at the later site.

(2) If the discharge at Kandizal site exceeds the Channel capacity (CHCAPB) at that point, the excess flow enters into the basin through the Kandizal inlet with inlet capacity defined as (CINLK).

(3) The Cumulative (+ve) basin storage is known from the step 2 and the water level in the basin is determined.

(4) The steps 2 and 3 are repeated till the water level in the basin does not exceed the maximum basin level (ALEVMA).

(5) The flows which do not enter the basin through the inlet are routed through the river reach 2 between the Kandizal inlet and Padshahibagh outlet for each time t, to get river flows at the later site.

(6) The river flows in excess of Srinagar city channel capacity are diverted into the flood spill Channel (F.S. Channel).

(7) The river stages are calculated for the corresponding discharges at the Padshalibagh and the F.S. Channel exit. The out flows from the basin through these out lets take place when the river stages at these outlets are lower than the water level in the basin. After the outflow

cumulative (-ve) basin storage is known and the basin level is determined.

(8) Step 7 is repeated till the water level in the basin is lowered to its minimum value (ALEVNI).

(9) The flood detention period in the basin is measured form the time water starts entering into the basin, as in step 2, upto the time the water level in the basin is lowered to its minimum value, as in step 8.

4.5.2 DETERMINATION OF FLOOD HYDROGRAPH AT SANGAM

To simulate the behaviour of the detention basins A and B it was necessary to route various floods through these basins. Therefore, flood hydrograph are developed for various assumed flood peaks using equations 4.2 and 4.4. By using eq.(4.2) the volume for the assumed peak can be found out. After knowing volume and peak of a flood hydrograph, eq.(4.3) can be used in order to find the Time base of the hydrograph. For the same volume and peak, the peak time of hydrograph can be found out by using eq.(4.4).

The triangular flood hydrograph was plotted knowing T_b, T_p and peak discharge. Generally these triangular volumes will have higher values then that calculated from eq.(4.2). In order to reduce the triangular volume to the given volume, various trial of curvolinear hydrograph were assumed keeping T_b, T_p and flood peak same till the hydrograph for the given volume of Eq.4.2 was obtained. This was done by using the planimeter for each trial the volume of smoothed hydrograph(curvel-linear hydrograph) was checked, if it tallied with given volume, then it was taken as final hydrograph for that peak. Otherwise, again it was adjusted, smoothed till the hydrograph for the given volume by Eq.4.2 was obtained. The hourly ordinates of each flood hydrograph read out and the same were used for the simulation computations (Refer Sec.4.5). The values of T_p, T_b are shown in Table 4.5 and the corresponding flood hydrographs in Fig.4.3, after adding the base flows.

4.5.3 <u>Simulation Calculation</u>

For the simulation study of the detention basins the design variables, the inputs, and the constants used are defined in sec.4.5.3.1 and 4.5.3.2

4.5.3.1 <u>Detention Basin A</u>

<u>I-Design Variables</u>

For the basin A, except the basin capacity all the other design variables were kept fixed, and were taken from the project report[8]. These are given below:

1. River channel capacity(CHCAPPA) for all reaches = 60000 cusecs

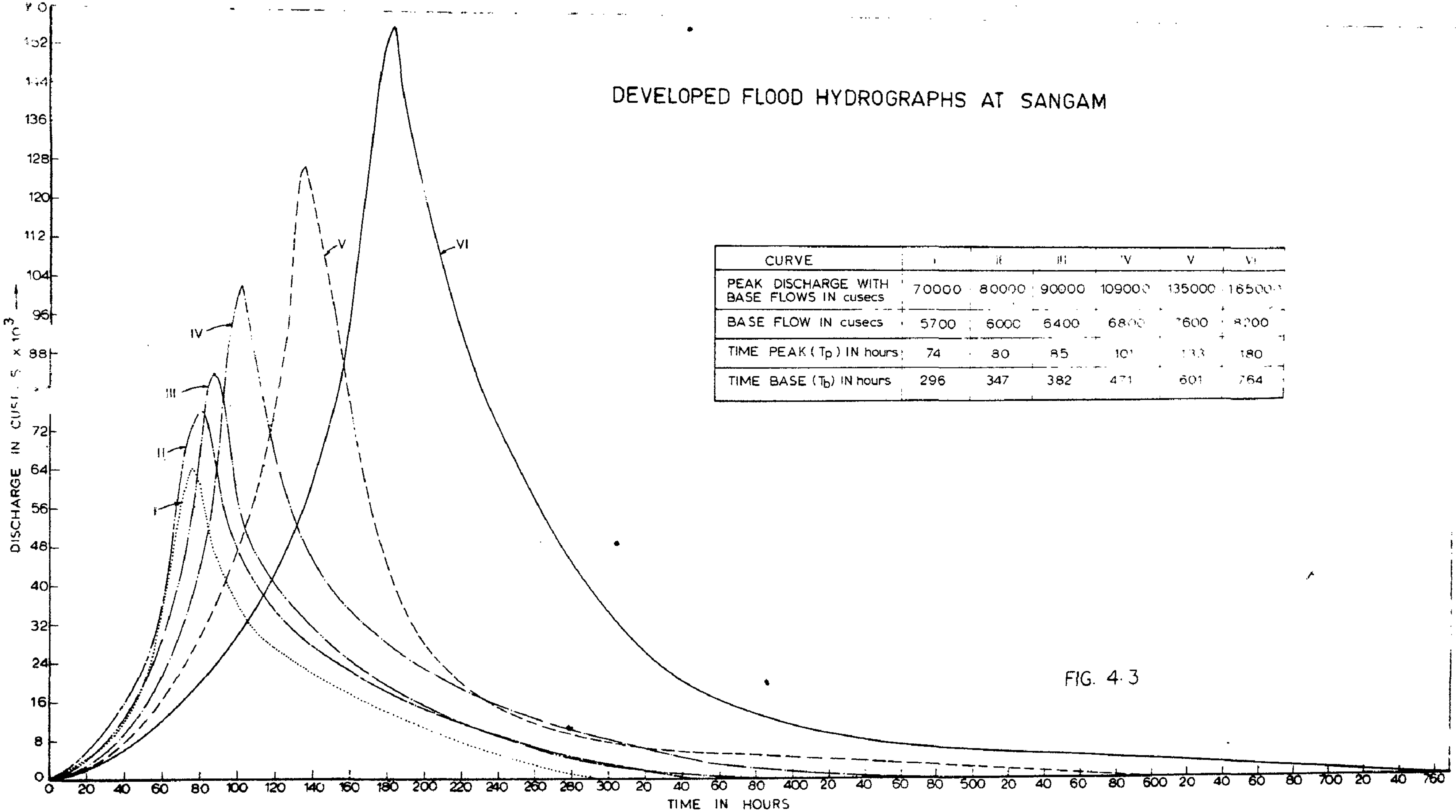
2. Inlet Capacity
   (a) At Dogriporo (CINLD) = 15000 cusecs
   (b) At Tokna (CINLT) = 15000 cusecs

TABLE 4.5

DEVELOPED FLOOD HYDROGRAPHS AT SANGAM

S. No.	Peak discharge with base flood in cusecs	Volume in Acre feet	Time base (T_b) in Hours	Time Peak (T_p) in Hours
1	70000.0	501727.79	296	74
2	80000.0	594869.26	347	80
3	90000.0	691274.13	382	85
4	109000.0	882523.69	471	101
5	135000.0	1159313.4	601	133
6	165000.0	1497392.4	764	180

DEVELOPED FLOOD HYDROGRAPHS AT SANGAM



CURVE	I	II	III	IV	V	VI
PEAK DISCHARGE WITH BASE FLOWS IN cusecs	70000	80000	90000	109000	135000	165000
BASE FLOW IN cusecs	5700	6000	6400	6800	7600	8200
TIME PEAK (T_p) IN hours	74	80	85	101	133	180
TIME BASE (T_b) IN hours	296	347	382	471	601	764

FIG. 4·3

3. Sill levels

(a) Outlets

(i) At Banderpora = 5207.5 feet

(ii) At Lelhar = 5207.5 feet

4. The basin capacities (max. basins levels) considered for the simulation are given in Table 4.6.

II- Input

The flood hydrographs at Sangam which were routed through the basin are given in Table 4.5.

III- Constants

The constants used are

1. Constants X, and K for channel routing are given in Table 4.4.

2. Constants for outlets

(a) At Banderpora] = COFF1 = 300.0
(b) At Lelhar] COFF2 = 447.6

Computer programme described in sec.4.5.1 was used to simulate the behaviour of the detention basin A. Various floods for assumed peaks at Sangam as given in Table 4.5, and Fig.4.3 are routed through the basin using the operating procedure given in sec.4.5.1.1 for different basin capacities. These flood hydrographs are given in Fig.4.3, the routing period was taken as one hour. The flood detention period in the basin, the maximum

TABLE 4.6

DATA FOR SIMULATION AND DETENTION PERIOD OBTAINED FOR BASIN 'A'

S. No.	Peak discharge at Sangam in in Cusecs	Maximum Basin level in feet	Detention period (D_t) in Hours
1	2	3	4
BASIN 'A'			
1	70000.0	5218.60	305
		5220.10	305
		5224.60	305
2	82000.0	5215.60	376
		5218.60	376
		5224.60	376
3	90000.0	5212.60	377
		5214.60	389
		5218.60	392
		5220.10	392
4	109000.0	5212.60	412
		5214.60	424
		5218.60	428
5	135000.0	5212.60	470
		5214.60	485
		5218.60	500
6	165000.0	5214.60	544
		5218.60	550
		5220.60	555

water level attained in the basin are given in Table 4.6 for each flood and for each basin capacity.

4.5.3.2 Detention Basin B

I-Design Variables

For the basin B also, except the basin capacity all the other design variables were kept fixed, and were taken from the project report.[8] These are given below:

1. River channel capacity for all reaches (CHCAPB) = 50000.0 cusecs

2. Inlet capacity

   (a) At Kandizal(CINLK) = 10000.0 cusecs

3. Sill levels

   Outlets

   (i) At Padshahibagh = 5196.0 feet

   (ii) At F.S. Channel = 5196.0 feet

4. The basin capacities (maximum basin levels) considered for the simulation are given in Table 4.8.

II-Input

Only three flood hydrographs, modified by basin A for this capcity (218.6) available at the downstream of Lelhar outlet were routed through basin B. The flood hydrographs at the Kandizal inlet basin B were obtained by routing othe above floods available at the downstream of Lelhar, through reach 1 of the river between Lelhar and Kandizal. These are given in Table 4.7.

III-Constants

The constants used were

1. Constants X, and K for channel routing are given in Table 4.4.

2. Constants of outlets

(a) At Padshahibagh

C_1 = 163.0 FOR L = 49 feet and Cd_1 = 0.62

C_2 = 224.0 FOR L = 49 feet and Cd_2 = 0.62

(b) At F.S. Channel

C_1 = 350.0 FOR L = 105 feet and Cd_1 = 0.62

C_2 = 522.0 FOR L = 105 feet and Cd_2 = 0.62

Computer programme described in sec.4.5.1 was used for simulation of basin B. Three floods as shown in Table 4.8 were routed through the basin using the operating procedure given in sec.4.5.1.2 for different basin capacities. The routing period was one hour. The flood detention period, the maximum water level attained in the basin are given in Table 4.8.

Other results regarding the modified flood hydrographs downstream of Padhahibagh [illegible] flow reaching Srinagar city, and the flow diverted in the F.S. Channel are given in Table 4.9.

TABLE 4.7

MODIFIED FLOOD HYDROGRAPH AT KANDIZAL INLET

(a) For Peak Flood = 90000.0 At Sangam

Time in Hours	Discharge in Cusces	Time in Hours	Discharge in Cusces
0	6400.0	28	11560.8
1	6400.4	29	11899.4
2	6404.1	30	12255.5
3	6419.3	31	12635.1
4	6454.4	32	13037.2
5	6510.0	33	13454.2
6	6581.8	34	13878.5
7	6664.8	35	14312.8
8	6755.3	36	14765.2
9	6853.4	37	15231.4
10	6965.5	38	15713.4
11	7099.2	39	16226.3
12	7257.2	40	16778.5
13	7440.1	41	17357.2
14	7643.4	42	17948.4
15	7860.6	43	18557.2
16	8094.3	44	19185.7
17	8342.6	45	18932.7
18	8595.7	46	20492.2
19	8855.3	47	21154.0
20	9126.0	48	21825.1
21	9406.2	49	22519.8
22	9694.6	50	23239.9
23	9990.1	51	23985.6
24	10294.7	52	24756.8
25	10603.7	53	25546.1
26	10915.2	54	26355.1
27	11233.2	55	27200.9

Table 4.7 (Condt.)

Time in Hours	Discharge in Cusces	Time in Hours	Discharge in Cusces
56	28087.5	84	48000.0
57	29001.1	85	48000.0
58	29942.4	86	48000.0
59	30917.1	87	48000.0
60	31925.1	88	48000.0
61	32974.6	89	48000.0
62	34071.9	90	48000.0
63	35210.6	91	59998.8
64	36388.6	92	59999.4
65	37593.4	93	59999.7
66	38824.8	94	59999.9
67	40093.2	95	59999.9
68	41419.0	96	60000.0
69	42801.4	97	60000.0
70	44221.4	98	60000.0
71	45670.6	99	60000.0
72	47156.2	100	60000.0
73	48000.0	101	60003.6
74	48000.0	102	60027.2
75	48000.0	103	60053.4
76	48000.0	104	59933.9
77	48000.0	105	59543.3
78	48000.0	106	58932.2
79	48000.0	107	58166.4
80	48000.0	108	57304.9
81	48000.0	109	56395.5
82	48000.0	110	55487.4
83	48000.0	111	54610.8

Table 4.7 (Condt.)

Time in Hours	Discharge in Cusces	Time in Hours	Discharge in Cusces
112	53784.2	141	41707.0
113	53019.2	142	41441.0
114	52314.7	143	41149.9
115	51662.7	144	40837.9
116	51092.2	145	40510.0
117	50723.0	146	40175.5
118	50463.1	147	39841.2
119	50181.2	148	39511.5
120	49857.2	149	39185.3
121	49489.0	150	38856.0
122	49089.6	151	38521.1
123	48668.2	152	38180.7
124	48238.4	153	37836.4
125	47804.5	154	37498.8
126	47365.3	155	37168.9
127	46925.2	156	36842.5
128	46496.8	157	36511.9
129	46085.7	158	36178.5
130	45686.8	159	35850.8
131	45288.5	160	35530.3
132	44882.0	161	35212.6
133	44464.9	162	34895.8
134	44037.4	163	34582.7
135	43603.0	164	34269.0
136	43172.9	165	33945.9
137	42754.3	166	33618.5
138	42384.0	167	33293.8
139	42149.9	168	32976.1
140	41944.4	169	32663.3

Table 4.7 (Condt.)

