AN ASSESSMENT OF SOME STATISTICAL TECHNIQUES FOR HYDROLOGICAL MODELLING IN SEMI-ARID AREAS

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Final report to the Water Research Commission for part of the project "Hydrological research in catchments of the eastern and southern Cape."

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FOREWORD

Since its inception in 1974, the Hydrological Research Unit of the Department of Geography at Rhodes University has directed most of its research effort towards assessing the application of mathematical rainfall-runoff models. In 1982 the Unit expanded its interests to begin research into the processes of mineralisation. To date, a total of three 5-year projects have been completed successfully and the associated reports to the Water Research Commission have been accepted and published. This report presents the results of part of a fourth 5-year project which was carried out between 1983 and 1988. The project was entitled 'Hydrological research in catchments of the eastern and southern Cape' and had two major themes; one associated with isolated event, deterministic modelling and the second with statistical modelling of rainfall and runoff in semi-arid areas. The research on the first of these topics was carried out by Dr. Hughes and Ms Beater, and is presented in a separate report. This report addresses the second of these topics which was carried out by Mr Herald.

Since 1974 the Unit has established three research areas for the collection of hydrological data. Initially a set of nested catchments were established within the watershed of the Ecca River a tributary of the Great Fish. These catchments were selected as representative of the semi-arid conditions of the eastern Cape. A second area within the sub-humid coastal region of the southern Cape was established in 1979. In 1987 the Unit established a third research area in the Sundays River of the eastern Cape for the study of salinity problems associated with irrigation. Data collection in the Ecca catchments is being brought to a close due to the development of a water supply scheme within the research area. These catchments will no longer be representative of natural conditions and therefore are being replaced by a new set of research catchments in the Bedford district of the eastern Cape. Instrumentation of this area began in 1988 and their establishment as research areas will form part of a new project (1988-1993).

I would like to express my thanks to all the staff of the Hydrological Research Unit for their contributions to this project. In particular I would like to thank Mr Herald who joined the Unit towards the end of 1984, one year into the period of this contract. During the last six months of this period he has also been closely involved with another research project investigating hydrosalinity problems within the Sundays River. The research completed by the Unit since 1974, as well as that of the foreseeable future have been made possible by funding from the Water Research Commission and through the use of facilities provided by Rhodes University to the Department of Geography. I wish to express my sincere thanks and appreciation to both these organisations. As I shall be retiring as Professor of Geography during 1989 this will be the last project that I will see through to its conclusion. I wish my successor and all those associated with the Unit every success in the future.

J B McI Daniel
(Project Leader and Head of the Department of Geography, Rhodes University.)

ACKNOWLEDGEMENTS

I would like to thank my colleagues in the Hydrological Research Unit and the Department of Geography for their support and encouragement during the course of this research project. In particular I am especially grateful to Professor John Daniel for his guidance as Project Leader and Dr. Denis Hughes for his constructive criticism. I also wish to express a special thanks to Jenny King and Anne Beater for preparing this final report, and to John Landman and Stanley Kara for their part in maintaining the Unit's research catchments and processing data. Mr Oakley West, Debbie Brodie and John Keulder of the Department's Cartographic Unit are also thanked for preparing the diagrams in this report.

I am also grateful to the following people, who comprised the Steering Committee, for their contributions to this project. Mr Dave Cousens deserves a special thanks for his guidance as responsible WRC advisor.
Mr J.M. Bosch : Department of Environment Affairs (alternate)
Mr H.C. Chapman : Water Research Commission
Mr D.W.H. Cousens : Water Research Commission (Chairman)
Prof. J.B. McI. Daniel : Rhodes University
Dr F.J. Kruger : Department of Water Affairs
Dr J.J. Lambourne : University of the Witwatersrand
Mr H. Maaren : Department of Water Affairs
Mr B.J. Middleton : Steffen, Robertson & Kirsten
Mr J. Myburgh : Department of Agriculture and Water Supply
Prof. R.E. Schulze : University of Natal
Mr M.J. Swart : University of Zululand
Mr P.W. Weideman : Water Research Commission.

ABSTRACT

This report is one volume of a set of final reports which present the results of the Water Research Commission project undertaken by the Hydrological Research Unit (HRU) of the Department of Geography at Rhodes University and titled "Hydrological research in catchments of the eastern and southern Cape". In particular, this report deals with objectives 3.1c and d of the initial project proposal, an investigation into the application of multiple regression and stochastic techniques for streamflow modelling in a semi-arid environment. Although these techniques have been widely used for the assessment of water resources elsewhere in the world, very little research on their data requirements is reported in the literature. This report is an attempt to satisfy some of these research needs.

The study comprises three major sections. Firstly, as it was necessary to develop a computer based system for storing and processing hydrological data this aspect of hydrological modelling was also investigated. The study examines both the time series characteristics of hydrological data and the data requirements of some common hydrological analyses. The findings of these investigations are used to determine the most appropriate file structure and data formats to develop a system for storing and processing hydrological data.

The second facet of this study comprises an investigation of the application of multiple regression techniques for predicting the characteristics of stormflow hydrographs in semi-arid catchments. In particular, the study set out to develop multiple regression models for predicting stormflow volumes, stormflow durations and stormflow peaks using rainfall derived independent variables. Although a great deal of attention has been focussed on the application of regression models to forested catchments, few studies have examined this technique for use in semi-arid environments. In 1981, Murray and Görgens reported on the development of multiple linear regression equations for predicting the characteristics of storm hydrographs for the semi-arid Ecca catchments. With the addition of a further seven years of data the current study re-examines the application of this modelling technique. The temporal resolution of the data used in this study has been increased from the hourly data, as used by Murray and Görgens, to breakpoint for streamflow and ten minute periods for catchment rainfall. The study concludes that this form of modelling does provide the hydrologist with a useful tool owing to its simple application and data requirements.

The third major focus of this study focussed on determining the application of ARMA (1,1) type models to simulating monthly rainfalls and streamflows within semi-arid environments. To assess the performance of ARMA (1,1) models for modelling rainfall a number of models were developed for successively longer subsets of the 1881 to 1980 periods of the monthly rainfall records for Alicedale and George. It was concluded that for the successful modelling of monthly rainfalls within semi-arid environments data periods of at least 40 to 50 years duration are required.

To examine the application of ARMA (1,1) type models for modelling monthly streamflows a 1000 year synthetic "observed" streamflow record for a semi-arid and a sub-humid rainfall record was developed. Models for subsets of these data series were developed and used for generating data series for comparison with the "observed" data series. The results of this investigation suggested

that this modelling approach is not the most appropriate for generating monthly streamflow series. This was attributed mainly to the relatively long period of data needed before they can be regarded as representative of the true long term data series, and also due to problems in normalising the highly skewed and discontinuous streamflow records. An alternative approach to simulating extensive monthly streamflow records for semi-arid environments is suggested.

Chapter One

INTRODUCTION

This report is one of a set of final reports that deal with the results of the Water Research Commission funded project undertaken by the Hydrological Research Unit (HRU) of the Department of Geography at Rhodes University and titled 'Hydrological research in catchments of the eastern and southern Cape'. There are three groups of objectives referred to in the project proposal. The first group of objectives (3.1a and b) comprised the continued collection of hydrological data and a survey of accumulated salts within the alluvial soils of the main and tributary channels of the Ecca catchments. The collection of hydrological data in the Ecca catchments, which began in 1976, has now ceased owing to the construction of an off-channel storage reservoir within the catchment. This reservoir is intended to store water transferred from the Orange River and used to supply the Lower Fish River irrigation scheme. The HRU is compiling a summary report of the hydrological characteristics of the Ecca catchments, as represented by the 12 years of data collected. The results of a survey of salts within the alluvial soils of the Ecca catchments have been published (Hughes and Moolman, 1987) and will also be presented in the report on the hydrological data collected within the Ecca catchments. The second group of objectives (3.1c and d) comprise an investigation into the application of regression and stochastic techniques for hydrological modelling in a semi-arid environment. A discussion of the procedures used and the results obtained from this investigation are presented in this report. Initially the third group of objectives (3.2a-g) were to focus upon the southern Cape catchments and proposed to investigate the use of single event deterministic models for simulating the complete hydrograph of flood events. These objectives were modified to comprise a comparison of the performance of four models in a number of different hydrological regimes. The results of that study are published in a separate report (Hughes and Beater, 1989).

1.1 RESEARCH AIMS

The climate of more than sixty per cent of South Africa is classified as being either arid or semi-arid where rainfalls are small and unreliable (Görgens, 1983). Owing to the difficulties of working in the harsh conditions often associated with these regions, understanding of the hydrological processes operating within arid and semi-arid areas are less well understood than those within more humid environments. Currently there is a need to carry out further research aimed at improving both the understanding of the hydrological processes and to assess the application of hydrological modelling techniques within these environments. Two important areas of statistical modelling that still remain relatively unresearched in South Africa are the application of multiple regression and stochastic techniques (van Biljon, 1982). Although both these techniques have been used widely for the assessment of water resources elsewhere in the world (Singh, 1982), very little research on their data requirements is reported in the literature. This study is an attempt to satisfy some of these research needs.

The study comprises three major sections. During the initial stages of this study it was necessary to develop a computer based system for storing and processing hydrological time series data that was more flexible than was currently available at Rhodes University. To do this the data storage and access requirements of a computer system for storing and processing hydrological time series data were investigated. A system to meet these requirements was developed for the Cyber 825 mainframe computer at Rhodes University and is described in this report. The study then assesses the use of multiple regression models for predicting the characteristics of storm hydrographs in a semi-arid environment. The third section of this study examines the data requirements of first order, autoregressive moving-average type models for simulating both monthly rainfall and monthly streamflows within a semi-arid environment. The specific aims of this study are :

i. To investigate and develop a computer based system for storing and processing hydrological time series data.
ii. To develop and assess multiple regression models for predicting the characteristics of stormflow hydrographs within a semi-arid environment.
iii. To assess the application and data requirements of first order autoregressive moving-average models for modelling monthly rainfalls and streamflows within a semi-arid environment.

1.2 RESEARCH PROCEDURE

To investigate the requirements of a computer based system for storing and processing hydrological data the characteristics of the more commonly recorded hydrological data and the data processing requirements of several hydrological analyses are examined. This includes an examination of the resolution and time series characteristics of different data types. The findings of this investigation prescribe the file structure and the methods of data access required to construct an efficient and flexible computer based data processing system. A system to meet these requirements was developed using Fortran V for the Cyber 825 mainframe computer at Rhodes University.

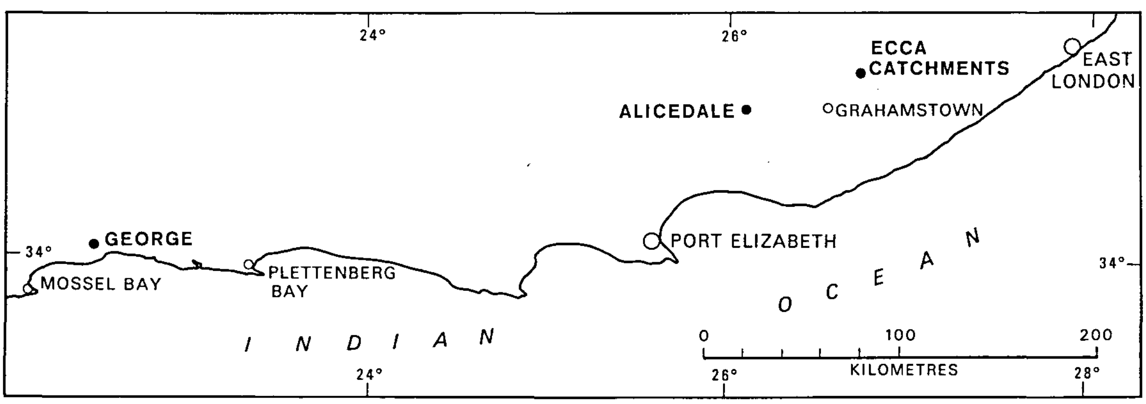

Figure 1:1 Location of the Ecca research catchments, Alicedale and George.

To assess the application of multiple regression models for predicting the characteristics of stormflow hydrographs within semi-arid areas, models for predicting stormflow volumes, stormflow durations and stormflow peaks are developed for three of the semi-arid Ecca research catchments (figure 1:1). These catchments, which have been monitored by the Hydrological Research Unit at Rhodes University since 1974, are described more fully in Chapter Two. Initially the rainfall data for these catchments were examined for missing data and subsequently ten minute catchment rainfall records were generated for each of the study catchments. The rainfall parameters used in developing the required regression models comprised values of total storm rainfall, mean and maximum 10 minute rainfall intensity, rainstorm duration and a series of indices for antecedent precipitation calculated for different durations preceeding the respective stormflow events. Similarly, the breakpoint streamflow records for these catchments were examined for their completeness. Then using an adaptation of the flow separation technique proposed by Hewlett and Hibbert (1967), stormflow events were identified and the parameters of total stormflow, quickflow, stormflow duration and peak discharge were extracted. Multiple regression equations were then developed using a stepwise multiple regression routine from the Bio-Medical Data Processing (BMDP) Statistical Library. The relative explanation of the rainfall parameters used to develop these models are compared and discussed in the light of the hydrological and physiographic information available.

The third section of this study comprises an assessment of first order, autoregressive moving-average (ARMA (1,1)) type models for modelling both monthly rainfalls and streamflows within semi-arid environments. The period of data required to develop and assess this type of model is greater than that currently recorded for the Ecca research catchments. Therefore, to assess these applications of ARMA(1,1) type models, monthly rainfall data for both Alicedale and George are used (figure 1:1). Both these records extend for periods in excess of one hundred years, and are of good quality. To assess the application of this modelling technique for generating synthetic monthly rainfall series, models are developed for different duration subsets of the Alicedale and George monthly rainfall records. Their goodness of fit and the summary statistics of a number of data series generated by these models are examined to determine their performance. To assess the application of this technique for modelling monthly streamflows, synthetic streamflow series of 1000 years' duration were generated by initially generating 1000 year monthly rainfall series using ARMA(1,1) models developed from the Alicedale and George monthly rainfall records respectively. Synthetic streamflow records were then generated by applying a deterministic monthly rainfall runoff model to these 1000 year rainfall records. ARMA (1,1) type models were then developed for successively longer periods of these streamflow series and used to develop further 1000 year streamflow series which are compared to determine the performance of this modelling technique.

1.3 RUNOFF GENERATION IN ARID AND SEMI-ARID ENVIRONMENTS

A great deal of research over the past twenty-five years has helped identify the dominant processes of runoff generation within humid environments (Hewlett and Hibbert, 1967; Kirkby and Chorley, 1967; Whipkey, 1967; Ragan, 1968; Betson and Marius, 1969; Dunne and Black, 1970; Weyman, 1970; Dunne *et al*, 1975; Anderson and Burt, 1978; Anderson and Kneale, 1980). However, the infrequent rainfalls, the spatial variability of soils and the sparse vegetation covers usually characteristic of arid and semi-arid regions result in hydrological regimes that are very different to those of more humid areas. These characteristics have often lead to research problems that have resulted in the mechanisms of runoff generation within these areas being less well understood. Yair and Lavee (1985) suggest that owing to this lack of understanding and also because data requirements can often not be met, sophisticated conceptual models are of little theoretical or practical value in these arid and semi-arid environments. They suggest that a more thorough understanding of the factors which control the processes of runoff generation within these climatic regions is necessary before such modelling techniques can be applied. In particular, what is the relative importance of the factors controlling the processes of Horton overland flow, shallow subsurface flow, saturated overland flow and groundwater flow in determining the hydrological regimes of arid and semi-arid environments?

The predominant mechanisms for rainfall generation may be characterised into two broad categories; convective and frontal. Within the study area, summer rainfalls are predominantly of the convective type, while winter rains are usually associated with larger scale frontal systems (Görgens, 1983). Convective storms are usually characterised by their localised intensity and brief duration. The spatial variability of convective type storms results from their cell type structure of convecting unstable air masses. They are often assumed to be scattered randomly in space with their paths being quite unpredictable. This variability leads to problems when monitoring rainfall and in particular when determining the areal rainfall input to rainfall runoff models.

The often localised, high intensity rainfalls of convective storms and the spatially highly variable nature of soils within most arid and semi-arid environments can result in spatially very variable runoff generation. Characteristically, flow records for low rainfall areas show a rapid response to rainfall, high local peak flows and rapid downstream decreases in area specific discharges. Therefore both spatial and temporal discontinuities can be considered important characteristics of the hydrological processes within arid and semi-arid environments. Yair and Lavee (1985) suggest two reasons for the discontinuities. Firstly they suggest that flow discontinuities can be explained by infiltration losses that increase downstream in parallel with increases in channel width and alluvial thickness. However, they also suggest that as these discontinuities often occur in very small watersheds draining less than 1 km^2, the main cause of this phenomenon is the spatial variability of rainfall. Runoff generated within an area covered by a localised convective rainfall may be quickly absorbed when it reaches an adjoining dry area.

Many studies conducted within humid environments show that the frequency and magnitude of stormflows are controlled largely by the extent and distribution of surface saturated areas (Dunne, 1978). Such areas may respond rapidly, even to low intensity rainfalls. These dynamic zones of surface saturation are usually found in topographic hollows, at the base of slopes and on areas of shallow soil. However, this situation is less likely to occur in arid and semi-arid areas where rainfall events are less frequent. The lack of significant subsurface flows within arid and semi-arid environments is supported by Yair and Damin (1980) and Yair (1983) who report that the lower sections of colluvial slopes within a semi-arid area of the Negev desert, Israel are often drier than their upper sections. This moisture pattern is in contradiction to that usually found in more humid areas where a systematic downslope increase in soil moisture is generally found (Anderson and Kneale, 1980). Therefore it may be suggested that within arid and semi-arid environments the spatial variability of soil moisture is not as important as within humid regions for determining runoff response.

As a consequence of the low rainfalls and high evaporative demands which result in low levels of moisture availability, the landscapes of arid and semi-arid regions are largely developed by physical rather than chemical processes. The resulting terrain is often rugged and has steep rocky slopes covered, at their bases, by scree or colluvial sections which are often rich in coarse rock fragments. Therefore, one may distinguish between two major types of surface material within typical semi-arid environments. Firstly, there are major areas of bare rock or very thin soils where infiltration and soil water storage are severly limited. Secondly, there are often major areas of fractured rock and colluvial material where infiltration rates and soil water storage capacities are generally high. As has been found for more humid regions, it is unlikely that rainfall intensities exceed the rates of infiltration of these surface materials, other than for very short periods of time. The greater spatial variability of both rainfall and of the factors controlling the processes of runoff generation within arid and semi-arid environments often leads to a spatially more random pattern to runoff generation. This, coupled with a poorer understanding of the factors controlling runoff generation within arid and semi-arid areas, could suggest that statistical rather than physically based deterministic approaches to hydrological modelling may prove more successfull within these drier climates.

Chapter 2

RESEARCH DESIGN AND THE DATA BASE

The current study comprises three distinct areas of research. Initially, the requirements of a computer based data storage and processing system are investigated. A system meeting these requirements was then developed for the Cyber mainframe computer at Rhodes University and is described in this report. The application of multiple regression equations for modelling the characteristics of stormflow hydrographs in semi-arid environments is then investigated. Finally, the study assesses the application of first order autoregressive moving-average models for modelling both monthly rainfalls and monthly streamflows within semi-arid environments. These areas of study are quite distinct and have different data requirements. The approaches adopted to investigate these aspects of hydrological modelling and the data bases used are now described.

2.1 RESEARCH DESIGN

2.1.1 Storage and Processing of Hydrological Data

Since the 1960's a major development within hydrological research and water resource management has been the growing use of computers for data storage and processing. However, within the literature there are very few reports on either the development or the requirements of computer systems to meet these needs. It is also apparent that at most centres of hydrological research, computing facilities have grown in stages to meet the immediate needs of the day. Unfortunately, with the increasing use of electronic data collection and the need for more sophisticated analytical techniques, many of these systems have become unwieldy for some purposes. For example, it was not easy to efficiently carry out the data checking and analytical procedures necessary for this study using the data storage method initially adopted by the Hydrological Research Unit at Rhodes University. Therefore, it was decided to develop a new computer based system for the storage and analysis of hydrological data. This task was carried out by initially examining the characteristics of hydrological data and investigating the data access requirements of typical analytical procedures used in hydrological research. This included an examination of both the resolution and the time series characteristics of the more common types of hydrological data. The computing methodology that would best marry the determined data characteristics and processing demands of hydrological research were then determined. This resulted in the development of a data storage and processing system comprising a series of Fortran V programs interactively called by a procedure of system commands. This system was developed to run on the Cyber 825 mainframe computer at Rhodes University. The computing framework adopted to carry out some typical hydrological analyses are described to illustrate the advantages of the proposed approach.

2.1.2 An Assessment of Multiple Regression Modelling

To assess the application of multiple regression models for predicting the characteristics of stormflow hydrographs in semi-arid environments, a number of models were developed for three of the Ecca research catchments. Initially all streamflow and raingauge data used in this study were checked for missing data and errors due to incorrect digitizing. This proved to be a fairly major task as much of this data had not been analysed previously. By using an adaptation of the stormflow separation technique proposed by Hewlett and Hibbert (1967), stormflows discharge from the three Ecca catchments used in this study were identified. Values for the storm hydrograph characteristics to be modelled were then determined for each of the identified events. These comprise the stormflow volume, quickflow volume, peak flow and the duration of each stormflow event as defined by an adaptation of the stormflow separation technique developed by Hewlett and Hibbert (1967). These parameters are defined more fully in Chapter Four. A continuous 10 minute rainfall record was constructed for each of the research catchments using the Thiessen method. Using these rainfall records, the total rainstorm catch, the mean and maximum rainfall intensity, the rainfall duration and a series of antecedent precipitation index values for durations, of five to thirty five, 24 hour periods preceding the rainfall associated with the identified stormflow events were determined. A stepwise multiple regression routine from the Bio-Medical Data Processing (BMDP) statistics library was then used to develop models for predicting the determined stormflow characteristics using the extracted rainfall parameters as independent variables. The coefficients of determination and standard errors of estimation for each step in the development of these models is examined to identify the "best" predictive models. The residuals for these models are also examined.

2.1.3 Autoregressive Moving-Average Modelling of Monthly Rainfalls and Streamflows in Semi-Arid Environments

Owing to the inherent random characteristics of many hydrological processes, hydrological time series data maybe readily modelled using stochastic techniques. Stochastic modelling techniques have been used widely for modelling streamflow and rainfall processes in semi-arid environments, especially for annual and monthly series. However, there are few published reports that examine the length of data record required for the successful application of these models. This report examines the application of first order autoregressive moving-average (ARMA (1,1)) models for modelling monthly rainfalls and stream discharges in a semi-arid environment. Although there are many different stochastic models available, ARMA(1,1) type models are among those most commonly adopted by practicing water resource planners (Salas, Delleur, Yevjevich and Lane, 1980). The main aim of this study is to determine the period of record required for the performance of ARMA (1,1) models of monthly rainfall and stream discharge in semi-arid environments to stabilise.

Owing to the relatively short period for which rainfall has been recorded in the Ecca catchments, monthly rainfall data for both Alicedale (Weather Bureau Station No. 56/139) and George (Weather Bureau Station No. 28/838) are adopted for this facet of the study. Both these rainfall records extend for over 100 years and are representative of two different rainfall regimes. The mean annual rainfall at Alicedale is 413 mm while that for George is 869 mm. The rainfall regimes of these study areas are described more fully in a later section of this chapter. To assess the data requirements for the successful development of ARMA (1,1) type monthly rainfall models, a number of models are developed for successively longer subsets of the Alicedale and George rainfall records. The performances of these models are determined by comparing their Porte Manteau lack of fit statistics and by comparing the summary statistics for a data series generated by each model with those for the respective 100 year periods of observed data.

To assess the performance of ARMA(1,1) models for modelling monthly streamflows, 1000 year monthly streamflow series are generated from the 100 year rainfall records for George and Alicedale respectively. ARMA(1,1) models are then developed for successively longer periods of these data series. As with the assessment of this modelling technique for monthly rainfall, the Porte Manteau lack of fit statistic and summary statistics for data series generated by these models are compared to the respective 1000 years of synthetic "observed" streamflow data.

2.2 THE ECCA RESEARCH CATCHMENTS

Since 1974 the Hydrological Research Unit at Rhodes University has monitored five nested catchments in a semi-arid zone about twenty kilometres north of Grahamstown. A sixth catchment was established in 1982. These research catchments range in area from 0,28 km^2 to 73,1 km^2 and are all drained by tributaries of the Ecca River, a tributary of the Great Fish River. Figure 2:1 shows the location, configuration and hydrometeorological gauging network of the Ecca research catchments. Although all six catchments have been assigned code numbers by the Department of Water Affairs, for the purposes of this report the Rhodes Hydrological Research Unit's designations of A, B, C, D, E and F have been adopted. Owing to the poor quality of the streamflow records for catchments C, D and F, only data for catchments A, B and E have been used for this study. The establishment and physiography of these research catchments are described in detail by Roberts (1978) and Görgens (1983). Owing to their relative smallness and because of their nested configuration, these catchments appear fairly uniform in terms of climate, vegetation and lithology. Currently, the predominant landuse of the Ecca catchments comprises small stock (goat) grazing with some larger stock (cattle) which are confined to the main valley bottom.

2.2.1 General Climate

The climate of the Ecca research catchments is characterised by large variations in temperature, and by highly variable seasonal and annual rainfalls. According to synthetically reconstructed rainfall records for the lower Great Fish River catchment, the long-term mean annual precipitation of the greater Ecca catchment is between 420mm (Midgley and Pitman, 1969) and 532mm (Middleton *et al.*, 1981). Records from the raingauge network in the Ecca catchments for the period from 1975 to 1986 yields a mean annual rainfall of 437 mm with a standard deviation of 138 mm (table 2:1). According to this data period, approximately 62,3 percent of the mean annual rainfall occurs in the "summer" months of October to March (figure 2:2). The larger runoff producing rainfall events are usually associated with advecting air from larger scale frontal systems that sweep along the south coast of the southern African sub-continent. During the summer months, localized convective thunderstorms are also an important component of the rainfall regime of the Ecca catchments. The highly variable nature of the rainfall climate of the Ecca catchments is attributed to their location in a transitional climate zone between the sub-humid all year rainfall region of the south and west to the more arid summer rainfall regions of the northwest and the temperate summer rainfall regions of the east. On a regional scale the general climate of the Ecca area is typical albeit somewhat more arid than the rest of the Albany Border area and somewhat less arid than the northern parts of the Great Fish River catchment (Görgens, 1983). Long-term mean annual free water surface evaporation is estimated at approximately 1362mm using monthly Symons pan figures from Pitman (1973) and regional conversion factors supplied by the Department of Environment Affairs (Roberts, 1978).

2.2.2 Geology and Soils

Three major geological units are found within the Ecca catchment, namely the Witteberg Group belonging to the Cape Supergroup, and the Dwyka and Ecca Groups representing the Karoo Supergroup (figure 2:3). Approximately seventy percent of the surface geological formations of the Ecca Catchment comprise the interbedded shales and sandstones of the Ecca Group. The shale and tillite of the Dwyka Group comprise a further twenty percent of the catchment. The soils are shallow and stoney on the ridge tops with deeper colluvial deposits in the valley bottom (Roberts, 1978).

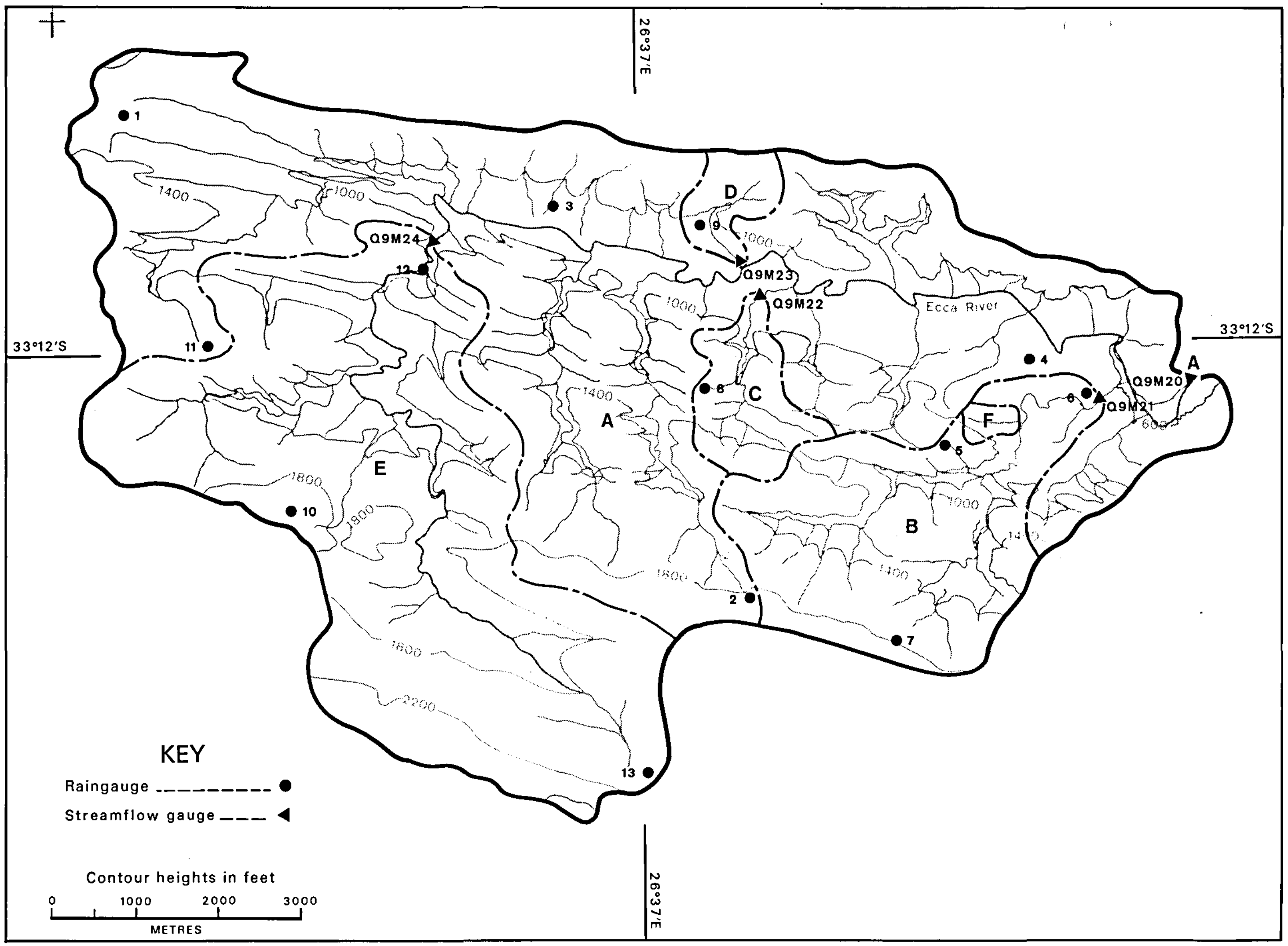

Figure 2:1 The hydro-meteorological gauging network in the Ecca research catchments.

Table 2:1 Mean catchment rainfall for Ecca A 1975 - 1986.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1975	28,42	47,33	47,92	10,31	2,71	38,59	9,95	12,66	91,04	2,30	17,27	56,42	364,92
1976	54,78	78,78	146,57	11,69	23,75	12,44	37,00	9,24	15,07	62,00	38,73	23,27	513,32
1977	16,93	153,37	16,89	51,84	68,60	4,92	2,53	10,23	34,53	6,80	73,90	109,76	532,35
1978	59,70	29,89	33,17	115,62	16,36	25,30	2,23	12,71	13,49	81,01	35,92	49,05	474,95
1979	45,81	92,97	17,55	1,92	43,17	23,65	199,93	137,68	30,57	46,19	12,35	12,31	664,10
1980	32,86	34,98	41,58	27,64	0,67	23,51	1,46	9,73	28,63	23,14	79,69	40,89	344,78
1981	45,16	17,84	116,25	9,24	67,58	10,50	0,33	60,91	9,10	77,33	32,97	54,00	501,21
1982	7,47	11,47	26,88	41,34	0,00	41,20	17,67	4,86	31,59	50,73	31,19	13,92	278,32
1983	8,43	14,02	14,87	27,90	12,30	19,48	90,62	1,32	32,22	58,89	44,35	24,54	348,94
1984	15,47	4,57	20,93	29,30	10,68	34,51	11,96	5,85	7,94	25,42	22,23	17,68	206,54
1985	33,03	93,25	27,26	37,22	5,41	19,33	2,05	0,88	3,47	128,78	136,63	91,65	578,96
Mean	31,64	50,95	46,35	33,09	22,88	23,04	34,16	24,19	27,06	51,14	47,75	44,86	437,13
STD	18,22	42,82	43,83	31,36	25,55	11,55	61,07	41,11	24,05	36,89	36,28	32,07	138,55
MIN	7,47	4,57	14,87	1,92	0,00	4,92	0,33	0,88	3,47	2,30	12,35	12,31	206,54
MAX	59,70	135,37	146,57	115,62	68,60	41,20	199,93	137,68	91,04	128,78	138,63	109,76	664,10

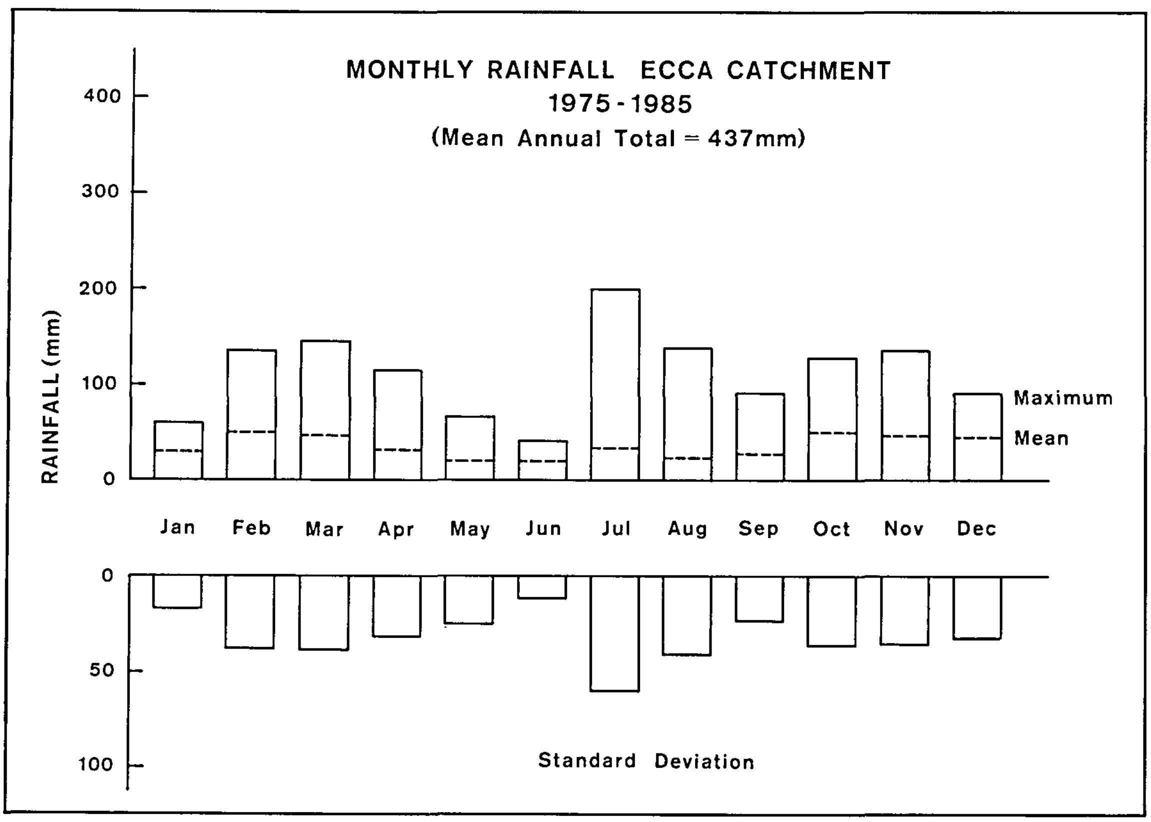

Figure 2:2 Mean monthly rainfall of Ecca catchment A.

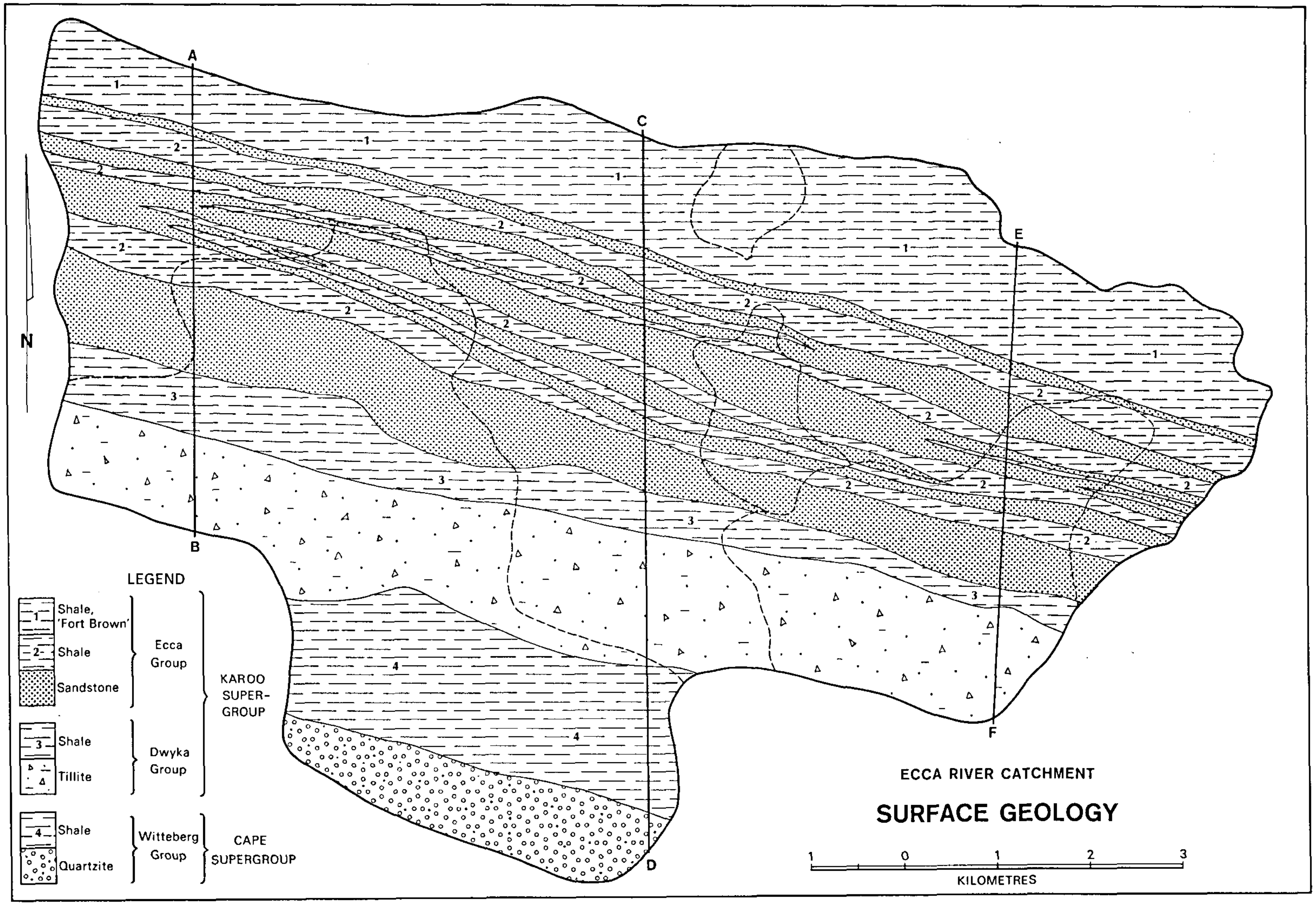

Figure 2:3 Surface geology of the Ecca catchments (from Roberts, 1978).

2.2.3 Physiography

A Witteberg quartzite ridge in the south of the Ecca Catchment forms the highest ground at 738 metres, giving a maximum basin relief of 570 metres. The main channel of the catchment has an east-west alignment which follows the general strike of the geology. The alternating bands of shale and sandstone result in the area being highly intersected with the main tributaries forming deeply incised valleys that run at right angles to the main channel. Roberts (1978) compiled a slope map from which he categorized the percentage areas of each sub-catchment according to five slope classes (figure 2:4). This shows the classification of slopes within catchments A and E to be fairly similar while a significantly smaller proportion of catchment B has slope angles of less than 10 percent.

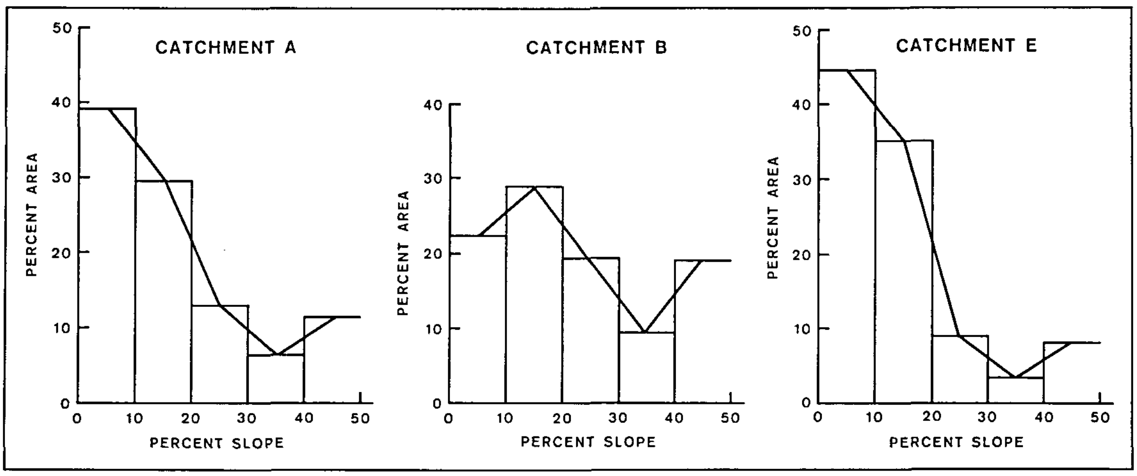

Figure 2:4 Classification of slopes within the Ecca catchments (from Roberts, 1978).

2.2.4 Vegetation

The predominant vegetation of the Ecca catchments is commonly known as Valley Bushveld and has been classified as "Karoo and Karriod Bushveld Type 10" (Acocks, 1975). This vegetation type comprises a tall sub-succulent bush in the upper catchment areas and on the lower slopes of the incised tributaries. This vegetation cover thins out to a low succulent scrub on the flatter areas and in particular in the lower parts of catchments A and B. Using areal and ground photographs Roberts (1978), classified 53 percent of the catchment area as having a sparse ground cover with only 11 percent, mainly on the ridge tops in the south-east, being classified as having a dense vegetation cover. However, the condition of the vegetation within these catchments appears fairly dynamic, with the proportion that may be classified as sparsely covered depending largely on the drought sequences which are a characteristic of this area.