Time in Hours	Discharge in Cusces	Time in Hours	Discharge in Cusces
170	32353.7	199	25170.7
171	32041.9	200	24943.0
172	31728.1	201	24718.8
173	31415.2	202	24502.2
174	31114.3	203	24295.7
175	30831.0	204	24097.5
176	30561.4	205	23903.4
177	30304.4	206	23706.6
178	30055.2	207	23504.3
179	29811.0	208	23303.1
180	29571.4	209	23104.5
181	29332.4	210	22903.6
182	29096.2	211	22699.2
183	28860.7	212	22496.9
184	28826.5	213	22301.9
185	28393.8	214	22114.3
186	28157.5	215	21937.5
187	27908.8	216	21764.0
188	27653.6	217	21583.0
189	27406.6	218	21390.7
190	27174.2	219	21190.7
191	26954.1	220	20992.1
192	26738.0	221	20798.7
193	26521.1	222	20611.3
194	26300.2	223	20425.4
195	26077.0	224	20238.3
196	25851.8	225	20051.1
197	25624.9	226	19867.3
198	25397.4	227	19687.3

Table 4.7 (Contd.)

Time in Hours	Discharge in Cusces	Time in Hours	Discharge in Cusces
228	19506.8	257	14648.4
229	19322.9	258	14502.7
230	19141.4	259	14358.6
231	18967.4	260	14209.6
232	18795.6	261	14057.1
233	18620.3	262	13903.4
234	18444.5	263	13755.0
235	18274.9	264	13616.6
236	18107.7	265	13487.3
237	17934.6	266	13365.9
238	17760.1	267	13254.6
239	17591.6	268	13155.7
240	17424.0	269	13068.4
241	17251.8	270	12988.4
242	17078.7	271	12907.6
243	16910.9	272	12819.3
244	16744.5	273	12724.1
245	16572.5	274	12631.5
246	16399.5	275	12545.4
247	16233.2	276	12459.4
248	16070.9	277	12367.5
249	15911.8	278	12269.3
250	15756.6	279	12168.5
251	15603.2	280	12066.8
252	15447.3	281	11963.3
253	15288.5	282	11859.5
254	15126.7	283	11759.8
255	14963.6	284	11667.3
256	14802.2	285	11578.7

Table 4.7 (Contd.)

1	2	1	
286	11488.1	317	9065.0
287	11393.7	318	9008.9
288	11296.7	319	8953.5
289	11196.2	320	8897.7
290	11090.8	321	8841.9
291	10982.7	322	8786.6
292	10872.9	323	8731.1
293	10763.0	324	8676.0
294	10654.3	325	8620.7
295	10547.2	326	8565.6
296	10446.3	327	8510.3
297	10353.5	328	8455.4
298	10266.2	329	8400.0
299	10178.9	330	8345.4
300	10092.2	331	8290.9
301	10011.8	332	8236.7
302	9939.2	333	8185.9
303	9871.8	334	8139.2
304	9807.7	335	8094.2
305	9746.7	336	8049.0
306	9687.7	337	8001.6
307	9629.7	338	7952.0
308	9572.3	339	7900.0
309	9515.4	340	7847.6
310	9458.6	341	7795.1
311	9401.9	342	7745.7
312	9345.3	343	7702.5
313	9289.1	344	7666.5
314	9233.5	345	7636.1
315	9177.5	346	7608.1
316	9121.3	347	7580.4

Table 4.7 (Contd.)

1	2	1	2
348	7552.9	373	6940.6
349	7526.8	374	6921.6
350	7502.7	375	6904.5
351	7478.6	376	6888.7
352	7450.6	377	6874.0
353	7416.1	378	6859.0
354	7375.5	379	6843.2
355	7331.2		
356	7287.4		
357	7247.4		
358	7213.7		
359	7186.2		
360	7164.0		
361	7145.8		
362	7129.5		
363	7114.3		
364	7099.9		
365	7085.9		
366	7070.0		
367	7052.4		
368	7034.4		
369	7016.1		
370	6998.7		
371	6980.3		
372	6960.5		

Table 4.7(Contd.)

MODIFIED FLOOD HYDROGRAPH AT KANDIZAL INLET

(b) For Peak flood = 10900.0 Cuses at Sangam

Time in Hours	Discharge in Cusces	Time in Hours	Discharge in Cusces
1	2	1	2
0	6800.0	26	10220.0
1	6800.1	27	10470.8
2	6807.8	28	10732.3
3	6834.5	29	11000.4
4	6887.5	30	11277.7
5	6956.1	31	11568.1
6	7028.8	32	11867.9
7	7106.2	33	12173.0
8	7196.6	34	12484.6
9	7301.3	35	12801.3
10	7412.1	36	13127.4
11	7522.3	37	13470.1
12	7630.4	38	13830.6
13	7739.1	39	14205.4
14	7857.6	40	14590.1
15	7994.5	41	14981.6
16	8151.2	42	15380.2
17	8323.6	43	15792.7
18	8506.9	44	16226.2
19	8697.2	45	16681.0
20	8891.7	46	17152.7
21	9089.0	47	17638.8
22	9291.0	48	18140.4
23	9505.0	49	18655.2
24	9735.9	50	19178.9
25	9976.7	51	19713.9

Table 4.7 (Contd.)

1	2	1	2
52	20258.8	81	45380.4
53	20810.5	82	46819.2
54	21373.1	83	48000.0
55	21949.8	84	48000.0
56	22544.9	85	48000.0
57	23157.1	86	48000.0
58	23781.0	87	48000.0
59	24412.3	88	48000.0
60	25061.5	89	48000.0
61	25744.5	90	48000.0
62	26463.8	91	48000.0
63	27213.0	92	48000.0
64	27988.5	93	48000.0
65	28794.2	94	48000.0
66	29630.1	95	48000.0
67	30490.0	96	480000.0
68	31372.3	97	480000.0
69	32281.0	98	480000.0
70	33213.3	99	480000.0
71	34157.1	100	480000.0
72	35117.0	101	480000.0
73	36101.4	102	480000.0
74	37103.8	103	480000.0
75	38122.9	104	480000.0
76	39181.1	105	480000.0
77	40299.3	106	480000.0
78	41487.5	107	480000.0
79	42734.6	108	480000.0
80	44026.9	109	480000.0

Table 4.7(Contd.)

1	2	1	2
110	48000.0	141.	54996.0
111	95741.0	142	54557.1
112	93865.0	143	54075.4
113	91851.9	144	53577.9
114	89815.0	145	53088.6
115	87871.9	146	52615.3
116	86046.1	147	52155.6
117	84319.2	148	51705.4
118	82677.6	149	51260.9
119	81095.8	150	50821.2
120	79556.2	151	50383.5
121	78081.9	152	49941.7
122	76672.4	153	49498.7
123	75279.1	154	49059.8
124	73862.1	155	48632.8
125	72424.6	156	48220.4
126	70989.4	157	47818.3
127	69585.8	158	47420.4
128	68259.6	159	47021.9
129	67016.6	160	46625.4
130	65809.1	161	46279.8
131	64592.3	162	46076.8
132	63364.5	163	45883.7
133	62141.4	164	45649.3
134	60934.6	165	45380.9
135	59765.2	166	45091.9
136	58639.0	167	44784.7
137	57567.6	168	44469.6
138	56563.7	169	44151.6
139	55756.2	170	43831.8
140	55375.6	171	43506.9

Table 4.7 (Contd.)

1	2	1	2
172	43178.4	203	33513.8
173	42842.1	204	33247.1
174	42508.1	205	32986.7
175	42171.4	206	32735.3
176	41836.1	207	32489.6
177	41499.4	208	32246.5
178	41161.8	209	32002.1
179	40821.2	210	31756.5
180	40484.9	211	31516.9
181	40149.6	212	31278.5
182	39813.2	213	31047.5
183	39476.2	214	30817.1
184	39138.0	215	30583.8
185	38804.0	216	30351.8
186	38472.9	217	30122.6
187	38148.8	218	29898.8
188	37831.3	219	29679.8
189	37520.6	220	29460.0
190	37211.8	221	29239.3
191	36902.5	222	29018.6
192	36595.6	223	28798.4
193	36291.3	224	28584.9
194	35991.8	225	28377.1
195	35695.8	226	28173.2
196	35405.8	227	27972.8
197	35122.7	228	27775.3
198	34844.4	229	27575.7
199	34570.8	230	27370.3
200	34301.5	231	27161.8
201	34039.2	232	26959.6
202	33779.6	233	26767.5

Table 4.7 (Contd.)

1	2	1	2
234	26583.0	265	21241.1
235	26398.0	266	21086.3
236	26211.2	267	20934.0
237	26024.5	268	20782.1
238	25835.9	269	20629.1
239	25646.4	270	20477.7
240	25460.6	271	20325.9
241	25276.8	272	20173.8
242	25096.9	273	20025.2
243	24919.1	274	19885.2
244	24743.1	275	19748.7
245	24568.6	276	19609.6
246	24393.9	277	19467.1
247	24219.3	278	19326.5
248	24046.3	279	19191.5
249	23873.3	280	19061.8
250	23699.4	281	18935.9
251	23526.3	282	18814.6
252	23353.9	283	18694.5
253	23181.6	284	18572.4
254	23010.4	285	18443.3
255	22838.4	286	18307.3
256	22667.3	287	18170.4
257	22498.0	288	18038.2
258	22335.0	289	17910.2
259	22175.1	290	17784.2
260	22016.1	291	17653.2
261	21860.2	292	17515.9
262	21704.8	293	17379.1
263	21548.4	294	17247.0
264	21394.2	295	17120.2

Table 4.7 (Contd.)

1	2	1	2
296	16997.5	326	13849.7
297	16878.1	327	13781.7
298	16761.3	328	13698.1
299	16645.2	329	13590.6
300	16530.3	330	13469.9
301	16415.3	331	13551.2
302	16301.2	332	13233.3
303	16187.2	333	13114.1
304	16072.6	334	12998.2
305	15958.8	335	12891.3
306	15845.4	336	12800.4
307	15732.2	337	12722.9
308	15619.1	338	12653.5
309	15506.5	339	12589.6
310	15394.8	340	12527.8
311	15282.5	341	12464.3
312	15170.3	342	12387.2
313	15058.9	343	12289.5
314	14947.1	344	12174.3
315	14836.0	345	12052.0
316	14724.4	346	11937.5
317	14613.6	347	11834.2
318	14504.0	348	11740.8
319	14400.9	349	11657.3
320	14306.5	350	11582.8
321	14218.5	351	11515.0
322	14134.7	352	11452.1
323	14055.8	353	11392.6
324	13982.3	354	11334.3
325	13914.7	355	11275.0

Table 4.7 (Contd.)

1	2	1	2
356	11210.5	386	9373.6
357	11138.4	387	9319.7
358	11062.5	388	9265.8
359	10986.5	389	9212.0
360	10911.1	390	9158.2
361	10836.8	391	9104.6
362	10765.3	392	9051.7
363	10698.7	393	8998.3
364	10635.7	394	8945.0
365	10576.0	395	8894.2
366	10517.9	396	8850.8
367	10461.2	397	8817.2
368	10403.3	398	8789.0
369	10342.1	399	8761.7
370	10276.7	400	8731.0
371	10211.6	401	8697.2
372	10148.9	402	8662.5
373	10088.2	403	8627.8
374	10030.1	404	8592.6
375	9973.7	405	8558.8
376	9918.1	406	8526.6
377	9862.4	407	8494.7
378	9807.6	408	8464.7
379	9753.2	409	8437.7
380	9699.0	410	8413.9
381	9645.0	411	8393.3
382	9590.8	412	8373.6
383	9536.0	413	8354.6
384	9481.6	414	8337.3
385	9427.5	415	8321.3

Table 4.7 (Contd.)

1	2	1	2
416	8306.7	444	7625.4
417	8292.6	445	7604.0
418	8279.0	446	7583.7
419	8264.3	447	7564.8
420	8247.9	448	7548.4
421	8228.1	449	7533.9
422	8203.8	450	7520.5
423	8174.8	451	7507.8
424	8145.4	452	7495.7
425	8117.3	453	7483.8
426	8090.5	454	7471.8
427	8064.8	455	7459.5
428	8038.2	456	7447.4
429	8011.0	457	7435.3
430	7982.9	458	7422.1
431	7952.2	459	7406.9
432	7919.7	460	7389.1
433	7888.0	461	7367.3
434	7858.1	462	7341.2
435	7831.0	463	7311.9
436	7806.0	464	7281.7
437	7782.1	465	7252.5
438	7758.6	466	7227.0
439	7736.0	467	7205.7
440	7713.8	468	7187.0
441	7691.7	469	7169.3
442	7669.2	470	7151.7
443	7647.2		

Table 4.7(Contd.)

(c) For Peak Flood = 165000.0 Cusces at Sangam.

Time in Hours	Discharge in Cusecs	Time in Hours	Discharge in Cusecs
1	2	1	2
0	8200.0	26	10366.9
1	8200.2	27	10535.1
2	8202.0	28	10714.4
3	8209.6	29	10901.9
4	8227.2	30	11094.5
5	8255.0	31	11290.3
6	8290.9	32	11487.9
7	8332.6	33	11686.5
8	8379.3	34	11885.8
9	8432.6	35	12085.4
10	8494.5	36	12285.9
11	8567.3	37	12492.5
12	8652.3	38	12716.0
13	8744.9	39	12959.2
14	8839.5	40	13215.2
15	8934.6	41	13479.0
16	9032.3	42	13742.4
17	9135.1	43	13999.6
18	9244.9	44	14255.8
19	9363.3	45	14511.1
20	9488.8	46	14765.2
21	9623.3	47	15031.8
22	9769.1	48	15315.1
23	9919.2	49	15604.9
24	10065.5	50	15898.8
25	10211.8	51	16200.8

Table 4.7 (Contd.)

1	2	1	2
52	16507.4	82	27203.1
53	16814.0	83	27623.3
54	17119.4	84	28046.6
55	17425.8	85	28463.6
56	17736.5	86	28896.1
57	18049.7	87	29356.4
58	18366.4	88	29822.9
59	18696.9	89	30282.9
60	19041.0	90	30743.2
61	19385.7	91	31207.4
62	19726.0	92	31669.5
63	20070.0	93	32133.6
64	20418.9	94	32600.3
65	20769.6	95	33058.6
66	21121.3	96	33504.8
67	21475.6	97	33947.8
68	21837.9	98	34396.6
69	22208.1	99	34846.0
70	22579.0	100	35297.8
71	22945.3	101	35756.1
72	23307.0	102	36237.5
73	23667.4	103	36746.1
74	24033.8	104	37273.2
75	24409.4	105	37808.1
76	24793.3	106	38354.7
77	25183.4	107	38917.1
78	25611.5	108	39498.7
79	26095.5	109	40106.4
80	26431.5	110	40737.6
81	26803.9	111	41380.0

Table 4.7 (Contd.)

1	2	1	2
112	42033.4	143	48000.0
113	42700.4	144	59997.4
114	43378.7	145	59998.6
115	44065.5	146	59999.3
116	44757.4	147	59999.6
117	45453.5	148	59999.8
118	46153.7	149	59999.9
119	46861.5	150	60000.0
120	47575.9	151	60000.0
121	48000.0	152	60000.0
122	48000.0	153	60000.0
123	48000.0	154	60000.0
124	48000.0	155	60000.0
125	48000.0	156	60000.0
126	48000.0	157	60000.0
127	48000.0	158	60000.0
128	48000.0	159	60000.0
129	48000.0	160	60278.3
130	48000.0	161	62683.7
131	48000.0	162	70198.9
132	48000.0	163	81148.2
133	48000.0	164	90851.4
134	48000.0	165	98831.9
135	48000.0	166	105496.3
136	48000.0	167	111168.1
137	48000.0	168	115914.4
138	48000.0	169	119803.8
139	48000.0	170	123833.7
140	48000.0	171	127729.6
141	48000.0	172	131873.1
142	48000.0	173	136177.6

Table 4.7 (Contd.)

1	2	1	2
174	140308.1	205	127004.9
175	144012.9	206	125417.7
176	147120.8	207	123866.6
177	149639.7	208	122337.4
178	151806.4	209	120453.6
179	153805.4	210	116068.8
180	155744.8	211	106697.9
181	157456.4	212	97354.8
182	158715.3	213	95229.1
183	160748.0	214	97928.4
184	162023.6	215	101396.4
185	162375.3	216	103911.8
186	161813.3	217	105181.2
187	160588.3	218	105461.3
188	158978.0	219	105111.8
189	157153.4	220	104416.7
190	155170.2	221	103526.0
191	153022.9	222	102480.2
192	150760.5	223	101333.6
193	148513.5	224	100178.6
194	146313.7	225	99050.2
195	144106.9	226	97932.4
196	141976.9	227	96823.6
197	139991.2	228	95742.1
198	138125.9	229	94703.1
199	136347.9	230	93702.4
200	134654.1	231	92719.5
201	133056.1	232	91744.1
202	131549.2	233	90782.1
203	130082.5	234	89838.8
204	128574.8	235	88916.4

Table 4.7 (Contd.)

1	2	1	2
236	88022.6	268	63507.2
237	87157.4	269	62837.7
238	86309.8	270	62173.5
239	85462.6	271	61508.7
240	84614.5	272	60852.0
241	83781.7	273	60205.1
242	82961.1	274	59560.8
243	82137.3	275	58921.5
244	81310.5	276	58294.0
245	80486.6	277	57791.6
246	79679.8	278	57637.8
247	78901.7	279	57447.6
248	78141.0	280	57181.8
249	77379.8	281	56851.7
250	76609.5	282	56472.0
251	75829.6	283	56061.9
252	75043.4	284	55637.4
253	74261.3	285	55194.4
254	73501.8	286	54732.7
255	72777.2	287	54263.3
256	72059.9	288	53786.9
257	71329.8	289	53311.1
258	70581.4	290	52838.3
259	69827.6	291	52360.9
260	69093.9	292	51881.3
261	68385.7	293	51402.8
262	67681.9	294	50923.6
263	66980.4	295	50441.4
264	66289.9	296	49957.3
265	65600.9	297	49471.7
266	64899.6	298	49049.3
267	64195.4	299	48814.6

Table 4.7 (Contd.)

1	2	1	2
300	48568.4	331	36456.0
301	48294.8	332	36132.2
302	47978.3	333	35820.0
303	47623.7	334	35521.2
304	47242.8	335	35226.5
305	46849.0	336	34933.4
306	46451.1	337	34641.7
307	46042.9	338	34350.5
308	45624.8	339	34066.4
309	45200.4	340	33784.1
310	44764.5	341	33502.2
311	44320.2	342	33227.0
312	43881.8	343	32959.6
313	43449.9	344	32697.6
314	43020.5	345	32435.7
315	42598.6	346	32167.0
316	42181.3	347	31895.4
317	41767.3	348	31622.6
318	41354.6	349	31357.9
319	40951.1	350	31107.8
320	40554.6	351	30876.5
321	40156.6	352	30651.1
322	39755.1	353	30423.9
323	39356.9	354	30199.5
324	38963.4	355	29979.3
325	38577.0	356	29763.2
326	38200.0	357	29551.2
327	37831.5	358	29342.4
328	37474.7	359	29133.1
329	37128.2	360	28919.8
330	36788.9	361	28704.2

Table 4.7 (Contd.)

1	2	1	2
362	28491.9	393	23227.6
363	28286.1	394	23081.0
364	28088.5	395	22935.4
365	27901.6	396	22794.1
366	27721.9	397	22658.8
367	27543.1	398	22527.8
368	27359.9	399	22400.2
369	27170.4	400	22275.0
370	26974.8	401	22151.9
371	26776.5	402	22029.4
372	26582.3	403	21908.0
373	26395.9	404	21785.7
374	26220.1	405	21662.0
375	26054.2	406	21531.5
376	25889.4	407	21393.6
377	25717.2	408	21254.7
378	25541.6	409	21119.9
379	25372.8	410	20990.5
380	25211.4	411	20865.8
381	25050.9	412	20743.0
382	24888.5	413	20621.8
383	24723.3	414	20503.0
384	24558.5	415	20385.4
385	24397.5	416	20268.1
386	24243.5	417	20150.3
387	24099.3	418	20034.9
388	23953.5	419	19925.1
389	23803.6	420	19823.9
390	23655.2	421	19727.8
391	23511.8	422	19629.7
392	23370.9	423	19527.4

Table 4.7 (Contd.)

1	2	1	2
424	19421.3	456	16523.4
425	19311.6	457	16422.1
426	19200.6	458	16329.5
427	19088.3	459	16247.6
428	18976.2	460	16174.8
429	18869.8	461	16110.8
430	18773.2	462	16054.4
431	18686.2	463	16001.8
432	18605.5	464	15948.8
433	18525.0	465	15895.5
434	18440.2	466	15840.0
435	18354.0	467	15783.0
436	18270.1	468	15725.0
437	18191.4	469	15666.4
438	18116.8	470	15607.7
439	18041.3	471	15549.6
440	17965.1	472	15490.9
441	17888.8	473	15432.1
442	17809.6	474	15374.0
443	17723.0	475	15315.6
444	17629.5	476	15258.5
445	17531.4	477	15203.6
446	17434.6	478	15154.6
447	17344.6	479	15111.3
448	17262.8	480	15071.0
449	17186.7	481	15031.1
450	17110.6	482	14988.8
451	17027.3	483	14941.7
452	16935.8	484	14890.4
453	16838.1	485	14838.1
454	16735.2	486	14787.5
455	16629.7	487	14740.4

Table 4.7 (Contd.)

1	2	1	2
488	14695.6	519	13856.3
489	14652.9	520	13831.2
490	14613.7	521	13804.8
491	14578.3	522	13777.2
492	14546.1	523	13750.6
493	14516.1	524	13727.0
494	14487.9	525	13706.4
495	14461.2	526	13688.3
496	14434.6	527	13671.9
497	14408.0	528	13656.6
498	14381.8	529	13641.9
499	14356.3	530	13627.6
500	14330.4	531	13613.6
501	14304.6	532	13599.7
502	14279.3	533	13585.8
503	14253.8	534	13572.0
504	14225.8	535	13558.5
505	14203.4	536	13545.5
506	14178.4	537	13532.2
507	14153.0	538	13518.7
508	14128.1	539	13505.1
509	14102.8	540	13491.7
510	14078.1	541	13478.9
511	14053.5	542	13465.6
512	14028.4	543	13452.1
513	14003.9	544	13438.8
514	13979.4	545	13426.0
515	13954.4	546	13412.8
516	13929.9	547	12984.1
517	13905.6	548	11905.5
518	13881.3	549	12659.4

Table 4.7 (Contd.)

1	2	1	2
550	13024.6	581	12889.7
551	13200.1	582	12867.2
552	13281.2	583	12846.4
553	13315.6	584	12827.5
554	13326.2	585	12809.6
555	13325.4	586	12791.9
556	13318.2	587	12773.8
557	13307.1	588	12754.5
558	13292.3	589	12733.8
559	13275.0	590	12712.8
560	13255.8	591	12691.7
561	13236.8	592	12670.4
562	13218.6	593	12648.9
563	13202.3	594	12627.4
564	13187.1	595	12605.9
565	13173.4	596	12584.3
566	13160.4	597	12561.5
567	13147.3	598	12535.4
568	13134.6	599	12506.3
569	13121.8	600	12475.4
570	13109.6	601	12443.1
571	13097.4	602	12409.4
572	13084.5	603	12376.5
573	13070.8	604	12346.0
574	13055.2	605	12318.4
575	13037.2	606	12292.9
576	13018.5	607	12269.0
577	12998.9	608	12246.1
578	12973.0	609	12223.8
579	12943.8	610	12201.8
580	12915.2	611	12180.1

Table 4.7 (Contd.)

1	2	1	2
612	12158.5	642	11423.0
613	12136.9	643	11401.3
614	12115.4	644	11379.6
615	12094.6	645	11358.3
616	12073.5	646	11337.4
617	12052.2	647	11316.3
618	12030.8	648	11295.0
619	12009.4	649	11273.9
620	11987.9	650	11253.2
621	11966.4	651	11232.1
622	11944.9	652	11211.1
623	11922.4	653	11190.4
624	11897.3	654	11169.4
625	11869.4	655	11148.1
626	11840.1	656	11126.3
627	11811.9	657	11102.9
628	11785.6	658	11076.3
629	11760.9	659	11047.4
630	11737.4	660	11017.2
631	11713.9	661	10986.3
632	11688.7	662	10957.0
633	11660.0	663	10930.4
634	11630.1	664	10905.6
635	11600.4	665	10882.3
636	11571.9	666	10860.8
637	11544.7	667	10840.6
638	11518.0	668	10820.8
639	11492.4	669	10800.1
640	11468.1	670	10778.3
641	11444.9	671	10756.6

Table 4.7 (Contd.)

1	2	1	2
672	10734.9	703	10011.3
673	10713.3	704	9991.4
674	10692.2	705	9971.5
675	10670.0	706	9951.5
676	10644.9	707	9931.4
677	10614.5	708	9911.1
678	10581.4	709	9889.6
679	10535.2	710	9866.5
680	10454.2	711	9842.4
681	10404.3	712	9818.8
682	10376.1	713	9796.4
683	10363.8	714	9774.8
684	10356.9	715	9746.4
685	10348.9	716	9701.3
686	10337.6	717	9657.4
687	10323.2	718	9641.4
688	10306.8	719	9644.1
689	10288.8	720	9650.0
690	10270.0	721	9653.1
691	10250.7	722	9652.1
692	10231.1	723	9647.7
693	10211.2	724	9640.8
694	10191.4	725	9631.3
695	10171.4	726	9618.8
696	10151.5	727	9603.0
697	10131.5	728	9584.0
698	10111.5	729	9561.9
699	10091.5	730	9539.0
700	10071.4	731	9516.3
701	10051.2	732	9494.6
702	10031.2	733	9473.3

Table 4.7 (Contd.)

1	2	1	2
734	9452.6	757	8824.0
735	9432.1	758	8782.1
736	9411.8	759	8743.8
737	9391.6	760	8709.3
738	9371.5	761	8675.1
739	9350.3	762	8635.3
740	9325.8	763	8584.9
741	9296.4		
742	9264.3		
743	9233.3		
744	9205.0		
745	9179.5		
746	9155.7		
747	9132.1		
748	9107.2		
749	9080.2		
750	9052.2		
751	9025.0		
752	8999.1		
753	8972.2		
754	8941.6		
755	8906.0		
756	8866.3		

TABLE 4.8

DATA FOR SIMULATION AND DETENTION PERIOD OBTAINED FOR BAIN 'B'

S.No.	Peak discharge at Sangam in Cusecs	Maximum Basin Level in feet	Detention period (D_t) in Hours
1	2	3	4
BASIN 'B'			
1	90000.0	5200.40	519
		5202.40	549
2	109000.0	5200.40	575
		5202.40	600
3	165000.0	5200.40	745
		5202.40	755
		5204.40	758
		5206.40	760

TABLE - 4.9

MODIFIED FLOOD VALUES AT PADSHAHIBAGH

I BASIN LEVEL = 5202.4

Note:- Flow towards Srinagar = 33000Cusecs.

Values given in Col.3 were obtained by Routing using CHROUT.

Peak Discharge at Sangam	Time in Hours	RIVER FLOW VALUES AT PADSHAHI BAGH		Flood Spill Channel RD 7000
		Without Basin Routing	With Basin Routing	
1	2	3	4	5
90000.0	74	48647.3	48032.1	15032.0
Cusecs	80	59862.9	48000.0	15000.0
	86	79165.1	48000.0	15000.0
	91	87902.0	48000.0	15000.0
	92	87724.8	48000.0	15000.0
	98	77950.7	60525.9	27525.9
	104	68275.9	59992.5	26999.5
	110	68697.3	55941.3	22941.3
	116	53058.9	51374.3	28374.3
	122	49297.9	49290.4	16290.4
	124	48167.2	48453.4	15453.4
109000	84	48298.1	48047.0	15047.0
Cusecs	90	59506.2	48000.0	15000.0
	96	81374.1	48000.0	15000.0
	102	102590.8	48000.0	15000.0
	106	107187.0	48000.0	15000.0
	108	105833.7	48000.0	15000.0
	114	92195.4	90848.2	57848.2
	120	81156.8	80324.4	47324.4
	126	72476.5	71706.8	38706.8

Table 4.9 (Contd.)

1	2	3	4	5
	132	64635.6	63978.8	30978.8
	138	57606.9	57063.1	24063.1
	144	52477.5	53827.2	20827.2
	150	48868.4	51040.9	18040.9
	151	48381.5	50602.3	17602.3
165000 Cusecs	122	48278.6	48016.2	15016.2
	128	53003.3	48000.0	15000.0
	134	58352.7	48000.0	15000.0
	140	63962.9	48000.0	15000.0
	146	70495.0	48000.0	15000.0
	152	78405.6	53513.5	20513.5
	158	88390.2	60000.0	27000.0
	164	100435.1	86060.2	53060.2
	170	120853.7	121810.4	88810.4
	176	143887.0	145589.6	112589.6
	182	[illegible]	158103.4	125103.4
	186	162451.9	162128.5	129128.5
	188	160662.6	159796.0	126796.0
	194	148590.7	147411.7	114411.7
	200	136412.3	135497.9	102497.8
	212	107500.3	102009.4	69009.4
	218	105140.3	105357.4	72357.4
	224	101379.6	100756.1	67756.1
	230	94739.4	94201.3	61201.3
	236	88949.5	88468.3	55468.3
	242	83810.1	83370.9	50370.9
	248	78928.0	78520.6	45520.6
	254	74290.4	73881.5	40881.5
	260	69855.9	69459.8	36459.8
	266	65624.1	65250.8	33250.8

Table 4.9(Contd.)

1	2	3	4	5
	272	61532.9	61180.0	28180.0
	278	57705.7	57701.0	24701.0
	284	54184.5	55850.1	22850.1
	290	50757.1	53074.6	20074.6
	295	48071.6	50682.1	17682.1
II	BASIN LEVEL =	5200.4		
90000 Cusecs	74	48647.3	48032.1	15032.1
	80	59862.9	48000.0	15000.0
	86	79165.1	48000.0	15000.0
	91	87902.0	53513.0	20513.0
	92	87724.8	60525.0	27525.0
	98	77950.7	60000.0	27000.0
	104	68275.9	59999.5	26999.5
	110	68697.3	55941.3	22941.3
	116	53058.9	51374.3	28374.3
	122	49297.9	49290.4	16290.4
	124	48167.2	48453.6	15453.6
109000 Cusecs	84	48298.1	48047.0	15047.0
	90	59506.3	48000.0	15000.0
	96	81374.1	48000.0	15000.0
	102	102590.8	48000.0	15000.0
	106	107187.0	87331.0	54331.0
	108	105833.7	97698.0	64698.0
	109	103925.8	98573.1	65573.1
	112	96726.6	94811.8	61811.8
	118	84400.9	83495.1	50495.1
	124	75325.1	74571.5	41571.5
	130	67057.1	66411.6	33411.6

Table 4.9 (Contd.)