2.2.5 The Hydrological Data Base of the Ecca Catchments

Hydrological data have been collected for the Ecca research catchments since 1974. The current study uses streamflow data collected for catchments A, B and E, and rainfall records for gauges 1, 2, 3, 5, 6, 8, 9, 10, 11, 12 and 13 (figure 2:1 and 2:5). This discussion of the hydrological network within the Ecca is restricted to these data recording sites. Figure 2:5 displays the periods for which the respective raingauge records have been used for this study. Raingauge 5 was closed at the end of February 1980 owing to its difficult access and replaced by gauge 8 at a more accessible site of similar altitude and exposure. In 1983 five raingauges were located in catchment F. The records for these gauges have not been used in this study. An examination of the raingauge network illustrated in figure 2:1 shows that the distribution of raingauges in the western part of the research area is more sparse than for the rest of the Ecca catchment. This is unfortunate, but reflects the limited access to this area of the catchment owing to its remoteness and deeply incised terrain.

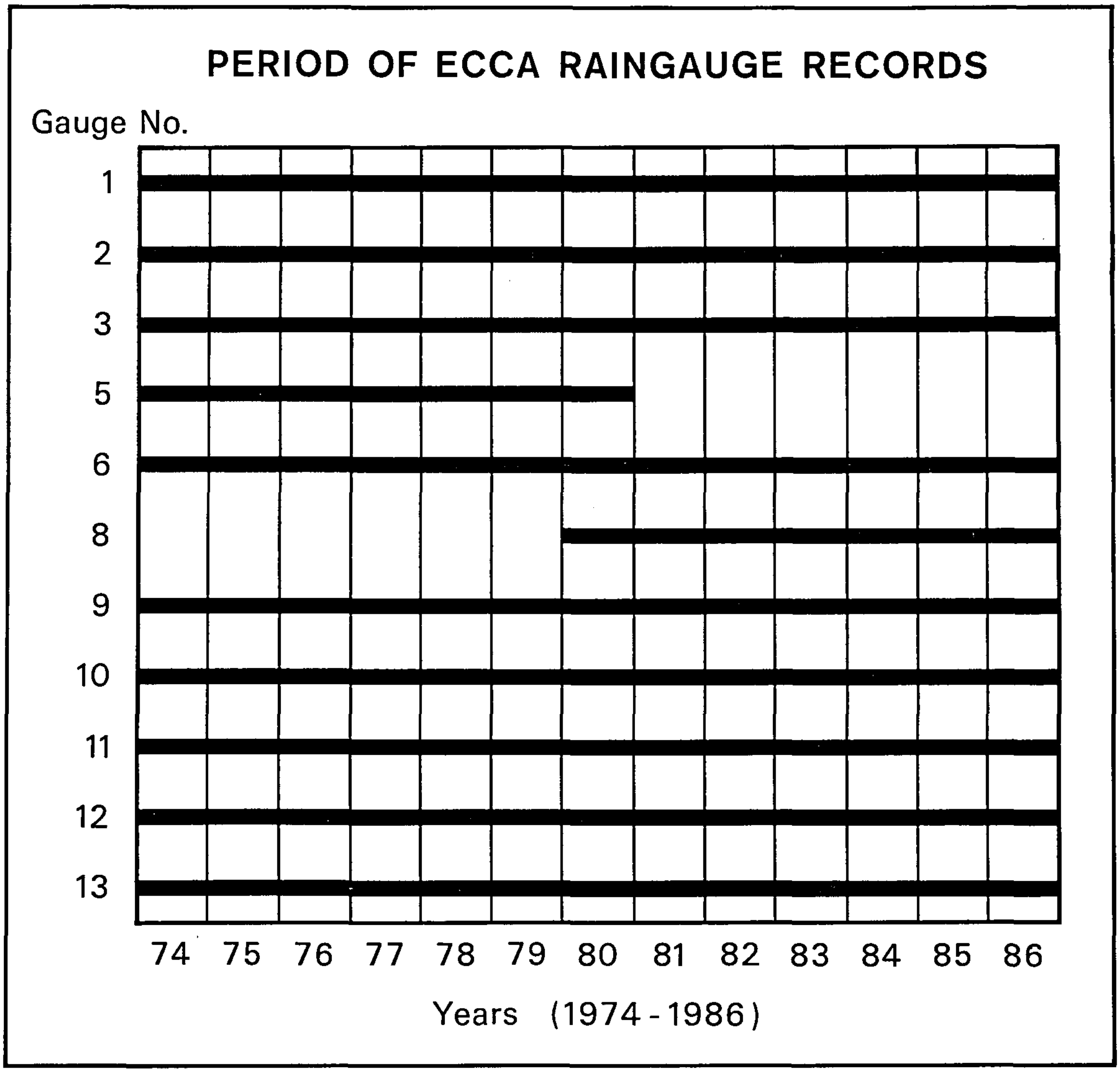

Figure 2:5 Periods of individual gauge records used in this study.

Many studies have emphasised the importance of accurate rainfall estimates for successful hydrological modelling. Often quoted sources (Hall and Barclay, 1975) suggest that estimates of areal rainfall, based on point observations, should only be regarded as an index of the true mean catchment rainfall and that errors of between 10 and 20 percent can be regarded as normal. They suggest that in mountainous areas or where wind may play an important role in determining rainfall catch, errors of up to 60 percent can be experienced. These findings suggest that for the deeply incised terrain of the Ecca catchments, which may lead to rain shadows during frontal storms, and also because of the prevalence of localized thunderstorms during summer, the highest possible density of raingauges should be used in these research catchments. Table 2.2 presents the densities of the raingauge networks used in the current study. It is not possible to compare the success of different raingauge networks due to the uniqueness of different rainfall climates and topographic conditions. However, the raingauge densities of the networks within the Ecca catchments compare favourably with those used in other South African rainfall-runoff modelling studies. For example, the research catchments established by the University of Zululand have a raingauge density of 1 gauge per 5,0 km^2 (Hope and Mulder, 1979) while the research catchments at Bethlehem, established as part of the rainfall augmentation study, have densities of between 1,8 km^2 and 13,3 km^2 per gauge (Cousens, 1980).

Table 2:2. Catchment areas and the densities of raingauge networks within the Ecca research catchments.

Ecca Catchment	Catchment Area (km^2)	No. of Gauges	Gauge Density ($Gauges.km^{-2}$)
A	73,1	10	7,31
B	9,1	3	3,03
E	23,1	6	3,85

Owing to the dusty and harsh environmental conditions in the Ecca catchments, syphon and clock failures have resulted in many periods of missing record as is depicted in Appendix A. Before using these records, periods of missing data were patched by substituting the rainfall records from alternate gauges. This is discussed more fully in the section on Data Assembly and Processing.

The streamflow gauging sites for catchments A, B and E comprise compound, sharp crested weirs with stream water level being continually recorded using Ott type R10 horizontal water level recorders. In an analysis of South African streamflow gauging practice, Muller (1977) evaluates the errors inherent to the records produced by the best flow gauging structures in the national network of the Department of Water Affairs. This report concluded that streamflow monitoring errors, including stage discharge rating errors are in the order of 10 percent. The major problems of streamflow monitoring within the Ecca and in particular for the weirs used to monitor flows from catchments A and B relate to the high sediment loads experienced during major flood events. During two such events, the weir pools were filled with sediment to a level above the inverts of their V notch sections. Even when the weirs have not been totally drowned, the infilling of the weir pool alone leads to an increase in the streamflows approach velocity, thereby altering their stage discharge relationships. This problem is due largely to the combined effects of the geology and drought sequences experienced in the Ecca catchments which result in cycles of sediment production and removal. This problem is enhanced by the location and design of these structures. With the streamflows being ephemeral and subject to very rapid changes in discharge, as is characteristic of arid and semi-arid environments, it is not possible to easily check the stage discharge relationships for the weirs in the Ecca catchments. Therefore, it is difficult to properly assess and compare the accuracy of streamflow measurements within the Ecca catchments to those of other monitoring sites within South Africa.

2.3 DATA ASSEMBLY AND PROCESSING

2.3.1 Ecca Hydro-meteorological Data

The rainfall data used in this study were recorded using Casella raingauges geared for both daily and weekly charts. Stream stage was recorded using Ott recorders geared for eight day charts. Both the rainfall and stream stage records were digitized to form breakpoint data. For this study the breakpoint rainfall and stream water level data were stored and processed using a random access file structure which is described in Chapter Three.

The rainfall record for each of the eleven raingauges used for this study was used to construct a record of coincidental ten minute rainfalls, recorded for each raingauge. Periods of missing rainfall data for any gauge was "synthesized" by simply replacing these periods with the ten minute record of the gauge most highly correlated with that of the missing record. These relationships were determined by correlating 12 hourly records for each gauge with that of coincidental records for all other gauges. The resulting correlation structure used to determine the order of gauge substitution is presented in Appendix B.

There are a number of methods available for estimating average areal rainfalls from point raingauge measurements. The most common of these are, arithmetic averaging, Thiessen weighting, isohyetal mapping and the interpolation to a regular grid using either trend surface or multiple regression techniques. After reviewing 15 versions of these methods Hall (1972) concluded that, provided there is an adequate raingauge network of reasonably evenly spaced gauges, no one method provides an obvious advantage. Görgens (1983) examined the comparative rainfall catch for twenty one typical storm events in the Ecca using isohyetal, Thiessen and arithmetic averaging approaches. The results of that study found that the Thiessen and arithmetic averaging approaches underestimated that of the isohyetal method by 3,4 and 4,2 percent respectively. Using the t-test, Görgens showed that the difference between these estimates of mean catchment rainfall were not significant at the 95 percent confidence interval. Görgens (1983) showed that with the exception of extremely localised thunderstorms, the Thiessen approach provides satisfactory estimates of mean catchment rainfalls for the Ecca catchments. As the isohyetical and interpolative methods are not practicable for the calculation of continuous catchment rainfall records they were not considered as viable alternatives for this study.

The Thiessen approach is easily adapted for computerised data processing. Initially, Thiessen weightings were determined graphically for the raingauge networks of catchments A, B and E respectively (Appendix C). Due to the closing of raingauge 5 and the subsequent opening of raingauge 8, during January of 1981, separate Thiessen weightings for all gauges were determined for the periods 1974 to 1980 and 1981 to 1986. By applying these Thiessen weightings to the records of 10 minute coincidental rainfalls of each raingauge, continuous ten minute mean catchment rainfall records were developed for catchments A, B and E respectively. These records were subsequently used to determine the rainfall parameters used for assessing the application of multiple regression models for predicting the characteristics of stormflow hydrographs in semi-arid environments.

2.3.2 Monthly Rainfall Data at George and Alicedale

Currently, the period for which rainfall data have been recorded in the Ecca research catchments is insufficient for the development and assessment of stochastic models for monthly rainfall. Therefore the current study adopts rainfall records for both Alicedale and George which both extend for a period of over 100 years (figure 1:1). Alicedale is located 40 km west of Grahamstown and is at an elevation of approximately 450 metres above sea level (figure 2:6). The mean annual rainfall at Alicedale for the period 1881 to 1980 was 413 mm with a standard deviation of 119mm.

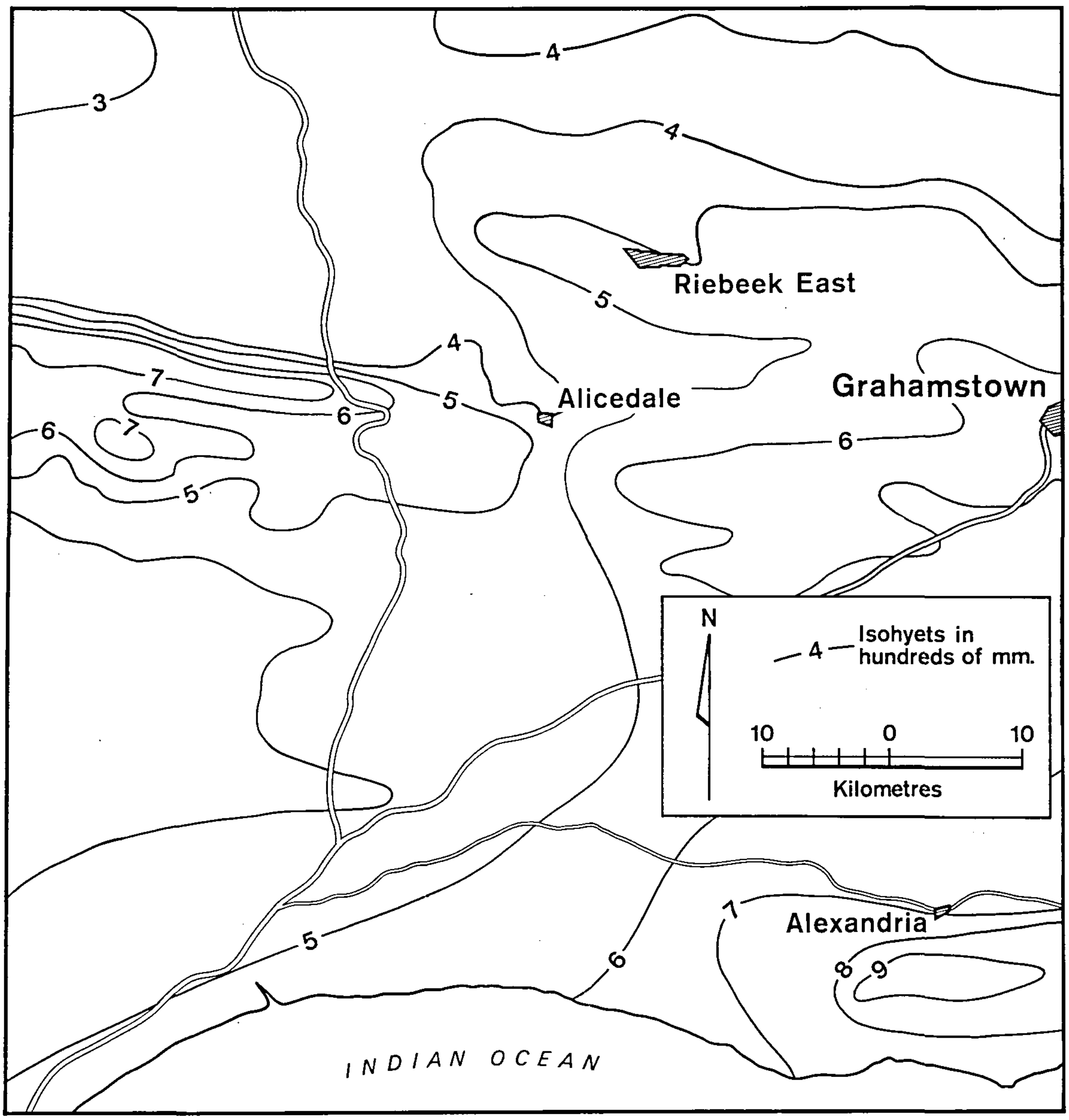

Figure 2:6 Location and isohyetal rainfall pattern of the Alicedale area (from Dept. of Works and Land Affairs, 1971).

George is located at an elevation of 220 metres on a narrow coastal plain approximately 10 kilometres from the coast (figures 2:7). The mean annual rainfall at George for the period 1881 to 1980 is 859 mm with a standard deviation of 156mm. By assessing this modelling technique for both a semi-arid and a more humid area (George) it is possible to gain an impression of how its performance varies when used in different rainfall regimes.

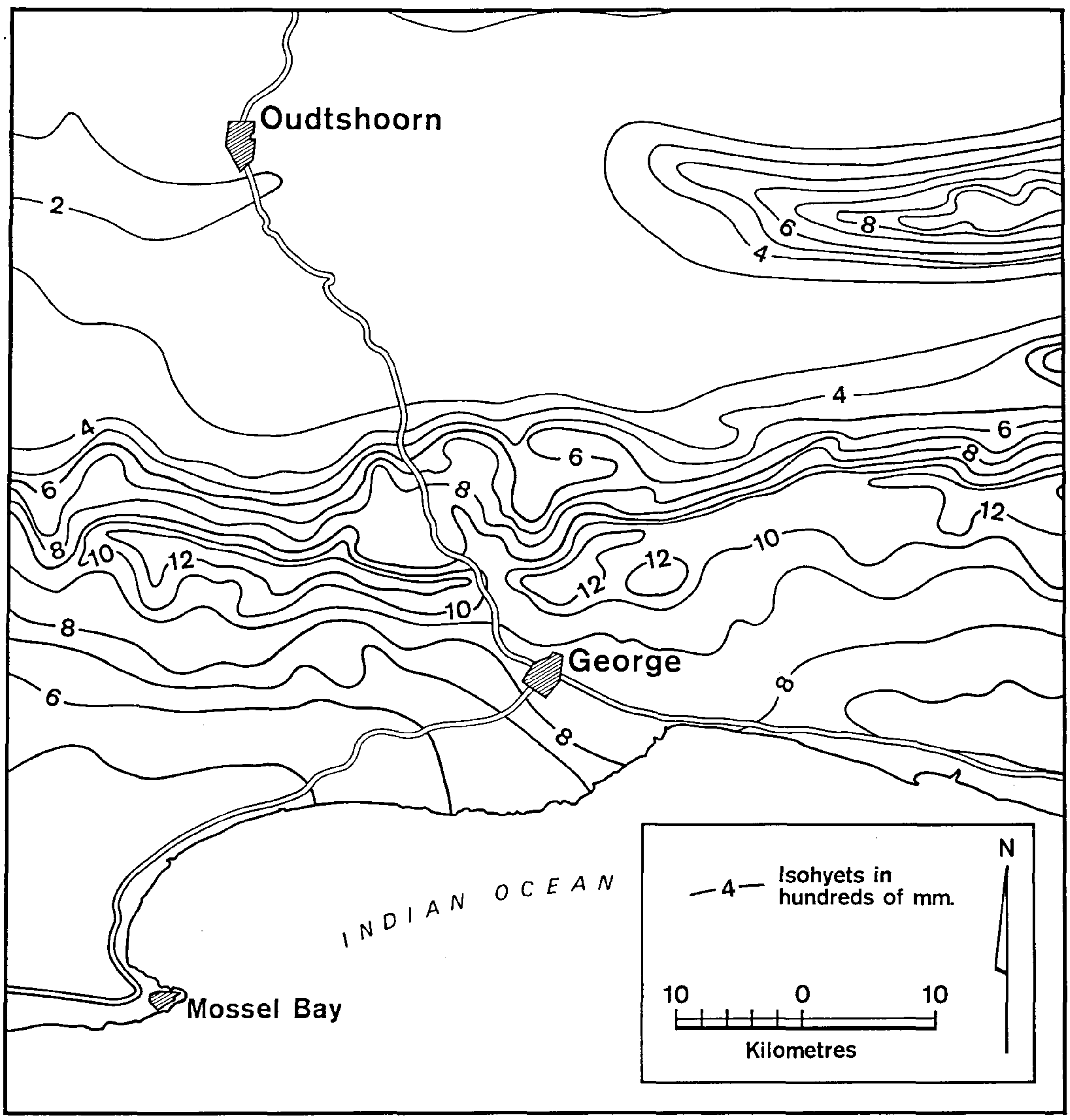

Figure 2:7 Location and isohyetal rainfall pattern of the George area (from Dept. of Works and Land Affairs, 1965).

Tables 2:3 and 2:4 present statistical summaries of the 100 year periods (1881 to 1980) of Alicedale and George rainfall data used in this study. The major difference between these two rainfall regimes is their mean annual rainfalls, with George receiving more than twice that for Alicedale. Both the annual and monthly rainfalls for these two locations are highly variable. The annual variability of rainfall recorded at both George and Alicedale is characterised by an almost cyclic pattern of drier and wetter periods, but there are no significant long term trends (figure 2:8 and 2:9). Examination of the mean monthly rainfalls for both sites shows that although there is marginally less rainfall during the months of June, July and August, neither site displays a strong seasonal variation in rainfall (figures 2:10 and 2:11). On average, March is the wettest month, with November providing a secondary peak in the seasonal rainfall regimes of both sites. Although the dominant rainfall processes at both sites are probably fairly similar, a comparison of the mean rainfall per rainday for each month (figures 2:12) suggests that rainfall intensities recorded at Alicedale are greater than those at George. This may indicate that convective type rainfalls, which are generally more intense than those associated with frontal systems, are more common in the Alicedale area.

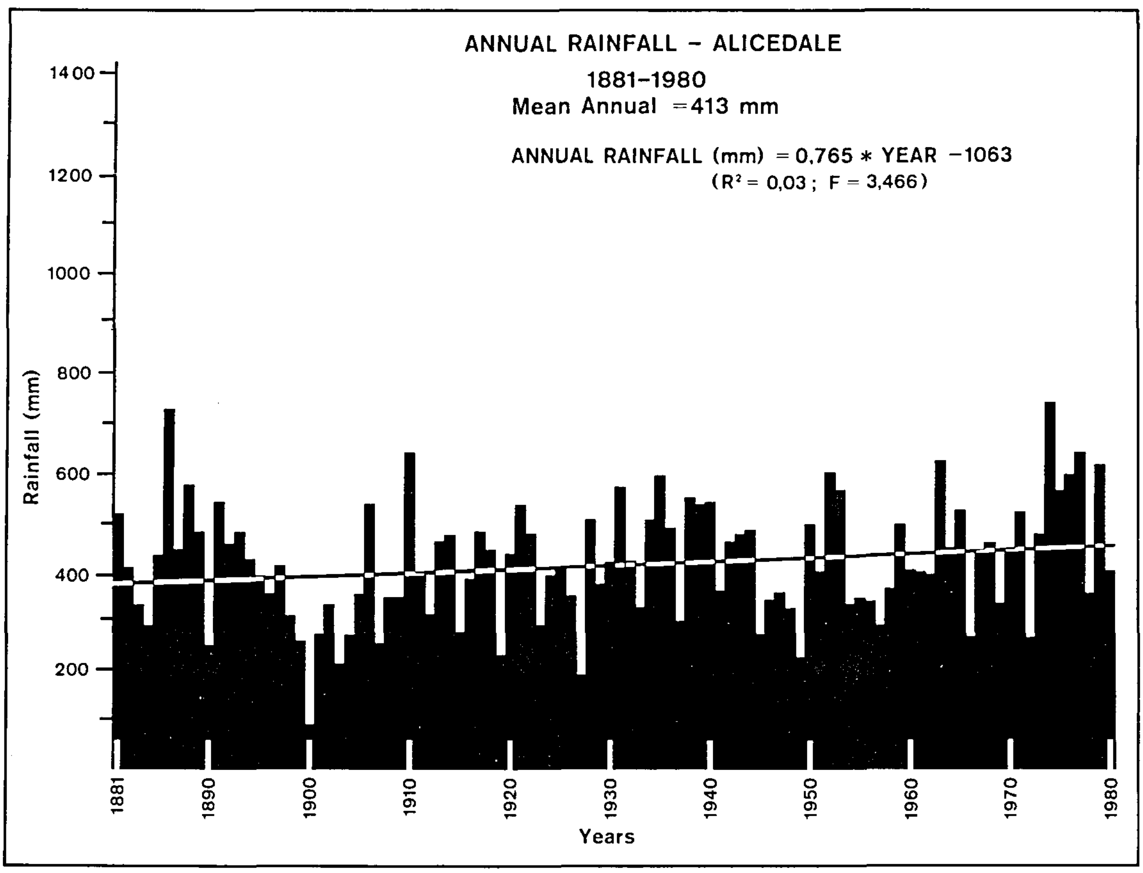

Figure 2:8 Annual rainfall recorded at Alicedale for the period 1881-1980.

Table 2:3 Statistical summary of rainfall recorded at Alicedale for 1881-1980.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	34,09	41,09	51,35	33,20	32,91	21,31	23,28	23,68	34,08	39,49	44,03	34,62	413,13
STDV	29,38	34,95	38,99	25,63	35,08	31,13	32,09	25,81	35,92	31,67	35,12	32,37	119,53
SKEW	1,12	1,95	1,38	0,86	2,31	1,67	3,56	1,86	2,04	1,50	0,93	1,65	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	196,00	185,00	110,00	207,00	106,00	216,00	133,00	189,00	168,00	144,00	172.00	737,00

Table 2:4 Statistical summary of rainfall recorded at George for 1881-1980.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	78,67	80,52	90,63	67,68	65,99	47,41	48,75	65,60	82,07	82,58	82,43	76,72	869,05
STDV	41,14	52,03	47,13	44,94	53,87	42,39	34,61	51,19	65,95	44,67	51,73	58,87	156,79
SKEW	0,62	1,53	1,65	2,04	2,04	3,16	1,467	2,12	3,01	1,01	1,36	3,22	
MIN	15,00	14,00	12,00	15,00	4,00	0,00	3,00	7,00	15,00	0,00	7,00	0,00	562,00
MAX	200,00	251,00	334,00	291,00	313,00	298,00	166,00	300,00	480,00	232,00	273,00	459,00	1409,00

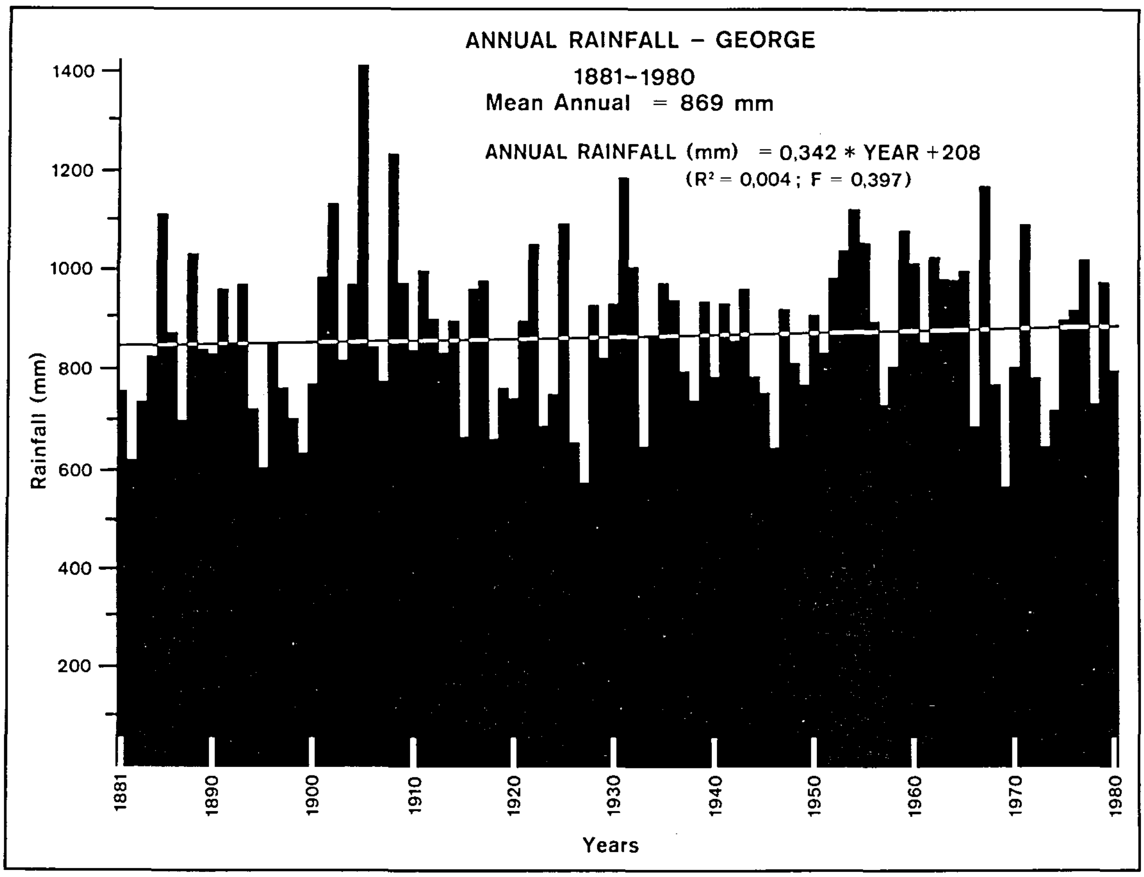

Figure 2:9 Annual rainfall recorded at George for the period 1881-1980.

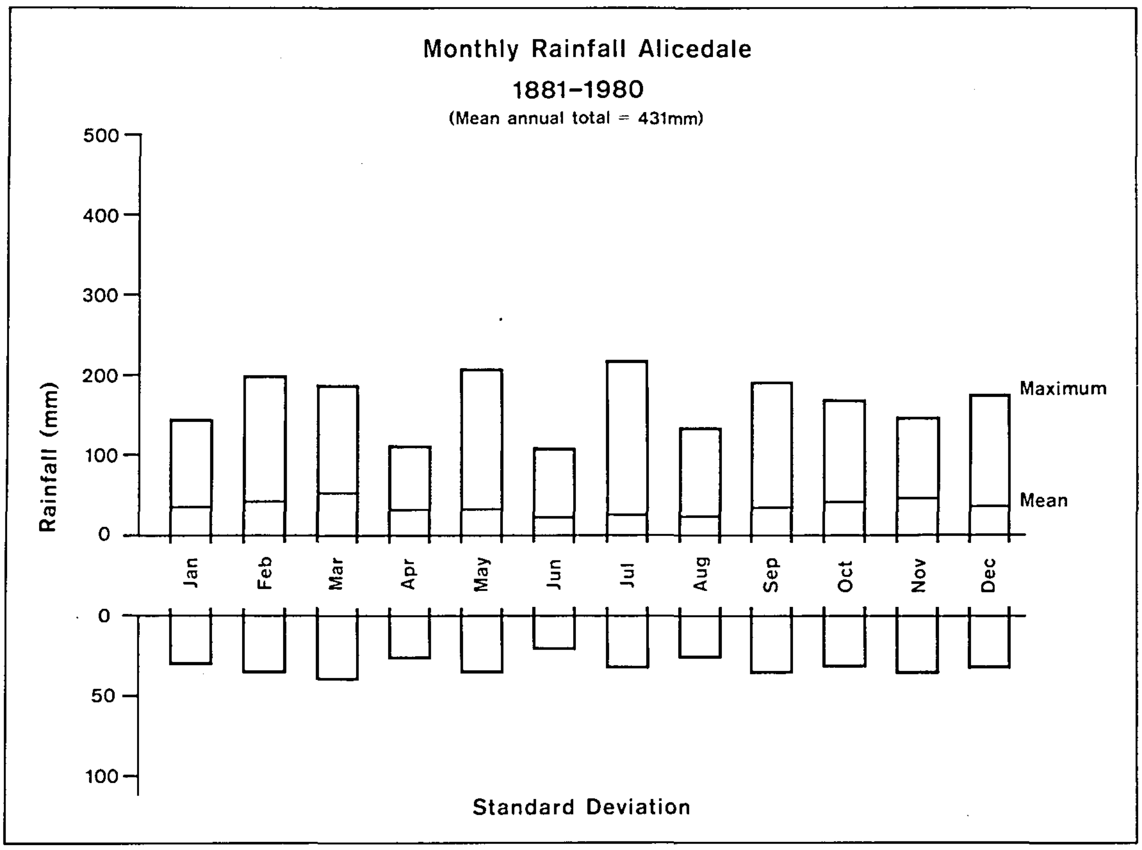

Figure 2:10 Mean monthly rainfall recorded at Alicedale for the period 1881-1980.

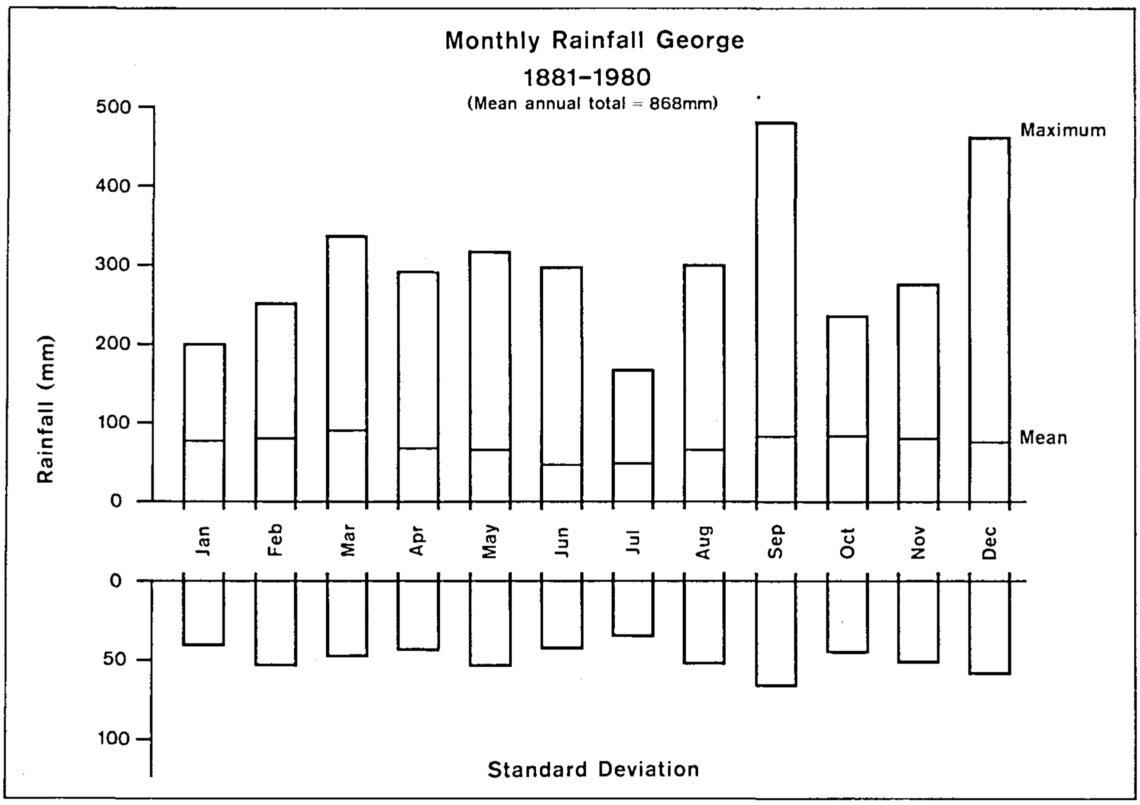

Figure 2:11 Mean monthly rainfall recorded at George for the period 1881-1980.

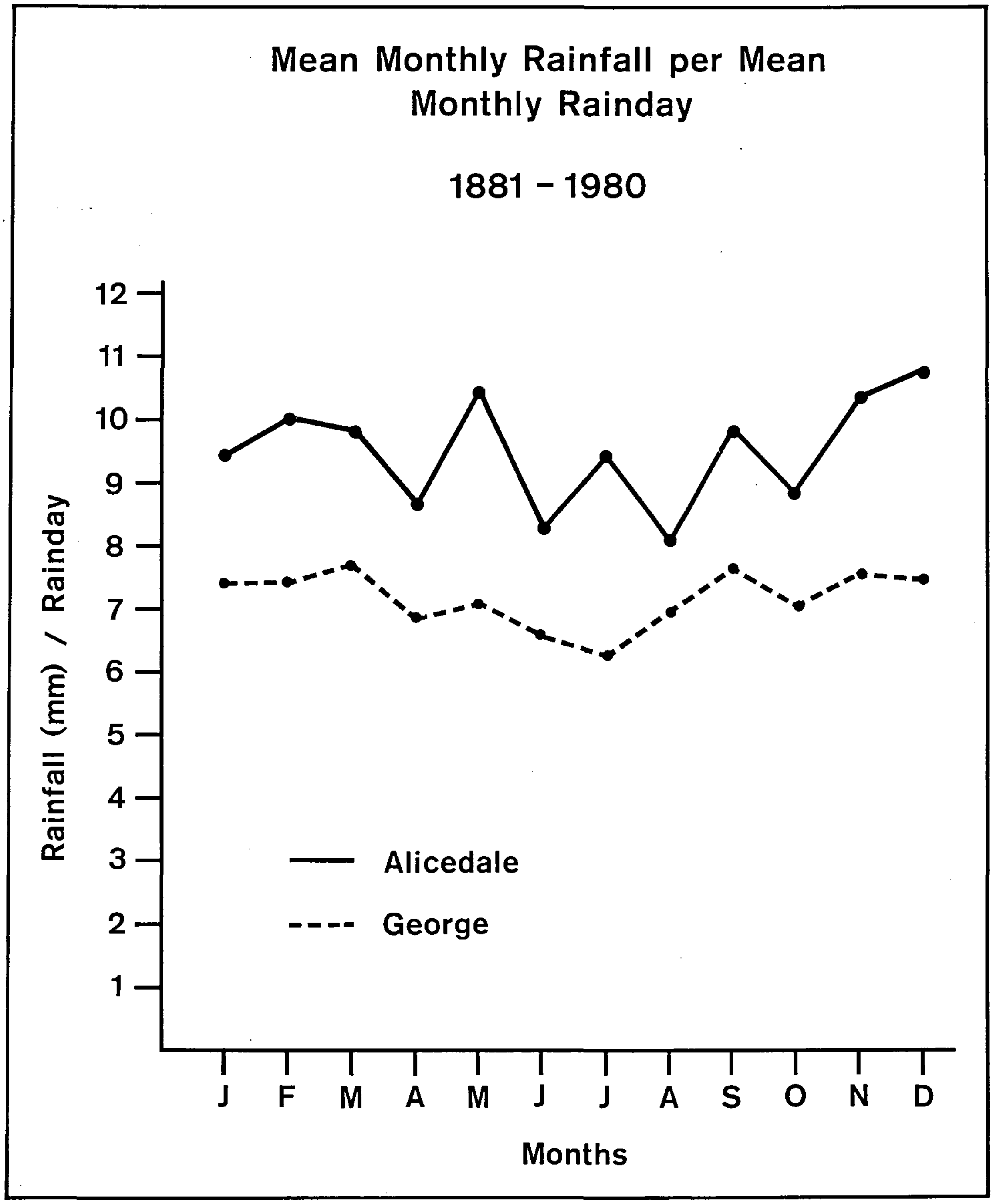

Figure 2:12 Mean rainfall per rainday for each month recorded at Alicedale and George for the period 1881-1980.

Chapter 3

DEVELOPMENT OF AN HYDROLOGICAL DATA PROCESSING SYSTEM

3.1 HYDROLOGICAL DATA PROCESSING

Since the early 1960's a major trend in hydrological research has been the growing dependence on computers for data storage and analysis. Yet, when one considers the importance of this facet of hydrological research there are very few reports on either the requirements or the development of computer systems for processing hydrological data. It appears that at most centres for hydrological research, computer facilities have grown to meet the immediate needs of the day rather than being planned for future requirements. Prior to the age of computers, hydrological data were stored in books of tables. Then with the introduction of computers, the early developers of many hydrological data base systems persisted with the storage of information in the form of tables with the computer merely acting as an electronic paging device. Some of these systems remain today with current researchers having to adopt complex data retrieval routines to gain access to required information. For example, the method of data storage initially adopted by the Hydrological Research Unit at Rhodes University was not easily accessed for data checking and some of the analyses required for this study. The "spread sheet" approach, commonly used for many commercial data base systems, has been adopted by some research organizations for the storage of hydrological data. However, this approach also does not fully recognise the "time series" nature of most hydrological data. An important focus of this study is to examine the temporal characteristics of hydrological data and to determine how best this data can be stored and analysed. A system which more fully recognises the "time series" nature of hydrological data has been developed at Rhodes for use on a Cyber 825 mainframe computer. This report focuses on the requirements of the hydrologist and does not attempt to discuss the merits of different computer hardware.

3.2 THE REQUIREMENTS OF DATA STORAGE SYSTEMS

Since the introduction of computers into water resource management and research, hydrologists have wanted to process an ever growing quantity of data more rapidly. Many analytical techniques now widely used in hydrological research are only possible by using high speed computers. The introduction of data loggers for data collection has not only increased the quantity of data collected, but has also provided the researcher with a greater flexibility in the recording of both temporal and process measurements (Herald, Hughes and Schultz, 1986). Therefore it is becoming increasingly important that data base systems be tailored specifically for the storage and analysis of hydrological data.

As hydrologists are generally interested in the temporal variations of hydrological processes, hydrological data often take the form of a time series. That is, it usually comprises a series of measurements recorded over a period of time. Traditionally, for ease of analysis and storage, time series data have comprised lists of measured values equally spaced through time. However, for many hydrological processes the prescription of equal time steps has the serious disadvantage that the time interval must be set before the data can be processed. This may lead to the adoption of time periods that are either so long that detail is lost or so short that the number of data values becomes unwieldy. Therefore, a truely non-interpretive data filing system which allows the temporal spacing of data values to be varied, so that all the significant details can be recorded as measurements become available, has significant advantages (figure 3:1).

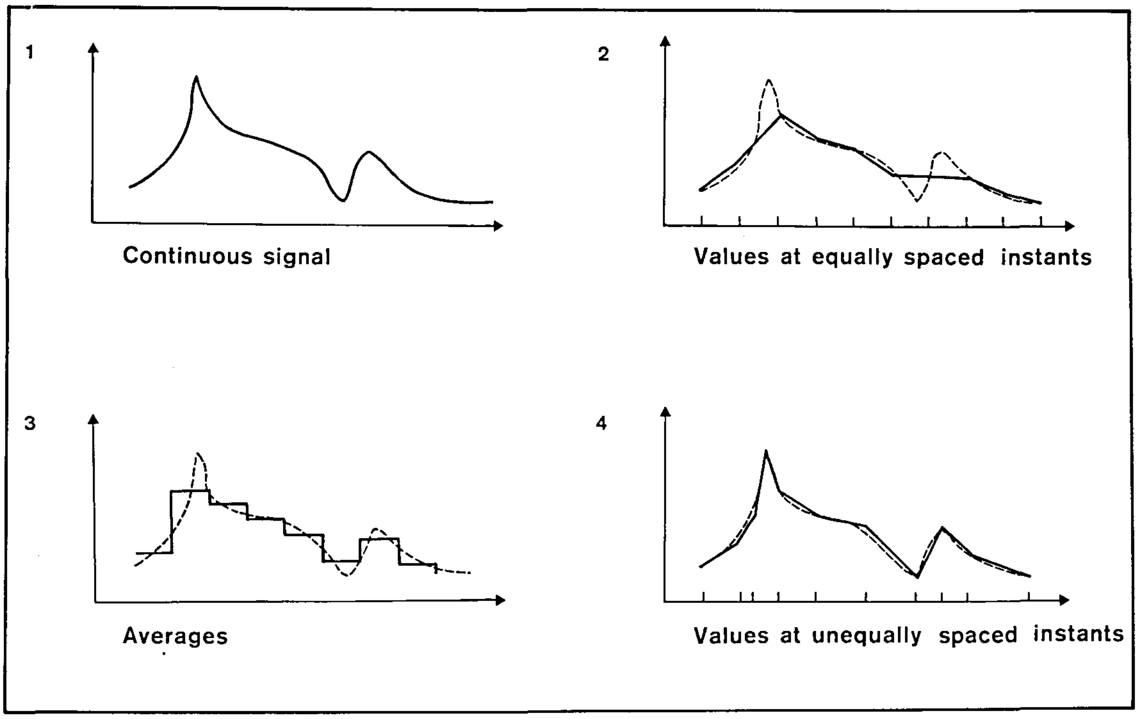

Figure 3:1 Comparison of the data definition retained when storing values at equally spaced instants (2), as average values for intervals of equal duration (3) and values at unequally spaced instants(4).

It is also important that a computerised system for the storage and analysis of hydrological time series data be compatible with the three common modes of hydrological data: instantaneous, incremental and averaged (figure 3:2). Data are instantaneous when the recorded information comprises measurements at discrete points in time. River stage and discharge records usually comprise this data type. These data may be recorded and stored for regularly or irregular spaced time instants depending on the rate of change of the recorded process. Incremental data are the accumulated values of a process over known intervals of time. Precipitation is frequently measured and recorded in this way. Data are averaged when the recorded data comprise average rates for known periods of time. Radiation and temperature data are commonly stored as this data type. Table 3:1 presents a more comprehensive list of data types and the methods used to record them.