1	2	3	4	5
	136	59806.7	59200.5	26200.5
	142	54018.1	54778.9	21778.9
	148	49944.0	51930.2	18930.2
	151	48381.5	50602.3	37602.3
16500	122	48278.6	480162.0	150162.0
	128	53003.3	48000.0	15000.0
	134	58352.7	48000.0	15000.0
	140	63962.9	60523.8	27523.8
	146	70495.0	60000.0	27000.0
	152	78405.6	60000.0	27000.0
	158	88390.2	75550.5	42550.5
	164	100435.1	117890.9	84890.9
	170	120853.7	142177.1	109177.1
	176	143887.0	156609.6	123609.6
	180	153741.3	162234.1	129234.1
	182	157614.1	161224.9	128224.9
	188	160662.6	149636.0	116636.0
	194	148590.7	137233.6	104233.6
	200	136412.3	127792.1	94792.1
	206	127063.8	111577.3	78577.3
	212	107500.3	104593.7	71593.7
	218	105140.3	101910.5	78910.5
	224	101379.6	95220.9	63220.9
	230	94739.4	89376.8	56376.8
	236	88949.5	84197.4	51197.4
	242	83810.1	79289.6	46289.6
	248	78928.0	74652.1	41652.1
	254	74290.4	70204.6	37204.6
	260	69855.9	65945.3	32945.3
	266	65624.1	61841.1	28841.1

Table 4.9 (Contd.)

1	2	3	4	5
	272	61532.9	58037.8	25037.8
	278	57705.7	56268.0	23268.0
	284	54184.5	53549.0	20549.0
	290	50757.1	50682.6	17682.6
	295	48071.6	48692.5	15692.5

III BASIN LEVEL = 5206.4

165000	122	48278.6	48016.2	15016.2
	128	53003.3	48000.0	15000.0
	134	58352.7	48000.0	15000.0
	140	63962.9	48000.0	15000.0
	146	70495.0	48000.0	15000.0
	152	78405.6	48000.0	15000.0
	158	88390.2	48000.0	15000.0
	164	100435.1	48000.0	15000.0
	170	120853.7	121827.1	88827.1
	176	143887.0	145589.6	112589.6
	182	157614.1	158103.4	125103.4
	185	162155.9	162234.1	129234.1
	188	160662.6	159796.8	126796.8
	194	148590.7	147411.7	114411.7
	200	136412.3	135497.8	112497.8
	206	127063.8	126211.8	113211.8
	212	107500.3	102009.4	69009.4
	218	105140.3	105357.4	72357.4
	224	101379.6	100756.1	67756.1
	230	94739.4	94201.3	61201.3
	236	88949.5	88468.8	55468.8
	242	83810.1	83370.9	50370.9

Table 4.9 (Contd.)

1	2	3	4	5
	248	78928.0	78520.6	45520.6
	254	74290.4	73881.5	40881.5
	260	69855.9	69459.8	36459.8
	266	65624.1	65250.8	32250.8
	272	61532.9	61180.0	28180.0
	278	57705.7	57701.0	24701.0
	284	54184.5	55850.1	22850.0
	290	50757.1	53074.6	20074.6
	295	48071.6	50682.6	17682.6

CHAPTER - 5

CHAPTER-5

ANALYSIS OF RESULTS AND CONCLUSION

5.1 ANALYSIS OF SIMULATION RESULTS

5.1.1 Detention Basin A

5.1.1.1 General

The table 5.1 shows the peak floods and maximum basin level which have been used for simulation for basin A alongwith the results of maximum rise of water levels in the basin and detention periods obtained. From the results it is seen that maximum rise in the water elevation achieved are less than the maximum basin levels for peaks upto 109000 cusecs, but for higher peaks the maximum basin levels considered are not sufficient to accomodate higher peaks. It is observed from Table5.1 that the basin level 5218.60 may be considered safe for flood peaks upto say 120000 cusecs.

According to the project report[8], the design flood of 90000 cusecs can be accommodated by basin A for a level of 5218.6 feet. But it is seen above that this level can even absorb flood peaks like 120000 cusecs. Also, the maximum level of basin A which can be technically considered is 5220.0 feet. Therefore, for the simulation of basin B, the level of basin A

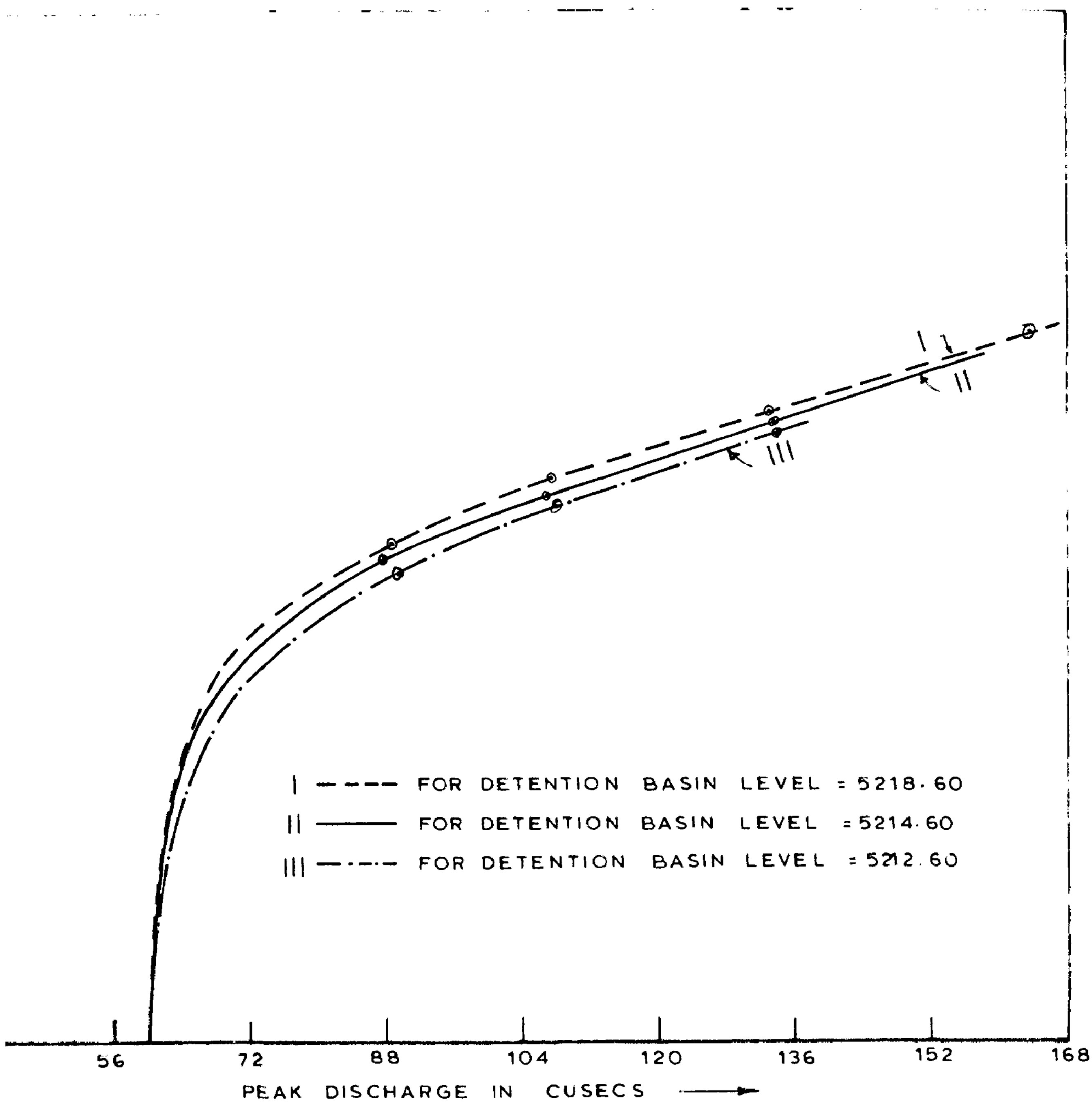
TABLE 5.1

Results of Simulation for Detention Basin 'A'

S.No.	Peak discharge at Sangam in Cusecs	Maximum Basin level in feet	Maximum Rise in water level in feet	Detention period (D_t) in Hours
1	2	3	4	5
BASIN A				
1	70000.0	5218.60	5209.71	305
		5220.10	5209.71	305
		5224.60	5209.71	305
2	82000.0	5215.60	5214.56	376
		5218.60	5214.56	376
		5224.60	5214.56	376
3	90000.0	5212.60	5212.27	377
		5214.60	5214.39	389
		5218.60	5216.55	392
		5220.10	5216.55	392
4	109000.0	5212.60	5212.60	412
		5214.60	5213.99	424
		5218.60	5217.77	428
5	135000.0	5212.60	5212.41 *	470
		5214.60	5214.33 *	485
		5218.60	5218.37 *	500
6	165000.0	5214.60	5214.10 *	544
		5218.60	5218.40 *	550
		5220.60	5220.20 *	555

*Rise in the water level in the basin possible if the corresponding basin level (Col. 3) is increased.

(5218.6 feet) was kept constant and the peak floods modified by this level of basin A were routed through basin B. As seen from table 5.1 the detention periods for peak 70000 cusecs are found same for various basin levels as the rise in maximum water level in the basin is also same. Which is justified again for the 82000 cusecs peak. But for other higher peaks this is not the case because for each basin level considered the maximum rise in water is also different. The detention period is also likely to vary with the shape of the flood hydrographs, and the routing period keeping other design variables constant. The triangular flood hydrographs were derived using equations and then the curvelinear shapes of these hydrographs were obtained by adjusting the triangular hydrographs with the help of a planimeter as discussed in sec. 4.5.2. Final shape of the hydrograph may vary if derived by a persons at different times or by different persons at a time. This variation in the shape will vary the detention period. Therefore, good and reliable results are expected for observed flood hydrographs. The routing period will vary the detention period as well. For this let us consider three ordinates of a flood hydrograph say 61000, 62000, and 63000 cusecs at an interval of one hour at times t_1, t_2, and t_3. If



5.1 _ PEAK DISCHARGE VS DETENTION PERIOD FOR BASIN 'A'

the routing period is one hour, the increment in the basin storage is $\left[\left(\frac{1000 + 2000}{2} \right) + \left(\frac{2000 + 3000}{2} \right) \right] x \frac{1}{43560}$
$= 9.1827x10^{-2}$ ac.ft. during the two hours from t_1 to t_3.
And if, the routing jperiod is two hours, the increment in this basin storage is $\left(\frac{1000 + 3000}{2} \right) x \frac{1}{43560} = 4.5913x10^{-2}$ acre/ft during t_1 to t_3. Hence the detention period will vary with the routing duration. Here, 60000 cusecs is channel capacity.

5.1.1.2 <u>Variation Of Detention Periods With Flood Peaks</u>

Flood peaks were plotted against the detention period as shown in fig.5.1 for various basin levels for basin A, From this figure it is seen that with the increase in flood peaks, the detention period also increases for a given design capacity (basin level) of the basin. The expected nature of this curve for basin level 5218.60 feet is also shown. The detention periods for peaks which are equal to and less them the channel capacity of 60000 cusecs should be zero as no inflow to the basin A can take place.

For other two basin levels 5214.6 feet and 5212.60 feet, only a few points were available to draw the curves. Therefore the expected nature of these curves were drawn on the basis of curve for basin level 5218.60 feet as shown in figure 5.1.

5.1.2 Detention Basin B

5.1.2.1 General

The Table 5.2 shows the maximum rise in the water levels attained and the detention periods for various basin levels which were obtained after simulation, corresponding to the flood peaks at Sangam and which were modified at Lelhar only. three floods were tried for basin B(Table 4.7.).The maximum rise in the water level in the basin is found equal to the maximum basin level for all the flood peaks and still some rise in the water level is possible if the basin level is increased. Therefore to accomodate these modified flood peaks fully the capacity of basin B may be increased in each case.

5.1.2.2 Variation Of Detention Periods With Floods Peaks

Flood peaks were plotted agianst detention period as shown in fig.(5.2)for various basin levels. The detention period for flood peaks equal to or less than the channel capacity 48000 cusecs should be zero as no inflow to the basin B can take place. Therefore, the expected nature of the curve may be like as shown in Fig.5.2 on the basis of fig.5.1.

5.1.2.3 Reduction In Flood Peaks At Padshahibagh

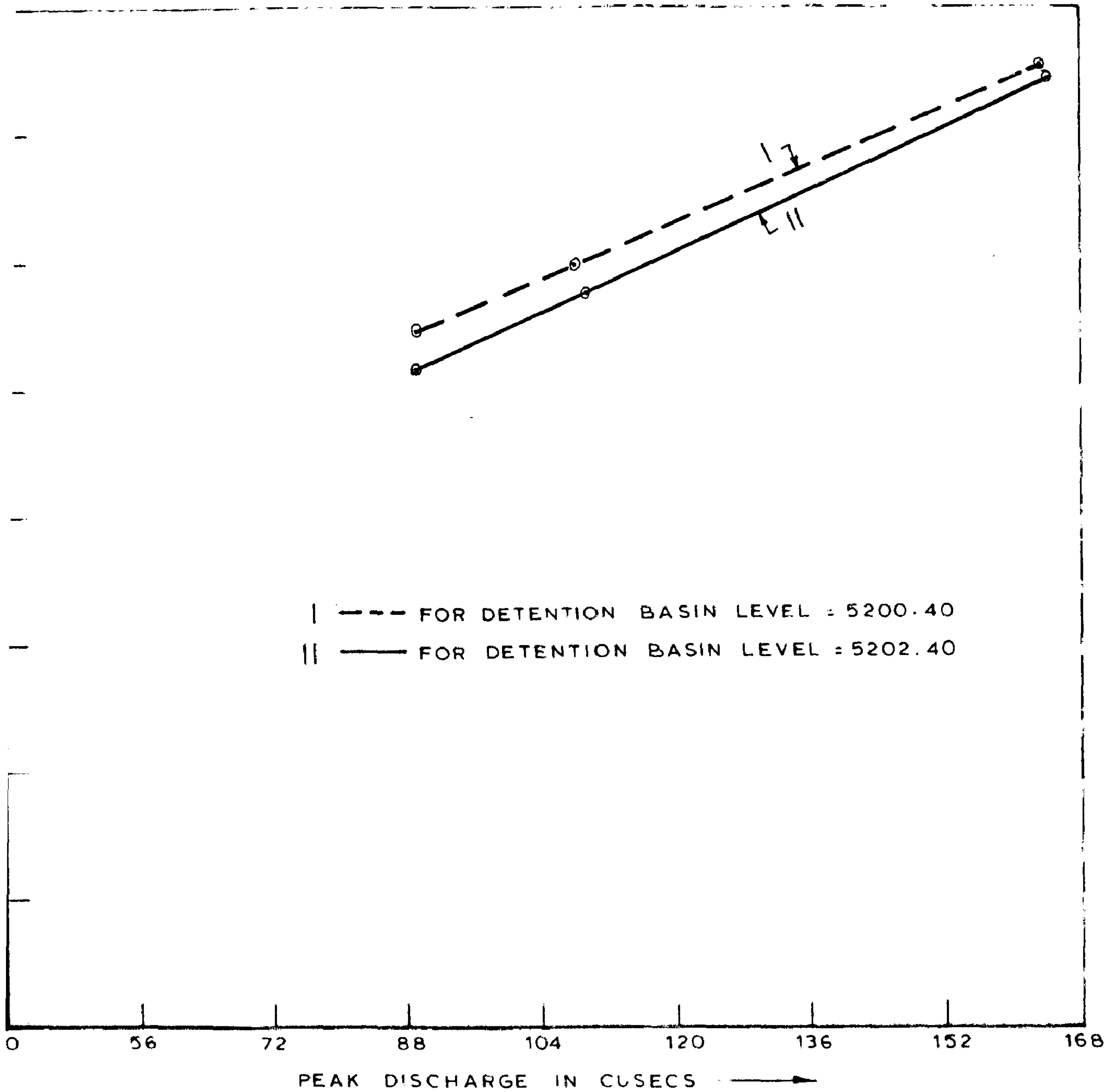
It was tried to see how many times the flow exceeds the channel capacity of 48000 cusecs at the

TABLE 5.2

Results of Simulation for Detention Basin 'B'

S.No.	Peak discharge at Sangam in Cusecs	Maximum Basin Level in feet	Maximum Rise in water level in feet	Detention Period (D_t) in Hours
1	2	3	4	5
BASIN B				
1	90000.0	5200.40	5200.30 *	519
		5202.40	5202.2 *	549
2	109000.0	5200.40	5200.20 *	575
		5202.40	5202.33 *	600
3	165000.0	5200.40	5200.19 *	745
		5202.40	5202.30 *	755
		5204.40	5204.10 *	758
		5206.40	5206.27 *	760

* Rise in the water level in the basin possible if the corresponding basin level (Col.3) is increased.