A third important characteristic of hydrological data is that the required information may not always be measured directly so that it is necessary to use rating equations to convert a recorded measure into the required information. The most common example of this is the measurement of river stage which is subsequently converted by way of a rating equation to a record of river discharge. However, in many situations the relationship between stage and discharge is not well defined for a period of time after recording has commenced. Rating relationships may also change through time or be found inadequate after a period of data analysis. It is therefore advantageous to have ready access to both the rated and unrated data and for the ratings to be easily altered.

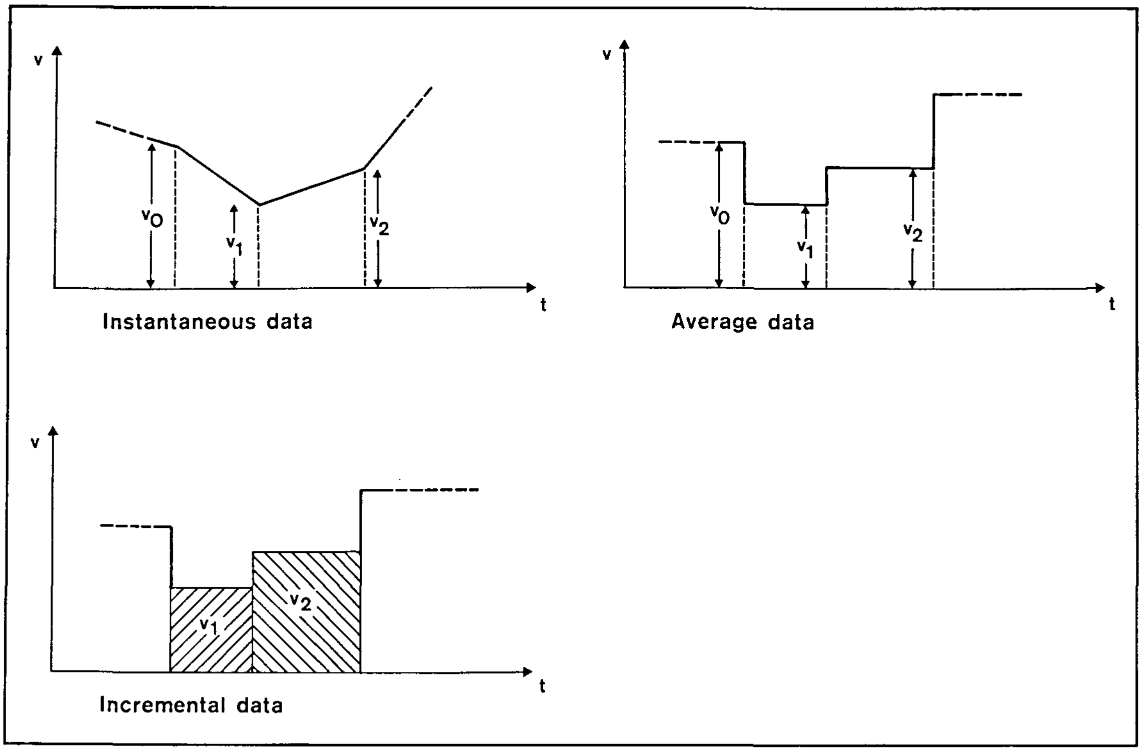

Figure 3:2 Instantaneous, averaged and incremental modes for recording and storing hydrological data.

Table 3:1 Suggested modes of data storage and time resolutions for recording some commonly used hydro-meteorological variables.

Variable	Instantaneous Regular	Instantaneous Non-regular	Incremental	Averaged	Finest Time Resolution (min)
Rainfall			*		5
Water level	*	*			5
Evaporation			*		30
Soil Moisture	*	*		*	30
Solar Radiation				*	30
Temperature				*	30
Humidity				*	30
Wind Speed				*	30
Wind Direction				*	30
Turbidity	*	*		*	5
Elec. Cond.	*	*		*	5

Having recognised the time series characteristics of most hydrological data it was necessary to determine how best to develop a system that provides the researcher with rapid access to computer files of this information. There are two basic filing structures available on most computer systems, sequential access and random access. The major differences between these two file types is that sequential files can only be read sequentially from their first record, whereas individual records within random access files may be directly addressed. Currently, sequential access files are most commonly used. This may be attributed to two factors: that the sequential file structure is the default mode on many computers; and also as the earlier Pascal compiler languages, which were commonly adopted as a computer science teaching language, did not facilitate random access files. Therefore, many computer users have had little experience of this type of file structure and have not fully appreciated the advantages of random access files for storing variable interval time series data. Some computers facilitate the use of indexed sequential files which are more rapidly accessed than sequential files, but nevertheless do not permit individual records to be directly addressed. This type of file structure enables the accessing of data by looking up a file of index keys which are used to identify specific data records. The major disadvantage of this type of file structure is that the storage space required for the key index files can substantially increase the total storage requirements necessary for data storage.

If set up correctly, records within a random access file may be directly accessed which facilitates the rapid searching of data using binary search routines. Conceptually, the researcher may directly address data stored in these files as though they were stored in large arrays. To permit this searching technique, time series data are stored with each record containing a time element, measured as the elapsed time since a base time, and a recorded process measurement. This enables any period of time to be rapidly accessed using a binary rather than a sequential search of the time elements. For example, to locate any specified data point from a file of 10,000 records requires a maximum of thirteen iterations of a simple binary search routine. This file structure also permits the rapid backward sequential reading of a file which is very useful when determining the antecedent conditions for points of time within a time series of hydrological data.

3.3 A RANDOM ACCESS SYSTEM

The above discussion on data storage requirements for hydrological research concluded that data should be stored as variable interval time series data, and that specific elements within a data file should be directly addressable. A data storage and analytical system that satisfies these requirements has been developed at Rhodes University for use on a CDC Cyber 825 mainframe computer. The system, called RHODES, comprises a suite of Fortran V programs which are accessed interactively using a CDC Network Operating System procedure file.

The main objective in developing RHODES was to provide a computer based data storage and analytical system for the rapid retrieval and analysis of hydrological data, with interactive control through user friendly, on-line menus. The philosophy behind this approach is the belief that the researcher should be equipped with a simple, easy to use system for storage, routine analysis and output of data. The system is also designed to output data reformed to meet the specific requirements of more sophisticated analyses such as model development and testing. RHODES is designed to take full advantage of directly addressable random access files. For each data record there are two files; a random access file containing the data and a sequential file on which information relevant to the data file is stored. This permits rapid access of both the stored data and of information describing the data base itself.

For the storage of data when only one parameter is recorded per time element, files of twenty characters per data record are used. This file structure is used for storing data such as rainfall, stream stage and evapotranspiration. It is proposed that files of 120 characters per record be used for storing weather station and water quality data which have more than one parameter per time element. Apart from the difference in the number of characters per record and the additional header information necessary to define the data elements of each record, both of these file structures have the same basic data format. From this point, the discussion will deal specifically with the files of 20 characters per record.

The first record of a data file contains a six character, alpha numeric site designation (figure 3:3). This site designation, preceded by the letter D is used as the name of the data file. The second record stores a value for the number of records in the file and a flag to check for the beginning and end of periods of missing data. The third record stores the area of the catchment and the number of significant digits of the store data. For point source data, such as rainfall, the catchment area is entered as zero. By storing a value for the number of significant digits it is possible to store all data sets, irrespective of the resolution of their process measurement, using the same data format. All data are stored as F10.0, and then on being accessed are multiplied by a significant digits factor to their correct order of magnitude. The data records are stored sequentially beginning at record 100. Each record comprises a time element as the elapsed time since 1850 and the recorded data value using a Fortran data format of I10, F10.0.

RHODES FILE STRUCTURE

TWO FILES FOR EACH DATA RECORD

20 Character/Record Random Access Data File; D - Site No.		80 Character/Record Sequential Access Information File; I - Site No.	
Rec. 1	Site Number	Rec. 1	File Header
Rec. 2	Last Record, Missing Data Flag	Rec. 5	Site Name
		Rec. 7	Site Number
Rec. 3	Catchment Area, Decimal Places	Rec. 9	Catchment Area
		Rec. 11	Data Record Begins
		Rec. 13	Data Record Ends
Rec. 100	Time element, Process Measurement	Rec. 15	Data Missing from
		Rec. 16	Data Missing to
Rec. 101	Time element, Process Measurement	Rec. 18	Data Missing from
		Rec. 19	Data Missing to
Rec. 102	Time element, Process Measurement	"	"
		"	"
"	"	"	"
"	"	"	"

Figure 3:3 Formats of the random access data files and the sequential access information files adopted for RHODES.

Streamflow data is stored as stage values in millimetres. The software used for accessing these data includes an option to convert stage values to discharge values using a cubic spline routine. For this purpose record numbers 9 to 99 are reserved for the storing information that defines the stage/discharge relationship for the stored stage record. Record 9 stores values for the number of evenly spaced stage intervals, starting from zero, used to define the stage discharge rating curve, and their interval in millimetres. Discharge values for the stage points defined in record 9 are listed from record 10 to 99. By storing the actual stage discharge relationship on the data file an alteration to the stage/discharge rating is simply done by editing this list of discharge values. Parameters for the cubic spline used to convert stage to discharge are determined at the time of data retrieval. By adopting this approach to storing rating data, the method of converting river stage to discharge is standardised for easier programming with no loss of data resolution.

For each random access data file, an 80 character per record sequentially accessed file is also created to store descriptive site information and to record periods of missing data. The main purpose of these files is to store and provide interactive access to information on both the quality of the data record and its collection site. The first ten records of these files contain information on the site number; a site descriptive title and catchment area (figure 3:2). Records eleven and thirteen specify the time and date for the beginning and end of the data file. From record fifteen information on the quality of the data record is listed with periods of missing data being automatically documented as new data is appended to the actual data files. The sequential type file structure was adopted for these information files as they are generally small, for which this file type is more efficient in terms of storage on the Cyber computer; and also to enable them to be more readily edited for the insertion of additional notes relevant to the respective data recording site.

The three file types (single parameter, multiple parameter and information files) are all named according to their relevant site number preceded by a character designating their file type. To access a data file the user is simply prompted by an interactive system procedure for the appropriate site number and file type code. All files are stored permanently on magnetic tape from which the data are loaded for analysis into a disk storage area called GGPOOL. To access or analyse a specific period of data, the user is requested to enter the relevant date and time using the correct year, month, day, hour and minute format (e.g. 19870904,2030). This time instant is then converted to the elapsed time in minutes since 1850 and used in a binary search of the data's time elements to locate the required data record. To carry out a binary search one initially divides a data set into two and then checks whether the required value is in the upper of lower half of the data set. The half of the data set that contains the required data value is again divided into two. This process is repeated until the required data point is located. Fifteen iterations of this type of search routine will locate an element from within a data file of 33 000 data records. The larger the file the more efficient this type of search procedure becomes. This method is sufficiently quick to enable individual data records from large files to be instantly accessed.

RHODES is designed to carry out a number of commonly used hydrological analyses and to create data files that are formatted correctly for less frequent analyses and modelling exercises. This is reflected by the basic menu which offers the following options:

1/ Exit from RHODES.
2/ Manipulate RHODES data files.
3/ Manipulate RHODES data.
4/ Output RHODES information and data files.
5/ Precipitation data analyses.
6/ Streamflow data analyses.
7/ Water quality data analyses.

Each of these options leads to a secondary menu which provides access to either specific analyses or to a third level menu. For example, by selecting the second option of the main menu the user is presented with options for the creation, manipulation and storage of RHODES data files.

1/ Return to RHODES main menu.
2/ Catalog of RHODES files on GGPOOL.
3/ Create new RHODES files on GGPOOL.
4/ Append new data to a RHODES file.
5/ Purge RHODES files from GGPOOL.
6/ Catalog of RHODES files on magnetic tape.
7/ Load RHODES file onto magnetic tape.
8/ Retrieve RHODES files from magnetic tape.
9/ Delete RHODES files from magnetic tape.

GGPOOL is the name of the disk space used for the temporary storage of files that are currently being analysed or are in common use. The second option of this menu provides a catalog of the files currently stored in this directly addressable disk space. The third option is used for the creation of new RHODES data and information files. This includes writing the correct header information to the created file depending on its file type. Option four enables newly captured data to be read and appended onto an existing or newly created data file. During this process the data record is scanned for periods of missing data which are flagged on the data file and also recorded on the respective RHODES information file. The fifth option enables files to be purged from GGPOOL. Option 6, 7, 8 and 9 provide for the storage and retrieval of RHODES files on magnetic tape. To carry out any one of these options the user is simply asked to enter the site number, a six character string, and the file type specifier RSDATA or WQDATA which distinguish data files of 20 and 120 characters per record respectively. The selected application is then carried out with manipulation of both the data and information files for the nominated site.

The selection of some second level options provides the user with a third level menu. For example, the selection of option five from the main menu presents the user with a selection of rainfall analyses. On selecting one of these second level options called 'Catchment rainfall analyses' the user is presented with a selection of analyses for the creation and manipulation of coincidental rainfall records at any fixed time interval for prescribed periods of any selected record. The creation of this file type is intended specifically as an intermediate step for the construction of mean catchment rainfall records and for the analysis of periods of missing data for complete raingauge networks. A short description of two of these precipitation analyses clearly displays the advantages of using an analytical system based on random access files. The construction of a mean catchment rainfall record is carried out in two steps. Firstly, raingauge data are merged to form a file of coincidental values of rainfall interpolated for a prescribed fixed time interval over the required duration of the catchment's precipitation record. Missing data information is also transferred to this file. The second phase involves the weighting and summation of individual gauge records to produce a file of mean catchment rainfall. As this approach essentially comprises reading from, and writing to, directly addressable data files, an extensive rainfall record may be processed with only minimal central memory requirements. Another of these rainfall analyses extracts and characterises rainfall events from a continuous data file. This analysis permits the user to specify the rainfall events to be analysed according to total catch and the duration between successive rainfall events. The program processes a data file sequentially for the specified period of analysis, locating and outputting information on the total catch, duration, maximum and mean intensities for the prescribed intervals, an intensity profile and values for a user specified antecedent precipitation index. The major advantages of using a random access system for these types of analyses are as follows: the data file is read directly, therefore saving on central memory requirements; the required periods of analysis are accessed rapidly, and having located a rainfall event that satisfies the user's requirements, an antecedent rainfall index may be determined by simply reading the data file backwards from the point of initial rainfall measurement for that event. When compared to using either sequential file structures and or systems which rely on large array storage, the approach described above offers both greater flexibility and more rapid data retrieval. Also it does not require the considerable storage overheads necessary to operate a system of indexed sequential files.

3.4 CONCLUDING REMARKS ON PROCESSING HYDROLOGICAL DATA

Hydrological data generally comprise a series of measurements recorded over a period of time, and take the form of time series data. Examination of these data shows that a data storage system should be able to accommodate data that have been recorded as regular and non-regular discrete, incremental or averaged values. This allows for the efficient storage of data with no loss of resolution. An examination of the analyses commonly used in hydrological research suggests that there are advantages if individual data instants are directly addressable. Bearing in mind the advantages of being able to address individual data elements, a data storage and analysis system has been developed at the Hydrological Research Unit at Rhodes University. This system, which is based on the use of random access files, permits a data element to be addressed directly through a binary search of the data's time elements. This permits the rapid access of data stored in a non-interpretive format that has many advantages, especially for the analysis of time series data.

Chapter 4

MULTIPLE REGRESSION MODELLING OF STORMFLOW CHARACTERISTICS WITHIN SEMI-ARID CATCHMENTS

4.1 INTRODUCTION

The main objective of the current section of this study is to assess the application of multiple regression models for predicting the characteristics of stormflow hydrographs within semi-arid catchments. In particular, the study sets out to develop multiple regression models for predicting stormflow volumes, stormflow durations and stormflow peaks using rainfall derived independent variables. Although a great deal of attention has been focussed on the use of multiple regression techniques for predicting stormflow volumes and peak discharges from forested catchments (Hewlett and Hibbert, 1967; Taylor and Pearce, 1980; Hewlett and Fortson, 1984) few studies have examined this modelling technique for use in semi-arid environments. In 1981, Murray and Görgens reported on the development of multiple linear regression models for estimating the characteristics of storm discharges from the semi-arid Ecca catchments. With the addition of a further seven years of data, the current study re-examines the application of this modelling technique. The temporal resolution of the data used in this study has been increased from hourly, as used by Murray and Görgens to digitized breakpoint data for streamflow and to ten minute intervals of mean catchment rainfalls. This study also puts greater emphasis on determining the duration preceding runoff events for which antecedent precipitation indices are most highly correlated to the stormflow characteristics. This is important, as the prevailing moisture status of a catchment is an important factor in determining runoff generation (Bernier, 1985) and therefore should be represented correctly by an independent variable.

4.2 DATA EXTRACTION

Initially all stormflow events discharged from Ecca catchments A, B and E (figure 2:1) were identified using an adaptation of the criteria and stormflow separation technique proposed by Hewlett and Hibbert (1967). This methodology was selected due to its common usage and its suitability for digital processing. The method separates rapid stormflow, termed quickflow, from that termed delayed flow by means of a straight line that rises at a gradient of 0,551 $l.s^{-1}.km^{-2}.h^{-1}$ from the initial point of rise on the hydrograph until it intersects with the hydrograph's falling limb (figure 4:1). Hewlett and Hibbert do not attach any particular significance to this separation line other than an apparent relationship between quickflow and rapid storm runoff from the small forested catchments for which the technique was initially developed. Although the slope proposed by Hewlett and Hibbert is most commonly adopted, some researches have used different slopes when applying this technique. The slope originally proposed by the proponents of this method is adopted for this study. Hewlett and Hibbert defined a stormflow event as running from the initial rise of a storm hydrograph to the point of initial rise of the following storm event (figure 4:1). They also suggested that events may include both single-peaked and multiple-peaked storms. For this study the definition of an event has been modified to meet the particular requirements of this study and especially the characteristics of ephemeral streams in the semi-arid Ecca catchments. Storm events are separated into quickflow and delayed flow as originally defined, except that the events are terminated at the intersection point of the separation line and the storm hydrograph and not at the beginning of the next event. This is considered particularly important as the study focuses on the stormflow characteristics of ephemeral streams, which in the case of the Ecca catchments may be separated by relatively long periods without flow. The application of this technique resulted in the identification of 40, 67 and 24 runoff events for Ecca catchments A, B and E respectively.

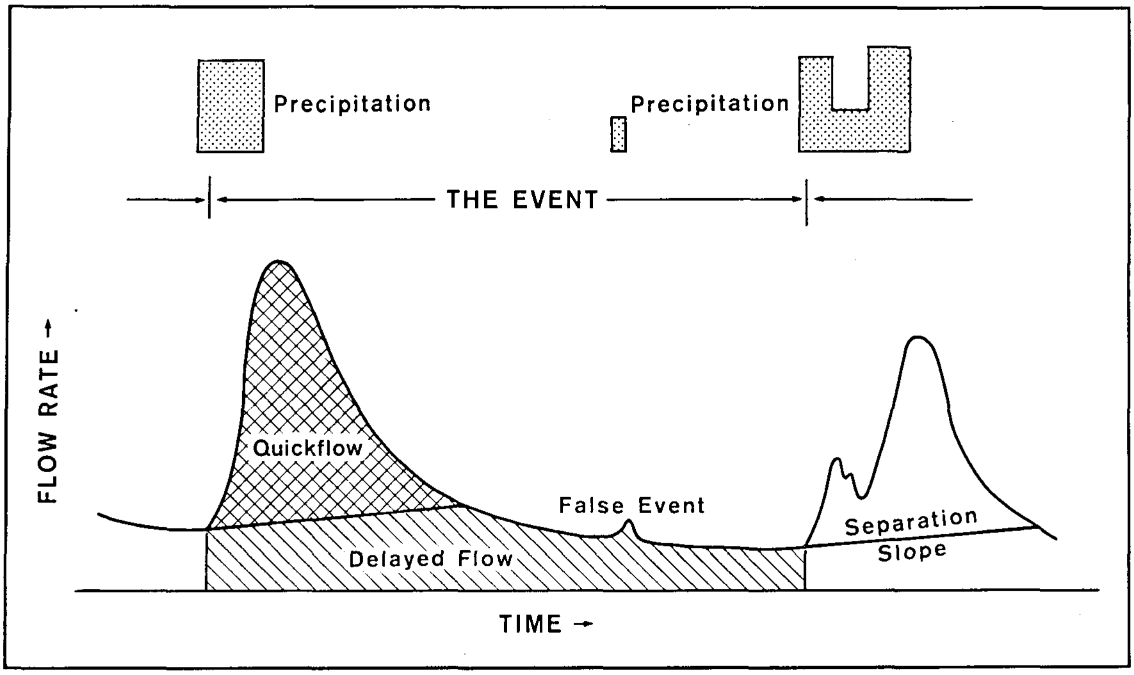

Figure 4:1 Definition of flow separation technique as proposed by Hewlett and Hibbert (1967).

Using the Thiessen polygon method, ten minute, mean catchment rainfall records were constructed for each of the Ecca catchments used for this study. For each of these precipitation records, all rainfall events separated by a minimum of 240 minutes and with a total rainfall catch of more than two millimetres were identified. The rainstorm parameters of total rainfall, rainfall duration, mean and maximum ten minute rainfall intensities and values for an antecedent precipitation index (API) were calculated for each identified event. The runoff response of a catchment depends on a number of factors including the status of its soil moisture. This is often indexed using a antecedent precipitation index (Linely *et al.*, 1975). One of the more commonly used of these indices takes the form:

$$API = K^1P_1 + K^2P_2 + \ldots + K^nP_n$$

where API is the antecedent precipitation index for day zero,

K is the decay constant which is usually less than unity,

P_1 is the precipitation on the day before day zero,

P_n is the precipitation on the n^{th} day before day zero.

Values of K are usually assumed to be in the range of 0,80 to 0,98. (Gray, 1975). For the current study, which seeks to determine the appropriate API for predicting the characteristics of storm hydrographs of the study catchments, index values for periods of 5; 10; 15; 20; 25; 30 and 35 days are calculated using K values of 0,800; 0,900; 0,925; 0,950; 0,975 and 1,00. Some researchers (Crozier, 1981) have attempted to adopt the same decay constant as that of the master recession curve for the study catchment. However, as this study focusses on investigating the use of regression equations comprising independent variables derived solely from rainfall data this approach was not adopted.

Although pan evaporation data has been collected within the Ecca research catchment, the value of these data to provide an index of catchment moisture status is questionable. For this reason, and also due to the general scarcity of pan evaporation data, other than within catchments established for research purposes, it was decided not to include an evaporative component in this assessment of a modelling technique that may be applied broader geographic context. Although Murray and Görgens initially considered pan evaporation for the development of their regression models, they also turned to the use of indices of antecedent precipitation to provide a measure of prevailing catchment moisture status.

For each period of rainfall associated with an identified stormflow event, data sets comprising the determined stormflow and rainfall parameters, including the API values calculated using the six different exponential decay constants were compiled for each of the three study catchments (Appendix D). Owing to an error in the discharge rating equation used in earlier studies of Ecca research catchments, the discharge values used in this study are approximately 10 percent less than those reported by Murray and Görgens (1981). A statistical summary of the discharge and rainfall data used in this study, excluding those for the indices for antecedent precipitation are presented in tables 4:1, 4:2 and 4:3.

Table 4:1 Statistical summary of rainfall and streamflow for the stormflow events selected for Ecca A.

Variable Name	Mean	Standard Deviation	Smallest Value	Largest Value	Skewness Coef.
Total Flow (mm)	3,1438	7,6451	0,0046	39,2482	3,2381
Quickflow (mm)	2,3422	6,3381	0,0015	32,553	3,4446
Peakflow ($m^3.S^{-1}$)	3,4102	7,1450	0,0720	32,482	2,8693
Flow Duration (mins)	911,0	1103,0	107,0	4934,0	1,952
Total Rainfall)	30,84	30,33	3,77	167,00	2,652
Rain Duration (mins)	1182,0	883,0	110,0	3690,0	0,8178
Mean Intensity* ($mm.h^{-1}$)	2,231	2,674	0,160	15,69	3,633
Max Intensity* ($mm.h^{-1}$)	18,139	16,331	1,32	75,06	1,6821

* Intensities determined for 10 minute rainfall record.

Table 4:2 Statistical summary of rainfall and streamflow for the stormflow events selected for Ecca B.

Variable Name	Mean	Standard Deviation	Smallest Value	Largest Value	Skewness Coef.
Total Flow (mm)	1,885	5,813	0,005	33,389	3,884
Quickflow (mm)	1,476	4,679	0,0002	26,033	3,935
Peakflow ($m^3.s^{-1}$)	0,344	0,611	0,0030	3,6520	3,0796
Flow Duration (mins)	654,0	1043,0	33,00	5172,0	2,4861
Total Rain (mm)	25,136	22,943	2,260	130,89	2,1493
Rain Duration (mins)	985,0	747,0	100,00	3700,0	1,1735
Mean Intensity* ($mm.h^{-1}$)	2,1951	2,953	0,25	20,35	4,4263
Max Intensity* ($mm.h^{-1}$)	16,9030	15,61	1,86	71,94	1,7648

* Intensities determined for 10 minute rainfall record.

Table 4:3 Statistical summary of rainfall and streamflow for the stormflow events selected for Ecca E.

Variable Name	Mean	Standard Deviation	Smallest Value	Largest Value	Skewness Coef.
Total Flow (mm)	2,5181	5,400	0,0017	21,6632	2,3469
Quickflow (mm)	1,856	4,0156	0,0004	14,6944	2,1722
Peakflow ($m^3.s^{-1}$)	0,975	1,8049	0,0150	7,6820	2,4987
Flow Duration (mins)	999,0	1212,0	57,00	5034,0	1,709
Total Rain (mm)	34,2	38,59	3,9900	174,500	2,4482
Rain Duration (mins)	1402,0	945,0	150,00	3535,0	0,6403
Mean Intensity* ($mm.h^{-1}$)	1,767	1,4784	0,2500	6,5700	1,7069
Max Intensity* ($mm.h^{1-1}$)	13,047	8,4795	1,560	29,40	0,6349

* Intensities determined for 10 minute rainfall record.

4.3 MODEL DEVELOPMENT

To assess the performance of the multiple regression models for modelling stormflow characteristics, models are developed for predicting total stormflows, quickflows, peakflows and stormflow durations. The independent variables for these models are selected from measures of total rainfall catch, rainfall duration, the maximum and minimum ten minute rainfall intensity and indices of antecedent precipitation. The values of API were determined for 5, 10, 15, 20, 25, 30 and 35 twenty-four hour periods preceding each period of rainfall associated with the identified stormflow events. Separate regression equations were developed for each of the above listed storm hydrograph parameters using data sets comprising API values calculated with exponential decay functions of 0,800; 0,900; 0,925; 0,975 and 1,000 respectively. This permitted the identification of the most appropriate period of rainfall accumulation and decay constant for determining index values of antecedent precipitation. In their examination of rainfall runoff relationships for the Ecca catchments, Murray and Görgens (1981) found no advantage in using either a log or cubic transformation of the data. Therefore, it was decided not to transform the data as proposed in some similar studies (e.g. Bren, Farrell and Leitch, 1978). This decision was subsequently ratified by an examination of the residuals for the modelled stormflow parameters. To develop these models a stepwise multiple regression routine, from the Bio-Medical Data Processing package, available on the Cyber 825 mainframe computer at Rhodes University, was used. To initially develop these models, the level of tolerance and the value of the F statistic criteria, used for determining the addition or removal of each independent variable, were set at the relatively low values of 0,01; 0,20 and 0,19 respectively. This set of variable selection criteria permitted the initial inclusion of independent variables that were later discarded from the final model. By initially including these variables in the models their relative contributions could be determined by comparing the values of their respective sequential F statistics. This provides an insight into the factors controlling runoff generation within the Ecca research catchments. Subsequent to an examination of the sequential F values, the improved coefficients of determination and standard errors of estimation for each step of model development, and of the correlation structure between the independent variables, the composition of the final models were decided. The selected "best" independent variables were then used to develop multiple linear regression models for total stormflows, quickflows, stormflow durations and peakflows for each of the three Ecca research catchments.

An examination of the correlation matrices for the six data sets compiled for each of the three study catchments showed that both rainfall catch and rainfall duration are the independent variables most highly correlated with the selected stormflow parameters (tables 4:4, 4:5 and 4:6). Measures of rainfall intensity were found not to be strongly correlated to the stormflow characteristics. The step by step inclusion and removal of independent variables during the development of the initial models and the associated changes to the coefficient of determination are presented in Appendix E. As could be expected, the variable that contributed most to these models and therefore was usually the first to be selected was that of total storm rainfall. Owing to the high correlation between rainfall total and rainstorm duration the second variable selected for all but that for predicting peakflows from catchment B was an index value for antecedent precipitation and not rainfall duration which was a also highly correlated to the modelled stormflow parameters. The coefficients of determination and independent variables of the model selected as the "best" predictor of the modelled stormflow parameters for each catchment are highlighted on tables 1 to 12 of Appendix E.

Table 4:4 Correlation matrix of rainfall and stormflow parameters of Ecca catchment A.

	PEAK	TFLOW	QFLOW	FDURAT	RDURAT	TRAIN	MNINT	MXINT	API05	API10	API15	API20	API25	API30	API35
PEAK	1,000														
TFLOW	0,977	1,000													
QFLOW	0,977	0,991	1,000												
FDURAT	0,906	0,920	0,894	1,000											
RDURAT	0,611	0,638	0,625	0,583	1,000										
TRAIN	0,791	0,737	0,782	0,630	0,671	1,000									
MNINT	-0,075	-0,090	-0,062	-0,128	-0,379	0,056	1,000								
MXINT	-0,087	-0,114	-0,076	-0,143	-0,277	0,174	0,427	1,000							
API05	0,033	0,008	-0,062	0,092	-0,010	-0,251	-0,246	-0,359	1,000						
API10	-0,046	-0,053	-0,129	0,060	-0,187	-0,423	-0,171	-0,402	0,825	1,000					
API15	-0,156	-0,163	-0,231	-0,034	-0,221	-0,488	-0,160	-0,417	0,675	0,847	1,000				
API20	-0,093	-0,106	-0,186	0,047	-0,218	-0,455	-0,119	-0,427	0,664	0,804	0,920	1,000			
API25	-0,099	-0,129	-0,208	0,051	-0,267	-0,514	-0,138	-0,475	0,632	0,769	0,844	0,939	1,000		
API30	0,015	0,161	-0,090	0,293	-0,122	-0,374	-0,158	-0,497	0,517	0,657	0,639	0,786	0,888	1,000	
API35	0,303	0,369	0,290	0,478	0,081	-0,258	-0,217	-0,495	0,376	0,593	0,579	0,632	0,695	0,896	1,000

Table 4:5 Correlation matrix for rainfall and stormflow parameters of Ecca catchment B.

	TFLOW	PEAK	QFLOW	FDURAT	RDURAT	TRAIN	MNINT	MXINT	API05	API10	API15	API20	API25	API30	API35
TFLOW	1,000														
PEAK	0,842	1,000													
QFLOW	0,856	0,997	1,000												
FDURAT	0,784	0,907	0,885	1,000											
RDURAT	0,292	0,403	0,402	0,365	1,000										
TRAIN	0,652	0,629	0,651	0,498	0,666	1,000									
MNINT	0,186	0,000	0,011	-0,037	-0,302	0,163	1,000								
MXINT	0,151	-0,067	-0,055	-0,097	-0,284	0,188	0,671	1,000							
API05	0,137	0,143	0,146	0,215	0,029	-0,138	-0,166	-0,277	1,000						
API10	-0,055	-0,036	-0,035	-0,061	-0,098	-0,071	-0,013	-0,038	-0,033	1,000					
API15	0,153	0,061	0,049	0,243	-0,180	-0,283	-0,046	-0,169	0,623	-0,067	1,000				
API20	0,183	0,076	0,069	0,253	-0,218	-0,277	-0,013	-0,161	0,594	-0,062	0,915	1,000			
API25	0,149	0,028	0,021	0,195	-0,242	-0,317	-0,035	-0,176	0,485	-0,077	0,754	0,886	1,000		
API30	0,271	0,301	0,283	0,418	-0,107	-0,146	-0,035	-0,153	0,402	-0,085	0,650	0,769	0,875	1,000	
API35	0,303	0,378	0,344	0,546	-0,067	-0,148	-0,063	-0,167	0,316	-0,002	0,595	0,690	0,781	0,941	1,000

Note the following annotation for tables 4:4 to 4:6.

PEAK Peak stormflow ($m^3.s^{-1}$)
TFLOW Total stormflow (mm)
QFLOW Total quickflow (mm)
FDURAT Duration of stormflow (mins)
RDURAT Duration of rainfall (mins)
TRAIN Storm rainfall (mm)
MNINT Mean 10 minute rainfall intensity ($mm.h^{-1}$)
MAXINT Maximum 10 minute rainfall intensity ($mm.h^{-1}$)
API05 API indices for 5 twenty four hour periods preceeding rainfall events.
"
......
API35 API indices for 35 twenty four hour periods preceeding rainfall events.

Table 4:6 Correlation Matrix for rainfall and stormflow parameters of Ecca catchment E.

	PEAK	TFLOW	QFLOW	FDURAT	RDURAT	TRAIN	MNINT	MXINT	API05	API10	API15	API20	API25	API30	API35
PEAK	1,000														
TFLOW	0,896	1,000													
QFLOW	0,939	0,993	1,000												
FDURAT	0,793	0,937	0,915	1,000											
RDURAT	0,567	0,589	0,595	0,466	1,000										
TRAIN	0,902	0,814	0,851	0,637	0,654	1,000									
MNINT	0,141	0,068	0,089	-0,050	-0,384	0,203	1,000								
MXINT	0,173	0,029	0,067	-0,180	-0,151	0,360	0,788	1,000							
API05	0,094	0,119	0,125	0,232	-0,175	-0,203	-0,077	-0,256	1,000						
API10	-0,016	0,012	0,010	0,139	-0,166	-0,352	-0,104	-0,371	0,823	1,000					
API15	-0,100	-0,079	-0,085	0,110	-0,179	-0,435	-0,221	-0,473	0,729	0,883	1,000				
API20	-0,006	-0,087	-0,092	0,133	-0,202	-0,453	-0,291	-0,553	0,759	0,861	0,948	1,000			
API25	-0,190	-0,171	-0,175	0,032	-0,172	-0,507	-0,347	-0,583	0,710	0,845	0,919	0,969	1,000		
API30	-0,100	0,064	0,026	0,260	-0,041	-0,397	-0,416	-0,655	0,643	0,774	0,804	0,843	0,883	1,000	
API35	-0,130	0,061	0,017	0,236	-0,031	-0,424	-0,412	-0,676	0,573	0,764	0,775	0,791	0,824	0,964	1,000

The regression models developed for predicting total stormflows comprise the variables of total storm rainfall and values of an API determined for a period of 35 twenty-four hour periods preceding each storm event. The exponential decay constant used for determining the indices of antecedent precipitation for both catchment A and B is 1,00; or no decay, while that for catchment E was 0,975. The coefficient of determination for each of the three models can be marginally increased by including a second measure for antecedent precipitation, calculated for a different durations preceding each storm event. However, this was not done due to the strong relationship between the different indices of antecedent precipitation. The regression coefficients, coefficients of determination and standard errors of the equations developed for predicting total stormflows are presented on table 4:7. It will be noted that the smallest coefficient of determination (0,5857) is for catchment B. All three models are statistically significant at the 95 percent confidence level. An examination of the residuals between the observed stormflow totals and those predicted (figures 4:2) also highlights the less successful modelling of catchment B. For both catchment A and E the residuals are found to be normally distributed with no trends to suggest that a data transformation will improve the fit of these models. That for catchment B shows that the two largest residuals are markedly greater than expected. An examination of the residual plots for these models shows a relatively large scatter with negative discharges being predicted for many small events. The largest residual is associated with an event of long duration beginning on August 20, 1979 which is underestimated by approximately 20 percent for catchments A and E and nearly 40 percent for catchment B. This event, the largest recorded during the study period, was approximately 50 percent greater than the second largest event. This lack of fit for an extreme event highlights the danger of using regression type models to predict stormflow characteristics for events that are poorly represented in the data used for model development.

Table 4:7 Regression coefficients for models of total stormflows from the Ecca research catchments A, B and E.

$$Y_1 = a_1 + b_1 X_1 + b_2 X_2 + b_3 X_3 \pm \text{Error}$$

where Y_1 = Total stormflow (mm)

X_1 = Total Rainfall Catch (mm)

X_2 = API for preceding 35 twenty four hour periods with decay constant K = 0,975

X_3 = API for preceding 35 twenty four hour periods with decay constant K = 1,000

Ecca Catchments	Coefficients a_1	b_1	b_2	b_3	r^2	Stand Error	F Ratio	F Stats.
A	-10,5829	0,2194	0,0750		0,9008	2,3101	134,42	4,08
B	- 0,5339	0,1899	0,0052		0,5887	0,3981	45,80	4,00
E	- 8,4582	0,1482		0,0711	0,8631	2,0908	66,21	4,35

F statistics at 95% confidence level.

As expected the models developed for predicting the quickflow generated from these catchments are very similar to those for predicting the total stormflow, with each model comprising independent variables of total storm rainfall and index values for antecedent precipitation determined for 35, twenty-four hour periods preceding each event. The optimum exponential decay constant found for determining API values for catchments A and B was 1,00 (i.e. no decay) while that for catchment E was 0,975. All three models are statistically significant at the 95 percent confidence level. The coefficients of determination for each of the three models can be improved with the addition of further measures of antecedent precipitation and rainfall duration. However, this was not done owing to their high correlation with the variables already included in these models (table 4:4 to 4:6) and also due to their relatively small contributions to the explanation of each model. The coefficients of determination and the standard errors of the equations developed for predicting quickflow totals are presented in table 4:8. It will be noted that the smallest coefficient of determination is again for catchment B (0,623). An examination of the residuals shows that they are normally distributed and do not display any obvious correlation with the magnitude of quickflow. However, the residual plots do suggest that these models are better predictors than those for total stormflow (figure 4.3). This may be expected as quickflows are more highly correlated to the rainfall parameters than total storm discharge which includes the delayed flow component. As with the models for total stormflow the largest residual is that for the event generated on August 20, 1979. Another similarity is that many of the smaller events are under estimated with negative discharges being predicted.

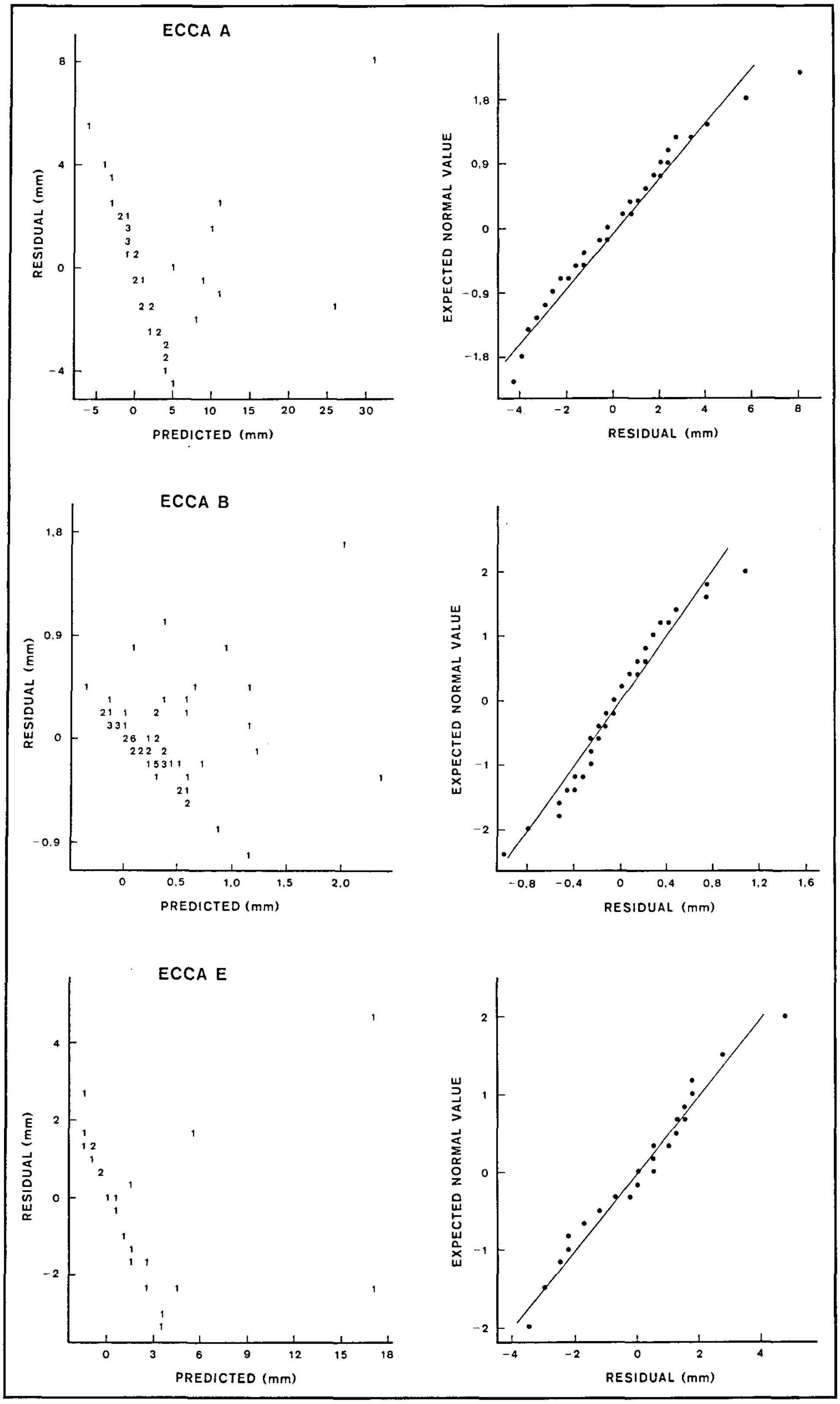

Figure 4:2 Residuals and expected residual values of regression models for total stormflow.

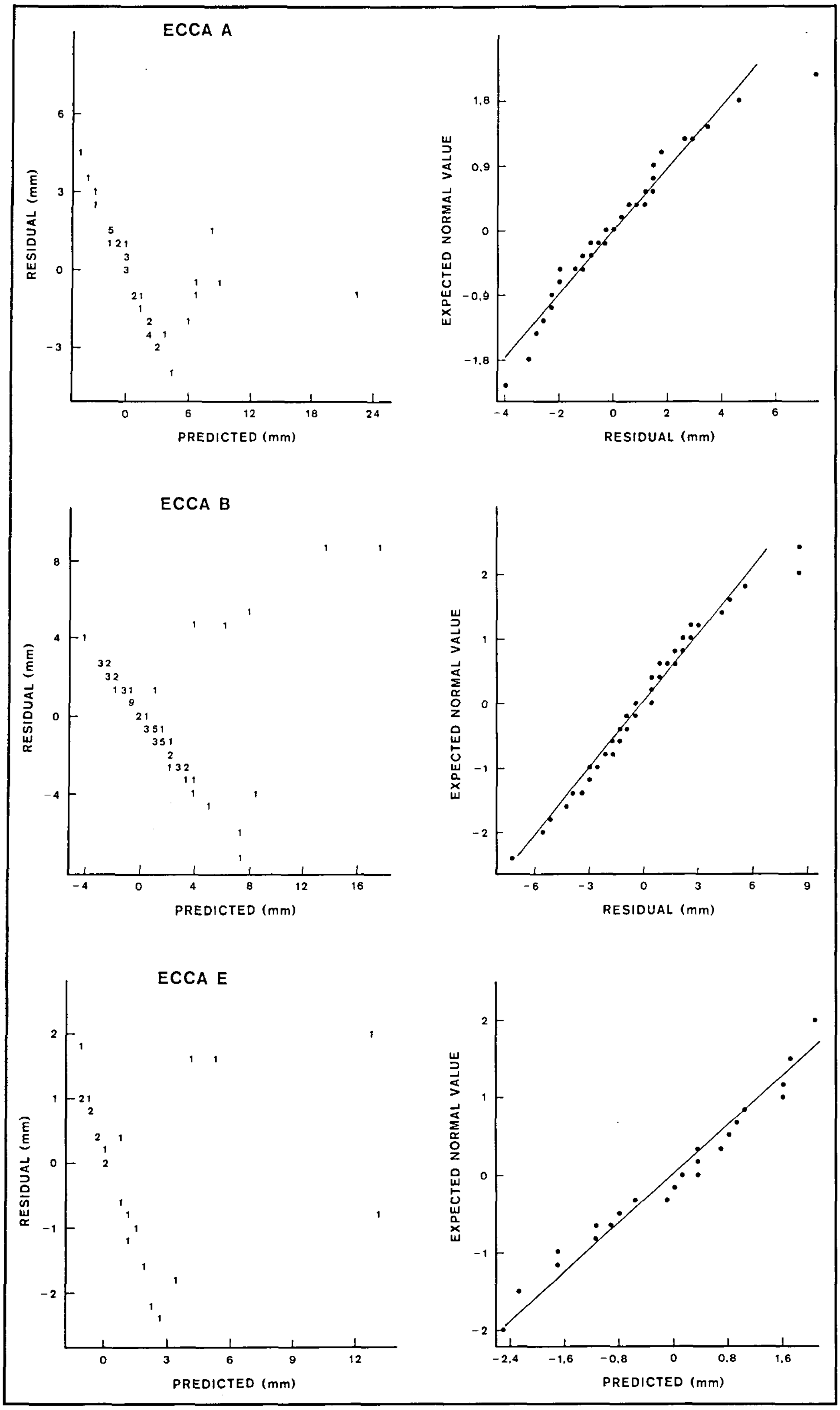

Figure 4:3 Residuals and expected residual values of regression models for total quickflow.

Table 4:8 Regression coefficients for models of quickflows from the Ecca research catchments A, B and E.

$$Y_1 = a_1 + b_1 X_1 + b_2 X_2 + b_3 X_3 \pm \text{Error}$$

where Y_1 = Quickflow (mm)

X_1 = Total Rainfall Catch (mm)

X_2 = API for preceding 35 twenty four hour periods with decay constant K = 0,975

X_3 = API for preceding 35 twenty four hour periods with decay constant K = 1,000

Ecca	Coefficients					Stand	F	F
Catchments	a_1	b_1	b_2	b_3	r^2	Error	Ratio	Stats.
A	- 9,7987	0,19195		0,06459	0,8715	2,3329	125,44	4,08
B	- 5,5876	0,14645		0,04422	0,6229	2,9183	52,86	4,00
E	- 6,0385	0,10882	0,04912		0,8975	1,3457	91,90	4,32

F statistics at 95% confidence level

The regression models developed for modelling peak discharges are also very similar to those developed to model quickflows and total stormflows. The first variable selected for these models was again the total storm rainfall followed by an index value for antecedent precipitation. For catchment B, a third variable, rainfall duration was also included as it makes a considerable contribution to that model's coefficient of determination. For both Ecca A and B the selected index values of antecedent precipitation were determined for 35 periods of twenty-four hours, using decay constants of 1,00 and 0,975 respectively. For catchment E the second variable selected was an index for antecedent precipitation determined for a duration of 20 twenty-four hour periods and a decay constant of 0,925. Although previously reported (Hewlett and Fortson, 1984), it is surprising how little the variables of mean and maximum ten minute rainfall intensity contribute to an explanation of peakflows (tables 4:4, 4:5 and 4:6). The regression coefficients, coefficients of determination and standard errors of the equations developed for predicting peakflows are presented in table 4:9. These tables also show that the three developed models are statistically significant at the 95 percent significance level. The regression coefficient for rainfall duration is negative, suggesting that mean rainfall intensity does play a part in determining peakflows. However, the relatively small contribution to model explanation by this variable compared to that by the variables of rainfall catch and the indices of antecedent precipitation suggest that peakflows are generated more by the spatial convergence of flow, rather than by the temporal convenience of rainfall through increased intensity. Again the smallest coefficient of determination is for catchment B. Examination of the residuals for these models again shows them to be normally distributed, with the exception of catchment B for which largest residuals are greater than expected (figure 4.4). As with the models for total stormflow and quickflow, negative peakflows have been predicted for many of the smaller storm events.

Table 4:9 Regression coefficients for models of peak discharges from the Ecca research catchments A , B and E.

$$Y_1 = a_1 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 \pm \text{Error}$$

where Y_1 = Peak Discharge ($m^3.s^{-1}$)
X_1 = Total Rainfall Catch (mm)
X_2 = Duration of rainfall (mm)
X_3 = API for preceding 20 twenty-four hour periods with decay constant K = 1,925
X_4 = API for preceding 35 twenty-four hour periods with a decay constant K = 0,975
X_5 = API for preceding 35 twenty-four hour periods with a decay constant K = 1,00

Ecca Catchments	Coefficients a_1	b_1	b_2	b_3	b_4	b_5	r^2	Stand Error	F Ratio	F Stats.
A	-12,33	0,22				0,09	0,88	2,73	168,04	4,08
B	- 0,50	0,02	-0,23E-3		0,01		0,65	0,36	39,27	4,00
E	- 1,54	0,05		0.02		0,02	0,93	0,51	63,58	4,32

F statistics at 95% confidence level

The regression models developed for modelling the duration of stormflow events discharged from catchments A and B comprise independent variables of total rainfall catch and an API determined for 35, twenty four hour periods using an exponential decay constant of 1,00 (ie no decay). For catchment E the selected model comprises three independent variables: total rainfall catch, an index for antecedent precipitation, calculated for 35, twenty four hour periods using a decay constant of 0,975 and the duration of the associated period of rainfall (table 4:10). The selection of an API value before the selection of either rainfall duration of rainfall total in the development of this model for catchment B was unexpected. As with the models for the other stormflow characteristics, the highest coefficient of determination was for catchment A (0,84), followed by that for catchment E (0,74) and catchment B (0,64). The three selected models are also shown to be significant at the 95 percent confidence level. As with the other models their residuals are shown to be normally distributed with no trends to suggest that a data transformation would improve their predictive performance (figure 4:5). Given that one can distinguish between two major types of rainfall that produce runoff within the Ecca catchments (convective and advection associated with large frontal systems), which have different temporal characteristics, that the variable of rainfall duration does not provide more explanation to these models of stormflow duration.

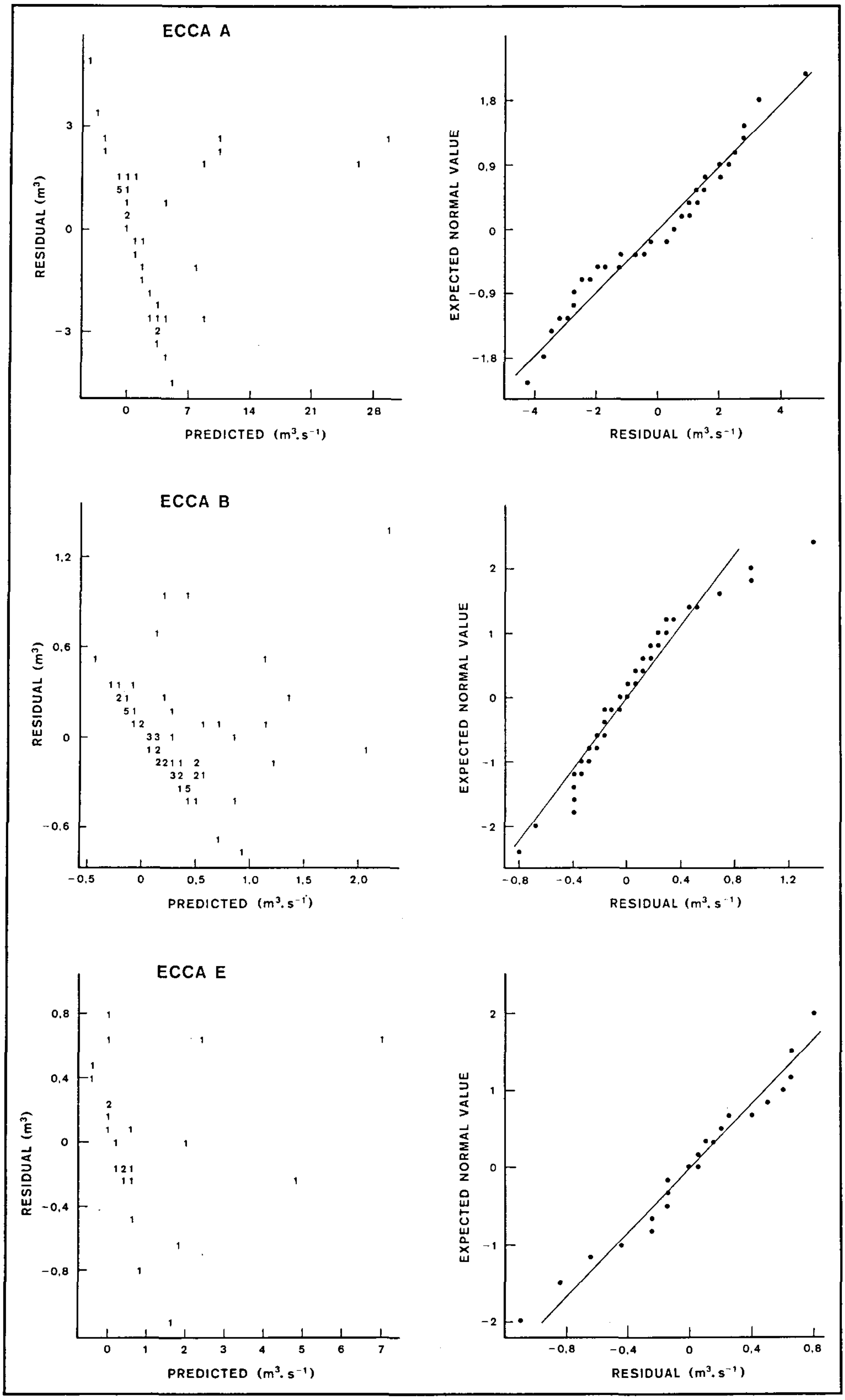

Figure 4:4 Residuals and expected residual values of regression models for peak stormflow.

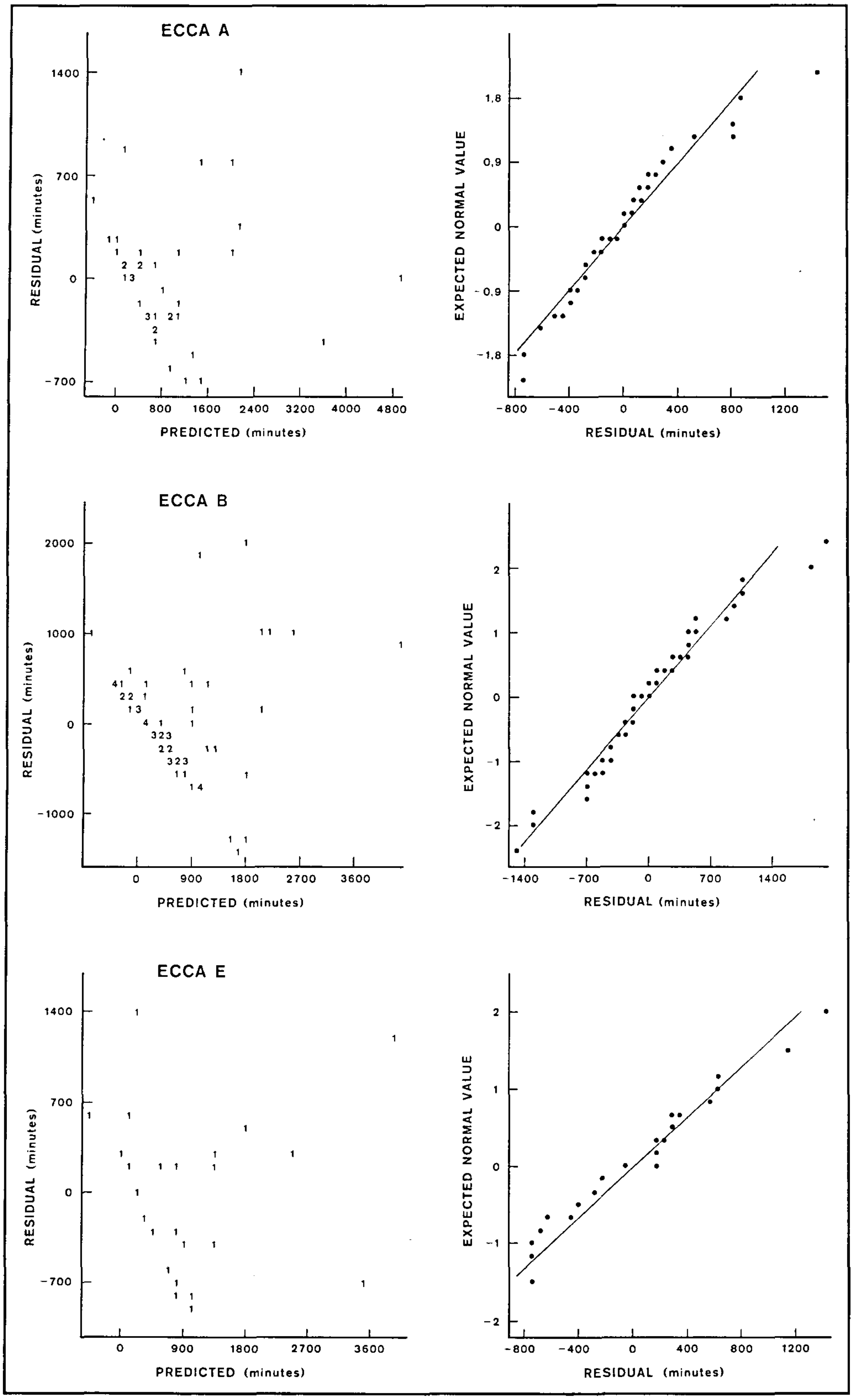

Figure 4:5 Residuals and expected residual values of regression models for duration of stormflow.

Table 4:10 Regression coefficients for models of duration of stormflow events from the Ecca research catchments A, B and E.

$$Y_1 = a_1 + b_1 X_1 + b_2 X_2 + b_3 X_3 \pm \text{Error}$$

where Y_1 = Duration of Event (min)

X_1 = Total Rainfall Catch (mm)

X_2 = API for 35 twenty-four hour periods with decay constant = 1,00

X_3 = Duration of Rainfall Event

Ecca			Coefficients			Stand	F	F
Catchments	a_1	b_1	b_2	b_3	r^2	Error	Ratio	Stats.
A	-1403	29,35	14,64		0,84	457	94,77	4,08
B	-1082	26,91	13,86		0,64	634	57,12	4,00
E	-1626	33,27	21,87	-0,26	0,74	666	18,93	4,35

F statistics at 95% confidence level

The multiple regression models developed for predicting the characteristics of stormflows discharged from three of the Ecca research catchments were all significant at the 95 percent confidence level. However, it should be noted that although their coefficients of determination are relatively high, especially for catchments A and E, they all tend to under predict the stormflow characteristics for both small and very large events. This problem, as related to small events, may be overcome by developing regression equations that pass through the origin as all of the rainfall events used for the development of these models produced some stormflow. This was not done as it would compromise the models' fit of the medium to larger events which are more important in most modelling exercises. The gross under prediction of stormflow characteristics for the event of August 20, 1988 is attributed to it being an extreme event with no other stormflows of similar magnitude being recorded. The magnitude of this event as discharged from catchment A was 50 percent greater than the next largest event. The only solution to this problem is to be aware of the likely errors when estimating the characteristics of extreme events using regression models. No matter what duration data record is used for the development of these models there will always be events of even greater magnitude for which the estimation of stormflow characteristics may prove difficult.

Owing to both the simple application and data requirements of multiple regression models this technique for modelling stormflow characteristics should not be simply dismissed in favour of the more sophisticated approaches. The results of a study by Loague and Freeze (1985), which is one of very few truely objective model evaluations reported in the literature, suggests that errors in excess of 40 percent may be expected from using more sophisticated and data intensive modelling techniques. After comparing the performance of two quasi-physically based models, a unit hydrograph model and regression models for a number of catchments using event based data they concluded that:

> "This study does not point to any one modelling approach as being superior to all others for all catchments. However, the fact that simpler, less data intensive models in the form of regressions and unit hydrographs provide as good or better predictions than a more physically based model is food for thought" (Loague and Freeze, 1985, p245).

The easily satisfied data requirements of regression modelling is well demonstrated by the independent variables selected in this study. The variables that consistently provided the greatest explanation were that of total storm rainfall and values for indices of antecedent precipitation. It was also shown that in most cases the measures of antecedent precipitation could be determined as the accumulated rainfall for a period of 35 days preceeding modelled runoff event. Therefore, although the data used to develop these models was of a fine time resolution, the results suggest that daily rainfalls from which storm rainfalls can be estimated would be quite satisfactory for modelling of both stormflow totals and peak discharges. The time resolution of data used for modelling the duration of runoff events would need to be more comparable to that of the required estimations. It is interesting to note that the measures of rainfall intensity were not selected in the development of the models for peak discharge. This finding concurs with the finding of Hewlett and Fortson (1984), who examined the importance of rainfall intensity as an independent variable for predicting peak flows in humid environments using regression models. Their results contradict the findings of Schreiber and Kincaid (1967) who developed multiple regression models for predicting runoff generated from a number of small bounded runoff plots by short duration convective storms in southern Arizona and New Mexico. They report that the two independent variables that provided most explanation in the prediction of storm discharge is total storm rainfall and the maximum five minute rainfall intensity. The difference between the results of these two studies is attributed to the differences in the catchment areas studied and therefore of the processes modelled. Runoff measured from small plots, especially when they are bound, is comprised largely of localised surface runoff, while that for a catchment study also comprises converging subsurface and groundwater flows.

4.4 CONCLUDING REMARKS ON THE ASSESSMENT OF MULTIPLE REGRESSION MODELLING

Stepwise multiple regression models were developed for predicting the stormflow characteristics of stormflow volume, peak stormflow and stormflow duration using rainfall derived independent variables. The best predictive models all took a similar form with independent variables of total storm rainfall and values for indices of antecedent precipitation. The consistency of model form is possibly one of the more important findings of this section of this study. The consistency of the variables selected for these models provides a guideline as to the data requirements for the development of multiple regression models for other semi-arid catchments. Unfortunately, owing to a scarcity of data it was not possible to develop a model for a number of different semi-arid catchments using variables to represent different catchment characteristics. However, it was shown that for models of individual catchments, rainfall data comprising total rainstorm catch and the accumulated rainfall for a period of 30 to 35 days preceding predicted event is sufficient. There are no advantages in constructing fine time interval rainfall records or determining exponentially decaying indices of antecedent precipitation. The models for all three catchments were statistically significant at the 95 percent confidence level and there coefficients of explanation were relatively high, especially for the two larger catchments. The models tended to under predict for both the smaller events and also for the largest event which was of an extreme magnitude when compared to the other events of the data record for the Ecca. However, for most events between these extremes, the predictive ability of this modelling technique was shown to be very comparable to those of more sophisticated modelling approaches.

Chapter 5

AUTOREGRESSIVE MOVING-AVERAGE MODELLING OF MONTHLY RAINFALL IN A SEMI-ARID ENVIRONMENT

Although autoregressive moving-average (ARMA) models are used widely for modelling hydrological time series, there are few reports that assess their application in different environments or provide guidelines on their data requirements. This study sets out to assess the application of first order autoregressive moving-average (ARMA(1,1)) models for modelling monthly rainfall series in a semi-arid environment. In particular, the study sets out to determine the period of data required for the performance of this type of stochastic model to stabilize.

5.1 RESEARCH METHOD

To assess the application of ARMA(1,1) type models for simulating monthly rainfalls within a semi-arid environment, models are developed for successively longer periods of the rainfall records for both Alicedale (Weather Bureau Station No. 56/139) and George (Weather Bureau Station No. 28/838). These rainfall records were selected as being representative of a semi-arid and more humid rainfall climate respectively. Also, the duration and quality of these records satisfy the requirements of this study. Both records have been recorded manually on a daily basis for the period 1881 to 1980 and contain few little missing data. By comparing the performance of ARMA(1,1) type models developed for different duration subsets of records for both a semi-arid and a more humid rainfall climate, it is possible to determine the relative performance of this type of model for use in these different environments as well as to determine their minimum data requirements.

The rainfall records for both Alicedale and George are described in Chapter Two. However, it is important to note the monthly and annual variability of these data. Although some of the standard deviations of monthly rainfalls recorded at Alicedale are greater than their respective means, the standard deviations for rainfalls recorded at George are of greater magnitude. Therefore the variability of monthly rainfalls at George is considered to be greater than that for Alicedale. As ARMA(1,1) models are developed for time series of standardized normal deviates, and not the actual rainfall values, the absolute variability of a monthly record may be of greater importance in determining its suitability for modelling using this type of model rather than the magnitude of its rainfall totals.

For each of the two rainfall records used in this study, ARMA (1,1) models are developed for five periods of 10, 20, 30, 40 and 50 years, three periods of 60, 70, 80 and 90 years, and one period of 100 years respectively. The subsets of more than twenty years duration overlap and are therefore not strictly independent. A possible solution to this problem would have been to use a synthetically generated data series of sufficient length to enable independent records of the required durations to be extracted. However, without firstly assessing the technique used to generate the longer data series, one cannot be sure that it is representative of the observed data. For this reason it was decided to use subsets of the observed data and accept that the subsets are not truely independent. This was considered a less serious problem than possibly using a rainfall series with non-representative statistical characteristics. The models developed for each period of data are then used to generate synthetic records of 100 year durations. These are compared to those of the original 100 years of observed data to determine the minimum period of data required for the performance of this type of model to stabilize. Porte Manteau lack of fit statistics, calculated for these models and summary statistics for data series generated by them are examined to determine how their performance improves as the duration of data used for their development is increased.

5.2 AUTOREGRESSIVE MOVING-AVERAGE MODELS

There are two basic approaches to stormflow modelling, the deterministic simulation of the hydrological system, and the statistical or stochastic simulation of a time series of process values. In the first approach, the hydrologic system is represented by a unique correspondence between the inputs and outputs of the modelled system, for example rainfall and streamflow. South African examples of this type of model include the Pitman (Pitman, 1973) and the ACRU (Schulze, 1984) models. On the other hand, in the stochastic approach the model is assumed to represent the most relevant statistical characteristics of an historical time series. This latter approach considers the chronological sequence of events with the aim being to understand the irregularities of their occurrence within a time series. A major problem in the application of stochastic modelling techniques is the availability of relatively long and continuous records of the variable to be modelled.

Of the stochastic approaches adopted for hydrological modelling, autoregressive type models are among the more commonly used (Salas *et al.*, 1980). These models are based on understanding the correlation structure within a time series so that they may be preserved within series of generated data. However, particularly for data series of great variability, an additional component, termed the moving-average component, which enhances the stochastic nature of a time series, is appended to these models. A conceptual justification for the autoregressive (AR) and moving-average (MA) components of an ARMA model may be illustrated by relating them to the components of a monthly streamflow record. During dry periods the streamflow for any given month is highly correlated with that for the previous month. Therefore the change in flow is easily modelled by the autoregressive component. However, during periods of rainfall the flow is more erratic due to the stochastic nature of rainfall inputs. This erratic behaviour is then modelled by a moving-average component in addition to the autoregressive component. This mixed model is called an autoregressive moving-average model and is usually denoted as ARMA (p,q) where p and q refer to the order of the AR and MA components respectively. An ARMA model of the order (p,q) is defined as:

$$Z_t = \underbrace{\sum_{j=1}^{p} \phi_j Z_{t-j}}_{\text{Autoregressive Component}} + E_t - \underbrace{\sum_{j=0}^{q} \theta_j E_{t-j}}_{\text{Moving-Average Component}}$$

where t is the time period.

Z_t is the process value for the time period t.

ϕ_j is the autoregressive parameter of lag j.

θ_j is the moving-average parameter of lag j.

E_t is the random number generated for time period t.

For such an ARMA (p,q) model p+q+2 parameters must be evaluated from the data. It is the application of this type of stochastic model with p and q both equal to one that is examined in this study.

5.3 MODEL IDENTIFICATION

The first step, when embarking on any stochastic modelling exercise, is to determine the most appropriate model and if relevant the order of the chosen model type. The second stage comprises the estimation of model parameters and finally an assessment of its goodness of fit. Although it was prescribed that this study examine and assess the application of ARMA (1,1) type models it is important to check that this modelling technique is appropriate. Salas *et al.,* (1980) suggest that model selection should be based on an examination of the original time series data and in particular on the behaviour of the autocorrelation functions r_k coupled with that of the partial autocorrelation function (table 5:1). These characteristics are best examined by graphically displaying these functions for a number of time periods. As r_k is approximately normal with zero mean and a variance of $1/N$, the approximate 95 percent probability limits are $\pm 2/\sqrt{N}$. If all the r_k values beyond lag q lie inside these limits it may be concluded that the process is moving-average of order q. If the Autocorrelation function attenuates, then it may be concluded that the process is autoregressive. When it is not clear whether the autocorrelation function truncates or attenuates then it is useful to examine the partial autocorrelation.

Table 5:1 Identification properties for AR, MA and ARMA processes (from Salas *et al.,* 1980).

Process	Autocorrelation	Partial Autocorrelation
AR(p)	Infinite in extent, consists of damped exponentials and/or damped waves. Attenuates as $\rho_k = \sum_{j=1}^{p} \phi_j \rho_{k-1}$	Finite in extent, peaks at lags 1 through p then cuts off.
MA(q)	Finite in extent, peaks at lags 1 through q then cuts off.	Infinite in extent, consists of damped exponentials and/or damped waves.
ARMA(p,q)	Infinite in extent, first q-p lags: irregular then damped exponential waves. Attenuates as $\rho_k = \sum_{i=1}^{p} \phi_i \rho_{k-1}$ $(k \geq q+1)$	Infinite in extent, first p-q lags irregular, then exponential and/or damped waves.

To determine the optimum model order, Akaike (1974) proposed a mathematical formulation which considers the principle of parsimony for comparing among competing ARMA (p,q) type models. His equation, called the Akaike Information Criteria (AIC), takes the form:

$$AIC(p,q) = N \ln(s_e^2) + 2(p+q)$$

where N is the sample size and s_e^2 is the maximum likelihood estimate of the residual variance. Under this criterion the model which gives the minimum AIC is the one selected.

5.4 MODEL DEVELOPMENT

Autoregressive moving-average models may be developed for either periodic or non-periodic time series. A periodic time series is defined as that for time steps of less than one year, when the data includes seasonally related variations. A common example of a periodic data set is that of monthly data, while an annual time series may be regarded as non-periodic. Two important criteria to be satisfied by a time series before it can be modelled using an ARMA type model is that it be both stationary and that its frequency distribution be approximately normal. There are two approaches to satisfying the first of these criteria for periodic time series. Models may be developed with periodic coefficients so that the stationarity criterion is satisfied within each time period, or the periodicity may be removed from the data before identifying model parameters. Owing to its computational complexity, the former method is not used widely. The second approach comprises transforming an hydrological time series to a time series of standardised variates. The usual transformation adopted to determine the series of standardised variates takes the form:

$$Z_{i,j} = \frac{Y_{i,j} - \bar{Y}_j}{SD_j}$$

where $Z_{i,j}$ is the standardised residuals for month j of year i.
$Y_{i,j}$ is the data value for the j^{th} year of the i^{th} month.
$\bar{Y}_j$ is the mean data value for month j.
SD_j is the standard deviation of data values for month j.
i is the year number.
j is the month number.

As the developed model is for a time series of standardised variates, it will generate series of standardised variates that need back-transforming to process values. This is done by reversing of the standardising procedure described above. The second data criteria is that its frequency distribution be approximately normal. Salas *et al.*, (1980) report that as the frequency distribution of the standardised variates need only approximate a normal distribution and that for this it is sufficient to use a series of square rooted standard variates. This can be tested by plotting this series on a normal probability plot or by examining the skewness of the time series. A coefficient for skewness (g) for a time series x_t, $t = 1, \ldots, N$ may be estimated as:

$$\Upsilon = \frac{\frac{1}{N}\sum_{t=1}^{N}(x_t-x)^3}{\left(\frac{1}{N}\sum_{t=1}^{N}(x_t-x)^2\right)^{3/2}}$$

where x is the sample mean (Snedecor and Cochran, 1967). If the series comes from a normal distribution, Υ is asymptotically normally distributed with mean zero and variance 6/N. Then the $(1-\alpha)$ probability limits on Υ may be defined by:

$$[-u_{1-\alpha/2}\sqrt{\tfrac{6}{N}},\ u_{1-\alpha/2}\sqrt{\tfrac{6}{N}}]$$

where $u_{1-\alpha/2}$ is the $1-\alpha/2$ quantile of the standard normal distribution. Therefore, if γ falls within these limits, the hypothesis of normality is accepted. Having transformed the hydrological data series into a series of normally distributed standardized variates, the autocorrelations and partial auto-correlation functions may be calculated and graphically displayed to determine whether an AR, MA or ARMA type model is most appropriate. As the current study set out to investigate the application of ARMA(1,1) type models this check is carried out only to determine the appropriateness of this model and not as a model selection process.

To determine initial estimates of the AR and MA parameters the autocorrelation coefficients for the time series of normalized deviates are determined. The relationships between these autocorrelation coefficients and the model parameters for each lag period may be expressed in what is known as the Yule Walker equations (Salas *et al.*, 1980). Using the method of moments these equations are solved to provide an initial estimate for the autoregressive model parameter. The first order moving-average process may be expressed as:

$$[-u_{1-\alpha/2}\sqrt{\tfrac{6}{N}},\ u_{1-\alpha/2}\sqrt{\tfrac{6}{N}}]$$

where r_1 is the first order autocorrelation coefficient and
θ_1 is the first order moving-average parameter.

This equation may be rearranged as a quadratic equation and solved for θ_1 to provide an initial estimate for the moving-average parameter. Having selected initial values for both the auto-regressive and moving-average components, the maximum likelihood method is used to re-define these estimates to provide acceptable parameter values for the final ARM(1,1) model of the standardised normal variates. Finally the Porte Manteau Lack of Fit test is adopted to test the goodness of the models fit. This test examines the residuals of the model to ensure that they are an independent series with no correlation structure. This test uses the statistic:

$$Q = N \sum_{k=1}^{L} r_k^2 (E)$$

where r_k (E) is the correlogram of the residuals E_t and L is the maximum lag considered for the test. For this study twenty four lags periods were considered sufficient for determining the Porte Manteau lack of fit statistic (Q). As the distribution of statistic Q approximates that of the Chi-squared distributed with L-p-q degrees of freedom, the adequacy of an ARMA model for Z_t may be checked by comparing the value of Q with the chi-square value $\chi^2(L\text{-}p\text{-}q)$ at a given significance level. If $Q < \chi^2(L\text{-}p\text{-}q)$, then E_t is an independent series and so the model is considered adequate.

5.6 MODEL ASSESSMENT

To determine the correct modelling process for both the Alicedale and George rainfall records, the behaviour of their autocorrelation and partial autocorrelation functions are examined (table 5:2). After the first lag both these functions stay within their 95 percent probability limits ($\pm 2/\sqrt{N}$ = 0,0566), which suggest that they are best modelled by a moving-average process. The oscillating pattern displayed by these functions suggests that models of these data should also include an autoregression component. Therefore an autoregressive moving-average model is considered appropriate for modelling these records of monthly rainfall.

A series of first order autoregressive moving-average models is developed using subsets of the monthly rainfall records for both Alicedale and George respectively. Tables 5:3 and 5:4 present the Porte Manteau lack of fit statistics (Q) calculated for each of the developed models using the residual values for the first 25 lag periods. The Chi square statistic for 23 degrees of freedom (number of lags - p - q) at the 90 percent confidence level is 32,01. As this value is greater than the Q statistic calculated for each of the developed models, the residuals series of each of these models are independent and all of the models are considered adequate. However, these statistics, which are summarised by figures 5:1 and 5:2, also display an improvement in the model fit as the period of data used for their development is increased. Figure 5:1 suggests that considerable improvements in the fit of the models for Alicedale may be gained by extending the duration of the calibration period up to 40 years. To extend the period of data used for developing these models beyond 40 years provides further improvements in model fit, but at a very much reduced rate. Similarly, when developing monthly rainfall models for George, figure 5:2 suggests that marked improvements in model fit may be gained by increasing the period used for model development up to 50 years. To extend the period of calibration beyond this point only leads to marginal improvements. Therefore it is suggested that for the development of ARMA(1,1) type models for monthly rainfall climates similar to those of Alicedale and George one should aim at using data records of approximately 40 to 50 years in duration. The longer duration record required to ensure that models of monthly rainfall at George perform as well as those for Alicedale is attributed to the greater variability of its monthly rainfall. This can be seen by comparing the standard deviations of these two monthly rainfall records (tables 2:3 and 2:4).

Table 5:2 Autocorrelation and partial autocorrelation functions of the Alicedale and George monthly rainfall record.

	Alicedale		George	
Lag No.	Auto-correlation	Partial Auto-correlation	Auto-correlation	Partial Auto-correlation
0	1,00000	1,00000	1,00000	1,00000
1	0,02238	0,02238	0,00302	0,00302
2	0,02631	0,02582	-0,01442	-0,01443
3	0,06513	0,06405	-0,00467	-0,00458
4	0,00079	-0,00261	-0,03364	-0,03383
5	0,03106	0,02797	-0,04699	-0,04699
6	0,07500	0,07010	-0,02203	-0,02293
7	0,02709	0,02324	0,01762	0,01600
8	-0,00818	-0,01638	0,04998	0,04789
9	0,04307	0,03387	-0,04089	-0,04408
10	0,00367	-0,00062	-0,04655	-0,04903
11	0,02140	0,01730	0,01344	0,01188
12	-0,01985	-0,03228	-0,04326	-0,04082
13	0,05686	0,05502	0,01862	0,02141
14	0,04726	0,04382	0,02166	0,01548
15	0,03500	0,02982	0,01348	0,00638
16	0,00679	-0,00661	-0,02728	-0,03188
17	-0,03954	-0,04665	-0,00760	-0,00374
18	-0,02407	-0,02811	0,03553	0,03914
19	0,02023	0,01513	0,02544	0,02487
20	0,06690	0,06120	0,03412	0,03766
21	0,03397	0,03193	-0,00103	-0,00796
22	-0,03332	-0,04305	0,01727	0,01431
23	0,00442	0,00220	0,00303	0,01280
24	-0,00960	-0,01209	-0,04069	-0,03075

(95 percent confidence limit = 0,05658)

Table 5:3 Porte Manteau Lack of Fit Statistics (Q) determined for models of Alicedale monthly rainfall.

Duration of Record (years)	Q statistic for model number: 1	2	3	4	5	Mean Q
10	30,477	30,481	30,128	29,179	29,952	30,043
20	27,819	27,675	27,668	26,491	28,306	27,592
30	26,884	26,625	26,634	26,104	26,296	26,508
40	26,664	26,330	25,969	25,921	25,931	26,163
50	26,278	26,320	25,903	25,838	26,076	26,083
60	26,881	26,065	25,952			25,966
70	25,796	25,709	25,813			25,773
80	25,704	25,856	25,859			25,796
90	25,588	25,649	25,832			25,656
100	25,651					25,651

Number of Lags = 25
Degrees of Freedom = 2
χ^2 (90%) = 32,007

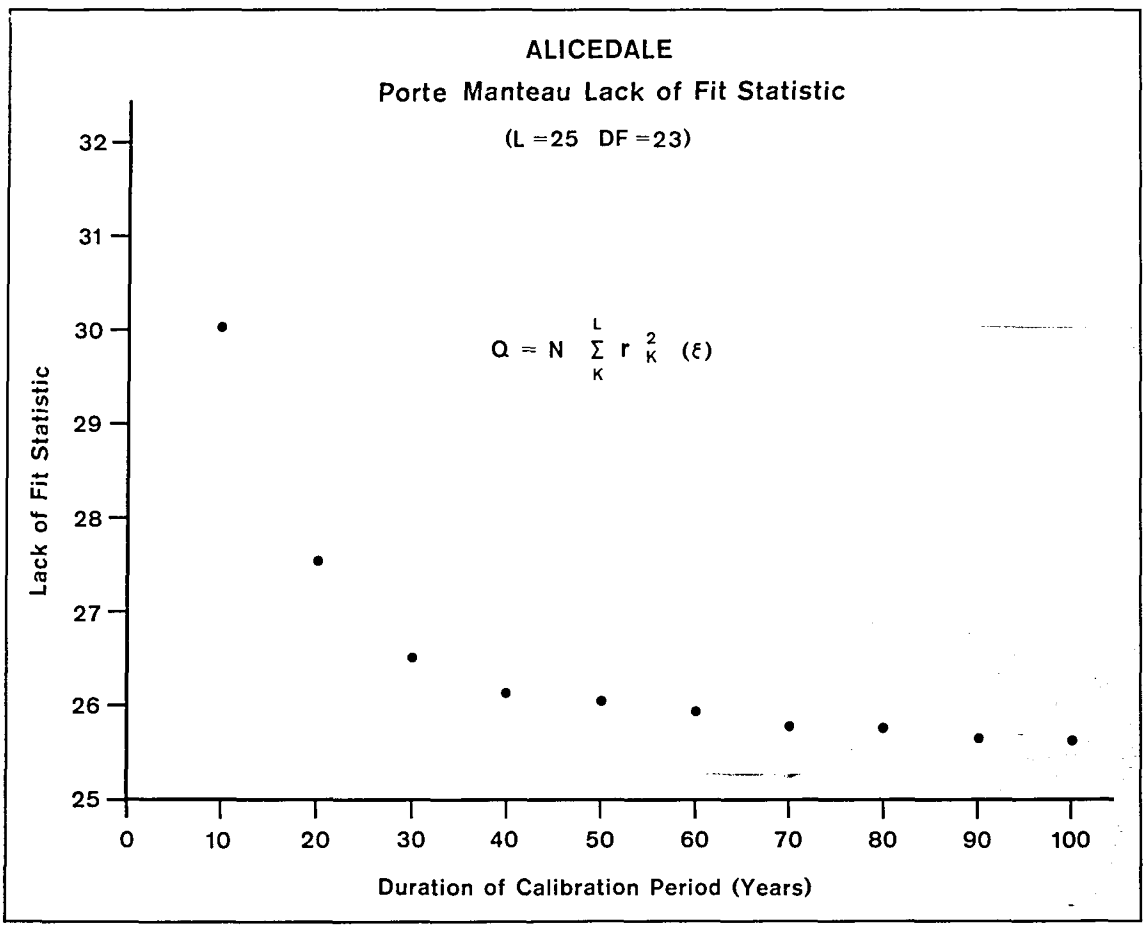

Figure 5:1 Mean Porte Manteau Lack of Fit Statistics for model of Alicedale monthly rainfall.

Table 5:4 Porte Manteau Lack of Fit Statistics (Q) determined for models of George monthly rainfall.

Duration of Record (years)	Q statistic for model number: 1	2	3	4	5	Mean Q
10	31,059	30,613	28,613	30,104	29,958	30,069
20	27,623	27,296	27,342	28,013	27,715	27,598
30	26,695	26,510	26,131	27,117	27,033	26,697
40	26,288	25,945	25,969	26,428	26,332	26,192
50	25,906	25,550	25,670	25,779	26,023	25,787
60	25,605	25,718	25,811			25,711
70	25,546	25,685	25,758			25,663
80	25,597	25,609	25,637			25,614
90	25,547	25,580	25,557			25,561
100	25,492					25,492

Number of Lags = 25
Degrees of Freedom = 2
χ^2 (90%) = 32,007

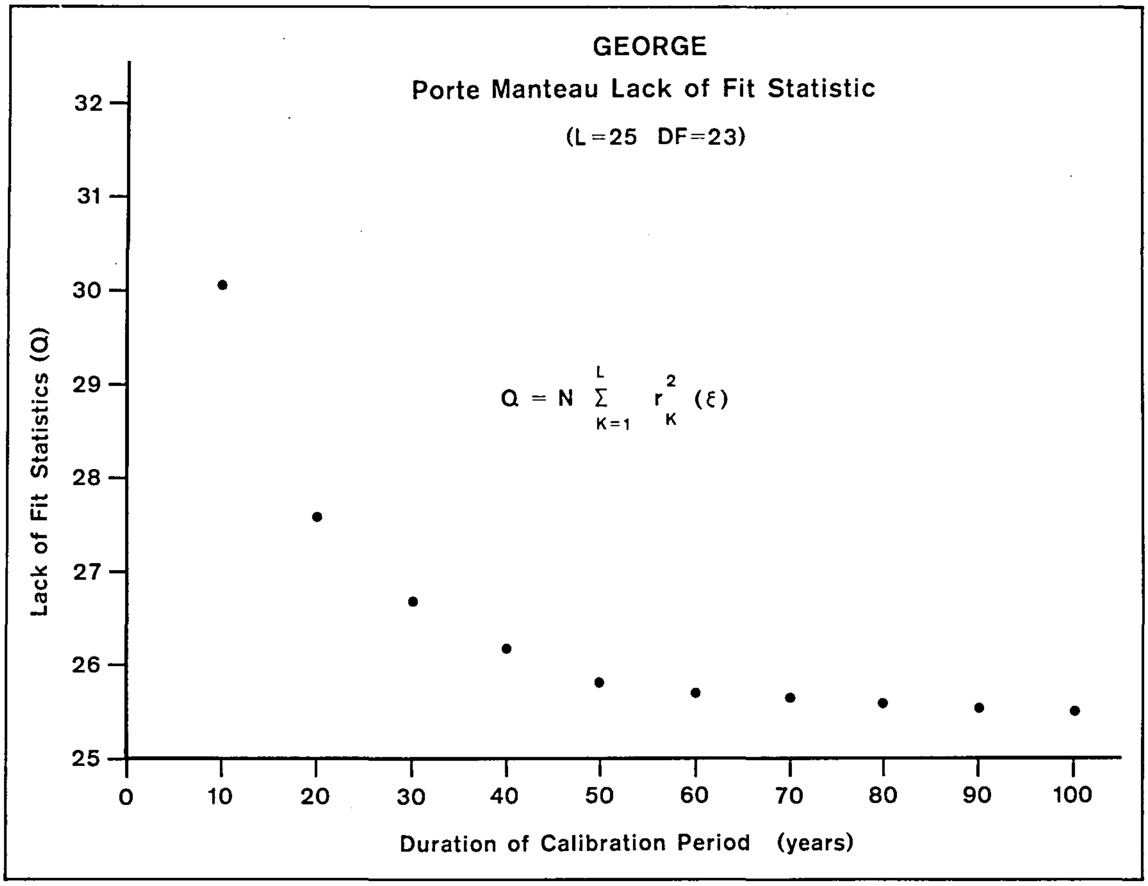

Figure 5:2 Mean Porte Manteau Lack of Fit Statistics for model of George monthly rainfall.