G. 5.2 – PEAK DISCHARGE VS DETENTION PERIOD FOR BASIN 'B' downstream of Padshahibagh with and without basin routing. For this purpose the flood hydrographs through various reaches using CHROUT, along the length of the river from Sangam to Padshahibagh, assuming that there were no basins. From the above final routed hydrographs at the Padshahibagh, the number of times the flood flows exceed the 48000 cusecs channel capacity were counted and are given in Table(5.3.) Similary, the number of these exceedences when the basins are existing are also given in Table 5.3 from the simulation computations carried out in sec(4.5.)

The percentage reduction in occurances of flood flows above 48000 cusecs is shown in Col.5 of Table 5.3, the variation in percentage reduction is clearly seen for various basin levels and for various peak floods.

The Pictiofal representation of these are given in Fig.5.3. It is seen from figure 5.3a that due to the presence of basins the reduction in the flood peak at the downstream of Padshahibagh for 90000 cusecs flood is quite considerable as compared to that of the other two flood peaks of 109000 cusecs, and 165000 cusecs.

By comparing the reduction in flood peak by increasing the maximum level of basin B (the maximum level of basin A is fixed at 5218.60 feet), it is

TABLE 5.3

REDUCTION OF FLOOD FLOWS DUE TO BASINS AT PADSHAHIBAGH

Maximum Basin level in Feet	Peak discharge at Sangam in Cusecs	No.of Exceedence of flood flows above 48000 cusecs without Basin Routing	No.of Exceedence of flood flows above 48000 cusecs with Basin Routing	% Reduction in occurence of flood flows above 48000 cusecs.
1	2	3	4	5
5200.40	90000.0	49 times	37 times	24.48
5202.40	90000.0	49 "	31 "	36.73
5200.40	109000.0	68 "	57 "	16.17
5202.40	109000.0	68 "	49 "	27.94
5200.40	165000.0	174 "	161 "	7.47
5202.40	165000.0	174 "	152 "	12.64
5204.40	165000.0	174 "	146 "	16.09
5206.40	165000.0	174 "	138 "	20.69

Note :- These values have been taken from table 4.9.

found that for 90000 cusecs flood. Peak fig.5.3a the reduction in flood peak nearly same for two basins levels of 5202.4 feet and 5200.4 feet, and as expected the routed flood hydrograph is slightly shifted for the first level. The shifting of the routed flood hydrograph is as expected for the 109000 cusecs flood peak also, fig.5.3b, but the reduction in flood peak is different for each basin level i.e. more reduction for 5202.4 feet and less for 5200.0 feet. However, these basin levels are not suitable for absorbing higher flodd peaks as in the case of the 165000 cusecs flood peak fig(5.3C).

The proposed level of basin B from the project report [8] is 5202.4 feet, which seems to be quite sufficient to absorb the 90000 flood peak (design flood) after it is modified by basin A.

5.1.3 Regression Analysis Of The Results

Relationship were obtained for levels 5218.6 feet and 5202.4 feet for basins A and B respectively between detention period D_t, and flood peak Q, by fitting polynomial [15] using computer programme (2) and also multiple regression analysis was carried out and relationships were obtained between detention period as the dependent variable and flood peak Q, volume V, and time base T_b as independent variables.

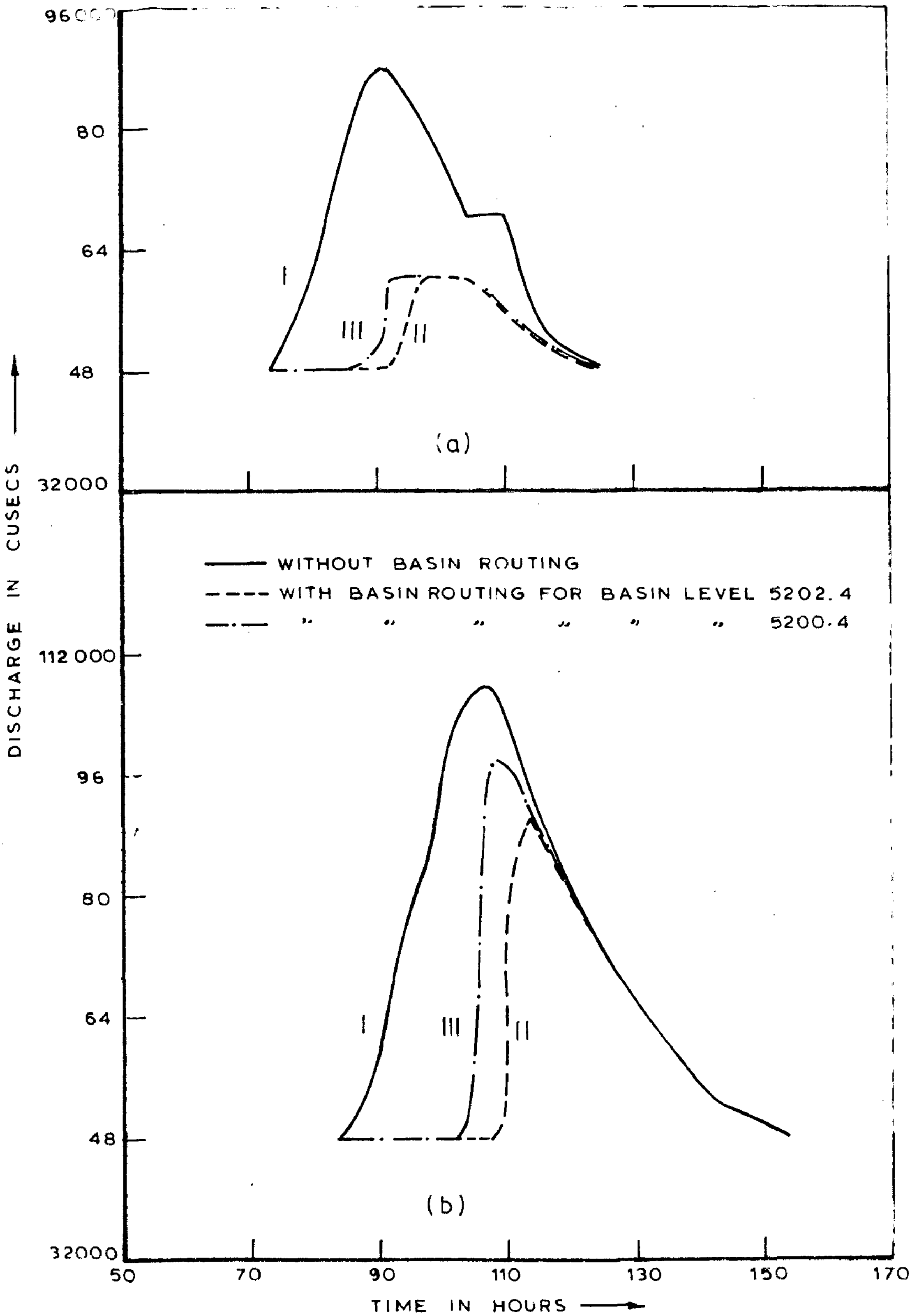


FIG 5.3 _ PICTORIAL REDUCTION OF FLOOD PEAKS AT PADSHAHIBAGH

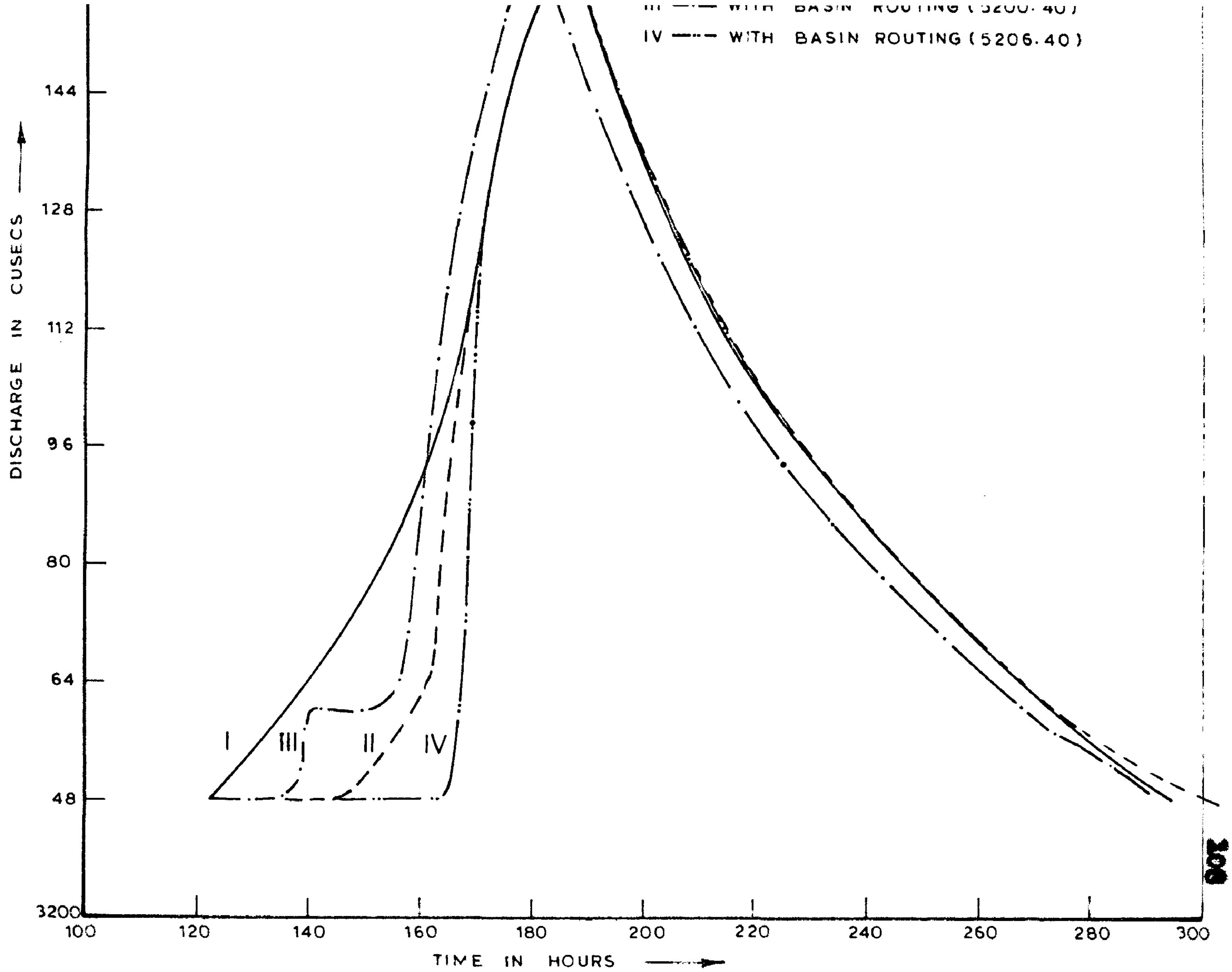


FIG. 5.3(c)_PICTORIAL REDUCTION OF FLOOD PEAKS AT PADSHAHIBAGH

5.1.3.1 Fitting Of Polynomial Between D_t and Q

For Basin A

$$D_t = -2.3863 \times 10^3 + 6.4888 \times 10^{-2} * (Q) - 4.9393 \times 10^{-7} * (Q)^2 + 1.2646 \times 10^{-12} * (Q)^3 \quad \ldots(5.1)$$

with correlation Index = 0.9971

For Basin B

$$D_t = -7.3777 \times 10^3 + 0.259998 \times (Q) - 2.6114 \times 10^{-6} \times (Q)^2 + 8.1126 \times 10^{-12} * (Q)^3 \ldots(5.2)$$

With correlation Index = 0.9988

5.1.3.2 Multiple Regression Analysis For detention period FOR BASIN A

Regression analysis was carried out among the various elements of the hydrograph. In the analysis the dependent variable (D_t) and three independent variables Q,V, T_b have been taken.

Where D_t is dentention Time in Hours, Q is peak discharge in cusecs, V is volume in Acre feet and T_b time base in Hours.

The computer Programme (2) was used and the following relationships were obtained for basin level 5218.6 feet.

(a) Relationship of D_t with Q,V, and T_b. The expression for detention period obtained was.

$$D_t = 55.43610 - 6.5335 \times 10^{-4} * Q + 2.723672 \times 10^{-5} * V + 0.788113 * T_b \quad \ldots(5.3)$$

Multiple correlation coefficient, R = 0.99514

Coefficient of Multiple Determination, R^2=0.99030

Standard deviation of Residuals = 11.2472

when all the three independent variables are considered the total variance explained is 99% as indicated by R^2.

(b) Relationship of (D_t) with V and T_b. The expression obtained was:

$$D_t = 72.01332 + 2.6833747 \times 10^{-5} * V + 0.62564806 * T_b \quad \ldots(5.4)$$

Multiple correlation coefficient, (R_{1-1}) = 0.994848

Coefficient of Multiple determination, $(R_{1-1})^2$=0.98972

Standard deviation of Residuals = 10.0286

(ii) Relationship of D_t, with Q and T_b

the expression obtained was:-

$$D_t = 87.88801 - 4.3581 \times 10^{-4} * (Q) + 0.71637 * (T_b) \ldots(5.5)$$

Multiple correlation coefficient (R_{1-2}) = 0.988498

Coefficient of Multiple determination, (R_{1-2})=0.988498

Coefficient of Multiple determination, $(R_{1-2})^2$=0.97712

Standard devition of Residuals = 14.961.