Although the Porte Manteau Lack of Fit statistic provides a useful measure of model fit by examining the correlation structure of model residuals, it is also important to consider how well the statistical characteristics of data generated by these models are preserved. This is done by comparing the summary statistics of 100 year monthly rainfall series generated using each of the ARMA(1,1) models with those for the original 100 year periods of observed data. In particular, the means and standard deviations of monthly values are examined. To generate these data series a value equal to that of the rainfall recorded in January 1880 was used as initial values of the generated data series for the two respective sites. The summary statistics for both the periods of data used to develop the respective models and the summary statistics for the generated series are presented in Appendices F and G. Figure 5:3 presents the mean absolute difference between both the monthly means of the data subsets used for model development and for the periods of generated data, and the mean monthly rainfall for the 100 year periods of observed data. These figures show how the difference between the mean monthly rainfalls of the data subsets, used for model development, and those of the 100 years of observed data decrease as their durations increase. Similarly, figure 5:3 also shows that the difference between the means of the generated data series and those of the 100 years of observed data also decreases with increased duration of the data subsets used for model development. However, the differences between the mean monthly rainfalls of the generated data and the 100 year observed records are always greater than those between the different duration subsets of observed data and that for the entire 100 years of observed record. Figure 5:4 presents the difference between the mean monthly standard deviations for both the subsets of observed data and the generated data sets, and the 100 years of observed data using similar plots to that of figure 5:3. When comparing the residuals between the standard deviations of both the subsets of observed data and the generated data series to that of the 100 years of observed data a similar pattern to that for the monthly means is observed. That is, with increased duration of the data subsets used for model development, the monthly standard deviations for both the subsets and of the generated data series become closer to those of the 100 years of observed data. It can also be seen that the standard deviations of the subsets of observed data converge closer and more rapidly to those of the 100 year observed records than those for the periods of generated data. These figures illustrate the two major factors that contribute to the successful generation of data series using not only ARMA (1,1) models but any other type of hydrological model. Firstly, the generated data are dependent on how well the observed data used for model development represents the characteristics of the long term rainfall climate to be modelled. Secondly, they are dependent on how well the developed model fits the observed data used for its development. Examination of figure 5:4 shows that there is little improvement in the models ability to preserve the correct standard deviation within a generated rainfall series for Alicedale when using data subsets of greater duration than 30 years. As for preservation of the mean, the generated data series do not stabilize until the duration of modelled data exceeds 40 to 50 years.

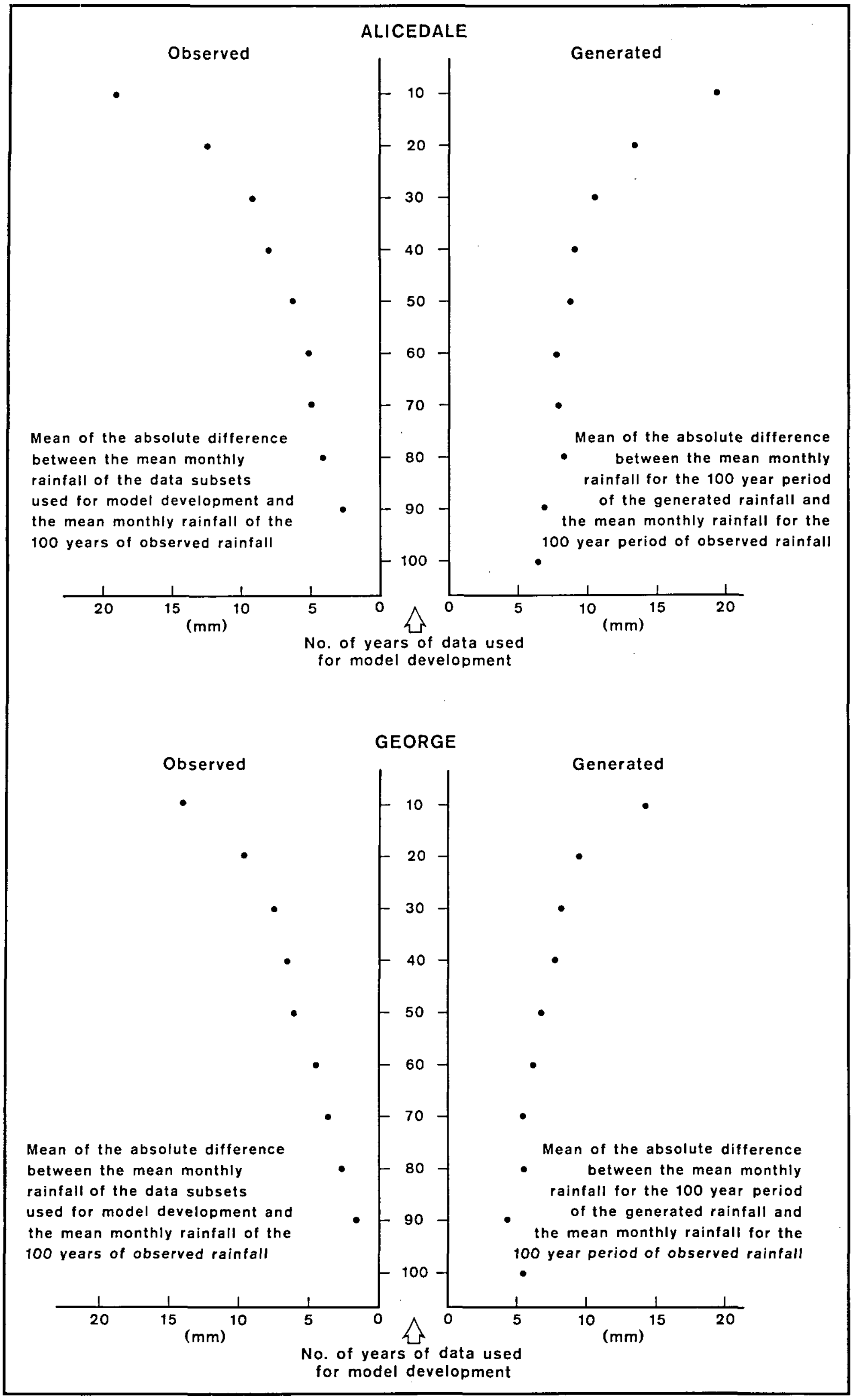

Figure 5:3 Mean absolute differences between the observed and generated mean monthly rainfalls.

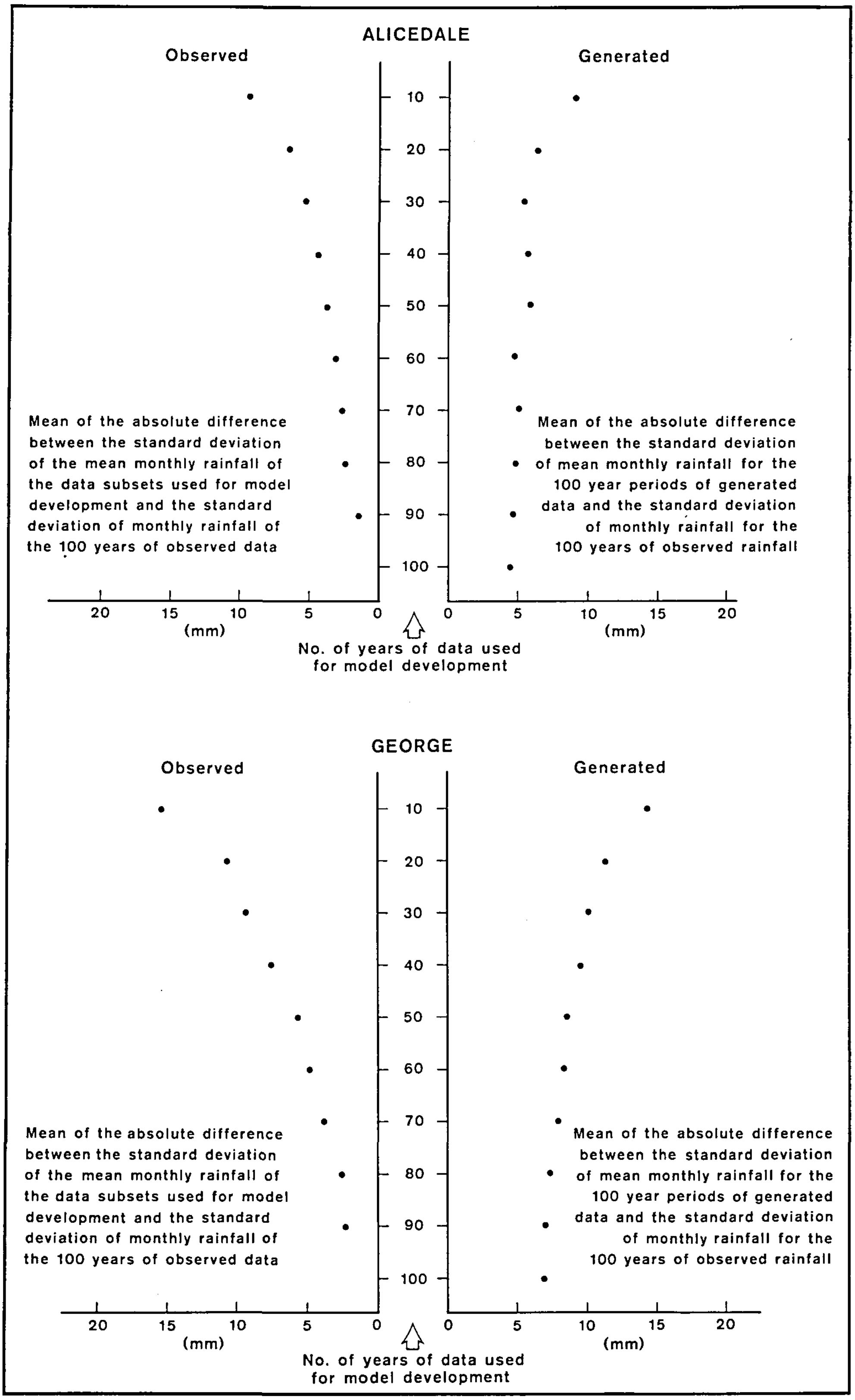

Figure 5:4 Mean absolute differences between the standard deviation of the observed and generated monthly rainfall.

5.7 CONCLUDING REMARKS ON MODEL PERFORMANCE

By comparing the Port Manteau Lack of Fit statistics for ARMA(1,1) models developed for different duration subsets of the Alicedale and George monthly rainfall records, it has been shown that the adequacy of these models improves as the period of data used for their development is extended. Similarly, an examination of the means and standard deviations of the data used for developing these models and those of the data generated by them also shows that the performance of ARMA(1,1) models improves as the period of data used for their development is increased. It has also been shown that by extending the duration of the calibration periods of these models, up to 40 years in the case of Alicedale and 50 years for George, marked improvements in the adequacy of these models could be gained. This is attributed to both an improvement in the actual performance of the model as well as the longer subsets becoming more representative of the longer term rainfall climates of the study areas. However, by using even greater durations of data, model performance improved only marginally. The longer period of data required for the performance of models of the George rainfall record to stabilize is attributed to the greater variability of that record. It is concluded that 40 to 50 years of data is required for the development of ARMA (1,1) type models of monthly rainfall before their performance stabilises and that this is dependent on the variability of the particular rainfall record.

CHAPTER 6

AUTOREGRESSIVE MOVING-AVERAGE MODELLING OF MONTHLY STREAMFLOWS WITHIN A SEMI-ARID ENVIRONMENT

This section of the study assesses the application of first-order autoregressive moving-average (ARMA(1,1)) models for modelling monthly streamflows within semi-arid environments. In particular, the study attempts to determine the period of data required for the performance of this type of model to stabilise.

6.1 RESEARCH METHOD

To assess the application of ARMA(1,1) models for simulating monthly streamflows within semi-arid environments, models are developed for successively longer periods of streamflow records representative of a semi-arid and a sub-humid environment respectively. As the duration of available streamflow records are insufficient for them to be divided into a number of independent subsets of durations long enough to develop ARMA type monthly models, extended synthetic streamflow records were generated. Two monthly streamflow records of 1000 years duration and referred to as the "observed" data were generated to represent both a semi-arid and a sub-humid runoff regime respectively. Monthly ARMA (1,1) models were then developed for successively longer periods of these data series. To assess the performance of these models their Porte Manteau lack of fit statistics and the summary statistics of data series generated through their application are compared.

6.2 THE SYNTHETIC STREAMFLOW RECORDS

The two synthetic "observed" monthly streamflow records were generated using PITM (Görgens, 1983), a version of Pitman's monthly streamflow model (Pitman, 1973). This model was applied to synthetic rainfall and evaporation records developed as representative of semi-arid and sub-humid regimes. The rainfall data were generated using a monthly ARMA(1,1) model developed for the 1881 to 1980 period of the rainfall records for Alicedale (Weather Bureau Station No. 56/139) and George (Weather Bureau Station No. 28/838) respectively. These models were developed using the approach described in section 5:4 of this study. The summary statistics of these rainfall records are presented in table 6:1 and 6:2, and show that the statistical characteristics of the original observed data for Alicedale and George are well preserved (figure 2:4 and 2:5).

Table 6:1 Statistical summary of the 1000 year rainfall record generated for Alicedale (mm).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	33	41	51	33	32	20	22	23	34	39	45	34	406
Stdv	29	33	41	26	29	19	22	24	31	31	36	30	119
Skew	1,3	1,2	1,3	1,0	1,7	1,4	1,3	1,7	1,6	1,2	1,3	1,5	0,4
Min	0	0	0	0	0	0	0	0	0	0	0	0	121
Max	216	212	234	142	183	102	115	155	244	173	216	223	857

Table 6:2 Statistical summary of the 1000 year rainfall record generated for George (mm).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	77	81	90	69	65	46	47	65	82	81	84	76	864
Stdv	39	48	46	40	45	33	29	43	52	45	49	48	152
Skew	0,7	0,9	0,8	0,8	1,2	1,0	0,7	1,0	1,0	0,8	1,0	1,0	0,3
Min	1	0	5	0	0	0	0	0	0	0	0	0	462
Max	280	305	264	228	270	167	147	255	362	251	300	327	1364

Extended evaporation records for the same period as the synthetic rainfall records were generated using A pan data from the Ecca research catchments and that recorded at the P.W. Botha Airport, George (Station No. K3E01). On a monthly basis, data values of the synthetic rainfall record were compared to the observed rainfall data recorded at the evaporation recording station. The evaporation value for the month with the rainfall value most similar to that of each month of the synthetic rainfall record was selected to construct the extended evaporation series for the two study areas. Although crude, this method of constructing a series of pan evaporation values provided records with realistic monthly and annual statistical characteristics.

To generate the required streamflow records, PITM a version of Pitman's monthly streamflow model (Pitman, 1973) was adopted. The main reason for selecting this model was that it was developed for South African conditions and had previously been calibrated and assessed for both the semi-arid Ecca catchments (Görgens, 1983) and for a number of sub-humid catchments near George (Hughes, 1982). Although Görgens expressed reservations about the success of PITM to model the highly variable runoff conditions of the Ecca catchments, he also expressed dissatisfaction with the more sophisticated Stanford model (Shaw, 1988). Owing to the time constraints of this study it was decided to adopt PITM for which calibrations were available, rather than set up and calibrate a more sophisticated model that in all likelihood would provide only marginally better results.

The input requirements of PITM comprise monthly rainfall totals, pan evaporation totals and monthly pan to free surface water conversion factors. Conceptually, PITM comprises an interception and a soil moisture store, both of finite capacity (figure 6:1). Surface runoff is generated by either an infiltration excess or by a form of interflow from the soil moisture store. A delayed flow component is produced by percolation from the soil moisture store. The two flow components, surface runoff and lower zone runoff are then routed separately, to provide for channel attenuation. The parameter values adopted to generate streamflow for a semi-arid environment are those determined by Görgens (1983) for Ecca catchment A (Site No. Q9M20), and those for the sub-humid series are those determined for the Maalgate catchment (Site No. K3M03) by Hughes (1982). These values are presented in table 6:3 and statistical summaries of the generated streamflow series for Alicedale and George are presented in tables 6:4 and 6:5 respectively.

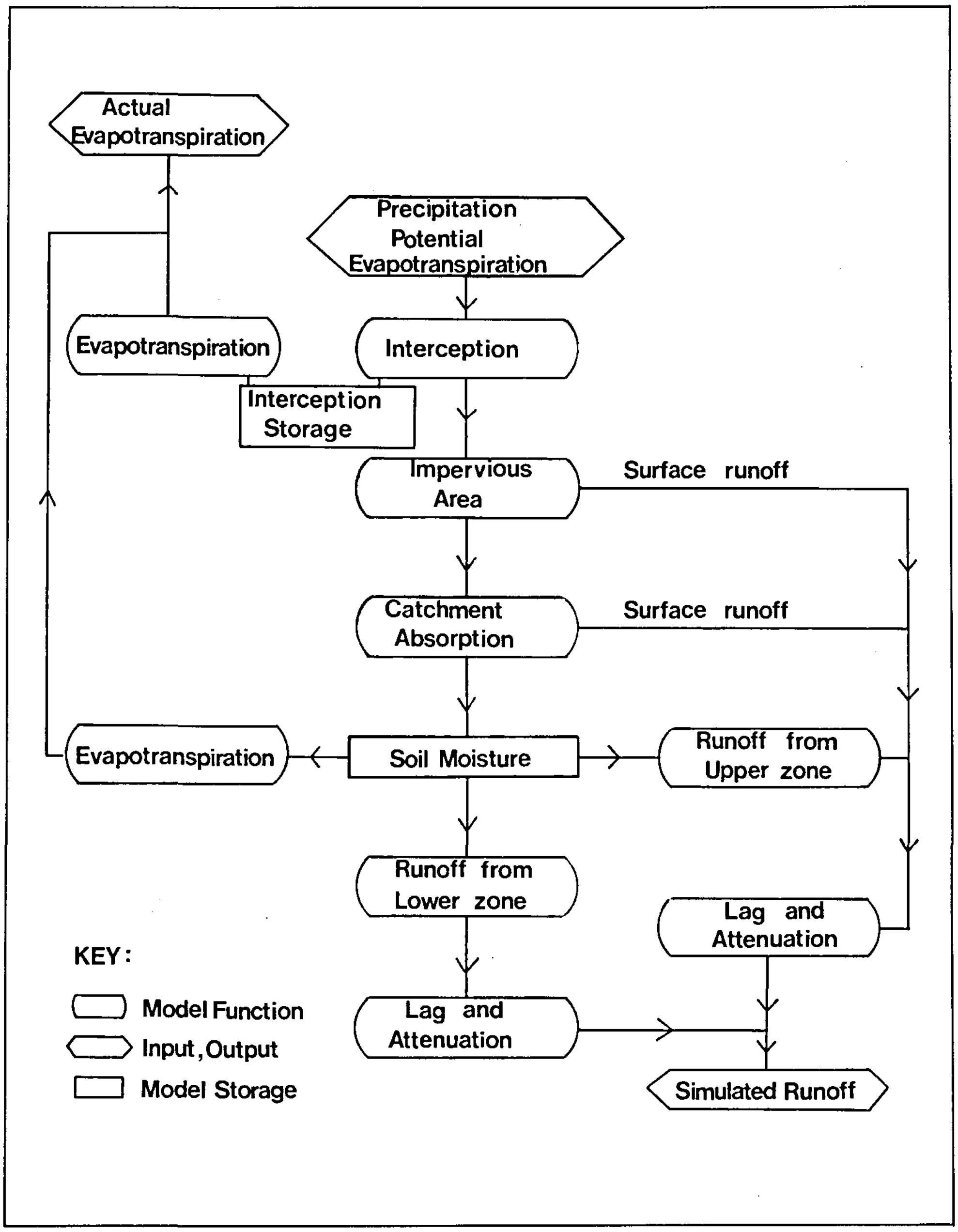

Figure 6.1 Flow diagram of model PITM (from Görgens, 1983).

Table 6:3 Parameters and parameter values used for model PITM to generate the synthetic flow records.

Parameter Description	Parameter Values Alicedale	Parameter Values George
Impervious fraction of catchment area connected to the channel network.	0,0	0,0
Maximum soil moisture percolation rate to groundwater ($mm.month^{-1}$).	0,001	34,0
Maximum interception storage (mm).	2,5	2,0
Power of soil moisture storage percolation curve.	2,0	2,0
Coefficient of evaporation - soil moisture relationship.	0,01	0,0
Maximum groundwater discharge rate ($mm.month^{-1}$).	0,001	8,0
Maximum soilmoisture capacity (mm).	145,0	170,0
Minimum catchment absorption rate ($mm.month^{-1}$).	109,0	0,0
Maximum catchment absorption rate ($mm.month^{-1}$).	334,0	350,0
Maximum interception storage (mm)	2,5	2,0
Delay coefficient for surface flow	0,09	0,0
Delay coefficient for groundwater flow	0,25	0,3

Table 6:4 Statistical summary of the 1000 year synthetic streamflow record generated for a catchment of 73,1 km^2 with physiographic characteristics the same as those for Q9M20 and a rainfall the same as that recorded at Alicedale ($m^3.10^3$).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	13	25	84	11	24	3	1	3	25	21	48	23	282
Stdv	145	172	413	50	209	41	6	40	251	126	300	197	805
Skew	22,9	14,1	7,7	7,0	12,7	22,3	14,9	19,2	16,9	9,1	9,4	16,2	5,1
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
Max	4041	3848	5079	582	3984	1140	125	1000	5968	1760	4043	4433	8050

Table 6:5 Statistical summary of the 1000 year synthetic streamflow record generated for a catchment of 73,1 km^2 with physiographic characteristics the same as those for Q9M20 and a rainfall the same as that recorded at George ($m^3.10^3$).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	1266	1455	1827	1432	1664	1181	1102	1403	2003	1860	1900	1438	18530
Stdv	1135	1597	1645	1169	1558	796	616	1340	1902	1612	1702	1560	6437
Skew	2,8	2,6	2,2	2,2	3,4	2,2	1,6	2,8	3,0	2,4	2,7	3,3	0,7
Min	76	7	98	81	122	112	146	79	141	134	226	66	5142
Max	11569	13589	11585	8568	13091	6234	4383	10386	18575	11646	13147	14475	45121

6:3 MODEL ASSESSMENT

To determine the correct modelling process for the two streamflow records the behaviour of their autocorrelation and partial autocorrelation functions were examined (table 6:6). After the first lag of both series these functions remain within their 95 percent probability limits (0,5658), which suggests that they are best modelled by a moving-average process. The oscillating pattern displayed by these functions suggests that models of these data should also include an autoregressive component. Therefore an autoregressive moving-average model is considered appropriate for modelling these records of monthly streamflow.

Table 6:6 Autocorrelation and partial autocorrelation functions of the Alicedale and George monthly streamflow records.

	Alicedale		George	
Lag No.	Auto correlation	Partial Auto correlation	Auto correlation	Partial Auto correlation
0	1,00000	0,00000	1,00000	0,00000
1	0,45940	-0,18283	0,29428	0,11465
2	0,06681	0,07313	0,19133	0,04309
3	0,00808	-0,04562	0,12243	-0,01397
4	-0,01138	0,00477	0,05119	-0,00261
5	-0,01902	0,01282	0,02843	0,00413
6	0,00147	0,01191	0,01881	0,05937
7	0,01850	0,10065	0,06243	0,01406
8	0,09071	0,11632	0,04521	0,07496
9	0,17807	-0,05618	0,09846	-0,00231
10	0,09251	0,01114	0,05613	0,02942
11	0,01105	0,04391	0,06669	0,01697
12	0,03265	0,05354	0,05754	0,00758
13	0,07245	0,04122	0,04038	0,02500
14	0,08294	-0,02035	0,05118	0,03067
15	0,04023	0,00174	0,05676	0,03447
16	0,00834	-0,02673	0,07117	0,01772
17	-0,00557	-0,01372	0,06007	-0,03594
18	-0,00412	0,00263	0,01515	0,01033
19	-0,00406	0,02073	0,02695	0,02917
20	-0,01768	0,02466	0,04389	0,00974
21	0,01370	0,08886	0,03508	-0,01738
22	0,10760	0,10212	0,01219	-0,01146
23	0,18504	-0,03540	0,00947	0,04189
24	0,10302	0,01429	0,05049	-0,04748
25	0,02741	0,00000	-0,01228	0,00000

First order autoregressive moving-average models were then developed for independent subsets of the 1000 year "observed" monthly records for durations of 10, 20, 30, 40, 50, 100, 150 and 200 years respectively. For each of these durations, five data subsets beginning at year 1, 201, 401, 601 and 801 were selected. To normalize these data series a square root transformation which approximates the normalizing of a gamma distribution (Salas *et al.*, 1975) was adopted. A log transformation was not considered due to the large number of months with zero flow, particularly that for Alicedale.

Tables 6:7 and 6:8 present the Porte Manteau lack of fit statistics (Q) calculated for each of the developed models using the residual values of the first 25 lag periods. The Chi square statistic for 23 degrees of freedom (number of lags - p - q) at the 90 percent confidence level is 32,01. This value is greater than the Q statistic calculated for all of the models developed from subsets of more than 10 years duration. Therefore the residual series for all the models developed using more than 10 years of data are considered independent. These statistics, which are summarised by figures 6:2 and 6:3, also display an improvement in model fit as the period of data used for their development is increased.

Table 6:7 Porte Manteau Lack of Fit Statistics (Q) determined for models of Alicedale monthly streamflow.

Duration of Record (years)	Q statistic for model number: 1	2	3	4	5	Mean Q
10	31,235	32,027	32,997	28,290	29,671	30,844
20	27,262	27,486	26,128	27,330	26,824	27,006
30	26,658	27,261	25,657	26,448	27,006	26,618
40	26,517	26,721	25,606	26,219	26,403	26,293
50	26,624	25,742	25,573	25,931	26,098	25,994
100	26,095	25,406	25,325	25,400	25,550	25,555
150	25,939	25,202	25,296	25,294	25,257	25,398
200	25,837	25,099	25,269	25,169	25,192	25,313

Number of Lags = 25
Degrees of Freedom = 2
χ^2 (90%) = 32,007

Table 6:8 Porte Manteau Lack of Fit Statistics (Q) determined for models of George monthly streamflow.

Duration of Record (years)	Q statistic for model number: 1	2	3	4	5	Mean Q
10	31,976	28,811	30,871	29,231	32,195	30,617
20	28,901	27,849	27,510	27,819	27,931	28,002
30	27,209	26,336	26,863	26,421	26,075	26,581
40	26,854	26,136	25,952	25,945	26,008	26,179
50	26,252	25,517	25,733	25,539	25,706	25,749
100	25,500	25,481	25,369	25,336	25,472	25,432
150	25,318	25,335	25,153	25,288	25,399	25,299
200	25,214	25,297	25,108	25,260	25,335	25,243

Number of Lags = 25
Degrees of Freedom = 2
χ^2 (90%) = 32,007

Figure 6:2 shows that considerable improvements in the fit of models for the Alicedale data may be gained by extending the duration of the calibration period up to 100 years. To extend the period of data used for developing these models beyond this duration leads to further improvements of model fit, but at a much reduced rate. Similarly when developing monthly streamflow models for George, figure 6:3 shows marked improvements in model fit may be gained by increasing the period used for model development up to 50 years. These results suggest that for areas of infrequent streamflows longer periods of monthly data are required to develop adequate ARMA streamflow models.

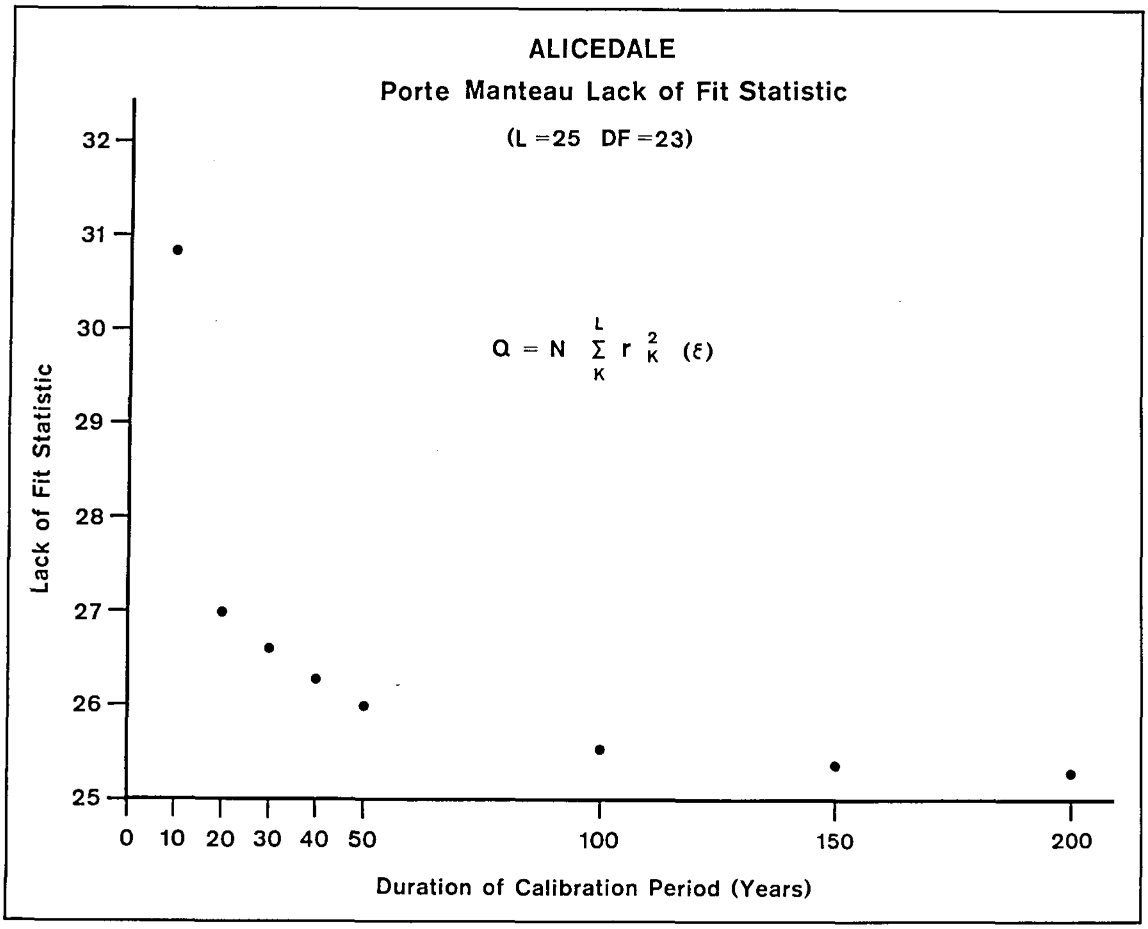

Figure 6:2 Mean Porte Manteau Lack of Fit Statistics for models of Alicedale monthly streamflow.

Although the Porte Manteau lack of fit statistics provides a useful measure of model fit by examining the correlation structure of the model residuals, it is also important to consider how well the statistical characteristics of the generated data are preserved. This is done by comparing the summary statistics of the 1000 year monthly streamflow records generated using each of the ARMA(1,1) models with those of the 1000 year "observed" data. The summary statistics for both the periods of data used to develop the respective models and the summary statistics for the generated series are presented in Appendices E and H.

Figures 6:4 and 6:5 present the mean absolute difference between both the monthly means of the data subsets for the 1000 year periods of "observed" data. These figures show how the difference between the mean monthly streamflows of the data subset used for model development and those of the 1000 years of "observed" data decrease as their durations increase. In fact this figure shows how the representation of the monthly means for both of the "observed" data series by data subsets is improved markedly as the duration of the subset is extended up to approximately 100 years. Similarly, figure 6:4 also shows that the differences between the means of the generated data series and those of the 1000 years of "observed" data decreases with increased duration of the data subsets used for model development. The model's success in preserving the correct monthly means is demonstrated by the convergence of the mean residuals for the generated data series being very similar to those of the data subsets used for model development.

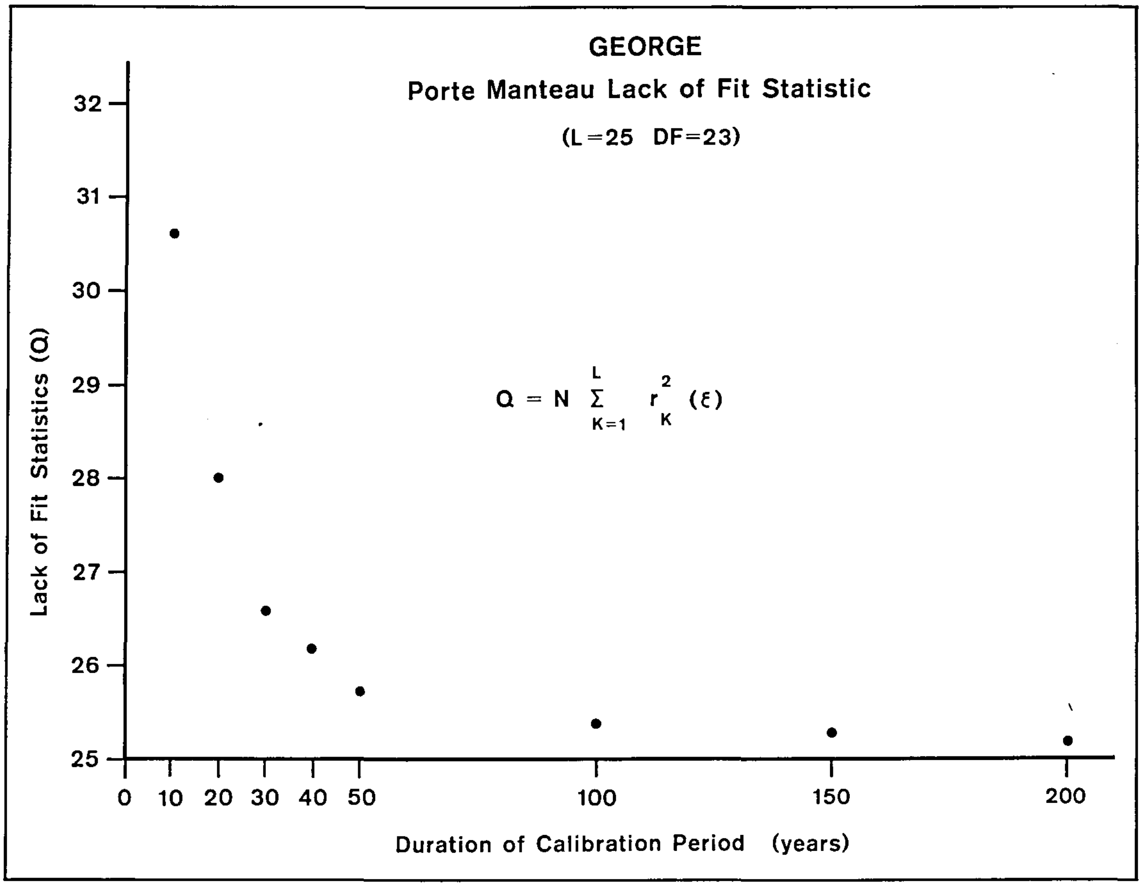

Figure 6:3 Mean Porte Manteau Lack of Fit Statistics for models of George monthly streamflow.

Figure 6:5 presents the differences between the mean monthly standard deviations for both the subsets of observed data and the generated data, and the 1000 years of "observed" data using similar plots to that of figure 6:4. When comparing the residuals between the standard deviations of both the subsets of observed data and the generated data series to that of the 1000 years of "observed" data a similar pattern to that for the monthly means is observed. That is, with increased duration of the data subsets used for model development, the monthly standard deviations of both the subsets and of the generated data series become closer to those of the 1000 years of "observed" data. In fact, as the mean residuals of the standard deviations for the generated series are at best almost three times those of their respective observed subset, it is concluded that the standard deviations are not successfully modelled by these ARMA models. These figures highlight the two major factors that contribute to the successful modelling of any data series. Firstly the model must be appropriate for the process being modelled and secondly the sample population used for model development must be representative of the data population being modelled.

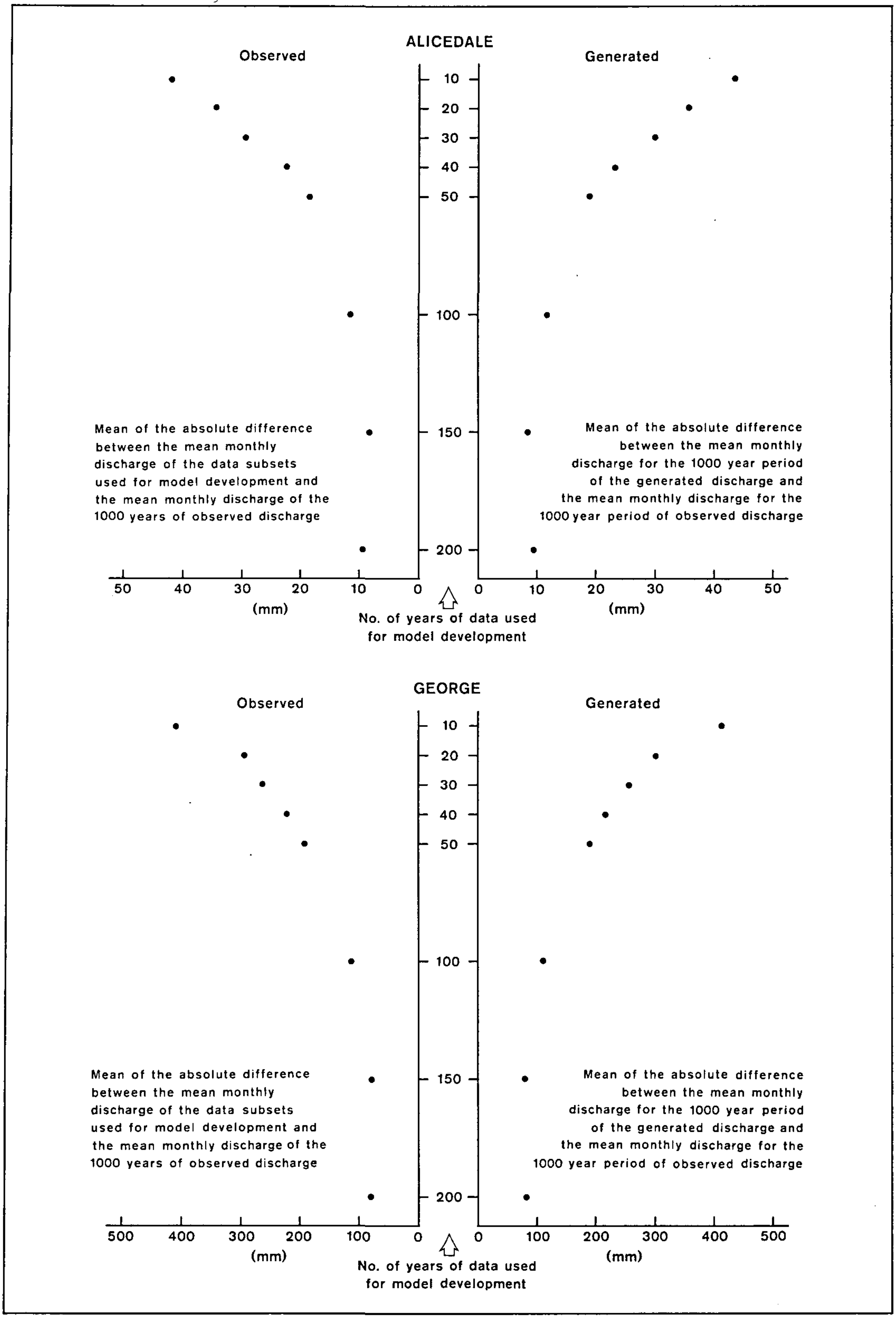

Figure 6:4 Mean absolute differences between the "observed" and generated mean monthly streamflows.

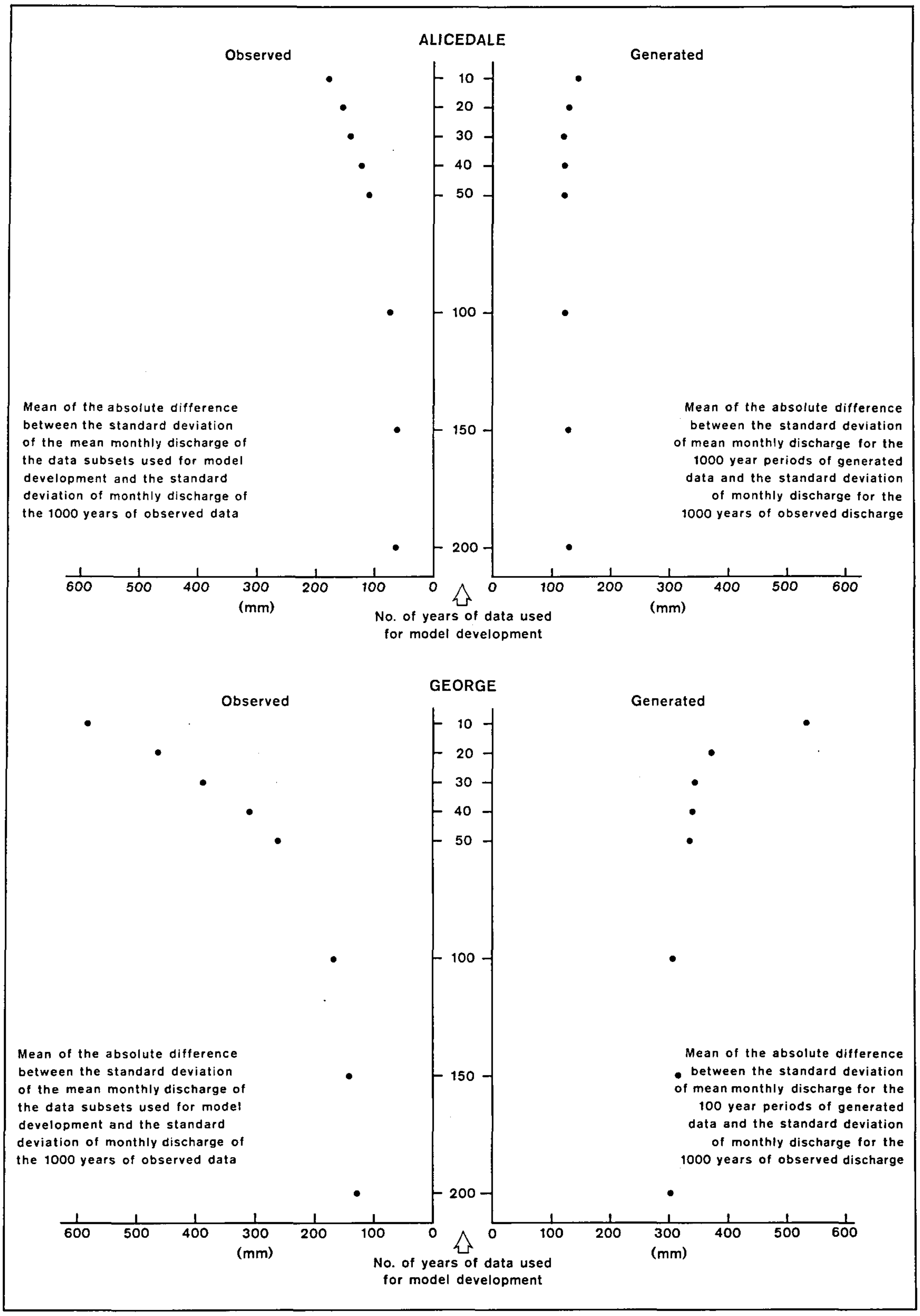

Figure 6:5 Mean absolute differences between the standard deviation of the "observed" and generated monthly streamflows.

Similarly, a comparison of the monthly skewness values for the "observed" and generated series (Appendices H and I) shows that this statistical characteristic is also not well preserved by this modelling technique, especially for the semi-arid Alicedale series. These problems, concerning the inability of the ARMA(1,1) models to generate data series with the correct frequency distribution of monthly streamflows is attributed to the transformation used for normalizing the observed data records. For this study a square root transformation, which is an approximate transformation for converting a gamma distribution to a normal distribution, was adopted. A log transformation was not considered owing to the large number of zero monthly flows, especially in the semi-arid series.

A major advantage in using ARMA type models for hydrological modelling is the ease with which they can be developed. However, if the selection of the transformation used for normalizing the calibration data is as important as suggested by these results then this advantage falls away especially for data series containing many zero values. Another major problem highlighted by figures 6:4 and 6:5 is the period of record required for the statistical characteristics of the data subsets to preserve the statistical characteristics of the entire data population. For both the semi-arid and sub-humid data series it is shown that greater durations of data are required for modelling streamflow series than was necessary in Chapter 5 for modelling the corresponding rainfall series. This suggests that a more satisfactory method of generating extended monthly streamflow series may be to generate extended rainfall series which are converted to a streamflow series using a deterministic model. An alternative approach currently under investigation by van Biljon of the Department of Water Affairs is to disaggregate annual streamflow series which are more easily modelled. Both these approaches are based on modelling more normally distributed data series for which a normalizing transformation is more easily determined.

6.4 CONCLUDING REMARKS ON MODEL PERFORMANCE

An examination of the autocorrelation function and partial autocorrelation functions for the standardised normal variates of the the synthetic streamflow series generated for both Alicedale and George suggested that ARMA(1,1) type models are appropriate for these data. By comparing the Porte Manteau lack of fit statistics for the developed ARMA(1,1) models it was shown that their adequacy improved as the periods of data used for their development was extended up to approximately 100 and 50 years for the Alicedale and George records respectively. Similarly, by comparing the means and standard deviations of the data subsets used for developing these models with those of their respective 1000 year "observed" data series it was shown that at least 100 years of data is required before it can be considered representative of the long term streamflow regime.

The ARMA(1,1) models developed for both Alicedale and George were shown to successfully preserve the mean of their respective observed data series. However, the statistical characteristics of variance and skewness were not modelled well. This was attributed to the transformation used to normalize the "observed" data series. Therefore, due to the long period of data required before it becomes representative of the long term streamflow regime and because of the frequent occurrence of zero data values which present problems when normalizing the data series, ARMA models are not recommended for simulating monthly streamflows within semi-arid environments. Alternative approaches that may prove more successful include the disaggregation of annual series that should prove easier to model using ARMA models and the generation of monthly rainfall series which may be converted to flow series using deterministic rainfall-runoff models.

Chapter 7

CONCLUSION

Initially this study set out to assess the application of multiple regression type models for predicting stormflow characteristics and first order autoregressive moving-average models for modelling monthly streamflows within semi-arid environments. However, as it was found necessary to develop a computer based system for storing and processing hydrological data this aspect of hydrological modelling was also examined. To assess the performance of ARMA (1,1) streamflow models it was necessary to generate two extended streamflow records. This was done by using ARMA (1,1) type models to generate extended rainfall series which were converted to streamflow series using a deterministic rainfall-runoff model. Therefore it was appropriate to also assess this type of stochastic model for modelling monthly rainfall series in a semi-arid environment.

7.1 HYDROLOGICAL DATA PROCESSING

Before developing a computer based system for storing and processing hydrological data, the time series characteristics of hydrological data and the data requirements of the more commonly used analyses were examined. As hydrologists are generally interested in the temporal variations of hydrological processes, hydrological data often takes the form of a time series. Although, for ease of storage and processing, this type of data has often been stored at fixed time intervals, this prescription of equal time steps has serious disadvantages. The prescription of time steps that are too long may lead to a loss in detail, while time steps that are too short may cause the data series to become long and unwieldy. Therefore a truly non-interpretive data filing system, which allows the temporal spacing of data values to be varied, so that all the specific detail can be recorded as measurements become available has significant advantages. The system should also be able to accommodate the three most common modes of hydrological data: instantaneous, incremental and averaged. A third important characteristic of hydrological data is that the required information may not be measured directly, so that it is necessary to use rating equations to convert a recorded measurement into the required information. The most common example of this is the measurement of river stage which is subsequently converted by a rating equation to a record of river discharge. It should also be recognised that the form of the rating equation is often unknown for some period after the start of data collection.

After examining the characteristics of the common types of hydrological data and the requirements of the more common hydrological analysis, a computer based system, called RHODES, was developed for the Cyber 825 mainframe computer at Rhodes University. RHODES comprises a system procedure that links a number of menu selected routines for the storage and analysis of time series data. For each site a directly addressable random access file is created for the storage of time series data. Each record of these data files contains a time instant, expressed in minutes since 1850 and the corresponding process measurement. This filing system permits the use of binary search routines for the very rapid location of data at any specified time instant within a data record. Indexed sequential files were not considered because of their considerable additional storage demands. Another important advantage of using a directly addressable file structure is for the calculation of antecedent conditions when it is convenient to read data files backwards starting from the record of the time instant for which the value is required. A sequential access file is also created for each site to store information that describes the recording site and catalogues any periods of missing data. Although the system procedure file that links the Fortran V programs of RHODES is written specifically for the Cyber 825 mainframe computer at Rhodes University, the basic concepts may be readily applied to develop similar analytical packages for use in most computer environments.

7.2 MULTIPLE REGRESSION MODELLING OF STORMFLOW DISCHARGE

In 1981 Murray and Görgens reported on the development of multiple linear models for predicting the characteristics of storm discharges from the semi-arid Ecca Research Catchments. With the addition of a further seven years of data the current study re-examined the application of this technique using data for Ecca catchments A, B and E. The temporal resolution of the data used in this study has been increased from hourly data, as used by Murray and Görgens (1981), to digitized breakpoint data for streamflow and ten minute intervals of mean catchment rainfalls. A greater emphasis was also put on determining the correct duration and exponential decay used for calculating indices of antecedent precipitation.

A stepwise multiple regression routing from the Bio-Medical Processing statistical library was used to develop models for predicting stormflow volumes, durations and peaks from rainfall derived independent variables. The variables considered for these models comprised measures of total stormflow, rainfall duration, maximum and minimum ten minute rainfall intensities and a series of API values which were determined for durations of 5, 10, 15, 20, 25 30 and 35 twenty four hour periods preceding each rainfall event using exponential decay constants of 0,800; 0,900; 0,925; 0,950; 0,975 and 1,000. Although the coefficients of determination for these models were relatively high, especially for the two larger catchments, an examination of the residuals showed that both the smaller and an extremely large event were underestimated. All of the selected models were statistically significant at the 95 percent confidence level. The fine time interval data that was generated for the development of these models proved unnecessary, especially as the measures of rainfall intensity were not included in the final models. Similarly, the variable of rainfall duration was found to contribute little to these models due to its high correlation to total rainfall catch. The results suggest that by using only measures of rainstorm depth and the accumulated rainfall totals for 30 to 35 days preceding each rainfall event, one can adequately predict the modelled stormflow characteristics. An examination of the residuals for the developed models supported the decision not to transform the data used in developing these models. As the study focussed on only three catchments, it was not possible to develop a set of generated models for predicting stormflow characteristics for semi-arid catchments. However, as there was no clearly defined trend to suggest that the magnitude of the regression coefficients were directly related to catchment area or some other easily recognised catchment parameter this may not be possible. It was concluded that due to its simple application and data requirements this multiple regression is a useful hydrological tool for modelling stormflow characteristics within semi-arid environments.

7.3 AUTOREGRESSIVE MOVING-AVERAGE MODELLING OF MONTHLY RAINFALL IN A SEMI-ARID ENVIRONMENT

This section of the study assessed the performance of autoregressive moving-average type models for modelling monthly rainfalls in a semi-arid environment. Owing to the relatively short period of time for which rainfall has been recorded in the Ecca catchments, the monthly rainfall records for both Alicedale and George were adopted for this facet of the study. Both these rainfall records extend for over 100 years and are representative of semi-arid and sub-humid rainfall climates respectively. It was therefore possible to compare the relative performance of this type of stochastic model in these two rainfall regimes.

Monthly ARMA (1,1) models were developed for a number of successively longer durations of the two data records. Their comparative performances were determined by comparing the Porte Manteau lack of fit statistics for each model as well as the summary statistics for 100 year periods of synthetic data generated by each model. By assessing the performance of ARMA (1,1) type models developed for both semi-arid and sub-humid rainfall regimes, it was possible to gain an impression of some of the factors that determine the performance of these models.

A comparison of the Porte Manteau lack of fit statistics for ARMA (1,1) models developed for different duration subsets of the Alicedale and George monthly rainfall records showed the adequacy of these models to improve as the period of data used for their development was extended. Similarly, a comparison of the means and standard deviations of the data used for their development and those of the data generated by them also shows that the performance of ARMA (1,1) models improve as the period of data used for their development is increased. By incrementing the duration of the calibration periods of these models, up to 40 years in the case of Alicedale and 50 years for George, a marked improvement in the adequacy of these models could be gained. However, by using even greater durations of data, model performance improved only marginally.

The improvements in the performance of these models, as the period of calibration is increased, is attributed to both an improvement in the actual performance of the model as well as the longer data subsets becoming more representative of the longer term rainfall climates of the respective study areas. The longer period of data required for the performance of models of the George rainfall record to stabilise is attributed to the greater variability of that record. It was concluded that 40 to 50 years of data are required for the development of ARMA (1,1) type models of monthly rainfall before their performance stabilises and that this is dependent on the variability of the particular rainfall record.

7.4 AUTOREGRESSIVE MOVING-AVERAGE MODELLING OF MONTHLY STREAMFLOWS WITHIN SEMI-ARID ENVIRONMENTS

Two 1000 year synthetic streamflow records were generated as representative of that for a semi-arid and a sub-humid streamflow regime. An examination of the auto-correlation and the partial autocorrelation functions of the standardised normal variates of these streamflow series showed that they could both be modelled by first order autoregressive moving-average processes.

Monthly ARMA (1,1) models were developed for a number of successively longer durations of the two synthetic "observed" monthly streamflow records. A comparison of the Porte Manteau lack of fit statistics showed that the adequacy of the ARMA (1,1) models improved markedly as the period of data used for their development was increased up to 50 years in the case of George and 100 years for Alicedale records respectively. Similarly by comparing the means and standard deviations of the data subsets used for developing these models with those of the entire 1000 years of "observed" data it was shown that at least 100 years of data is required before it can be considered representative of the long term streamflow regime. The models developed for both the Alicedale and George "observed" series were shown to successfully preserve the monthly means, but were less able to model the variance and skewness of the "observed" data. This was attributed to the transformation used to normalize the two "observed" records.

It was concluded that due to the extended period of data required to adequately model the monthly streamflows and also because of the difficulties in normalising highly skewed data series, that ARMA (1,1) models are not the most appropriate means of simulating monthly streamflow series for semi-arid environments. A better solution to the problem of simulating monthly streamflows is to use ARMA type models for generating monthly rainfall series which are converted to streamflow records using a deterministic rainfall-runoff model. An alternative approach may be to generate annual series which may be disaggregated to provide acceptable monthly records. Both of these suggested methods involve the normalising of less skewed distributions which seem to present fewer problems.

7.5 RECOMMENDATIONS FOR FURTHER RESEARCH

The performance of the multiple regression models developed for predicting stormflow characteristics was encouraging especially when their relatively simple application and data requirements are considered. However, their usefulness is limited until the regression coefficients can be predicted for ungauged streams using some form of parameter transfer. It would therefore seem useful to examine the physiographic characteristics of as many gauged catchments within semi-arid environments as are available to determine whether a set of generalised regression models for predicting stormflow characteristics can be developed.

The major problem experienced in this study's investigation of ARMA type models stemmed from difficulties in normalising the observed data series. It is felt that if this problem can be overcome, especially for the distributions of monthly streamflow records, then ARMA type models, which are simple to develop, could become a far more useful tool for semi-arid hydrology. The other major problem experienced when developing the ARMA models of this study was the extensive periods of data required before they could be regarded as representative of the total data population. The only solution to this latter problem, which was most relevant to streamflow data, is for the continued monitoring of long term hydrological records.

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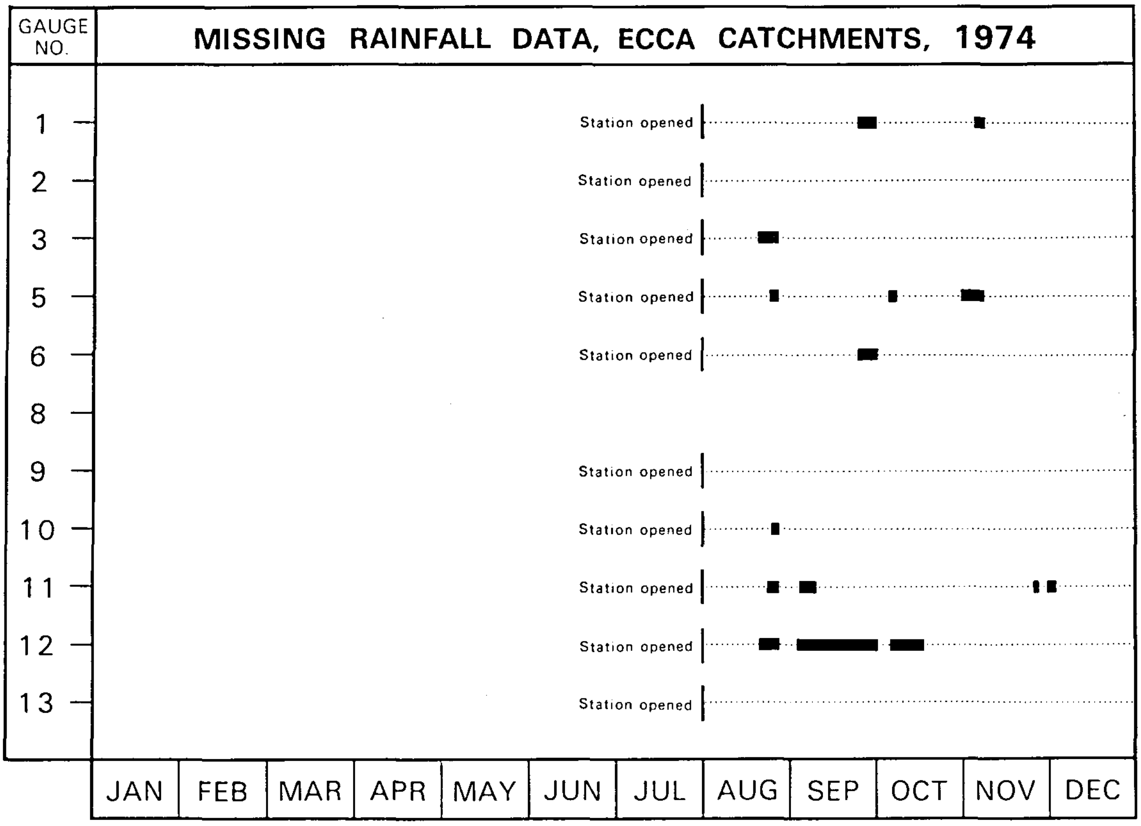
APPENDIX A

Annual plots illustrating the half day periods for which there are data missing from individual raingauge records of the Ecca research catchments.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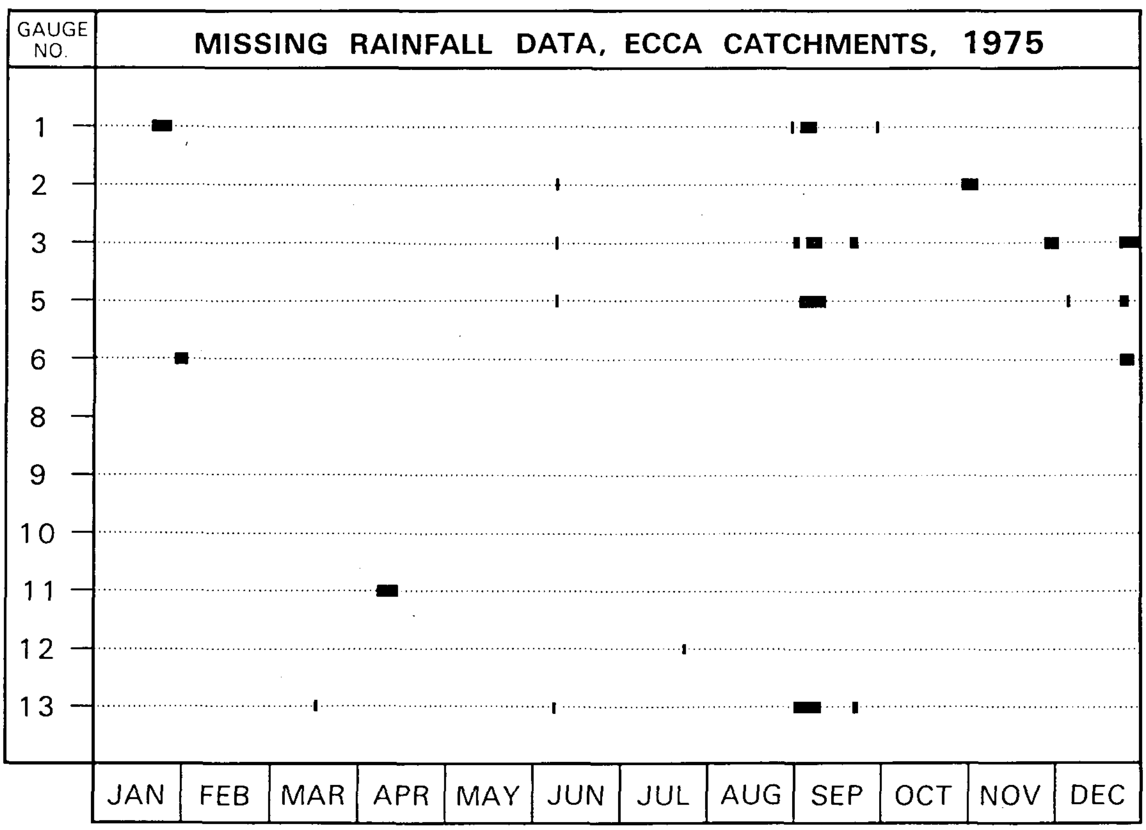
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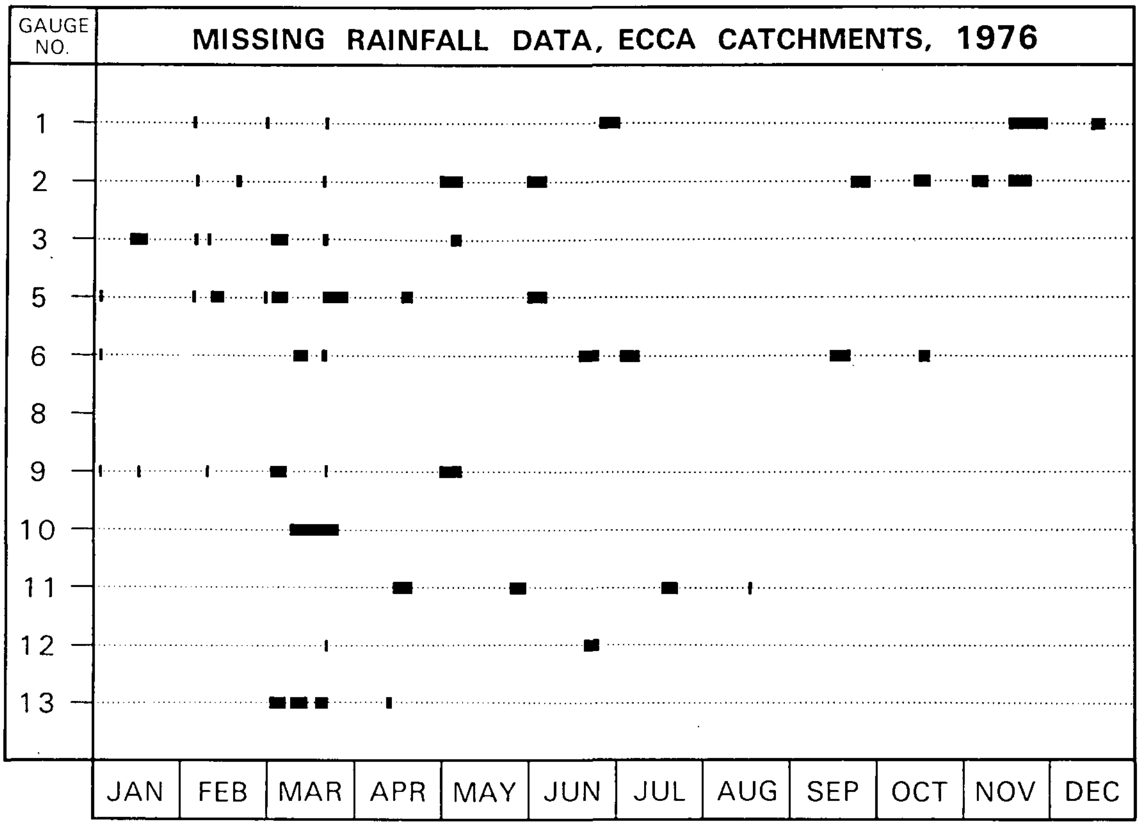
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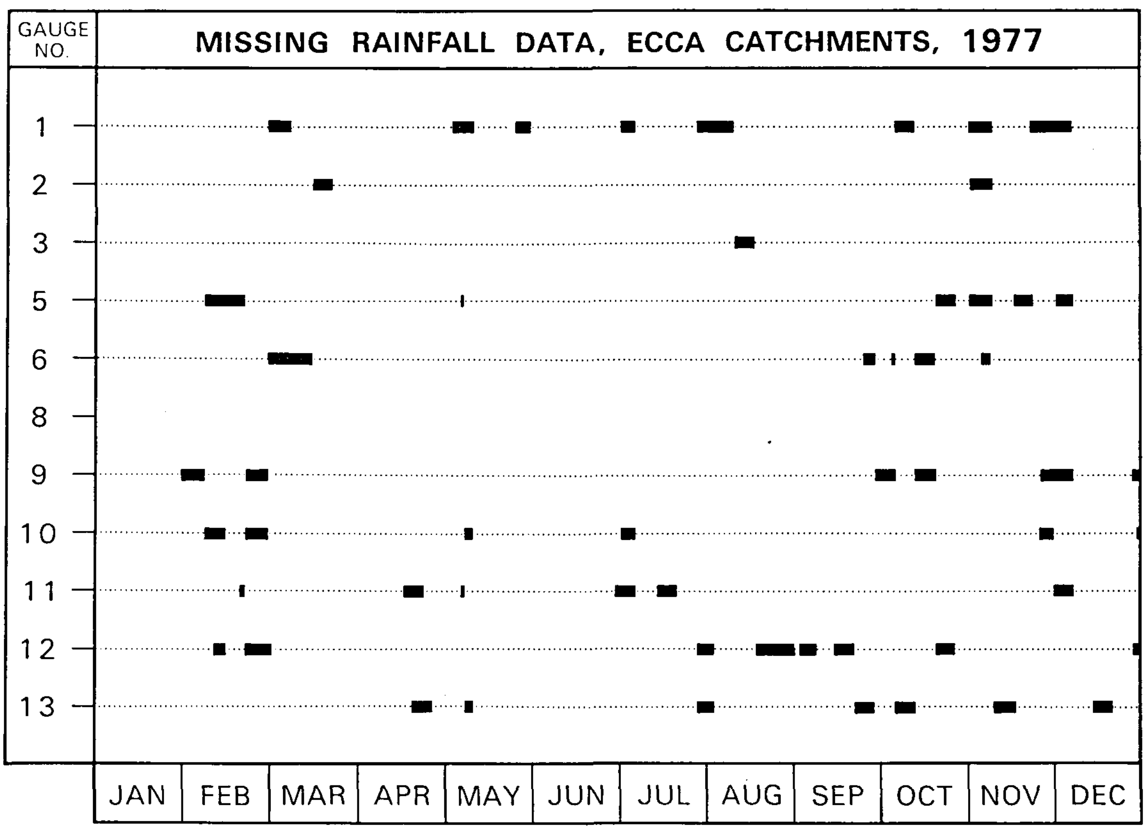
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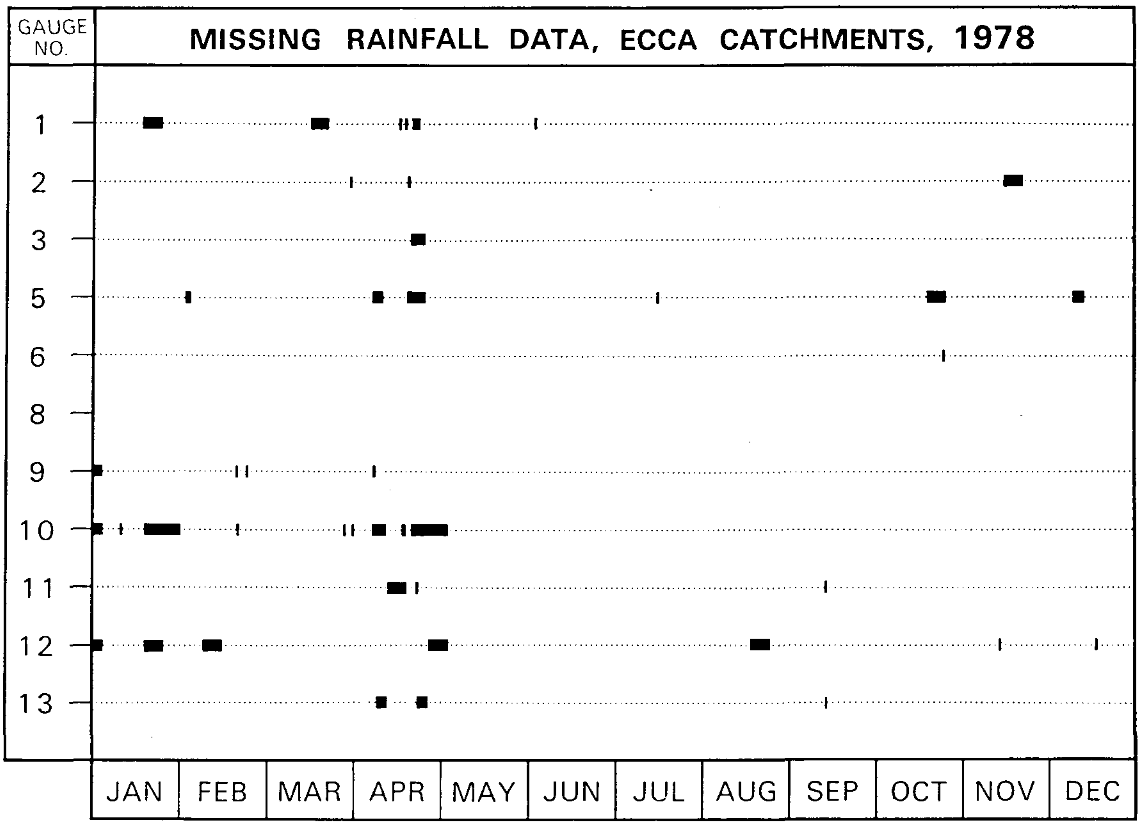
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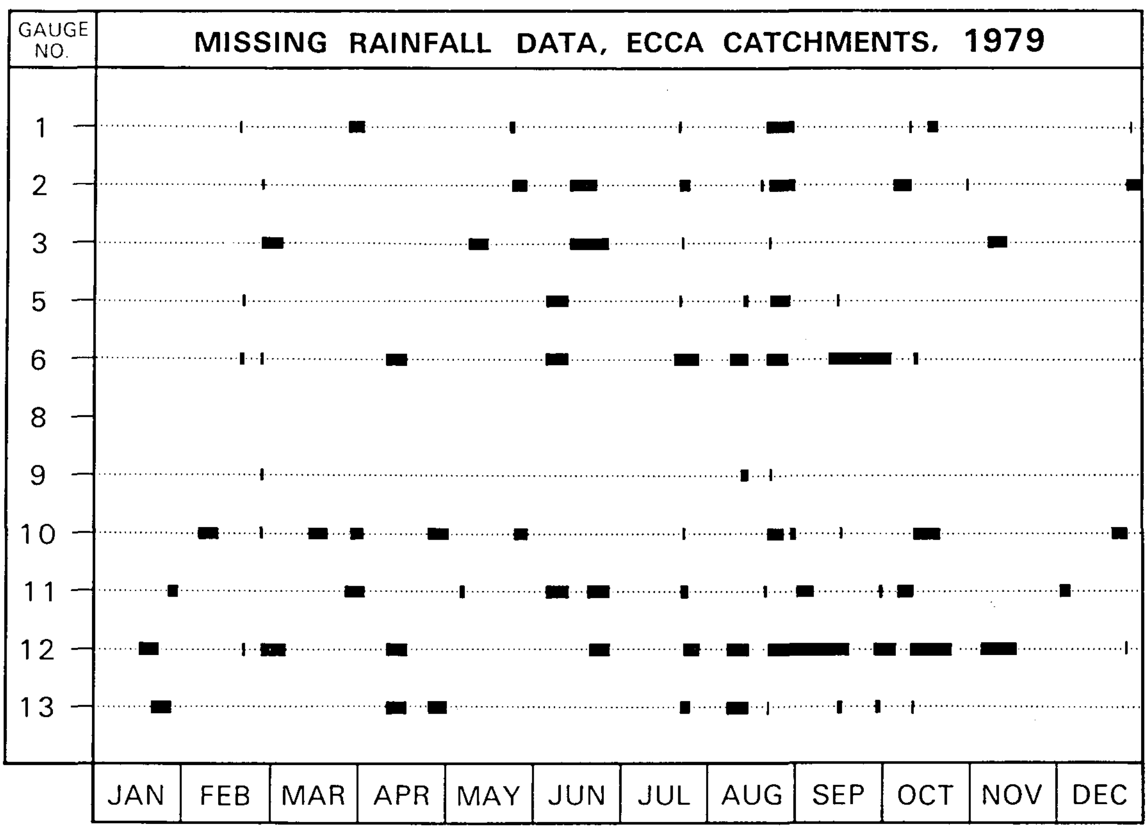
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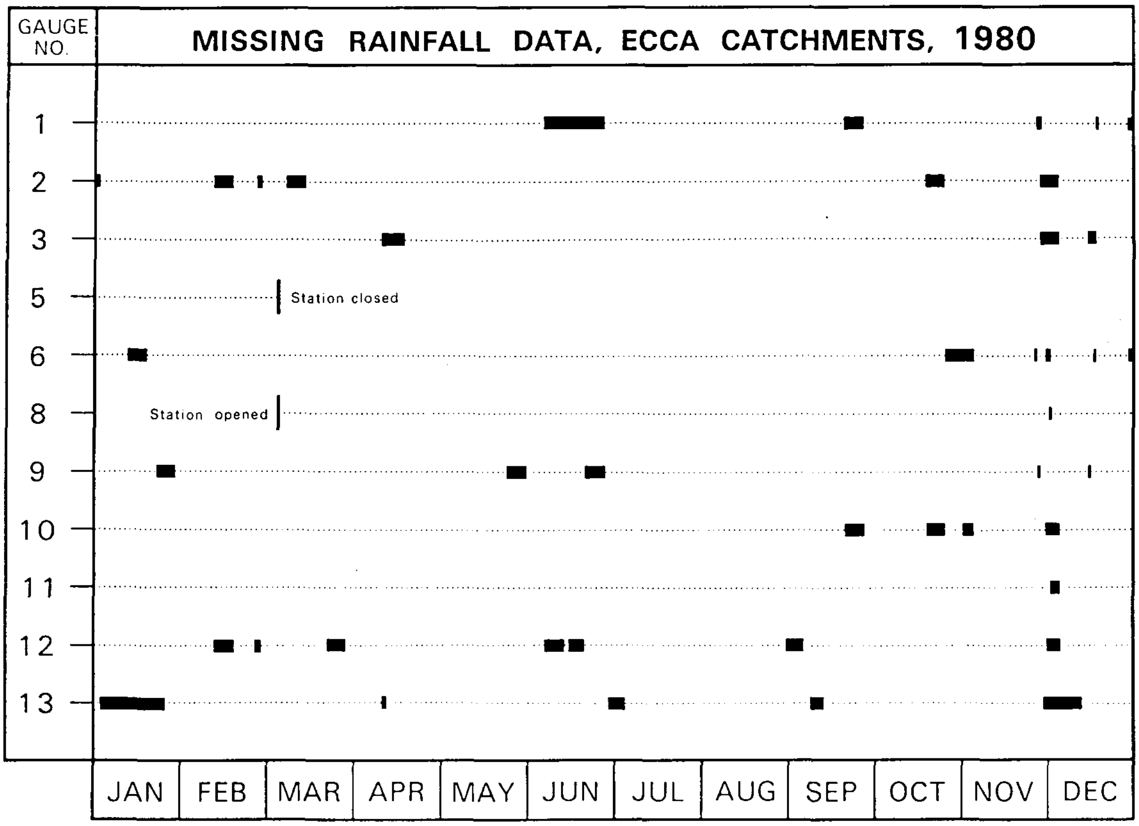
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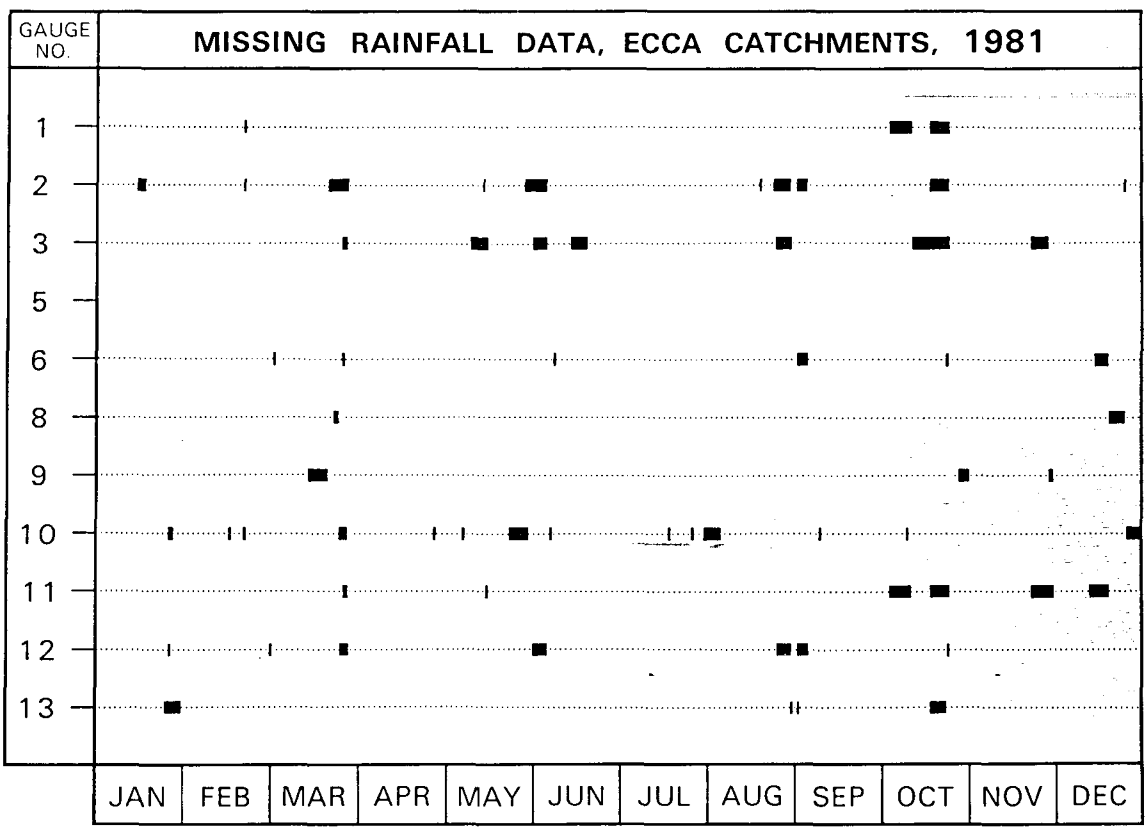
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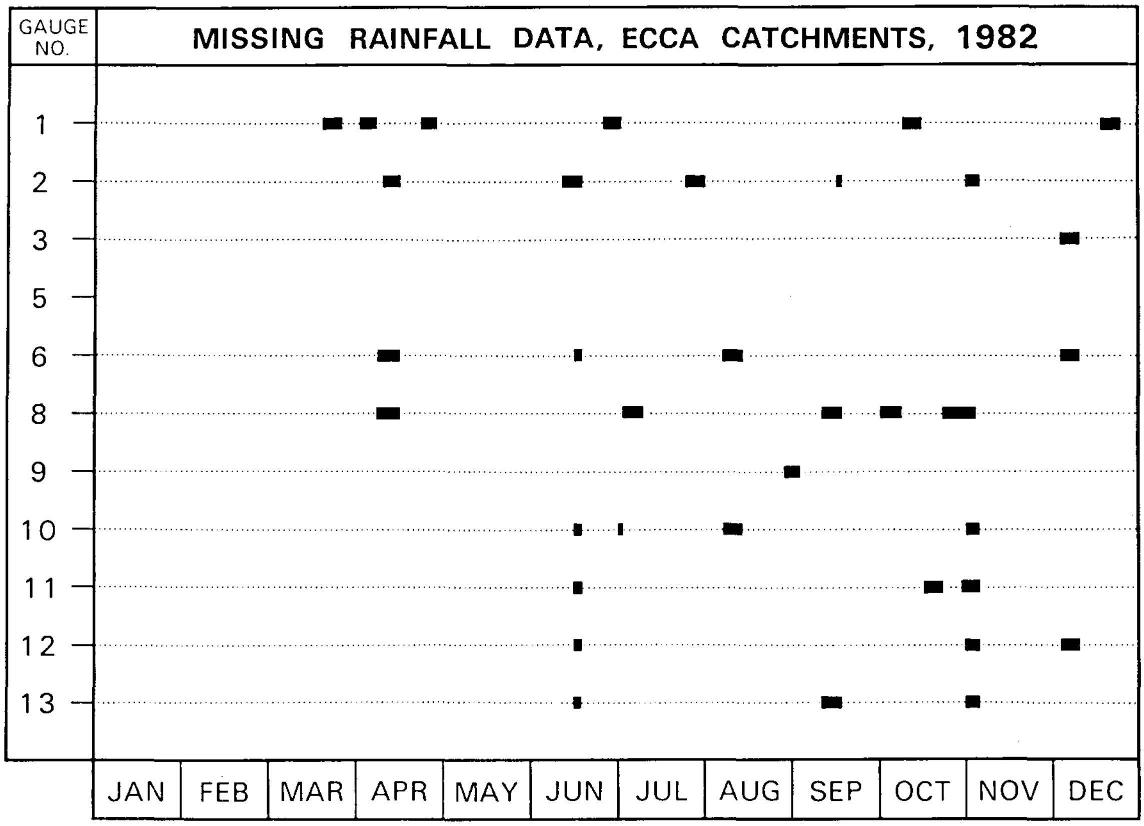
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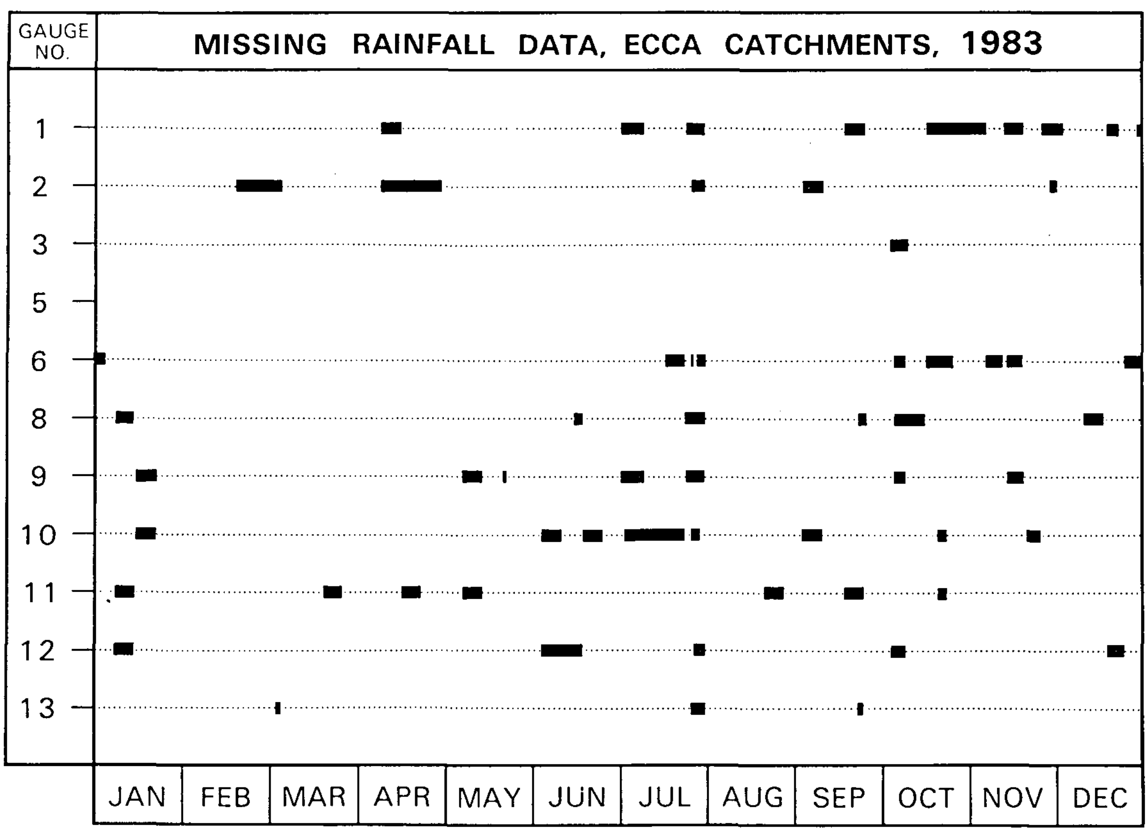
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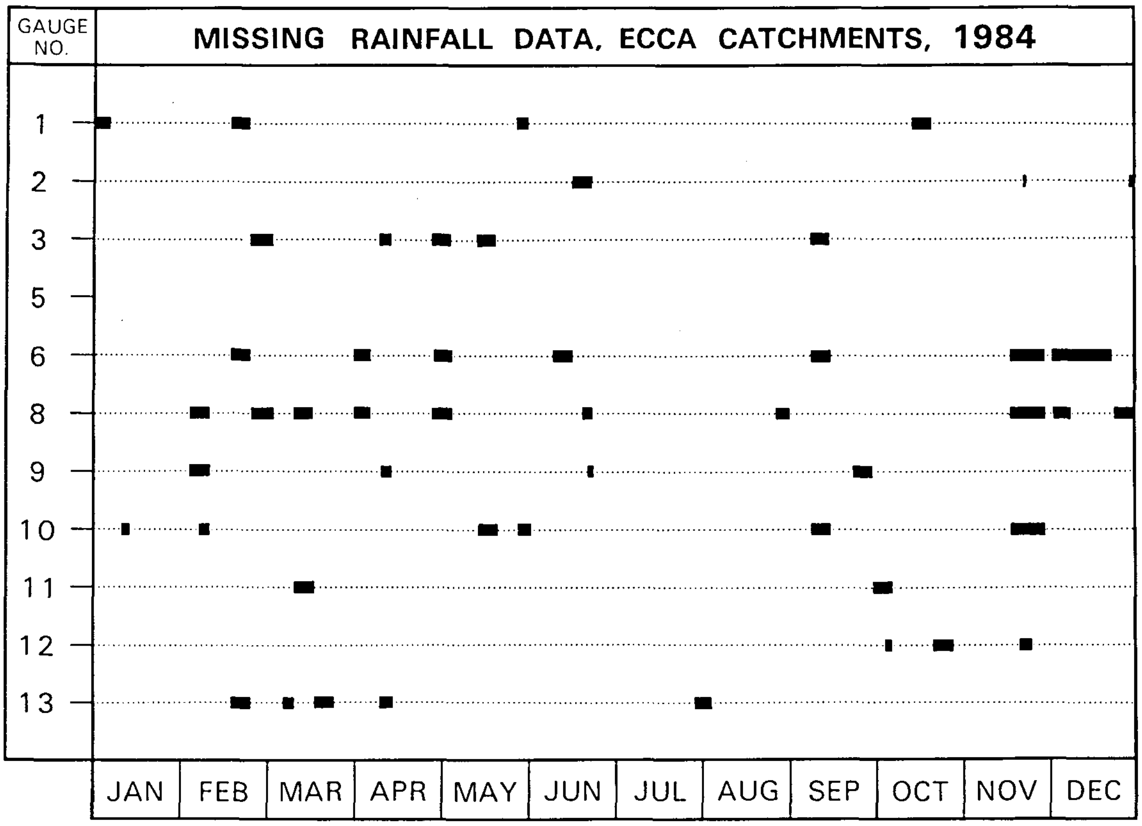
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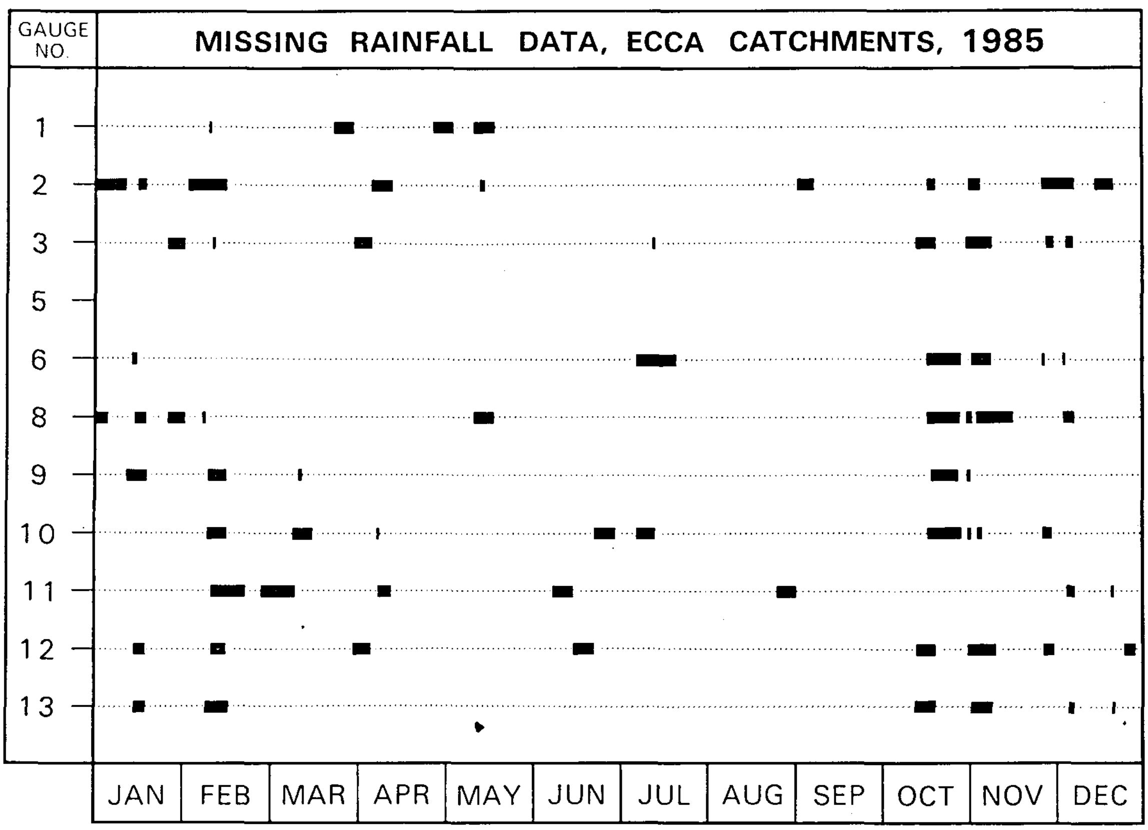
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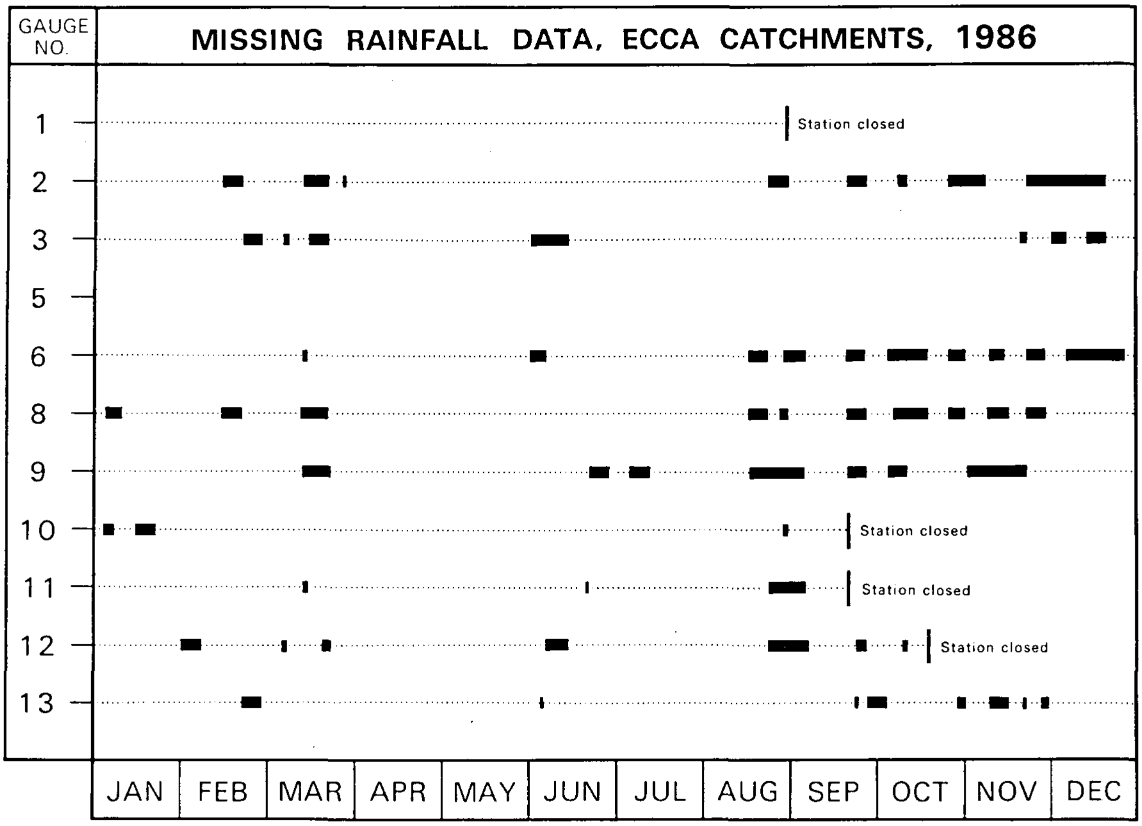
GAUGE NO.
MISSING RAINFALL DATA, ECCA CATCHMENTS, 1986
1
2
3
5
6
8
9
10
11
12
13
Station closed
Station closed
Station closed
Station closed
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