(iii) Relationship of D_t with P and V. The expression obtained was:-

$$D_t = 139.2935 + 2.4879622 \times 10^{-3} * (Q) + 2.466706 \times 10^{-5} * (V) \quad \ldots(5.6)$$

Multiple correlation coefficient, (R_{1-3})=0.988257

Coefficient of Multiple determination$(R_{1..3})^2$=0.97665

Standard deviation of Residuals = 15.116

When two independent variables are taken at a time the highest correlation is obtained in respect of volume and time base as indicated by value of $(R_{1-1})^2$=0.9897. And standard deviation of Residuals decreases when volume and time base are considered.

(c)(i) Relationship between D_t and Q

$$D_t = 161.9636 + 2.4254623 \times 10^{-3} * (Q) \quad .... (5.7)$$

Correlation coefficient, r = 0.982756

r^2 = 0.96586

(ii) Relationship between D_t and T_b

The expression obtained was:-

$$D_t = 98.6775 + 0.60817603 * (T_b) \quad ... \quad .... (5.8)$$

Correlation coefficient, r = 0.988367

r^2 = 0.97686

From the above results taking each independent variable separately it is found that the highest correlation is between detention time and time base.

Now it is seen from the above results shown in (a),(b) and (c) that the total variance explained is highest in case of (a) when all the three independent variables are considered.

FOR BASIN B

The regression analysis was also carried out on the same lines as for Basin A. The final relationship of detention time (D_t) with Peak (Q), Volume (V) and Time base (T_b) was obtained as:-

$$D_t = - 126.03867 + 10^{-3} * Q + 0.0 * V + 0.9 T_b$$

$$= - 126.03867 + 10^{-3} * Q + 0.9 T_b \qquad ....(5.9)$$

5.2 CONCLUSION

A simulation model has been developed for detention basins, in the context of Jehlum River Basin. The model predicts the behaviour of those basins during floods. Flood detention period of basins likely is to vary with (i) flood peaks, (ii) elements of the flood hydrograph and its shape, and (ii) finally the routing period.

The levels 5218.6 feet and 5202.4 feet of detention basins A and B respectively, as proposed in the project report[8], together can reduce the designed flood peak of 90000 cusecs by a considerable amount to save the Srinagar City from floods. For higher flood peaks either the proposed basin levels may be raised or the river channel and the Flood Spill Channel capacities may be increased.

5.3 SUGGESTIONS FOR FUTURE STUDY

(1) For future study the analysis should include the economical aspects of planning also;

(2) The combined regulation study of detention basins may be carried out to obtain basin operational plans, and

(3) Finally, an appropriate mathematical modelling approach may be developed to see if there is any close correspondence between the results of mathematical models and the simulation approach, and in what way can they be effectively used together?

R E F E R E N C E S

1. Institution of Engineer(INDIA)"Seminar on Flood BIHAR Centre and flood control Measures".

2. Linsley-Franzini "Water Resources Engineering"

3. Woodward,S,M: Hydraulics of the Miani Flood Control Project, The Miami Conservancy District Technical Report, pt.VII, Dayton, Ohio,1920.

4. Rewi Alley "Man Against Flood" New World Press Peking.

5. Hufschmidt. M.M. Fiering,M.B."Simulation Techniques for Design of Water Resources System"Harved University Press Cambridge, Mass,1966.

6. Maass et al., Design of Water Resources Systems, Macmillan,1962.

7. D.K. Srivastava, Optimization of Complex Water Resources Systems by Screening-Simulation Model, Ph.D. Thesis, Indian Institute of Technology, New Delhi, India,1976.

8. J and K Govt."Preliminary Project Report for Flood Control works above Wular(Part I).

9. UPPAL. H.L."Flood Control Drainage and Reclamation in Kashmir Valley".

10. Chow. V.T. "Hand book of applied hydrology"

11. Linsely, Khuler and Paulhus"Applied hydrology"

12. Varshney R.S."Engineering hydrology"/

13. C.W. and P.C. No.258 Sept.1972."Estimation of Design Flood Recommended Proceedures.

14. Jagdish Lal "Hydraulics".

15. Scourborugh, J.B."Numerical Mathematical Analysis".

16. Kupier"Water Resources System"

Appendix - 1

COMPUTER PROGRAMMES

NOTATIONS USED IN SIMULATION PROGRAMME

I	=	Number of the ith site
ITIME	=	ith time period in Hours
NSITE	=	Number of sites
NSET	=	Number of sets
RLB	=	Elevation of a basin in feet corresponding to a given basin storage.
SILL	=	Sill level of a basin outlet in feet.
GAUGE	=	River Gauge in feet corresponding to a given river discharge at a site.
COFF1	=	Coefficient for free weir equation used in detention basin routing.
COFF2	=	Coefficient for drowned weir equation used in detention basin routing.
RF	=	Routed flow through basin outlet at a particular time in cusecs.
XK	=	Value of "Storage Constant" i.e."K", used in channel routing.
X	=	a constant which expresses the relative importance of inflow and outflow in determining the storage, used in channel routing.
QI	=	Inflow into Basin through inlet at a particular time in cusecs.
F	=	Mean inflow into basin in cusecs at a particular time.
Q	=	River discharge at a site at a particular time in cusecs.

S	=	Cummulative storage in Basin in Acre afeet at a particular time.
QQ	=	River flows modified by basin A and going towards basin B in cusecs at a particular time.
QQQ	=	Assumed initial outflow value at a site in cusecs used in channel routing.
DELT	=	Routing Period in Hours.
BHSE	=	Base flow in cusecs.
CHCAPA	=	Capacity of channel for Basin A in cusecs
CHCAPB	=	Capacity of channel for Basin B in cusecs
CINLD	=	Capacity of inlet at Dogripora in cusecs
CINLT	=	Capacity of inlet at Tokna in cusecs
CINLK	=	Capacity of inlet at Kandizal in cusecs
BEDLB	=	Bed level at Bonderpora in feet.
BEDLL,	=	Bed level at Lalhar in feet
BEDLP	=	Bed level at Padshrhi Bagh in feet.
ALEVMA	=	Maximum Elevation in Basin in feet.
ALEVMI	=	Minimum elevation in Basin in feet/
NDETP,MDETP	=	Detension period in Hours for Basin A and Basin B respectively.

```
C    Z.A.BANDAY, M.E. HYDROLOGY DISSERTATION PROGRAM 1
C   LEAST SQUARE CURVEFITTING
    DIMENSION X(25),Y(25),B(25,27),C(25,27),D(26,27),CONST(26),A(26)
    DIMENSIONY1(25)
    DIMENSIONMM(50),NN(20)
    READ100,L
    DO10LL=1,L
    READ100,N
00  FORMAT(20I4)
    READ101,(X(I),I=1,N)
    PRINT1002
002 FORMAT(1X,10HX ORDINATE,/)
    PRINT201,(X(I),I=1,N)
01  FORMAT(6F12.5)
01  FORMAT(5F15.7)
    READ101,(Y(I),I=1,N)
    PRINT1003
003 FORMAT(1X,17HYORDINATE ACTUAL,/)
    PRINT201,(Y(I),I=1,N)
    PRINT1010
010 FORMAT(1X,20(1H-))
    SUM1=0.
    SUM2=0.
    DO20I=1,N
    SUM1=SUM1+Y(I)*Y(I)
0   SUM2=SUM2+Y(I)
    XN=N
    XMEAN=SUM2/XN
    SD=SQRT((SUM1-XMEAN*SUM2)/(XN-1.))
    READ100,MM(LL)
    N1=MM(LL)
    READ100,(NN(I),I=1,N1)
    N7=MM(LL)
    DO24KKK=1,N7
    CI=0.
    M=NN(KKK)
    PRINT202,M,N
02  FORMAT(1X,21HDEGREE OF POLYNOMIAL=,I3,1X,20HNO. OF OBSERVATIONS=
   1I3/)
    DO1I=1,N
    B(I,1)=1.
    MP1=M+1
    DO2I=1,N
    DO2J=2,MP1
    JM1=J-1
    B(I,J)=X(I)**JM1
    MP2=M+2
    DO3I=1,N
    B(I,MP2)=-Y(I)
    DO5K=1,MP1
    DO4I=1,N
    DO4J=1,MP2
    C(I,J)=B(I,J)*B(I,K)
    DO6J=1,MP2
    D(K,J)=0.
```

```
      DO6I=1,N
6     D(K,J)=D(K,J)+C(I,J)
5     CONTINUE
      DO8I=1,MP1
8     CONST(I)=-D(I,MP2)
      CALL MATIN(D,MP1)
      DO7J=1,MP1
      A(J)=0.
      DO7K=1,MP1
7     A(J)=A(J)+D(J,K)*CONST(K)
      PRINT205
205   FORMAT(1X,26HCOEFFICIENTS OF POLYNOMIAL,/)
      PRINT203,(A(J),J=1,MP1)
203   FORMAT(5E16.7)
      GAMA2=0.
      DO21I=1,N
      Y1(I)=A(1)
      MP1=M+1
      DO22J=2,MP1
22    Y1(I)=Y1(I)+A(J)*(X(I)**(J-1))
21    GAMA2=GAMA2+(Y(I)-Y1(I))**2
      G=GAMA2/(XN*SD*SD)
      PRINT1009,G
1009  FORMAT(1X,2HG=,F10.7)
      IF(G-1.)50,50,1005
50    CI=SQRT(1.-G)
1005  PRINT1004
1004  FORMAT(1X,21HY ORDINATE CALCULATED,/)
      PRINT203,(Y1(I),I=1,N)
      IF(G-1.)51,51,1006
51    PRINT23,CI
23    FORMAT(1X,18HCORRELATION INDEX=,F10.8,/)
      GO TO 1007
1006  PRINT1008
1008  FORMAT(1X,31HCORRELATION INDEX INDETERMINATE,/)
1007  PRINT1001
1001  FORMAT(1X,60(1H-))
24    CONTINUE
      PRINT1000
1000  FORMAT(1X,79(1H-))
10    CONTINUE
      STOP
      END

      SUBROUTINE MATIN(A,N)
      DIMENSION A(26,27),B(31),C(31)
      NN=N-1
      A(1,1)=1./A(1,1)
      DO8M=1,NN
      K=M+1
      DO3I=1,M
      B(I)=0.
      DO3J=1,M
```

```
3       B(I)=B(I)+A(I,J)*A(J,K)
        D=0.
        DO4I=1,M
4       D=D+A(K,I)*B(I)
        D=-D+A(K,K)
        A(K,K)=1./D
        DO5I=1,M
5       A(I,K)=-B(I)*A(K,K)
        DO6J=1,M
        C(J)=0.
        DO6I=1,M
6       C(J)=C(J)+A(K,I)*A(I,J)
        DO7J=1,M
7       A(K,J)=-C(J)*A(K,K)
        DO8I=1,M
        DO8J=1,M
8       A(I,J)=A(I,J)-B(I)*A(K,J)
        RETURN
        END
```

```
C   C   Z.A.BANDAY, M.E. HYDROLOGY DISSERTATION PROGRAM 2
C   C   PROGRAM FOR MULTIPLE REGRESSION ANALYSIS
        DIMENSION IP(5),Z(100,5),X(100,5),SUM(5),XBAR(5),AM(5,5),AY(5)
        DIMENSION B(5),SR(5),RM(5),RPAR(5) ,C(5,5),CY(5),CXBAR(5)
        DIMENSION S1(5),S2(5),S3(5),XB(5),BPAR(5),APAR(5),STDX(5),R(5)
        READ1,NDATA,NPAR,NS,NTRY
   1    FORMAT(5I5)
        NT=NPAR+1
        READ 1,(IP(I),I=1,NT)
        DO100J=1,NS
 100    READ 2,(Z(I,J),I=1,NDATA)
   2    FORMAT(10F8.3)
        K=NS-1
        S4=0.
        S5=0.
        DO 700 J=1,K
        S1(J)=0.
        S2(J)=0.
        S3(J)=0.
        DO 700 I=1,NDATA
        S1(J)=S1(J)+Z(I,J)
        S2(J)=S2(J)+Z(I,J)*Z(I,J)
  700   S3(J)=S3(J)+Z(I,J)*Z(I,NS)
        DO 601 I=1,NDATA
        S5=S5+Z(I,NS)*Z(I,NS)
 601    S4=S4+Z(I,NS)
        AN=NDATA
        FN=NDATA-1
        YB=S4/AN
        STDY=SQRTF((S5-AN*YB**2)/FN)
        DO 602 J=1,K
        XB(J)=S1(J)/AN
        BPAR(J)=(S3(J)-AN*XB(J)*YB)/(S2(J)-AN*XB(J)**2)
        APAR(J)=YB-BPAR(J)*XB(J)
        STDX(J)=SQRTF((S2(J)-AN*XB(J)**2)/FN)
 602    R(J)=(S3(J)-AN*XB(J)*YB)/(STDX(J)*STDY*FN)
        DO 603 J=1,K
 603    PUNCH 1000, BPAR(J),APAR(J),R(J)
 1000   FORMAT(3E16.7)
        PUNCH 47,(STDX(J),J=1,K),STDY
  47    FORMAT(5E16.7)
        PUNCH 47,(XB(J),J=1,K),YB
        IP1=IP(NT)
        DO 101 I=1,NDATA
  101    X(I,NT)=Z(I,IP1)
        DO 102 J=1,NPAR
        IPJ=IP(J)
        DO 102 I=1,NDATA
 102    X(I,J)=Z(I,IPJ)
        DO 103 J=1,NT
  103   SUM(J)=0.
        DO 104 J=1,NT
        DO 104 I=1,NDATA
 104    SUM(J)=SUM(J)+X(I,J)
```

```
      DO 105 J=1,NT
105   XBAR(J)=SUM(J)/AN
      DO 99 I=1,NDATA
 99   PUNCH 2,(X(I,J),J=1,NT)
      DO 106 J=1,NT
      DO 106 I=1,NDATA
106   X(I,J)=X(I,J)-XBAR(J)
      DO 107 J=1,NPAR
      DO 107 I=1,NPAR
107   AM(I,J)=0.
      DO 109 I=1,NPAR
109   AY(I)=0.
      AY2=0.
      DO 111 K=1,NDATA
      DO 110 I=1,NPAR
      AY(I)=AY(I)+X(K,I)*X(K,NT)
       DO 110 J=1,NPAR
110   AM(I,J)=AM(I,J)+X(K,I)*X(K,J)
111   AY2=AY2+X(K,NT)*X(K,NT)
      DO 97 I=1,NPAR
 97   PUNCH 96,(AM(I,J),J=1,NPAR),AY(I),AY2
 96   FORMAT(5E16.7)
      DO 80 I=1,NPAR
      DO 80 J=1,NPAR
 80   C(I,J)=AM(I,J)
      DO 500 I=1,NPAR
      PIVOT=AM(I,I)
      AM(I,I)=1.0
      DO 590 L=1,NPAR
590   AM(I,L)=AM(I,L)/PIVOT
      DO 500 L1=1,NPAR
      IF(L1-I) 600,500,600
600   T=AM(L1,I)
      AM(L1,I)=0.0
      DO 580 L=1,NPAR
580   AM(L1,L)=AM(L1,L)-AM(I,L)*T
500   CONTINUE
      DO 540 I=1,NPAR
      B(I)=0.0
      DO 540 J=1,NPAR
      B(I)=B(I)+AM(I,J)*AY(J)
540   CONTINUE
      S=0.
      DO 112 I=1,NPAR
112   S=S+B(I)*XBAR(I)
      B(NT)=XBAR(NT)-S
      PUNCH 3,(B(I),I=1,NT)
  3   FORMAT(5E16.7)
      S=0.
      DO 113 I=1,NPAR
113   S=S+B(I)*AY(I)
      FN1=NDATA-NPAR
      SDR=SQRTF((AY2-S)/FN1)
```

```
      RMULT=SQRTF(S/AY2)
      PUNCH 5,SDR,RMULT
 5    FORMAT(2E16.7)
      DO 81 I=1,NPAR
      DO 81 J=1,NPAR
81    AM(I,J)=C(I,J)
      IF(NTRY-1) 68,49,68
49    NK=NPAR-1
      DO 50 K1=1,NPAR
      DO 51 I=1,NK
      DO 52 J=1,NK
      IF(I-K1) 53,54,54
 53   IF(J-K1) 55,56,56
55    C(I,J)=AM(I,J)
      GO TO 52
56    C(I,J)=AM(I,J+1)
      GO TO 52
54    IF(J-K1) 57,58,58
57    C(I,J)=AM(I+1,J)
5     GO TO 52
58    C(I,J)=AM(I+1,J+1)
52    CONTINUE
51    CONTINUE
      DO 59 I=1,NK
59    PUNCH 96,(C(I,J),J=1,NK)
      DO 60 I=1,NK
      IF(I-K1) 61,62,62
62    CY(I)=AY(I+1)
      CXBAR(I)=XBAR(I+1)
      GO TO 60
61    CY(I)=AY(I)
       CXBAR(I)=XBAR(I)
60    CONTINUE
      PUNCH 96,(CY(I),I=1,NK)
      DO 1500 I=1,NK
      PIVOT=C(I,I)
       C(I,I)=1.0
      DO 1590 L=1,NK
1590  C(I,L)=C(I,L)/PIVOT
       DO 1500 L1=1,NK
      IF(L1-I)1600,1500,1600
1600  T=C(L1,I)
      C(L1,I)=0.0
      DO 1580 L=1,NK
1580  C(L1,L)=C(L1,L)-C(I,L)*T
1500  CONTINUE
      DO 63 I=1,NK
      B(I)=0.0
      DO 63 J=1,NK
      B(I)=B(I)+C(I,J)*CY(J)
 63   CONTINUE
      S=0.
      DO 64 I=1,NK
```

```
64   S=S+B(I)*CXBAR(I)
     B(NPAR)=XBAR(NT)-S
     PUNCH 3,(B(I),I=1,NPAR)
     S=0.0
     DO 65 I=1,NK
65   S=S+B(I)*CY(I)
     FN1=NDATA-NK
     SDR=SQRTF((AY2-S)/FN1)
     RM(K1)=SQRTF(S/AY2)
     PUNCH 5,SDR,RM(K1)
50   CONTINUE
     DO 66  J=1,NPAR
66   RPAR(J)=1.-(1.-RMULT**2)/(1.-RM(J)**2)
     PUNCH 67,(RPAR(J),J=1,NPAR)
67   FORMAT(5E16.7)
 68  CONTINUE
     STOP
     END
```