APPENDIX B

Correlations between 12 hourly simultaneous rainfall records for each of the Ecca raingauges adopted for this study.

Gauge No.	Gauge Number 1	2	3	5	6	9	10	11	12	13
1	1,0000									
2	0,8075	1,0000								
3	0,8916	0,8955	1,0000							
5	0,7642	0,8696	0,8867	1,0000						
6	0,7914	0,8595	0,8821	0,8901	1,0000					
9	0,8537	0,8923	0,9741	0,8764	0,9075	1,0000				
10	0,8518	0,8603	0,8779	0,7879	0,8136	0,8464	1,0000			
11	0,9058	0,8240	0,7912	0,7448	0,7914	0,8686	0,9390	1,0000		
12	0,8879	0,8809	0,9379	0,8425	0,8324	0,9329	0,8828	0,8341	1,0000	
13	0,7797	0,8829	0,8275	0,7486	0,7953	0,8394	0,8781	0,8141	0,8308	1,0000

Table B:1 Correlation between 12 hourly rainfalls as recorded by raingauges in the Ecca Catchments for the period 1975 to 1980.

Gauge No.	Gauge Number 1	2	3	5	6	9	10	11	12	13
1	1,0000									
2	0,8650	1,0000								
3	0,9075	0,8952	1,0000							
6	0,8790	0,8823	0,8832	1,0000						
8	0,8421	0,8374	0,8574	0,8663	1,0000					
9	0,8167	0,8866	0,9191	0,9321	0,8466	1,0000				
10	0,7782	0,8895	0,7852	0,8197	0,7614	0,8148	1,0000			
11	0,9183	0,8727	0,8772	0,8284	0,8134	0,7383	0,8181	1,0000		
12	0,8886	0,8974	0,8893	0,9024	0,8360	0,8996	0,8780	0,8290	1,0000	
13	0,7597	0,8723	0,7981	0,7953	0,7550	0,7814	0,8207	0,7918	0,7860	1,0000

Table B:1 Correlation between 12 hourly rainfalls as recorded by raingauges in the Ecca Catchments for the period 1981 to 1986.

APPENDIX C

Ecca catchments - Thiessen raingauge weightings and order of raingauge replacements.

Table C:1 Thiessan Gauge Weightings and gauge replacements for Ecca Catchment A (1975 - 1981).

GAUGE NO.	WEIGHTING	GAUGE REPLACEMENTS 1	2	3	4	5	6	7	8	9
ECCA01	0.0600	11	3	12	9	10	2	6	13	5
ECCA02	0.1105	3	9	13	12	5	10	6	11	1
ECCA03	0.0518	9	12	2	1	5	6	10	3	11
ECCA05	0.1465	6	3	9	5	12	10	1	13	11
ECCA06	0.1515	9	5	3	2	12	10	13	11	1
ECCA09	0.0886	3	12	6	2	5	11	1	10	13
ECCA10	0.1383	11	12	13	3	2	1	9	6	5
ECCA11	0.0900	10	1	9	12	2	13	6	3	5
ECCA12	0.0792	3	9	1	10	2	5	6	11	13
ECCA13	0.0836	2	10	9	12	3	11	6	1	5

Table C:2 Thiessan gauge weightings and gauge replacements for Ecca Catchment A (1981 - 1986).

GAUGE NO.	WEIGHTING	GAUGE REPLACEMENTS 1	2	3	4	5	6	7	8	9
ECCA01	0.0595	11	3	12	6	2	8	9	10	13
ECCA02	0.1166	12	3	10	9	6	11	13	1	8
ECCA03	0.0562	9	1	2	12	6	11	8	13	10
ECCA06	0.1530	9	12	3	2	1	8	11	10	13
ECCA08	0.1267	6	3	9	1	2	12	11	10	13
ECCA09	0.0866	6	3	12	2	8	1	10	13	11
ECCA10	0.1241	2	12	13	6	11	9	3	1	8
ECCA11	0.0918	1	3	2	12	6	10	8	13	9
ECCA12	0.1111	6	9	2	3	1	10	8	11	12
ECCA13	0.0744	2	10	3	6	11	12	9	1	8

Table C:3 Thiessan gauge weightings and gauge replacements for Ecca Catchment B (1975 - 1981).

GAUGE NO.	WEIGHTING	GAUGE REPLACEMENTS 1	2	3	4	5	6	7	8	9
ECCA02	0.6136	3	9	13	12	5	10	6	11	1
ECCA05	0.3503	6	3	9	5	12	10	1	13	11
ECCA06	0.0361	9	5	3	2	12	10	13	11	1

Table C:4 Thiessan gauge weightings and gauge replacements for Ecca Catchment B (1981 - 1986).

GAUGE NO.	WEIGHTING	GAUGE REPLACEMENTS 1	2	3	4	5	6	7	8	9
ECCA02	0.5650	12	3	10	9	6	11	13	1	8
ECCA06	0.3681	9	12	3	2	1	8	11	10	13
ECCA08	0.0669	6	3	9	1	2	12	11	10	13

Table C:5 Thiessan gauge weightings and gauge replacements for Ecca Catchment E (1975 - 1981).

GAUGE NO.	WEIGHTING	GAUGE REPLACEMENTS 1	2	3	4	5	6	7	8	9
ECCA02	0.0581	9	5	3	2	12	10	13	11	1
ECCA10	0.4436	11	12	13	3	2	1	9	6	5
ECCA11	0.1800	10	1	9	12	2	13	6	3	5
ECCA12	0.0872	3	9	1	10	2	5	6	11	13
ECCA13	0.2619	2	10	9	12	3	11	6	1	5

Table C:6 Thiessan gauge weightings and gauge replacements for Ecca Catchment E (1981 - 1986).

GAUGE NO.	WEIGHTING	GAUGE REPLACEMENTS 1	2	3	4	5	6	7	8	9
ECCA02	0.0250	12	3	10	9	6	11	13	1	8
ECCA08	0.0022	6	3	9	1	2	12	11	10	13
ECCA10	0.3862	2	12	13	6	11	9	3	1	8
ECCA11	0.1857	1	3	2	12	6	10	8	13	9
ECCA12	0.1653	6	9	2	3	1	10	8	11	12
ECCA13	0.2356	2	10	3	6	11	12	9	1	8

RAINFALL-RUNOFF DATA FOR ECCA CATCHMENT A

DATE	STORMFLOW PARAMETERS				RAINFALL PARAMETERS				API VALUES DETERMINED FOR DIFFERENT LAGS (NO. OF 24 HOUR PERIODS PRECEDING EVENT)						
	PEAK ($M^3.S^{-1}$)	TOTAL (M^3)	Q-FLOW (M^3)	DUR. (MINS)	DUR. (MINS)	TOTAL INT.*	MAX INT.*	MEAN INT.*	5	10	15	20	25	30	35
760321	0.251	0.0430	0.0147	321	1110	11.08	0.60	2.10	20.92	26.00	53.37	89.29	89.64	94.77	95.75
760321	6.455	5.4347	3.9668	2310	2200	46.39	1.27	5.82	32.00	37.08	64.45	85.02	100.37	105.85	106.81
760329	0.342	0.1115	0.5511	453	410	14.88	2.18	10.32	0.28	63.64	79.03	101.17	111.12	147.04	147.41
770227	0.273	0.0482	0.0287	266	110	28.76	15.69	36.06	0.88	22.07	46.15	72.15	80.47	87.01	82.77
770228	1.074	0.4530	0.2946	759	800	27.13	2.03	21.12	29.65	50.83	50.86	100.92	108.89	109.24	111.54
770306	2.720	0.6186	0.4767	719	240	5.06	1.27	11.46	5.11	61.89	75.37	83.10	132.65	139.00	141.48
770507	1.169	0.4788	0.2658	880	1900	52.44	1.66	28.98	8.47	8.47	47.09	47.75	56.19	59.89	60.81
771201	0.352	0.0598	0.0350	300	110	17.48	9.53	32.28	14.04	44.01	45.35	45.96	59.15	76.90	80.99
780110	0.360	0.0548	0.0342	274	320	18.79	3.52	34.92	2.77	26.26	92.54	94.87	95.06	95.46	95.91
780110	0.425	0.1505	0.0670	551	430	6.10	0.85	10.14	21.55	34.01	110.86	113.64	113.83	114.25	114.63
780420	0.410	0.0907	0.0530	370	1920	48.03	1.50	8.76	7.36	8.06	21.54	30.37	44.97	47.44	47.44
780421	2.147	1.3317	0.8986	1255	910	36.99	2.44	23.70	55.39	55.48	69.57	69.65	82.69	93.49	95.47
790228	0.173	0.0242	0.0121	210	520	24.62	2.84	25.08	25.70	60.73	60.98	62.86	68.35	69.14	73.17
790721	28.502	24.3202	21.5236	3189	3080	167.00	2.96	25.62	0.53	0.65	1.31	4.94	7.14	7.14	7.16
790723	10.430	8.5755	5.6213	2109	1600	27.09	1.02	5.64	167.90	168.45	168.55	169.21	172.84	175.04	175.04
790820	32.482	39.2482	32.5535	4934	3690	113.04	1.15	10.26	4.59	11.04	11.04	11.05	11.10	117.44	206.55
790826	1.790	0.9731	0.2102	744	160	5.80	2.18	8.34	25.83	117.65	119.91	124.10	124.11	124.13	152.08
801129	0.147	0.0163	0.0072	182	1040	36.58	2.11	57.00	11.72	12.46	14.26	15.03	18.82	20.29	21.22
801130	0.121	0.0131	0.0052	170	570	22.86	2.41	21.96	44.24	48.48	49.30	51.61	53.11	56.83	57.80
801201	0.359	0.1065	0.0341	513	970	20.11	1.24	26.52	60.62	71.20	72.15	74.47	75.97	78.54	80.66
810325	0.251	0.0371	0.0193	254	2150	46.72	1.30	9.60	16.10	17.05	17.05	17.05	40.30	45.03	49.76
810326	0.564	0.1232	0.0710	436	730	23.69	1.95	8.88	62.82	62.85	63.77	63.77	86.94	91.75	95.17
810326	0.512	0.1861	0.1088	530	850	4.21	0.30	1.50	86.51	86.55	87.48	87.48	101.41	114.84	118.88
811022	1.742	0.9703	0.7072	978	690	43.51	3.78	59.10	0.05	15.16	15.36	16.62	16.62	16.62	16.62
811026	0.274	0.0473	0.0277	267	270	16.33	3.63	18.36	44.42	54.75	59.56	59.76	61.00	61.00	61.00
811223	0.668	0.1105	0.0827	318	810	35.01	2.59	75.06	0.16	2.75	15.27	19.07	22.29	33.51	44.47
831003	0.226	0.0375	0.2102	245	1390	35.29	1.52	14.46	0.83	6.35	22.23	22.24	32.97	32.97	32.97
850204	0.116	0.0126	0.0069	144	320	10.22	1.92	19.86	16.72	20.94	20.94	23.53	47.75	48.57	48.79
850208	0.112	0.0117	0.0056	149	2020	11.41	0.34	3.48	34.64	39.83	39.83	39.83	66.39	66.64	64.67
850210	0.191	0.0284	0.0150	221	2110	25.40	0.72	6.42	30.32	47.04	51.25	51.25	55.04	78.06	78.88
850301	0.072	0.0046	0.0015	107	120	3.77	1.89	13.44	13.33	14.61	20.94	34.12	67.44	93.42	98.60
851016	0.179	0.0248	0.0129	208	1640	55.29	2.02	9.42	14.57	16.91	17.04	17.15	17.17	17.23	17.29
851030	0.436	0.0736	0.0491	299	2720	40.79	0.90	8.64	6.28	6.30	71.20	76.16	78.50	78.65	78.72
851101	13.330	13.5520	10.1291	3528	1340	47.90	2.14	10.32	64.22	70.45	70.60	139.84	140.47	142.70	142.84
851104	5.362	5.2663	0.4651	775	1520	3.94	0.16	1.32	111.81	118.41	118.43	179.06	188.29	190.63	190.78
851125	13.057	10.2205	8.4962	2504	1210	48.54	2.41	24.06	3.61	6.36	6.42	20.63	89.16	144.49	144.59
851203	5.722	10.8422	6.2118	2874	2360	19.25	0.49	5.22	11.48	60.23	66.42	66.46	79.69	97.89	198.41
851206	1.578	0.9955	0.1767	789	1720	7.55	0.26	7.50	30.79	79.39	83.02	85.77	85.83	100.03	168.48
851208	1.605	0.8952	0.1871	699	470	9.99	1.28	4.32	25.61	39.58	88.24	94.52	94.56	107.77	117.64
851224	0.427	0.1603	0.0515	629	750	14.72	1.18	18.54	20.95	27.38	27.55	46.24	76.93	125.56	129.17

* Intensity in $mm.hr^{-1}$

RAINFALL-RUNOFF DATA FOR ECCA CATCHMENT B

DATE	PEAK	TOTAL	Q-FLOW	DUR	DUR	TOTAL	MEAN	MAX.	API VALUES DETERMINED FOR DIFFERENT LAGS (NO. OF 24 HOUR PERIODS PRECEDING EVENT)						
	STORMFLOW PARAMETERS				RAINFALL PARAMETERS										
	($M^3.S^{-1}$)	(M3)	(M3)	(MINS)	(MINS)	INT.*	INT.*	INT.*	5	10	15	20	25	30	35
760103	0.016	0.0064	0.0046	82	280	22.83	4.89	52.20	3.09	7.95	29.45	44.51	44.51	58.60	60.91
760109	0.854	0.1905	0.1797	198	180	11.18	3.73	32.10	0.00	26.16	31.07	51.73	55.33	67.63	81.72
760206	0.043	0.0385	0.2765	199	750	23.79	1.90	12.96	15.21	17.04	18.93	33.21	39.15	50.28	73.41
760210	0.009	0.0044	0.0017	99	820	10.85	0.79	3.30	41.52	45.17	48.45	56.39	63.19	69.30	80.24
760302	0.020	0.0107	0.0070	117	780	15.47	1.19	5.76	15.26	15.81	21.05	21.46	63.04	78.25	81.15
760321	0.128	0.1450	0.0992	408	1100	15.34	0.84	3.12	20.12	23.72	51.86	82.59	83.14	88.38	88.38
760321	1.055	5.4509	4.1880	2143	2200	63.59	1.73	38.10	35.46	39.06	67.20	86.20	97.93	103.72	103.72
760328	0.045	0.0606	0.0385	283	410	15.08	2.21	9.48	0.41	85.65	99.75	121.18	131.20	161.93	162.48
770227	0.857	0.5050	0.4694	360	110	37.30	20.35	52.26	0.79	20.38	43.87	71.05	77.05	78.60	78.88
770228	0.840	1.0962	0.8485	949	600	24.90	2.49	17.28	38.09	57.68	57.68	108.35	112.70	114.50	116.15
770306	1.368	0.4664	0.4226	399	240	5.71	1.43	18.24	5.56	68.55	80.45	88.14	138.56	142.47	144.96
770423	0.058	0.0479	0.0361	207	440	36.87	5.03	37.86	0.00	10.08	15.11	16.28	17.81	17.81	18.53
770507	1.239	2.0406	1.6272	1226	1890	65.00	2.06	34.44	10.06	10.0 6	61.34	62.54	71.69	77.15	78.72
771126	0.035	0.0248	0.0161	178	580	33.52	3.47	46.74	0.00	1.94	2.56	17.22	37.64	39.90	39.90
771201	0.683	0.4758	0.4419	351	100	23.44	14.06	71.94	15.29	46.50	48.44	49.06	63.72	81.28	86.40
771230	0.129	0.1779	0.1300	417	2390	67.18	1.69	17.82	1.95	1.95	2.01	2.26	3.46	36.16	73.76
780109	0.304	0.1248	0.1114	220	290	18.87	3.90	36.36	3.74	21.09	88.44	89.95	89.95	90.26	91.30
780110	0.008	0.0040	0.0019	64	410	2.26	0.33	3.24	22.61	30.05	107.31	108.82	108.82	109.13	109.85
780420	0.104	0.1298	0.0877	391	1850	44.94	1.46	10.20	7.80	8.69	19.88	29.06	44.56	46.81	46.81
780421	0.438	1.2000	0.9288	993	900	38.69	2.58	29.04	52.74	52.77	64.82	64.90	78.60	90.05	91.75
781102	0.026	0.0188	0.0116	162	1080	21.20	1.18	25.98	0.97	23.39	26.61	39.76	41.19	85.84	86.02
790221	0.012	0.0072	0.0030	123	990	34.68	2.10	22.02	0.39	2.31	2.93	6.24	7.78	12.00	31.19
790228	0.279	0.1427	0.1298	217	420	27.01	3.86	51.00	14.66	49.72	49.90	51.64	55.57	56.36	61.33
790720	3.652	26.2080	22.6261	3609	2180	130.89	3.60	23.58	0.45	0.62	1.62	7.11	8.97	8.97	8.97
790724	1.631	13.1667	10.5171	3104	1570	28.27	1.08	4.86	161.75	162.20	162.38	163.37	168.86	170.72	170.72
790810	0.022	0.0275	0.0142	220	580	4.52	0.47	3.18	0.00	0.03	0.07	55.92	190.02	190.52	191.64
790820	2.045	33.3893	26.0331	5172	2730	96.27	2.12	10.02	4.53	12.20	12.20	12.23	12.28	172.76	202.67
790826	0.257	1.6483	0.9978	1538	150	5.68	2.27	9.00	27.75	112.94	116.09	120.61	120.64	120.68	149.60
790831	0.107	0.6004	0.3358	981	450	8.37	1.12	6.96	1.50	29.26	118.63	121.78	126.30	126.33	126.37
800321	0.003	0.0005	0.0002	33	100	6.62	3.97	18.66	0.03	2.85	10.87	14.53	37.21	42.00	42.77
801201	0.241	0.0918	0.0828	181	506	14.48	1.55	16.50	19.44	21.78	22.11	23.95	24.69	26.04	27.33
801201	0.151	0.1983	0.1477	429	960	15.06	0.94	22.68	28.09	36.19	36.59	38.43	39.17	39.90	41.81
810302	0.003	0.0007	0.0036	36	260	13.80	3.18	19.20	10.72	12.08	13.12	15.77	15.98	18.63	21.37
810325	0.118	0.0943	0.0784	241	2140	44.82	1.26	12.78	12.54	14.54	14.54	14.54	36.47	39.07	41.46
810326	0.205	0.1605	0.1367	294	710	23.44	1.98	12.60	57.36	57.42	59.36	59.36	81.24	83.88	85.24
810326	0.109	0.1661	0.1203	408	810	3.37	0.25	1.86	80.79	80.84	82.81	82.81	96.61	107.33	108.69
810530	0.059	0.0392	0.0305	178	1250	19.88	0.95	5.34	20.00	20.00	20.00	36.91	40.97	41.15	47.78

* Intensity in $mm.hr^{-1}$

RAINFALL-RUNOFF DATA FOR ECCA CATCHMENT B(CONT.)

DATE	STORMFLOW PARAMETERS PEAK ($M^3.S^{-1}$)	TOTAL (M3)	Q-FLOW (M3)	DUR (MINS)	RAINFALL PARAMETERS DUR (MINS)	TOTAL INT.*	MEAN INT.*	MAX. INT.*	API VALUES DETERMINED FOR DIFFERENT LAGS (NO. OF 24 HOUR PERIODS PRECEDING EVENT) 5	10	15	20	25	30	35
810828	0.015	0.0078	0.0047	107	2230	22.09	0.59	5.46	14.59	15.41	22.12	22.50	22.58	22.60	22.61
810829	0.010	0.0049	0.0020	102	320	5.14	0.96	3.06	22.67	36.70	42.33	44.61	44.61	44.69	44.72
810831	0.039	0.0186	0.0140	129	2040	15.22	0.45	6.24	29.81	44.40	49.98	52.27	52.31	52.39	52.42
811026	0.036	0.4424	0.3463	591	200	16.01	4.80	18.60	43.31	49.49	56.81	57.16	58.51	58.51	58.51
811223	0.508	0.3271	0.2972	330	810	31.23	2.31	69.60	0.04	3.50	14.84	18.78	22.20	32.31	45.38
820615	0.024	0.0158	0.0101	143	850	34.58	2.44	6.06	0.39	6.75	6.75	6.75	6.75	6.75	6.75
821205	0.028	0.0070	0.0052	81	660	9.02	0.82	19.08	2.14	2.37	2.41	32.58	32.58	32.64	44.38
830724	0.061	0.0286	0.0239	131	3700	71.09	1.15	5.88	0.01	0.40	0.60	1.48	1.48	3.00	3.00
830727	0.058	0.0249	0.0192	144	710	4.22	0.36	2.52	71.16	71.55	71.57	71.82	72.63	73.51	74.15
830727	0.042	0.0839	0.0462	370	530	4.29	0.49	4.50	75.53	75.53	75.92	76.18	77.00	77.81	78.52
831003	0.184	0.0794	0.0711	174	1350	31.06	1.38	18.36	0.96	6.38	21.70	21.71	31.58	31.58	31.58
831112	0.115	0.0435	0.0393	124	720	12.85	1.07	8.58	2.93	9.42	9.42	14.25	14.35	23.41	27.25
831120	0.003	0.0006	0.0003	34	740	10.53	0.85	7.80	9.13	21.93	28.94	31.35	31.35	36.18	43.75
840620	0.006	0.0012	0.0006	45	730	30.77	2.53	11.28	1.31	7.07	7.07	7.12	10.13	10.13	11.21
850208	0.050	0.0191	0.0153	117	1650	11.71	0.43	9.78	31.62	47.30	47.31	47.31	74.17	74.36	75.84
850210	0.085	0.0474	0.0387	178	2110	22.72	0.65	6.42	38.61	53.56	59.01	59.01	63.34	86.07	87.36
850302	0.127	0.0242	0.0217	95	110	3.77	2.06	17.04	13.26	14.32	21.12	33.92	66.32	99.11	105.04
850314	0.043	0.0092	0.0080	68	420	13.61	1.94	12.96	6.22	72.59	15.96	24.81	27.03	32.25	68.72
850422	0.008	0.0019	0.0008	63	780	15.38	1.18	11.28	2.47	2.94	20.70	21.14	21.31	23.23	23.23
851015	0.049	0.0303	0.0224	169	670	5.10	0.46	5.40	9.86	12.53	12.53	12.53	12.53	12.53	12.64
851015	0.112	0.1399	0.1056	353	1640	50.34	1.84	10.44	14.96	17.63	17.63	17.63	17.63	17.63	17.74
851030	0.123	0.0616	0.0534	173	710	7.24	0.61	4.68	5.88	5.88	62.19	71.18	73.85	73.85	73.85
851030	0.232	0.1210	0.1053	239	1520	34.55	1.36	10.50	13.12	13.12	65.27	78.42	81.09	81.09	81.09
851101	0.133	0.1287	0.0952	349	790	13.46	1.02	5.58	57.59	59.45	59.65	124.75	124.75	127.42	127.42
851102	1.582	16.2319	13.5114	3144	1290	49.50	2.30	15.30	67.47	73.12	73.28	137.91	138.42	141.09	141.09
851203	1.123	12.8486	8.8357	3820	1840	8.11	0.26	2.70	3.16	54.18	59.36	59.38	73.63	87.36	192.95
851206	0.514	4.5662	2.3840	2817	310	5.21	1.01	10.68	11.81	11.81	63.14	68.01	68.09	82.98	138.02
851219	0.160	0.9961	0.5463	1279	1060	24.87	1.41	13.32	5.45	5.57	23.03	34.68	85.30	89.01	90.88
851224	0.132	0.5903	0.3680	899	710	13.44	1.14	21.18	24.61	32.67	32.79	50.24	61.90	112.52	116.23
860104	0.292	1.2504	0.7380	1365	1600	31.85	1.19	19.56	0.00	10.94	30.54	46.11	46.12	63.68	75.34

* Intensity in $mm.hr.^{-1}$

RAINFALL-RUNOFF DATA FOR ECCA CATCHMENT E

DATE	STORMFLOW PARAMETERS				RAINFALL PARAMETERS				API VALUES DETERMINED FOR DIFFERENT LAGS (NO. OF 24 HOUR PERIODS PRECEDING EVENT)						
	PEAK ($M^3.S^{-1}$)	TOTAL (M3)	Q-FLOW (M3)	DUR (MINS)	DUR (MINS)	TOTAL INT.*	MEAN INT.*	MAX. INT.*	5	10	15	20	25	30	35
760321	1.090	2.3680	1.7525	1496	2200	45.21	1.23	7.92	35.07	39.73	76.36	97.88	118.90	125.92	128.87
770507	0.572	0.3004	0.2368	481	1900	58.99	1.86	20.94	9.40	9.40	51.47	51.85	61.78	65.73	66.93
780203	0.556	0.0079	0.0058	87	270	22.49	5.00	29.40	4.13	30.20	32.59	32.64	53.56	57.10	104.28
790721	7.682	14.5215	12.4448	2748	3070	174.50	3.15	25.80	0.67	0.94	1.98	5.88	8.24	8.24	8.28
790723	3.089	8.8345	6.7259	2769	1600	26.49	0.99	6.78	176.10	176.81	177.04	178.07	181.97	184.33	184.33
790820	4.637	21.6632	14.6944	5034	3530	124.03	1.75	10.98	4.97	11.20	11.20	11.20	11.31	183.35	214.42
790826	0.626	2.0415	1.3037	1638	150	6.28	2.51	8.46	28.87	129.46	132.54	135.69	135.69	135.76	163.48
790901	0.230	0.5249	0.2865	938	1110	6.95	0.38	5.52	8.17	14.60	143.89	145.12	150.12	150.12	150.12
790915	0.113	0.1445	0.0716	515	1000	26.53	1.59	13.68	0.06	0.79	9.83	17.16	43.22	152.81	155.89
801130	0.234	0.0383	0.0333	135	570	24.43	2.57	26.64	55.63	61.28	61.96	65.38	66.42	69.39	71.09
810326	0.015	0.0017	0.0004	69	730	23.76	1.95	8.70	63.49	63.55	65.21	65.21	93.63	100.70	106.51
811026	0.067	0.0299	0.0181	207	210	23.00	6.57	29.10	42.68	50.57	59.61	59.95	61.74	61.74	61.74
831003	0.057	0.0273	0.0145	216	1870	35.39	1.14	15.72	0.35	6.73	22.32	22.32	33.42	33.42	33.42
851101	0.165	0.2596	0.1090	740	1080	14.98	0.76	6.78	45.48	48.17	48.37	117.73	118.37	120.76	120.95
851102	2.090	7.2173	5.6674	2374	1330	46.17	2.08	11.40	56.56	63.24	63.40	132.17	133.31	135.70	136.00
851104	0.321	0.6414	0.3840	966	960	3.99	0.25	1.56	85.96	110.41	110.41	167.13	180.00	182.75	183.02
851110	0.385	0.0160	0.0083	167	3120	15.71	0.30	5.34	8.81	108.42	115.12	115.12	180.59	184.75	187.52
851125	0.311	0.0840	0.0718	211	1220	36.48	1.79	21.54	3.90	7.94	7.97	24.33	91.93	138.28	138.73
851201	0.032	0.0040	0.0025	72	330	12.62	2.29	14.16	0.00	37.45	44.38	44.45	60.81	116.05	172.52
851203	0.017	0.0020	0.0011	57	2350	17.68	0.45	3.96	13.86	50.70	58.24	58.31	73.95	90.73	182.37
851207	0.753	1.3599	0.5699	1695	520	10.01	1.16	4.80	23.08	38.90	75.54	83.28	83.35	98.99	108.50
851219	0.165	0.2114	0.0716	713	1220	21.36	1.05	5.16	3.57	3.68	20.98	52.48	88.96	92.89	96.93
851224	0.094	0.0721	0.0347	369	1240	14.98	0.72	11.10	23.28	26.85	26.96	44.26	75.76	112.25	116.18
860104	0.110	0.0629	0.0382	300	1980	28.82	0.87	17.70	0.0	14.79	38.12	41.83	41.94	59.24	90.74

* Intensity in $mm.hr.^{-1}$

APPENDIX E

Stages in the development of the multiple regression equations developed for modelling the characteristics of streamflow from Ecca Catchments A, B and E.

Table E:1 Development of regression model for modelling total stormflow from Ecca catchment A.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression 1	2	3	4	5	6	7	8	9	10
0.800	R^2	0,5434	0,6041	0,6252	0,6434	0,6565					
	VARIABLE	TRAIN	MXINT	API35	API05	RNDUR					
0,900	R^2	0,5434	0,6328	0,7485	0,7611	0,7743					
	VARIABLE	TRAIN	API35	API15	RNDUR	API05					
0,925	R^2	0,5434	0,6647	0,9032	0,9125	0,9137	0,9143				
	VARIABLE	TRAIN	API35	API25	API15	API10	API05				
0,950	R^2	0,5434	0,7241	0,9068	0,9128	0,9142	0,9160	0,9184	0,9197	0,9204	
	VARIABLE	TRAIN	API35	API25	API15	RNDUR	API05	API10	API20		
0,975	R^2	0,5434	0,8073	0,8964	0,9050	0,9070	0,9088	0,9112	0,9130	0,9138	
	VARIABLE	TRAIN	API35	API25	API30	API05	API15	API20	RNDUR	MXINT	
1,000	R^2	**0,5434**	**0,8790**	0,8986	0,9084	0,9128	0,9166	0,9176	0,9185	0,9191	0,9212
	VARIABLE	**TRAIN**	**API35**	API25	API05	RNDUR	API10	API30	MXINT	API15	API20

Highlighted variables selected for final model, * variables removed.

Table E:2 Development of regression model for modelling total stormflow from Ecca catchment B.

Decay const. (K)		Independent variables added at each stages of the stepwise regression 1	2	3	4	5	6	7	8	9	10
0.800	R^2	0,3951	0,4591	0,4799	0,5065	0,5208	0,5235				
	VARIABLE	TRAIN	API35	API05	MXINT	RNDUR	MNINT				
0,900	R^2	0,3951	0,4921	0,5226	0,5364	0,5523	0,5675	0,5699	0,5726	0,5774	
	VARIABLE	TRAIN	API35	API15	MXINT	API20	RNDUR	MNINT	API05	API10	
0,925	R^2	0,3951	0,5127	0,6856	0,6966	0,7275	0,7304				
	VARIABLE	TRAIN	API35	API25	MXINT	RNDUR	API05				
0,950	R^2	0,3951	0,5443	0,6883	0,7001	0,7300	0,7384				
	VARIABLE	TRAIN	API35	API25	MXINT	RNDUR	API05				
0,975	R^2	0,3951	0,5843	0,6798	0,6995	0,7119	0,7429	0,7454			
	VARIABLE	TRAIN	API35	API25	API05	RNDUR	MXINT	API30			
1,000	R^2	**0,3951**	**0,6215**	0,6674	0,7048	0,7182	0,7479	0,7504	0,7519		
	VARIABLE	**TRAIN**	**API35**	API25	API05	RNDUR	MXINT	API10	API30		

Highlighted variables selected for final model, * variables removed.

Table E:3 Development of regression model for modelling total stormflow from Ecca catchment E.

Decay const. (K)		Independent variables added at each stages of the stepwise regression									
		1	2	3	4	5	6	7	8	9	10
0.800	R^2	0,6620	0,7612	0,7997	0,8201						
	VARIABLE	TRAIN	API30	MXINT	MNINT						
0,900	R^2	0,6620	0,7842	0,8085	0,8261	0,8356					
	VARIABLE	TRAIN	API35	MXINT	MNINT	API15					
0,925	R^2	0,6620	0,8015	0,8907	0,8930	0,9036	0,9056	0,9087			
	VARIABLE	TRAIN	API35	API25	MXINT	MNINT	API05	API10			
0,950	R^2	0,6620	0,8316	0,8901	0,9132	0,9157	0,9174	0,9197	0,9243		
	VARIABLE	TRAIN	API35	API25	API20	API15	API10	MNINT	MXINT		
0,975	R^2	**0,6620**	**0,8631**	0,8757	0,9128	0,9220	0,9248	0,9258	0,9326	0,9138	
	VARIABLE	**TRAIN**	**API35**	API25	API20	API30	API05	MXINT	MNINT		
1,000	R^2	0,6620	0,8366	0,8836	0,8906	0,9189	0,9281	0,9305	0,9318	0,9373	
	VARIABLE	TRAIN	API35	API05	API25	API20	API30	API10	MXINT	MNINT	

Highlighted variables selected for final model, * variables removed.

Table E:4 Development of regression model for modelling quickflow from Ecca catchment A.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression									
		1	2	3	4	5	6	7	8	9	10
0.800	R^2	0,6121	0,6583	0,6662	0,6823	0,6854					
	VARIABLE	TRAIN	MXINT	API10	API05	RNDUR					
0,900	R^2	0,6121	0,6649	0,7592	0,7697	0,7767					
	VARIABLE	TRAIN	API35	API15	API05	RNDUR					
0,925	R^2	0,6121	0,6885	0,9056	0,9122	0,9168	0,9193	0,9215			
	VARIABLE	TRAIN	API35	API25	RNDUR	API10	MXINT	API05			
0,950	R^2	0,6121	0,7346	0,9064	0,9134	0,9164	0,9181	0,9201	0,9234	0,9239	
	VARIABLE	TRAIN	API35	API25	RNDUR	API05	MXINT	API05	API10	API20	
0,975	R^2	0,6121	0,8035	0,8947	0,9131	0,9158	0,9174	0,9190			
	VARIABLE	TRAIN	API35	API25	API30	RNDUR	MXINT	API05			
1,000	R^2	**0,6121**	**0,8715**	0,8978	0,9041	0,9123	0,9162	0,9195			
	VARIABLE	**TRAIN**	**API35**	API25	RNDUR	API05	API10	MXINT			

Highlighted variables selected for final model, * variables removed.

Table E:5 Development of regression model for modelling quickflow from Ecca catchment B.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression									
		1	2	3	4	5	6	7	8	9	10
0.800	R^2	0,4244	0,4905	0,5081	0,5312	0,5515	0,5545				
	VARIABLE	TRAIN	API35	API05	MXINT	RNDUR	MNINT				
0,900	R^2	0,4244	0,5203	0,5483	0,5619	0,5762	0,5973	0,6001	0,6020	0,6067	
	VARIABLE	TRAIN	API35	API15	API20	MXINT	RNDUR	MNINT	API10	API15	
0,925	R^2	0,4244	0,5384	0,6757	0,6864	0,7226	0,7264	0,7274			
	VARIABLE	TRAIN	API35	API25	RNDUR	MXINT	API05	API15			
0,950	R^2	0,4244	0,5651	0,6766	0,6874	0,7233	0,7330	0,7340			
	VARIABLE	TRAIN	API35	API25	MXINT	RNDUR	API05	MNINT			
0,975	R^2	0,4244	0,5965	0,6669	0,6872	0,7037	0,7364	0,7375	0,7385		
	VARIABLE	TRAIN	API35	API25	API05	RNDUR	MXINT	API30	MNINT		
1,000	R^2	**0,4244**	**0,6229**	0,6538	0,6915	0,7091	0,7405	0,7424	0,7434		
	VARIABLE	**TRAIN**	**API35**	API25	API05	RNDUR	MXINT	API10	MNINT		

Highlighted variables selected for final model, * variables removed.