3

```
C  C   Z.A.BANDAY, M.E.HYDROLOGY DISSERTATION PROGRAM :
C      PROGRAM FOR SIMULATION STUDIES
C      BASIN  A
       DIMENSION RLB(1,950),SILL(4),GAUGE(4,950),COFF1(2),COFF2(2),RF(
      150)
       DIMENSION XK(4),X(4),Q(4,950)
       DIMENSION QI(2,950),F(1,950),S(1,950)
       DIMENSION  QO(950)
       DIMENSION QQQ(4)
       COMMON  RLB,SILL,GAUGE,COFF1,COFF2,RF
       COMMON  XK,X,Q,DELT
       READ 105,NTIME,NSITE
 105   FORMAT(2I5)
       NN=NTIME+1
       DO 150  I=1,4
       DO 150  ITIME=1,NN
 150   Q(I,ITIME)=0.
       READ 100,(XK(I),I=1,3)
       READ 100,(X(I),I=1,3)
       READ 100,(SILL(I),I=1,4)
       READ 100,DELT
       READ 100,(COFF1(I),I=1,2)
       READ 100,(COFF2(I),I=1,2)
 100   FORMAT(5F14.6)
       READ 101,(Q(1,ITIME),ITIME=1,NN)
       READ 101,BASE
       DO 1002 ITIME=1,NN
 1002  Q(1,ITIME)=Q(1,ITIME)+BASE
       READ 101,(QQQ(I),I=1,4)
       READ 101,CHCAPA,CINLD,CINLT
       READ 100,BEDLB,BEDLL
 101   FORMAT(7F10.1)
       PRINT 103,(XK(I),I=1,3),(X(I),I=1,3)
 103   FORMAT(8HXK(I) --/3F14.6/7HX(I) --/3F14.6)
       PRINT 104,(Q(1,I),I=1,NTIME)
 104   FORMAT(19HDISCHARGE AT SANGAM/9HIN CUSECS//(7F10.1))
       PRINT 106
 106   FORMAT(5HNSITE,15HOUTFLOW ASSUMED/)
       DO 600 I=1,4
 600   Q(I,1)=QQQ(I)
       DO 107 I=1,4
       PRINT 108,I,Q(I,1)
 108   FORMAT(I3,5X,F10.1)
 107   CONTINUE
       READ 105,NSET
       DO 511 ISET=1,NSET
       READ 100,ALEVMA,ALEVMI
       I=1
       J=1
       K=0
```

```
      RLBP=ALEVMI
      SUMP=CHCAPA
      NDETP=0
      YYP=0.
      SUM2=0.
      PRINT 512,CHCAPA,CINLD,CINLT
      PRINT 513,ALEVMA,ALEVMI
      PRINT 514,BEDLB,BEDLL
  512 FORMAT(2X,28HCHANNEL CAPACITY OF BASIN A=,F10.1/2X,31HCAPACITY OF
     1INLET AT DOGRIPORA=,F10.1/2X,27HCAPACITY OF INLET AT TOKNA=,F10.1)
  513 FORMAT(2X,29HMAXIMUM ELEVATION IN BASIN A=,F10.2,3X,18HMINIMUM ELE
     2VATION=,F10.2)
  514 FORMAT(2X,23HBEDLEVEL AT BANDERPORA=,F14.6,5X,19HBEDLEVEL AT LELHA
     3R=,F14.6)
      CALL CHROUT(I,NTIME)
      PRINT 111, (Q(1,ITIME),ITIME=1,NTIME)
      PRINT 111, (Q(2,ITIME),ITIME=1,NTIME)
  111 FORMAT(25HROUTED VALUES FOR 4 SITES//(7F10.1))
      DO 140 ITIME=1,NTIME
      QI(I,ITIME)=0.
  140 QI(I+1,ITIME)=0.
      DO 611 ITIME=1,NTIME
      F(J,ITIME)=0.
      RF(I+2,ITIME)=0.
      RF(I+3,ITIME)=0.
      GAUGE(I+2,ITIME)=0.
  611 GAUGE(I+3,ITIME)=0.
      LLL=0
      DO 1 ITIME=1,NTIME
      SUM=(Q(I,ITIME)+Q(I+1,ITIME))/2.
      XX=SUM-CHCAPA
      IF(XX-(CINLT+CINLD))3001,3001,3000
 3000 EXCESS=XX-(CINLT+CINLD)
      XX=CINLT+CINLD
      GO TO 3002
 3001 EXCESS=0.
 3002 IF(XX)1001,2,2
 1001 IF(LLL)145,145,10
    2 QQ(ITIME)=CHCAPA+EXCESS
      Y=XX-CINLT
      IF(XX)6,6,7
    7 IF(Y)3,3,4
    3 QI(I+1,ITIME)=XX
      GO TO 5
    4 QI(I+1,ITIME)=CINLT
      QI(I,ITIME)=XX-CINLD
      GO TO 5
    6 IF(Y)8,8,9
    8 QI(I,ITIME)=XX
      GO TO 5
    9 QI(I,ITIME)=CINLD
      QI(I+1,ITIME)=XX-CINLT
    5 SUMP=SUM
      YY=(QI(I,ITIME)+QI(I+1,ITIME))
```

```
      IF(YY)142,142,143
143   F(J,ITIME)=(YYP+YY)/2.
      YYP=YY
      Z=F(J,ITIME)*DELT*3600./43560.
      SUM2=SUM2+Z
      S(J,ITIME)=SUM2
      RLB(J,ITIME)=FRLB(J,SUM2)
      NDETP=NDETP.1
      LLL=1
142   IF(RLB(J,ITIME)-ALEVMA)1,10,10
145   QQ(ITIME)=SUM
1     CONTINUE
10    JTIME=ITIME-1
      DO 146 ITIME=JTIME,NTIME
146   QQ(ITIME)=(Q(I,ITIME)+Q(I+1,ITIME))/2.
      DO 147 ITIME=1,NTIME
147   Q(I+1,ITIME)=QQ(ITIME)
      L=I+1
      CALL CHROUT(L,NTIME)
      PRINT 111, (Q(2,ITIME),ITIME=1,NTIME)
      L=I+2
      CALL CHROUT(L,NTIME)
      PRINT 111, (Q(3,ITIME),ITIME=1,NTIME)
      PRINT 111, (Q(4,ITIME),ITIME=1,NTIME)
      DO 144 ITIME=JTIME,NTIME
      Z=0.
      IF(RLB(J,ITIME)-ALEVMI)141,141,15
15    A1=(Q(3,ITIME)+Q(4,ITIME))/2.
      L=3
      GAUGE(3,ITIME)=GDIS(L,A1)
      GAUGE(3,ITIME)=GAUGE(3,ITIME)+BEDLB
      L=4
      GAUGE(4,ITIME)=GDIS(L,A1)
      GAUGE(4,ITIME)=GAUGE(4,ITIME)+BEDLL
      IF(GAUGE(3,ITIME)-RLB(J,ITIME))11,502,502
11    L=3
      CALL OUTFL(J,L,ITIME)
      Z=Z+RF(3,ITIME)
502   IF(GAUGE(4,ITIME)-RLB(J,ITIME))13,210,210
13    L=4
      CALL OUTFL(J;L,ITIME)
      Z=Z+RF(4,ITIME)
210   IF(Z)503,503,504
504   Z=Z/2.
      Z=Z*DELT*3600./43560.
      S(J,ITIME+1)=S(J,ITIME)-Z
      A3=S(J,ITIME+1)
      RLB(J,ITIME+1)=FRLB(J,A3)
      RLBP=RLB(J,ITIME)
503   NDETP=NDETP+1
      Q(I+3,ITIME)=Q(I+3,ITIME)+Z/(DELT*3600.)*43560.
      IF(Z)161,161,144
161   S(J,ITIME+1)=S(J,ITIME)
```

```
      RLB(J,ITIME+1)=RLB(J,ITIME)
144   CONTINUE
      KKK=NTIME
      GO TO 612
141   KKK=ITIME-1
612   PRINT 149,NDETP
149   FORMAT(1X,23HTOTAL DETENSION PERIOD=,I3)
      PRINT 510,(Q(I+3,ITIME),ITIME=1,NTIME)
510   FORMAT(18HINFLOW FOR BASIN B/9H+N CUSECS//(7F10.1))
      PRINT 601
601   FORMAT(5H TIME,5X,9HDISCHARGE,1X,9HINFLOW AT,1X,9HINFLOW AT,1X,4H
     4EAN,6X,8HCUMULATI,2X,9HELEVATION)
      PRINT 602
602   FORMAT(6H HOURS,4X,9HAT DOGRIP,1X,9HDOGRIPORA,1X,5HTOKNA,5X,7HC
     5LOW,4X,10HVE STORAGE,1X,8HIN BASIN)
      PRINT 603
603   FORMAT(10X,10HORA CUSECS,1X,6HCUSECS,3X,6HCUSECS,4X,6HCUSECS,4X,
     6ACRE-FT,3X,4HFEFT)
      DO 604 K=1,KKK
      PRINT 605,K,Q(1,K),QI(1,K),QI(2,K),F(J,K),S(J,K),RLB(J,K)
605   FORMAT(1H ,I3,7X,5F10.1,F10.2)
604   CONTINUE
      PRINT 606
606   FORMAT(1H ,4HTIME,5X,5HGAUGE,5X,5HGAUGE,5X,7HOUTFLOW,3X,7HOUTFL
     73X,8HCUMULATI,2X,9HELEVATION)
      PRINT 607
607   FORMAT(1H ,5HHOURS,4X,10HBANDERPORA,1X,6HLELHAR,3X,10HBANDERPOR
     8X,6HLELHAR,3X,10HVE STORAGE,1X,8HIN BASIN)
      PRINT 608
608   FORMAT(10X,4HFEFT,6X,4HFEET,6X,6HCUSECS,4X,6HCUSECS,4X,7HACRE-FT,
     8X,4HFEET)
      DO 609 K=1,KKK
      PRINT 610,K,GAUGE(3,K),GAUGE(4,K),RF(3,K),RF(4,K),S(J,K),RLB(J,K)
610   FORMAT(1H ,I3,6X,2F10.3,3F10.1,F10.2)
609   CONTINUE
511   CONTINUE
      STOP
      END

      PROGRAM FOR CHHANEL ROUTING
      SUBROUTINE  CHROUT(I,NTIME)
      DIMENSION RLB(1,950),SILL(4),GAUGE(4,950),COFF1(2),COFF2(2),RF(
     150)
      DIMENSION XK(4),X(4),Q(4,950)
      COMMON  RLB,SILL,GAUGE,COFF1,COFF2,RF
      COMMON  XK,X,Q,DELT
      DENOM=XK(I)*(1.-X(I))+0.5*DELT
      C1=DELT/DENOM
      C2=(0.5*DELT-XK(I)*X(I))/DENOM
      DO 1ITIME=1,NTIME
      Y=C2*(Q(I,ITIME+1)-Q(I,ITIME))
      Z=C1*(Q(I,ITIME)-Q(I+1,ITIME))
      Q(I+1,ITIME+1)=Q(I+1,ITIME)+Y+Z
1     CONTINUE
```

```
      RETURN
      END

      PROGRAM FOR OUTFLOW
      SUBROUTINE OUTFL(J,I,ITIME)
      DIMENSION RLB(1,950),SILL(4),GAUGE(4,950),COFF1(2),COFF2(2),RF(4,
     150)
      DIMENSION XK(4),X(4),Q(4,950)
      COMMON RLB,SILL,GAUGE,COFF1,COFF2,RF
      COMMON  XK,X,Q,DELT
      H1=RLB(J,ITIME)-SILL(I)
      IF(GAUGE(I,ITIME)-SILL(I)1,1,2
1     H2=0.
      GO TO 3
2     H2=GAUGE(I,ITIME.-SILL(I)
3     Z=(H1-H2)
      Q1=COFF1(J)*Z**1.5
      Q2=COFF2(J)*H2*SQRT(Z)
      RF(I,ITIME)=Q1+Q2
      RETURN
      END

      PROGRAM FOR STORAGE ELEVATION CURE
      FUNCTION FRLB(J,X)
      FRLB=5208.029+.0002416*X-.1123E-10*X*X
      RETURN
      END

      PROGRAM FOR GAUGE DISCHARGE RELATION
      FUNCTION GDIS(I,X)
      GO TO(1,2,3,4),I
1     GDIS=0.026037*X**0.603847
      GO TO 5
2     GDIS=0.031719*X**0.602165
      GO TO 5
3     GDIS=0.026266*X**0.6197
      GO TO 5
4     GDIS=0.022315*X**0.634
5     RETURN
      END
```

```
 150   FORMAT(@THOMAS-FIERING BI-VARIATE MODEL@//)
       DO 7 J = 1,12
       DO 8 K = 1,2
       DO 8 MY = 1,2
       S11(K,MY)=0.
       S22(K,MY)=0.
   8   S21(K,MY)=0.
       DO 9 I = J,N,12
       S11(1,1)=S11(1,1)+SQ1(I)*SQ1(I)
       S11(2,2)=S11(2,2)+SQ2(I)*SQ2(I)
       S11(1,2)=S11(1,2)+SQ1(I)*SQ2(I)
       S22(1,1)=S22(1,1)+SQ1(I+1)*SQ1(I+1)
       S22(2,2)=S22(2,2)+SQ2(I+1)*SQ2(I+1)
       S22(1,2)=S22(1,2)+SQ1(I+1)*SQ2(I+1)
       S21(1,1)=S21(1,1)+SQ1(I+1)*SQ1(I)
       S21(1,2)=S21(1,2)+SQ1(I+1)*SQ2(I)
       S21(2,1)=S21(2,1)+SQ2(I+1)*SQ1(I)
       S21(2,2)=S21(2,2)+SQ2(I+1)*SQ2(I)
   9   CONTINUE
       S11(2,1) = S11(1,2)
       S22(2,1) = S22(1,2)
       DO 99 I = 1,2
       DO 99 JK = 1,2
        S11)I,JK*=S11)I,JK*/AN
        S22)I,JK*=S22)I,JK*/AN
  99    S21)I,JK*=S21)I,JK*/AN
        DELTA = S11)1,1**S11)2,2*-S11)2,1**S11)1,2*
        B)1,1,J*=)S21)1,1**S11)2,2*-S21)1,2**S11)2,1**/DELTA
        B)1,2,J*=)S11)1,1**S21)1,2*-S21)1,1**S11)1,2**/DELTA
        B)2,1,J*=)S21)2,1**S11)2,2*-S21)2,2**S11)2,1**/DELTA
        B)2,2,J*=)S11)1,1**S21)2,2*-S21)2,1**S11)1,2**/DELTA
       VARZ1(J) = S22(1,1)-B(1,1,J)*S21(1,1)-B(1,2,J)*S21(1,2)
       VARZ2(J) = S22(2,2)-B(2,1,J)*S21(2,1)-B(2,2,J)*S21(2,2)
       COVAR(J) = S22(1,2)-B(1,1,J)*S21(2,1)-B(1,2,J)*S21(2,2)
       MJ = J+1
       WRITE(PRABHA,151)MON(MJ),MON(J)
       DO 1521 KI = 1,2
       WRITE(PRABHA,152)(S11(KI,KJ),KJ=1,2),(S22(KI,KJ),KJ=1,2),
      1 (S21(KI,KJ),KJ=1,2)
 1521   CONTINUE
   7   CONTINUE
C      RESIDUALS
       DO 222 I = 2,N
        JJ = MOD)I,12*
        IF)JJ.EQ.0*JJ=12
        QEST1=B)1,1,JJ**SQ1)I-1*.B)1,2,JJ**SQ2)I-1*
        QEST2=B)2,1,JJ**SQ1)I-1*.B)2,2,JJ**SQ2)I-1*
        QEST1=QEST1*SD1)JJ*.AV1)JJ*
        QEST2=QEST2*SD2)JJ*.AV2)JJ*
       I1=I-1
       RESDU1(I1)=Q1(I)-QEST1
 222   RESDU2(I1)=Q2(I)-QEST2
```

```
C  C   Z.A.BANDAY, M.E. HYDROLOGY DISSERTATION PROGRAM 4
C      PROGRAM FOR SIMULATION STUDIES
C      BASIN  B
       DIMENSION RLB(1,950),SILL(4),GAUGE(4,950),COFF1(2),COFF2(2),RF(4,
      150)
       DIMENSION XK(4),X(4),Q(4,950)
       DIMENSION QI(2,950),F(1,950),S(1,950)
       DIMENSION  QQ(950)
       DIMENSION QQQ(3)
       DIMENSION FLSRI(950)
       COMMON  RLB,SILL,GAUGE,COFF1,COFF2,RF
       COMMON  XK,X,Q,DELT
       READ 105,NTIME,NSITE
  105  FORMAT(2I5)
       NN=NTIME+1
       DO 150 I=1,3
       DO 150 ITIME=1,NN
  150  Q(I,ITIME)=0.
       READ 100,(XK(I),I=1,3)
       READ 100,(X(I),I=1,3)
       READ 100,(SILL(I),I=1,4)
       READ 100,DELT
       READ 100,(COFF1(I),I=1,2)
       READ 100,(COFF2(I),I=1,2)
  100  FORMAT(5F14.6)
       READ 101,(Q(1,ITIME),ITIME=1,NN)
       READ 101,(QQQ(I),I=1,3)
       READ 101,CHCAPB,CINLK
       READ 100,BEDLP,BEDLF
  101  FORMAT(7F10.1)
       PRINT 103,(XK(I),I=1,3),(X(I),I=1,3)
  103  FORMAT(8HXK(I) --/3F14.6/7HX(I) --/3F14.6)
       PRINT 104,(Q(1,I),I=1,NTIME)
  104  FORMAT(19HDISCHARGE AT KANDZL/9HIN CUSECS//(7F10.1))
       PRINT 106
  106  FORMAT(5HNSITE,15HOUTFLOW ASSUMED/)
       DO 600 I=1,3
  600  Q(I,1)=QQQ(I)
       DO 107 I=1,3
       PRINT 108,I,Q(I,1)
  108  FORMAT(I3,5X,F10.1)
  107  CONTINUE
       READ 105,NSET
       DO 511 ISET=1,NSET
       READ 100,ALEVMA,ALEVMI
       I=1
       J=2
       K=0
       MDETP=0
       CALL CHROUT(I,NTIME)
       PRINT 111, (Q(1,ITIME),ITIME=1,NTIME)
       PRINT 111, (Q(2,ITIME),ITIME=1,NTIME)
  111  FORMAT(25HROUTED VALUES FOR 3 SITES//(7F10.1))
```

```
      RLBP=ALEVMI
      PRINT 512,CHCAPB,CINLK
      PRINT 513,ALEVMA,ALEVMI
      PRINT 514,BEDLP,BEDLF
  512 FORMAT(2X,28HCHANNEL CAPACITY OF BASIN B=,F10.1/2X,30HCAPACITY OF
     1INLET AT KANDIZAL=,F10.1)
  513 FORMAT(2X,29HMAXIMUM ELEVATION IN BASIN B=,F10.2,3X,18HMINIMUM EL
     2VATION=,F10.2)
  514 FORMAT(2X,23HBEDLEVEL AT PADSHIBAGH=,F14.6,5X,23HBEDLEVEL AT FSC
     3D7000=,F14.6)
      YP=0.
      SUM2=0.
      BNIFLP=0.
      BNFSCP=0.
      DO 208 ITIME=1,NTIME
  208 QI(I+1,ITIME)=0.
      DO 611 ITIME=1,NTIME
      F(J,ITIME)=0.
      FLSRI(ITIME)=0.
      RF(I+2,ITIME)=0.
      RF(I+3,ITIME)=0.
      GAUGE(I+2,ITIME)=0.
  611 GAUGE(I+3,ITIME)=0.
      LLL=0
      DO 200 ITIME=1,NTIME
      XX=Q(I+1,ITIME)+2000.-CHCAPB
      IF(XX-CINLK)3001,3001,3000
 3000 EXCESS=XX-CINLK
      XX=CINLK
      GO TO 3002
 3001 EXCESS=0.
 3002 IF(XX)2000,202,202
 2000 IF(LLL)205,205,206
  202 QI(I+1,ITIME)=XX
      QQ(ITIME)=CHCAPB-2000.
      YY=QI(I+1,ITIME)
      F(J,ITIME)=(YP+YY)/2.
      YP=YY
      Z=F(J,ITIME)*DELT*3600./43560.
      SUM2=SUM2+Z
      S(J,ITIME)=SUM2
      RLB(J,ITIME)=FRLB(J,SUM2)
      MDETP=MDETP+1
      LLL=1
      IF(RLB(J,ITIME)-ALEVMA)200,206,206
  205 QQ(ITIME)=Q(I+1,ITIME)
  200 CONTINUE
  206 JTIME=ITIME-1
      DO 300 ITIME=JTIME,NTIME
  300 QQ(ITIME)=Q(I+1,ITIME)
      DO 301 ITIME=1,NTIME
  301 Q(I+1,ITIME)=QQ(ITIME)
      L=I+1
      CALL CHROUT(L,NTIME)
      PRINT 111, (Q(2,ITIME),ITIME=1,NTIME)
      PRINT 111, (Q(3,ITIME),ITIME=1,NTIME)
      KL=JTIME+1
```

```
      DO 4000 ITIME=1,KL
 4000 FLSRI(ITIME)=Q(3,ITIME)
      DO 302 ITIME=JTIME,NTIME
      Z=0.
      XX=0.
      IF(RLB(J,ITIME)-ALEVMI)303,303,209
 209  A1=Q(I+2,ITIME)
      L=I+2
      GAUGE(L,ITIME)=GDIS(L,A1)
      GAUGE(L,ITIME)=GAUGE(L,ITIME)+BEDLP
      IF(Q(L,ITIME)-33000.) 204,204,203
 203  XX=Q(I+2,ITIME)-33000.
      FLSRI(ITIME)=33000.
      GO TO 401
 204  FLSRI(ITIME)=Q(I+2,ITIME)
 401  XX=XX+BNFSCP
      L=I+3
      GAUGE(L,ITIME)=GDIS(L,XX)
      GAUGE(L,ITIME)=GAUGE(L,ITIME)+BEDLF
      IF(GAUGE(L,ITIME)-RLB(J,ITIME))305,306,306
 305  CALL OUTFL(J,L,ITIME)
      Z=Z+RF(L,ITIME)
      BNFSCP=RF(L,ITIME)
 306  L=I+2
      IF(GAUGE(L,ITIME)-RLB(J,ITIME))307,400,400
 307  CALL OUTFL(J,L,ITIME)
      Z=Z+RF(L,ITIME)
 400  IF(Z)308,308,350
 350  Z=Z/2.
      BNIFLP=BNIFL
      Z=Z*DELT*3600./43560.
      S(J,ITIME+1)=S(J,ITIME)-Z
      A2=S(J,ITIME+1)
      RLB(J,ITIME+1)=FRLB(J,A2)
      RLBP=RLB(J,ITIME)
 308  MDETP=MDETP+1
      IF(Z)309,309,302
 309  S(J,ITIME+1)=S(J,ITIME)
      RLB(J,ITIME+1)=RLB(J,ITIME)
 302  CONTINUE
      KKK=NTIME
      GO TO 612
 303  KKK=ITIME-1
 612  PRINT 304,MDETP
 304  FORMAT(1X,34HTOTAL DETENSION PERIOD IN BASIN B),I3)
      PRINT 510,(FLSRI(ITIME),ITIME=1,NTIME)
 510  FORMAT(21HINFLOW FOR CITY REACH/9HIN CUSECS//(7F10.1))
      PRINT 601
 601  FORMAT(5H TIME,5X,8HDISHARGE,1X,9HINFLOW AT,1X,4HMEAN,6X,8HC[illegible]
     4I,2X,9HELEVATION)
      PRINT 602
 602  FORMAT(6H HOURS,4X,9HAT KANDIZ,1X,8HKANDIZAL,2X,7HCINFLOW,3X,[illegible]
     5 STORAGE,1X,8HIN BASIN)
```

```
      PRINT 603
603   FORMAT(10X,9HAL CUSECS,1X,6HCUSECS,4X,7HACRE-FT,3X,4HFEET)
      DO 604 K=1,KKK
      PRINT 605,K,Q(2,K),QI(2,K),F(J,K),S(J,K),RLB(J,K)
605   FORMAT(1H ,I3,6X,5F10.1,F10.2)
604   CONTINUE
      PRINT 606
606   FORMAT(5H TIME,5X,5HGAUGE,5X,5HGAUGE,5X,7HOUTFLOW,3X,7HOUTFLOW,3X,
     68HCUMULATI,2X,9HELEVATION)
      PRINT 607
607   FORMAT(1H ,5HHOURS,4X,10HPADSHIBAGH,1X,7HSPILLCH,2X,10HPADSHIBAGH,
     71X,7HSPILLCH,3X,10HVE STORAGE,1X,8HIN BASIN)
      PRINT 608
608   FORMAT(10X,4HFEET,6X,4HFEET,6X,6HCUSECS,4X,6HCUSECS,4X,7HACRE-FT,
     8X,4HFEET)
      DO 609 K=1,KKK
      PRINT 610,K,GAUGE(3,K),GAUGE(4,K),RF(3,K),RF(4,K),S(J,K),RLB(J,K)
610   FORMAT(1H ,I3,6X,2F10.3,3F10.1,F10.2)
609   CONTINUE
511   CONTINUE
      STOP
      END

      PROGRAM FOR CHHANELL ROUTING
      SUBROUTINE  CHROUT(I,NTIME)
      DIMENSION RLB(1,950),SILL(4),GAUGE(4,950),COFF1(2),COFF2(2),RF(4,
     150)
      DIMENSION XK(4),X(4),Q(4,950)
      COMMON  RLB,SILL,GAUGE,COFF1,COFF2,RF
      COMMON  XK,X,Q,DELT
      DENOM=XK(I)*(1.-X(I))+0.5*DELT
      C1=DELT/DENOM
      C2=(0.5*DELT-XK(I)*X(I))/DENOM
      DO 1ITIME=1,NTIME
      Y=C2*(Q(I,ITIME+1)-Q(I,ITIME))
      Z=C1*(Q(I,ITIME)-Q(I+1,ITIME))
      Q(I+1,ITIME+1)=Q(I+1,ITIME)+Y+Z
1     CONTINUE
      RETURN
      END

      PROGRAM FOR OUTFLOW
      SUBROUTINE OUTFL(J,I,ITIME)
      DIMENSION RLB(1,950),SILL(4),GAUGE(4,950),COFF1(2),COFF2(2),RF(
     150)
      DIMENSION XK(4),X(4),Q(4,950)
      COMMON  RLB,SILL,GAUGE,COFF1,COFF2,RF
      COMMON  XK,X,Q,DELT
      H1=RLB(J,ITIME)-SILL(I)
      IF(GAUGE(I,ITIME)-SILL(I))1,1,2
1     H2=0.
      GO TO 3
```

```
2     H2=GAUGE(I,ITIME)-SILL(I)
      Q1=COFF1(J)*Z**1.5
      Q2=COFF2(J)*H2*SQRT(Z)
      RF(I,ITIME)=Q1+Q2
      RETURN
      END

      PROGRAM FOR STORAGE ELEVATION CURE
      FUNCTION FRLB(J,X)
      FRLB=5195.638+.000321*X-.1983E-10*X*X
      RETURN
      END

      PROGRAM FOR GAUGE DISCHARGE RELATION
      FUNCTION GDIS(I,X)
      GO TO (5,1,2,3),I
1     GDIS=0.037821*X**0.584528
      GO TO 5
2     GDIS=0.040889*X**0.57714
      GO TO 5
3     GDIS=0.040889*X**0.57714
5     RETURN
      END
```