Table E:6 Development of regression model for modelling quickflow from Ecca catchment E.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression											
		1	2	3	4	5	6	7	8	9	10		
0.800	R^2	0,7237	0,8314	0,8581	0,8736								
	VARIABLE	TRAIN	API30	MXINT	MNINT								
0,900	R^2	0,7237	0,8520	0,8673	0,8730	0,8868							
	VARIABLE	TRAIN	API35	API15	MXINT	MNINT							
0,925	R^2	0,7237	0,8653	0,9159	0,9188	0,9243	0,9274	0,9284	0,9297	0,9290			
	VARIABLE	TRAIN	API35	API25	RNDUR	MXINT	MNINT	API05	API10	*RNDUR			
0,950	R^2	0,7237	0,8857	0,9140	0,9330	0,9353	0,9363	0,9393	0,9416				
	VARIABLE	TRAIN	API35	API25	API20	API15	MNINT	MXINT	API10				
0,975	R^2	**0,7237**	**0,8975**	0,9086	0,9120	0,9225	0,9377	0,9396	0,9391	0,9400	0,9449		
	VARIABLE	**TRAIN**	**API35**	RNDUR	API05	API25	API20	API30	*RNDUR	MNINT	MXINT		
1,000	R^2	0,7237	0,8552	0,8917	0,9127	0,9127	0,9177	0,9224	0,9266	0,9290	0,9429	0,9428	0,9465
	VARIABLE	TRAIN	API30	API05	API35	API30	RNDUR	MXINT	MNINT	API25	API20	RNDUR	API30

Highlighted variables selected for final model, * variables removed.

Table E:7 Development of regression model for modelling peakflow from Ecca catchment A.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression 1	2	3	4	5	6	7	8	9	10
0.800	R^2	0.6253	0.7505	0,7757	0,7818						
	VARIABLE	TRAIN	API35	API05	MNINT						
0,900	R^2	0,6253	0,7367	0,8351	0,8436	0,8477					
	VARIABLE	TRAIN	API35	API15	API05	MNINT					
0,925	R^2	0,6253	0,7672	0,8979	0,9040	0,9083	0,9098	0,9204			
	VARIABLE	TRAIN	API35	API20	API10	RNDUR	API15	MNINT			
2,950	R^2	0,6253	0,8173	0,9084	0,9142	0,9169	0,9204	0,9224	0,9231	0,9246	
	VARIABLE	TRAIN	API35	API20	RNDUR	API25	API15	MNINT	API05	API10	
0,975	R^2	0,6253	0,8724	0,9023	0,9098	0,9135	0,9154	0,9176	0,9191	0,9208	0,9204
	VARIABLE	TRAIN	API35	API20	RNDUR	API30	API05	API25	API15	MNINT	API20
1,000	R^2	**0,6253**	**0,9008**	0,9080	0,9141	0,9225	0,9245	0,9258			
	VARIABLE	**TRAIN**	**API35**	RNDUR	API05	API20	MNINT	API10			

Highlighted variables selected for final model, * variables removed.

Table E:8 Development of regression model for modelling flow from Ecca catchment B.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression 1	2	3	4	5	6	7	8	9	10
0.800	R^2	0,4257	0,5147	0,5872	0,6144	0,6166					
	VARIABLE	TRAIN	API35	API05	RNDUR	MNINT					
0,900	R^2	0,4257	0,5640	0,6102	0,6344	0,6491	0,6523	0,6551	0,6570		
	VARIABLE	TRAIN	API35	RNDUR	API05	API20	API15	API10	MNINT		
0,925	R^2	0,4257	0,5860	0,6296	0,6477	0,6537					
	VARIABLE	TRAIN	API35	RNDUR	API25	API05					
0,950	R^2	0,4257	0,6057	0,6485	0,6840						
	VARIABLE	TRAIN	API35	RNDUR	API30						
0,975	R^2	**0,4257**	**0,6090**	**0,6516**	0,6673	0,6809	0,6855	0,6866			
	VARIABLE	**TRAIN**	**API35**	**RNDUR**	API30	API10	API25	MNINT			
1,000	R^2	0,4257	0,5887	0,6324	0,6541	0,6692	0,6813	0,6840	0,6861		
	VARIABLE	TRAIN	API35	RNDUR	API05	API30	API25	API15	API10		

Highlighted variables selected for final model, * variables removed.

Table E:9 Development of regression model for modelling peakflow from Ecca catchment E.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression									
		1	2	3	4	5	6	7	8	9	10
0.800	R^2	0,8129	0,9091	0,9206	0,9246	0,9331					
	VARIABLE	TRAIN	API30	API05	RNDUR	MXINT					
0,900	R^2	0,8129	0,9242	0,9272	0,9347	0,9370					
	VARIABLE	TRAIN	API20	RNDUR	MXINT	API05					
0,925	R^2	**0,8129**	**0,9263**	0,9302	0,9362	0,9378	0,9377	0,9386	0,9393		
	VARIABLE	**TRAIN**	**API20**	RNDUR	MXINT	API15	*API20	API35	API05		
0,950	R^2	0,8129	0,9258	0,9307	0,9359	0,9404	0,9423	0,9441			
	VARIABLE	TRAIN	API20	RNDUR	API35	API05	MXINT	API30			
0,975	R^2	0,8129	0,9211	0,9281	0,9333	0,9405	0,9420	0,9419	0,9427		
	VARIABLE	TRAIN	API20	API10	RNDUR	MXINT	API15	*API20	API35		
1,000	R^2	0,8129	0,9154	0,9275	0,9334	0,9410	0,9431	0,9430	0,9437		
	VARIABLE	TRAIN	API10	API20	RNDUR	MXINT	API15	*API20	API35	API15	API10

Highlighted variables selected for final model, * variables removed.

Table E:10 Development of regression model for modelling storm duration for Ecca catchment A.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression										
		1	2	3	4	5	6	7	8	9	10	
0.800	R^2	0,3966	0,4851	0,5268	0,5679	0,5688	0,5690					
	VARIABLE	TRAIN	API35	API05	RNDUR	MXINT	MNINT					
0,900	R^2	0,3966	0,5493	0,7162	0,7346	0,7523	0,7577	0,7604				
	VARIABLE	TRAIN	API35	API15	API05	RNDUR	MXINT	MNINT				
0,925	R^2	0,3966	0,5966	0,7937	0,8302	0,8352	0,8379	0,8397				
	VARIABLE	TRAIN	API35	API25	API15	API10	MXINT	MNINT				
0,950	R^2	0,3966	0,6627	0,8030	0,8168	0,8208	0,8228					
	VARIABLE	TRAIN	API35	API25	API15	API05	RNDUR					
0,975	R^2	0,3966	0,7793	0,8364	0,8470	0,8504	0,8537	0,8563	0,8595	0,8587	0,8614	0,8615
	VARIABLE	TRAIN	API35	API15	API30	MXINT	API05	API10	RNDUR	*MXINT	MNINT	MXINT
1,000	R^2	**0,3966**	**0,8367**	0,8409	0,8438	0,8516	0,8545	0,8628	0,8662	0,8709	0,8729	
	VARIABLE	**TRAIN**	**API35**	MXINT	API05	API15	API30	API25	API10	RNDUR	MNINT	

Highlighted variables selected for final model, * variables removed.

Table E:11 Development of regression model for modelling storm durations for Ecca catchment B.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression 1	2	3	4	5	6	7	8	9	10
0.800	R^2	0,2483	0,3566	0,4161	0,4443	0,4475	0,4493				
	VARIABLE	TRAIN	API35	API15	MXINT	MNINT	RNDUR				
0,900	R^2	0,2483	0,4323	0,4712	0,4903	0,5056	0,5143	0,5181			
	VARIABLE	TRAIN	API35	API05	MXINT	API15	API20	MNINT			
0,925	R^2	0,2483	0,4729	0,6738	0,6809	0,6883	0,6947				
	VARIABLE	TRAIN	API35	API25	API10	MXINT	RNDUR				
0,950	R^2	0,2483	0,5302	0,7359							
	VARIABLE	TRAIN	API35	API30							
0,975	R^2	0,2483	0,5959	0,7345	0,7454	0,7548	0,7599	0,7739	0,7759	0,7793	0,7808
	VARIABLE	TRAIN	API35	API30	API05	API25	RNDUR	MXINT	API20	API10	MNINT
1,000	R^2	0,2483	**0,6409**	0,7141	0,7546	0,7638	0,7711	0,7856	0,7898	0,7951	0,7970
	VARIABLE	TRAIN	**API35**	API30	API05	API10	RNDUR	MXINT	API25	API20	MNINT

Highlighted variables selected for final model, * variables removed.

Table E:12 Development of regression model for modelling storm duration from Ecca catchment E.

Decay Const. (K)		Independent variables added at each stages of the stepwise regression 1	2	3	4	5	6	7	8	9	10	
0.800	R^2	0,4059	0,5985	0,6760	0,7144							
0,7200												
	VARIABLE	TRAIN	MXINT	API30	MNINT	RNDUR						
0,900	R^2	0,4059	0,6172	0,6938	0,7270	0,7408						
	VARIABLE	TRAIN	API35	MXINT	MNINT	API10						
0,925	R^2	0,4059	0,6138	0,6918	0,7248	0,7317						
	VARIABLE	TRAIN	API20	MXINT	MNINT	RNDUR						
0,950	R^2	0,4059	0,6922	0,7356	0,7959	0,8225	0,8337	0,8516	0,8571			
	VARIABLE	TRAIN	API35	API25	API20	MXINT	PAI10	MNINT	PAI15			
0,975	R^2	**0,4059**	**0,7185**	**0,7395**	0,7809	0,7853	0,7898	0,8069	0,8068	0,8794	0,8785	0,8815
	VARIABLE	**TRAIN**	**API35**	**RNDUR**	MXINT	MNINT	API30	API25	*API35	API20	*RNDUR	API35
1,000	R^2	0,4059	0,6852	0,7366	0,8610	0,8684	0,8828	0,8855				
	VARIABLE	TRAIN	API30	API20	API25	MXINT	MNINT	API05				

Highlighted variables selected for final model, * variables removed.

APPENDIX F

Alicedale observed and generated monthly rainfall data.

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1890

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	45,90	32,90	49,60	45,60	41,10	15,20	33,90	34,90	29,30	33,70	42,00	40,70	444,80
STDV	37,70	23,64	22,01	28,50	30,77	21,99	55,24	29,30	24,36	23,56	23,03	27,69	142,29
SKEW	2,01	0,38	0,58	1,18	0,57	2,67	2,34	0,29	1,30	1,47	0,83	0,71	
MIN	9,00	2,00	18,00	11,00	5,00	0,00	0,00	0,00	2,00	6,00	7,00	11,00	243,00
MAX	141,00	69,00	94,00	110,00	93,00	75,00	176,00	79,00	85,00	87,00	90,00	93,00	722,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1890

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	44,54	32,89	48,56	44,48	38,27	16,92	37,46	30,86	31,35	34,42	40,52	40,62	440,88
STDV	34,60	28,05	18,76	23,53	26,56	19,87	45,05	30,08	22,27	22,69	22,46	21,25	114,91
SKEW	1,43	1,30	0,20	0,70	0,65	2,11	1,96	1,42	1,07	1,17	1,39	0,81	
MIN	1,29	0,77	0,48	3,56	0,10	0,00	0,02	0,00	0,01	0,83	0,57	0,01	228,13
MAX	182,99	121,64	100,46	115,18	123,21	99,08	210,21	147,77	108,18	117,34	151,19	117,60	764,69

OBSERVED MONTLY RAINFALL (mm) FOR 1901 - 1910

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	18,10	42,50	37,60	26,60	32,00	22,80	7,10	10,60	37,30	36,40	42,00	40,40	353,40
STDV	24,14	50,20	32,99	20,67	44,78	19,01	9,74	11,38	35,08	20,10	37,65	33,03	131,89
SKEW	1,42	2,79	0,47	0,49	2,33	0,15	0,82	0,47	1,37	-0,75	0,15	1,81	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	213,00
MAX	73,00	181,00	97,00	56,00	149,00	55,00	22,00	27,00	117,00	61,00	93,00	122,00	635,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1910

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	18,04	42,72	35,19	25,57	29,67	24,63	8,08	9,36	39,96	38,49	39,99	39,84	351,54
STDV	25,86	45,90	30,43	18,91	30,94	27,28	10,90	11,17	36,18	31,53	44,94	26,74	120,37
SKEW	2,47	1,62	1,09	1,03	1,74	1,93	2,17	1,84	1,40	1,41	2,93	0,97	
MIN	0,00	0,07	0,02	0,01	0,00	0,00	0,00	0,00	0,17	0,02	0,00	0,54	148,37
MAX	150,67	219,17	141,56	89,24	171,36	138,88	52,41	60,39	182,89	145,89	310,79	134,35	738,86

OBSERVED MONTLY RAINFALL (mm) FOR 1921 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	22,50	42,30	59,20	25,50	23,90	25,90	21,10	22,10	31,90	37,60	45,30	34,10	391,40
STDV	13,75	26,27	48,02	22,40	15,71	20,28	17,32	11,05	24,75	25,54	41,08	26,96	101,44
SKEW	0,62	0,65	1,79	1,21	0,48	1,47	0,77	-0,14	0,88	0,78	0,92	0,25	
MIN	0,00	15,00	10,00	4,00	4,00	1,00	1,00	7,00	3,00	7,00	7,00	0,00	186,00
MAX	51,00	83,00	176,00	70,00	51,00	74,00	53,00	36,00	78,00	90,00	114,00	78,00	530,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1921 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	22,27	41,59	57,50	24,87	22,55	27,79	22,46	20,78	34,29	39,22	42,89	33,46	389,56
STDV	17,91	27,62	33,52	16,96	14,37	21,32	19,07	10,44	23,34	27,41	37,11	25,70	88,96
SKEW	1,44	1,03	0,65	0,88	0,65	1,41	1,38	0,74	0,97	1,24	2,16	1,18	
MIN	0,54	5,57	2,57	0,14	0,79	0,41	0,00	2,68	0,00	0,59	0,08	0,09	214,52
MAX	96,08	131,05	155,35	82,14	71,53	106,89	86,08	55,79	109,17	133,73	243,65	128,15	622,40

OBSERVED MONTLY RAINFALL (mm) FOR 1941 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	27,40	36,70	45,00	34,90	37,50	22,60	16,50	9,20	16,20	51,00	41,60	37,90	376,50
STDV	18,60	29,55	22,51	31,00	62,02	24,93	13,70	13,90	14,08	41,10	40,13	30,06	92,83
SKEW	1,00	0,42	-0,26	1,55	2,73	1,67	1,02	1,63	0,52	0,36	1,11	1,18	
MIN	2,00	0,00	6,00	11,00	0,00	0,00	0,00	0,00	0,00	0,00	4,00	7,00	223,00
MAX	61,00	82,00	78,00	98,00	207,00	83,00	40,00	37,00	41,00	118,00	126,00	103,00	490,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1941 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	26,69	37,04	43,93	34,04	35,05	25,16	17,44	7,90	17,57	53,60	39,77	37,81	376,07
STDV	19,91	38,93	20,99	22,35	34,94	29,67	15,77	10,03	15,78	50,90	36,93	22,50	116,72
SKEW	1,39	1,54	0,50	0,95	1,47	2,11	1,45	1,93	1,35	1,55	2,53	0,92	
MIN	1,06	0,02	0,00	0,14	0,00	0,00	0,09	0,00	0,12	0,00	0,13	1,06	190,48
MAX	105,49	167,59	106,26	106,37	175,97	147,27	71,83	52,52	77,15	255,89	257,26	122,13	706,83

OBSERVED MONTLY RAINFALL (mm) FOR 1961 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	28,10	29,70	72,60	33,00	32,10	34,70	18,80	33,60	31,90	36,20	44,30	34,70	429,70
STDV	32,04	19,78	53,57	25,02	36,40	36,43	20,09	28,78	44,58	27,01	27,98	50,83	97,10
SKEW	1,65	1,14	0,66	1,16	2,42	1,21	1,13	2,17	2,44	0,84	1,34	2,62	
MIN	0,00	12,00	0,00	7,00	7,00	2,00	0,00	3,00	3,00	2,00	13,00	0,00	263,00
MAX	101,00	68,00	176,00	86,00	128,00	106,00	54,00	108,00	150,00	92,00	109,00	172,00	619,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1961 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	27,60	29,26	69,78	32,52	29,92	38,07	20,26	30,67	34,85	37,53	42,73	33,22	426,41
STDV	31,80	19,86	48,19	19,59	23,40	35,94	21,06	21,88	32,52	29,75	25,01	29,46	105,40
SKEW	2,00	1,04	0,98	0,79	0,86	1,68	1,68	1,10	1,35	1,34	1,50	1,37	
MIN	0,02	2,95	0,33	0,58	0,01	0,10	0,00	0,11	0,08	0,02	0,33	0,00	216,52
MAX	176,91	88,70	227,47	95,12	107,98	173,10	96,53	109,30	159,80	146,45	167,38	155,80	716,22

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	44,85	31,20	40,15	40,00	35,25	20,20	22,35	26,35	33,00	34,95	45,30	33,40	407,00
STDV	34,63	25,22	27,99	25,76	29,31	22,68	40,34	24,97	36,83	21,88	41,32	24,16	137,08
SKEW	1,48	1,04	0,49	1,16	0,71	1,57	3,36	0,89	1,91	1,01	1,26	0,86	
MIN	9,00	2,00	0,00	5,00	0,00	0,00	0,00	0,00	0,00	6,00	4,00	0,00	89,00
MAX	141,00	95,00	98,00	110,00	93,00	75,00	176,00	79,00	144,00	87,00	144,00	93,00	722,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	42,76	31,09	38,11	38,19	32,12	22,21	24,60	23,52	34,54	34,87	42,76	32,36	397,13
STDV	34,36	28,28	25,35	22,35	26,25	23,47	30,19	24,26	30,74	22,45	37,77	21,07	132,68
SKEW	1,40	1,36	0,88	0,66	0,84	1,97	1,88	1,49	1,28	1,17	1,36	0,91	
MIN	0,12	0,26	0,55	1,45	0,00	0,01	0,01	0,00	0,02	1,65	0,06	0,87	45,80
MAX	170,96	123,32	116,88	97,64	123,92	120,95	137,36	119,87	134,48	117,04	262,24	107,57	739,26

OBSERVED MONTLY RAINFALL (mm) FOR 1901 - 1920

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	27,65	37,55	43,25	32,65	32,95	23,65	14,60	14,60	35,15	33,75	38,65	35,00	369,45
STDV	23,63	37,42	30,70	19,92	36,34	17,88	18,17	15,30	32,50	18,62	30,42	30,49	109,42
SKEW	0,51	3,21	0,09	-0,02	2,03	0,09	1,78	1,22	1,36	0,11	0,48	1,33	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	123,00
MAX	73,00	181,00	97,00	62,00	149,00	55,00	69,00	59,00	117,00	70,00	93,00	122,00	636,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1920

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	27,27	37,34	41,24	32,00	30,62	25,73	16,30	12,69	38,04	35,09	36,83	34,25	367,41
STDV	31,68	34,43	30,62	20,01	27,81	25,02	20,32	14,78	32,72	24,73	33,76	25,66	103,79
SKEW	2,04	1,37	0,99	0,84	1,26	1,73	2,02	1,81	1,29	1,25	2,45	1,13	
MIN	0,09	0,23	0,15	0,65	0,01	0,00	0,06	0,00	0,31	0,57	0,33	0,03	172,90
MAX	177,22	156,32	143,79	96,57	140,11	123,90	95,48	78,10	162,58	119,91	229,91	131,87	677,71

OBSERVED MONTLY RAINFALL (mm) FOR 1921 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,25	43,00	59,45	30,40	27,90	16,90	30,15	23,15	26,30	45,25	47,00	33,60	425,35
STDV	25,57	26,66	40,46	28,70	30,28	17,56	22,85	22,83	23,42	30,54	36,18	31,81	107,92
SKEW	0,71	0,22	1,39	1,09	2,94	1,91	0,58	1,38	0,88	0,26	0,62	1,26	
MIN	0,00	0,00	10,00	0,00	3,00	0,00	1,00	0,00	3,00	6,00	7,00	0,00	186,00
MAX	85,00	83,00	176,00	100,00	141,00	74,00	75,00	83,00	93,00	91,00	114,00	119,00	592,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1921 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31,89	42,63	58,22	29,69	26,12	18,82	31,82	20,41	39,08	46,76	44,92	32,95	423,30
STDV	31,42	33,93	31,08	23,91	20,31	19,42	26,25	19,57	22,79	34,72	35,16	25,79	96,91
SKEW	1,78	1,17	0,68	1,17	0,84	1,80	1,35	1,49	0,85	1,27	2,05	1,22	
MIN	0,04	2,82	2,12	0,12	0,00	0,11	0,02	0,02	0,51	0,00	0,19	0,04	228,07
MAX	173,05	146,23	151,44	112,94	91,90	93,09	119,80	97,13	113,69	172,05	236,97	134,93	681,97

OBSERVED MONTLY RAINFALL (mm) FOR 1941 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,80	41,35	44,35	30,65	32,70	18,50	22,40	15,00	32,30	49,00	41,50	31,70	392,25
STDV	30,71	37,47	24,55	26,75	46,75	19,04	20,08	15,46	44,97	50,43	41,35	27,44	98,05
SKEW	1,05	1,30	0,15	1,34	3,07	2,11	1,80	1,11	2,56	1,22	1,19	1,11	
MIN	0,00	0,00	6,00	4,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	223,00
MAX	109,00	141,00	91,00	98,00	207,00	83,00	83,00	55,00	189,00	168,00	142,00	103,00	596,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1941 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,34	41,78	43,25	29,70	30,82	20,52	23,69	12,97	35,23	51,44	39,33	31,15	392,21
STDV	35,21	41,48	22,38	20,73	28,28	21,77	20,83	14,29	36,24	53,88	39,78	22,86	117,87
SKEW	1,91	1,43	0,58	1,01	1,24	1,84	1,41	1,68	1,48	1,70	2,75	1,16	
MIN	0,00	0,01	0,00	0,02	0,00	0,01	0,00	0,00	0,02	0,00	0,04	0,43	196,74
MAX	193,47	176,98	109,60	99,12	134,73	104,88	94,76	71,86	176,96	272,70	279,52	121,23	770,48

OBSERVED MONTLY RAINFALL (mm) FOR 1961 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,90	52,35	69,55	32,30	35,75	27,30	26,90	39,30	33,65	34,50	47,70	39,40	471,00
STDV	31,17	44,28	57,30	27,54	32,98	27,36	48,36	37,71	41,55	26,67	26,70	46,31	127,15
SKEW	0,99	1,97	0,94	0,59	1,53	1,86	3,45	1,41	2,24	1,13	0,77	1,84	
MIN	0,00	12,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	0,00	13,00	0,00	262,00
MAX	101,00	196,00	185,00	86,00	128,00	106,00	216,00	133,00	150,00	100,00	109,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1961 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,76	51,97	67,25	31,66	33,47	30,25	29,95	34,85	37,14	35,67	46,07	38,38	469,40
STDV	35,57	42,84	47,79	25,81	26,46	27,60	37,23	31,05	32,32	30,02	25,48	32,04	114,81
SKEW	1,92	1,18	1,07	1,19	0,84	1,62	2,02	1,39	1,21	1,40	1,35	1,32	
MIN	0,02	2,06	1,39	0,05	0,05	0,00	0,02	0,17	0,33	0,06	0,83	0,00	239,75
MAX	197,82	178,14	222,39	121,51	115,19	129,97	172,93	151,35	154,04	149,41	170,47	168,95	809,20

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1910

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	35,93	34,97	39,30	35,53	34,17	21,07	17,27	21,10	34,43	35,43	44,20	35,73	389,13
STDV	33,63	35,04	29,20	24,67	34,46	21,23	33,90	22,49	35,71	20,97	39,51	27,06	135,54
SKEW	1,44	2,76	0,44	1,06	1,58	1,20	4,00	1,25	1,66	0,54	0,96	1,37	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	181,00	98,00	110,00	149,00	75,00	176,00	79,00	144,00	87,00	144,00	122,00	722,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1910

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,77	35,02	37,07	33,63	31,15	23,11	19,25	18,62	36,01	35,38	41,53	34,52	380,04
STDV	38,67	34,27	27,19	22,46	27,50	24,81	24,96	20,76	32,26	24,89	39,86	22,95	131,97
SKEW	1,86	1,43	1,02	0,80	1,03	1,98	1,99	1,65	1,27	1,27	2,62	0,95	
MIN	0,00	0,01	0,00	0,50	0,14	0,03	0,02	0,01	0,15	0,54	0,29	1,65	53,82
MAX	197,39	147,64	124,95	96,93	130,68	126,91	114,73	104,64	143,24	128,66	281,25	117,84	740,75

OBSERVED MONTLY RAINFALL (mm) FOR 1901 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	25,93	39,13	48,57	30,27	29,93	24,40	16,77	17,10	34,07	35,03	40,87	34,70	376,77
STDV	20,75	33,72	37,30	20,68	31,00	18,39	17,86	14,29	29,74	20,81	33,77	28,90	105,58
SKEW	0,67	2,79	1,33	0,35	2,32	0,60	1,34	0,73	1,30	0,52	0,74	1,05	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	186,00
MAX	71,00	181,00	176,00	70,00	149,00	74,00	69,00	59,00	117,00	90,00	144,00	122,00	636,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	25,57	38,79	46,54	29,59	27,85	26,42	18,47	15,14	36,76	36,48	38,94	33,94	374,50
STDV	27,42	32,93	32,63	19,23	23,90	24,05	21,21	15,43	29,82	25,76	35,23	25,61	101,37
SKEW	1,91	1,29	0,91	0,88	1,14	1,64	1,84	1,54	1,21	1,26	2,40	1,13	
MIN	0,01	0,99	0,02	0,36	0,00	0,00	0,00	0,02	0,67	0,60	0,23	0,00	180,58
MAX	151,78	151,16	152,88	92,33	119,42	119,43	97,96	79,15	146,82	124,34	238,50	130,71	666,40

OBSERVED MONTLY RAINFALL (mm) FOR 1921 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	30,63	40,90	54,63	31,90	31,10	18,80	25,60	18,50	29,60	47,17	45,20	35,03	409,07
STDV	23,26	27,31	35,75	29,03	42,61	20,06	21,05	21,13	22,67	33,80	36,93	31,03	104,18
SKEW	0,82	0,24	1,51	1,18	3,14	1,81	0,87	1,55	1,03	0,36	0,73	1,16	
MIN	0,00	0,00	6,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	4,00	0,00	186,00
MAX	85,00	83,00	176,00	100,00	207,00	83,00	75,00	83,00	93,00	118,00	126,00	119,00	592,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1921 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31,27	40,62	54,04	30,66	29,44	20,89	27,33	16,03	32,48	49,00	43,08	34,59	409,42
STDV	29,60	35,82	27,57	23,35	26,70	23,11	23,78	17,92	23,89	40,18	35,77	25,38	102,03
SKEW	1,72	1,24	0,55	1,10	1,28	1,86	1,43	1,82	1,02	1,40	2,03	1,16	
MIN	0,08	0,83	1,93	0,02	0,00	0,04	0,00	0,00	0,11	0,03	0,01	0,11	210,59
MAX	149,26	157,08	131,43	115,97	133,59	111,83	109,58	94,37	108,59	205,68	233,29	131,70	692,95

OBSERVED MONTLY RAINFALL (mm) FOR 1941 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31,23	37,47	53,77	31,43	32,50	23,90	21,20	21,20	32,17	44,73	42,43	32,70	404,73
STDV	30,69	32,75	38,33	25,78	42,93	26,64	19,81	22,21	44,07	43,94	36,95	36,02	97,71
SKEW	1,16	1,53	1,28	1,22	2,90	1,87	1,50	2,19	2,39	1,42	1,17	2,35	
MIN	0,00	0,00	0,00	4,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	223,00
MAX	109,00	141,00	176,00	98,00	207,00	106,00	83,00	108,00	189,00	168,00	142,00	172,00	619,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1941 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	30,83	37,56	52,06	30,56	30,49	26,50	22,59	18,53	35,14	46,80	40,36	31,86	403,28
STDV	34,34	35,03	32,43	20,48	26,91	27,84	21,28	18,97	35,18	46,35	36,28	25,30	114,37
SKEW	1,94	1,36	0,84	0,96	1,14	1,83	1,51	1,55	1,44	1,62	2,41	1,26	
MIN	0,02	0,36	0,18	0,01	0,00	0,07	0,04	0,00	0,01	0,01	0,10	0,02	197,26
MAX	189,24	149,62	154,08	98,37	126,51	133,95	96,75	94,30	171,37	233,13	249,50	134,17	770,22

OBSERVED MONTLY RAINFALL (mm) FOR 1951 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,67	50,23	60,93	30,33	33,13	23,00	27,37	33,13	38,57	38,67	45,60	34,77	450,40
STDV	33,67	43,91	50,42	25,75	30,81	23,70	41,41	32,92	47,60	40,52	33,11	40,30	122,37
SKEW	0,83	1,69	1,24	0,64	1,61	2,25	3,54	1,79	1,97	2,02	1,04	2,05	
MIN	0,00	7,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	262,00
MAX	109,00	196,00	185,00	86,00	128,00	106,00	216,00	133,00	189,00	168,00	142,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1951 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,89	49,97	59,15	29,86	31,03	25,58	29,92	29,33	42,75	40,15	43,60	33,84	450,07
STDV	40,02	43,21	40,64	23,62	24,26	23,49	34,19	26,41	39,64	39,13	33,64	28,54	114,11
SKEW	1,99	1,22	1,06	1,14	0,80	1,62	1,85	1,41	1,28	1,60	2,00	1,34	
MIN	0,02	0,94	1,67	0,09	0,02	0,01	0,00	0,10	0,00	0,01	0,25	0,01	224,34
MAX	224,29	180,46	190,04	110,56	102,58	109,33	156,82	127,44	190,33	196,70	227,52	151,45	792,69

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1920

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	36,25	34,38	41,70	36,33	34,10	21,93	18,48	20,48	34,08	34,35	41,98	34,20	388,23
STDV	30,53	31,66	29,04	23,03	32,61	20,23	31,13	21,29	34,30	20,07	35,97	27,17	123,89
SKEW	1,41	1,81	0,27	0,87	1,51	0,99	3,80	1,24	1,61	0,66	1,11	1,17	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	181,00	98,00	110,00	149,00	75,00	176,00	79,00	144,00	87,00	144,00	122,00	722,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1920

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	35,09	34,30	39,61	34,80	31,31	23,95	20,39	18,00	35,99	34,57	39,63	33,05	380,70
STDV	36,06	31,53	27,97	21,68	26,25	24,57	25,22	20,22	31,60	23,11	35,66	23,38	124,13
SKEW	1,77	1,38	1,00	0,77	0,90	1,90	1,94	1,67	1,25	1,22	2,40	1,06	
MIN	0,03	0,00	0,04	1,06	0,02	0,00	0,04	0,03	0,06	0,89	0,01	1,94	59,75
MAX	187,98	135,43	130,35	94,60	124,86	124,30	117,27	101,73	143,04	120,11	247,64	121,41	771,24

OBSERVED MONTLY RAINFALL (mm) FOR 1895 - 1936

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	30,14	38,67	45,12	31,21	30,21	21,60	19,21	18,38	34,00	37,95	40,95	33,31	380,76
STDV	27,03	32,18	36,87	23,92	33,08	17,84	20,69	18,66	30,35	24,15	34,43	29,67	114,67
SKEW	1,09	2,33	1,28	0,77	2,22	0,77	1,25	1,64	1,19	0,53	0,75	1,29	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	113,00	181,00	176,00	100,00	149,00	74,00	75,00	83,00	117,00	90,00	114,00	122,00	636,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1895 - 1936

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	29,61	38,43	43,15	30,36	28,06	23,64	21,06	16,11	37,02	39,35	39,15	32,61	378,54
STDV	32,99	34,36	31,50	21,92	24,66	22,26	24,13	17,04	30,63	28,73	34,99	25,25	106,34
SKEW	1,93	1,31	1,03	1,06	1,13	1,69	1,85	1,60	1,24	1,26	2,42	1,20	
MIN	0,00	0,76	0,16	0,03	0,04	0,02	0,00	0,00	1,10	0,16	0,14	0,11	179,77
MAX	180,54	149,25	149,90	104,97	118,75	107,60	112,43	86,25	153,31	143,12	240,84	134,21	679,48

OBSERVED MONTLY RAINFALL (mm) FOR 1911 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,28	38,83	53,20	33,60	31,80	20,23	24,73	18,53	30,45	43,15	42,73	33,68	403,18
STDV	22,39	25,61	33,88	26,67	39,14	19,42	21,02	20,20	24,75	31,17	33,93	30,13	99,32
SKEW	0,66	0,40	1,31	0,98	3,02	1,41	0,93	1,46	1,26	0,63	0,88	1,08	
MIN	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	4,00	0,00	186,00
MAX	85,00	83,00	176,00	100,00	207,00	83,00	75,00	83,00	106,00	118,00	126,00	119,00	596,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1911 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31,80	38,55	52,06	33,08	29,74	22,51	26,36	15,97	33,25	44,68	40,80	33,17	401,96
STDV	27,11	32,61	28,25	23,14	25,60	23,09	24,48	17,63	25,10	35,31	32,27	24,83	94,24
SKEW	1,58	1,22	0,70	0,95	1,05	1,79	1,51	1,72	1,08	1,34	2,07	1,16	
MIN	0,40	1,53	1,54	0,04	0,04	0,16	0,07	0,00	0,31	0,03	0,12	0,26	215,85
MAX	148,28	139,16	137,12	109,77	117,20	110,51	111,23	88,94	120,96	174,31	217,78	129,99	667,22

OBSERVED MONTLY RAINFALL (mm) FOR 1926 - 1965

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,63	41,45	56,58	30,53	30,10	18,13	25,48	20,10	34,25	50,75	43,65	30,33	415,95
STDV	30,32	31,63	39,67	27,99	39,04	20,18	21,69	20,24	36,00	40,82	36,64	27,98	106,02
SKEW	0,82	1,03	1,40	1,19	3,16	2,02	1,12	1,26	2,30	0,98	0,89	1,46	
MIN	0,00	0,00	6,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	186,00
MAX	109,00	141,00	176,00	100,00	207,00	88,00	83,00	83,00	89,00	168,00	142,00	119,00	619,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1926 - 1965

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	33,89	41,48	54,69	28,95	28,21	20,16	26,81	17,50	36,85	51,65	41,19	29,30	410,67
STDV	36,26	37,72	31,48	22,64	24,19	21,93	23,69	18,42	32,91	45,67	37,03	22,30	117,30
SKEW	1,87	1,31	0,74	1,09	1,01	1,90	1,43	1,61	1,26	1,52	2,36	1,21	
MIN	0,04	0,58	1,35	0,01	0,02	0,00	0,05	0,00	0,46	0,14	0,05	0,30	91,14
MAX	198,02	160,21	150,49	100,24	113,72	106,36	107,91	91,97	156,16	232,42	253,37	117,27	763,31

OBSERVED MONTLY RAINFALL (mm) FOR 1941 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,85	46,85	56,95	31,48	34,23	22,90	24,65	27,15	32,98	41,75	44,60	35,55	431,93
STDV	30,54	40,87	45,34	26,81	39,96	23,69	36,62	30,99	42,74	40,49	34,50	37,77	119,05
SKEW	0,98	1,69	1,45	0,91	2,63	2,03	3,94	1,98	2,32	1,55	0,99	1,91	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	223,00
MAX	109,00	196,00	185,00	98,00	207,00	106,00	216,00	133,00	189,00	168,00	142,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1941 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,39	46,93	55,04	30,33	32,12	25,30	26,93	23,60	36,06	43,58	42,50	34,65	429,42
STDV	35,40	43,17	36,24	23,24	27,76	25,37	29,98	24,82	34,58	42,48	34,93	27,53	119,74
SKEW	1,91	1,34	0,93	1,14	1,10	1,75	1,81	1,61	1,37	1,59	2,17	1,26	
MIN	0,00	0,56	0,03	0,01	0,03	0,32	0,00	0,00	0,00	0,00	0,01	0,02	206,37
MAX	195,34	184,16	170,85	110,74	129,19	121,48	137,72	123,85	167,40	213,23	236,94	145,59	795,22

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	33,50	35,96	45,20	34,16	32,06	22,72	19,00	20,80	33,64	35,00	42,64	34,18	388,86
STDV	28,42	30,57	33,83	23,10	30,14	20,10	28,77	19,59	32,40	21,02	36,63	26,85	118,78
SKEW	1,60	2,47	1,22	0,87	1,67	1,02	3,78	1,21	1,58	0,70	1,03	0,99	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	181,00	176,00	110,00	149,00	75,00	176,00	79,00	144,00	90,00	144,00	122,00	722,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,48	35,74	43,04	32,81	29,49	24,74	20,74	18,32	35,73	35,42	40,37	33,12	382,01
STDV	33,07	31,51	29,85	21,26	24,00	24,45	24,53	19,38	30,21	23,88	36,10	23,76	120,97
SKEW	1,76	1,34	0,99	0,84	0,87	1,83	1,90	1,55	1,22	1,22	2,39	1,10	
MIN	0,43	0,58	0,10	0,50	0,00	0,00	0,01	0,00	1,33	0,76	0,02	1,50	82,55
MAX	173,63	135,05	140,00	92,20	113,82	122,77	114,04	95,96	138,46	123,90	250,32	124,40	712,86

OBSERVED MONTLY RAINFALL (mm) FOR 1891 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,72	38,12	47,22	32,10	30,22	21,26	20,06	18,66	35,92	38,84	43,98	32,66	391,76
STDV	26,63	31,41	36,08	23,90	31,91	18,90	20,44	18,95	32,16	24,66	38,03	28,78	113,62
SKEW	0,84	2,18	1,07	0,78	2,16	0,98	1,23	1,48	1,49	0,56	0,88	1,31	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	113,00	181,00	176,00	100,00	149,00	75,00	75,00	83,00	144,00	91,00	144,00	122,00	636,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1891 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,27	37,91	45,43	31,44	28,21	23,37	21,94	16,34	39,08	40,31	41,91	32,06	390,26
STDV	33,44	33,61	31,76	21,85	24,48	23,19	24,04	17,43	31,42	28,96	38,11	24,20	103,86
SKEW	1,86	1,31	0,96	0,96	1,12	1,75	1,77	1,64	1,16	1,26	2,44	1,15	
MIN	0,16	0,86	0,09	0,00	0,01	0,13	0,06	0,00	0,88	0,25	0,27	0,05	189,53
MAX	184,79	148,99	149,45	104,05	118,26	113,43	110,50	89,22	153,92	141,77	260,62	125,50	686,36

OBSERVED MONTLY RAINFALL (mm) FOR 1906 - 1955

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31,42	43,30	49,18	33,40	32,72	20,14	23,24	17,38	33,02	44,64	45,80	34,94	409,18
STDV	23,82	33,97	33,81	25,34	39,55	18,29	20,61	18,96	33,01	38,29	36,06	31,54	106,35
SKEW	0,69	1,86	1,20	0,90	2,77	1,33	0,95	1,51	2,56	1,26	0,81	1,06	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	186,00
MAX	85,00	181,00	176,00	100,00	207,00	83,00	75,00	83,00	189,00	168,00	142,00	122,00	636,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1906 - 1955

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	30,94	43,03	47,84	32,88	30,57	22,33	25,01	14,95	36,13	46,66	43,67	34,24	408,21
STDV	29,29	37,20	28,94	22,31	26,35	22,57	25,11	16,83	29,75	42,67	54,91	26,53	104,08
SKEW	1,73	1,25	0,83	0,92	1,06	1,77	1,63	1,76	1,18	1,51	2,17	1,20	
MIN	0,00	1,50	0,24	0,00	0,03	0,21	0,01	0,00	1,11	0,03	0,01	0,06	214,16
MAX	160,86	159,84	137,93	106,23	122,05	108,50	114,37	85,65	143,41	208,98	243,26	138,65	725,57

OBSERVED MONTLY RAINFALL (mm) FOR 1921 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31,64	39,68	56,04	31,02	30,66	21,10	24,78	21,98	33,82	44,94	44,26	33,06	412,98
STDV	28,48	30,30	38,89	26,70	38,10	23,49	21,31	22,25	36,96	38,78	36,34	34,07	101,34
SKEW	1,01	1,11	1,29	1,12	2,99	2,02	1,04	1,80	2,33	1,22	0,92	1,96	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	186,00
MAX	109,00	141,00	176,00	100,00	207,00	106,00	83,00	108,00	189,00	168,00	142,00	172,00	619,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1921 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31,65	39,50	54,78	30,59	28,72	23,66	26,32	19,23	37,32	46,71	42,21	32,46	413,14
STDV	33,46	34,76	32,08	22,27	24,36	24,64	23,85	19,18	32,24	42,21	35,84	25,54	102,49
SKEW	1,86	1,25	0,83	1,01	0,99	1,81	1,47	1,55	1,21	1,49	2,25	1,24	
MIN	0,00	0,78	0,22	0,01	0,01	0,12	0,13	0,00	0,41	0,00	0,04	0,01	213,60
MAX	185,42	144,05	153,58	104,96	107,63	116,37	108,32	94,23	154,79	209,58	244,86	134,62	723,31

OBSERVED MONTLY RAINFALL (mm) FOR 1931 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,68	46,22	57,50	32,24	33,76	19,90	27,56	26,56	34,52	43,98	45,42	35,06	437,40
STDV	30,59	38,47	43,00	28,14	39,70	22,23	34,87	30,75	39,45	39,28	33,86	37,36	116,44
SKEW	0,75	1,61	1,36	0,90	2,53	2,25	3,48	1,79	2,28	1,26	0,85	1,83	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	223,00
MAX	109,00	196,00	185,00	100,00	207,00	106,00	216,00	133,00	189,00	168,00	142,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1931 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,91	46,06	56,04	31,65	31,59	22,30	29,80	22,94	38,08	45,73	43,41	34,35	436,84
STDV	37,27	42,18	34,87	24,86	27,16	23,32	31,47	24,76	33,52	42,79	34,36	27,24	112,43
SKEW	1,85	1,29	0,91	1,14	1,10	1,81	1,71	1,68	1,24	1,54	2,08	1,25	
MIN	0,00	0,43	0,01	0,21	0,06	0,11	0,00	0,01	0,25	0,10	0,12	0,04	217,06
MAX	205,95	173,37	165,83	116,74	119,50	109,97	143,59	122,47	161,82	212,63	233,14	143,94	771,66

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,92	37,25	47,62	34,35	32,03	20,25	22,37	21,37	34,82	37,98	43,65	34,00	400,60
STDV	28,82	30,14	34,00	24,98	31,73	19,38	28,97	21,66	30,91	24,36	35,81	28,53	119,20
SKEW	1,27	2,10	1,06	0,87	1,86	1,20	3,00	1,26	1,51	0,66	0,92	1,17	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	181,00	176,00	110,00	149,00	75,00	176,00	83,00	144,00	91,00	144,00	122,00	722,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	33,91	37,09	45,53	32,79	29,59	22,24	24,30	18,73	37,02	38,43	41,29	32,85	393,76
STDV	34,70	32,93	30,29	23,02	24,18	23,09	27,56	20,28	29,64	27,19	35,84	24,20	120,36
SKEW	1,78	1,33	0,94	0,92	0,89	1,89	1,82	1,62	1,15	1,27	2,30	1,14	
MIN	0,26	0,67	0,20	0,02	0,00	0,01	0,00	0,00	0,92	0,30	0,00	1,00	78,93
MAX	184,00	140,15	142,68	100,03	114,47	115,18	127,56	101,33	137,57	140,36	246,55	126,95	714,52

OBSERVED MONTLY RAINFALL (mm) FOR 1901 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	30,90	40,63	49,02	31,23	31,18	19,68	22,38	17,58	34,58	42,67	42,38	33,43	395,68
STDV	26,45	33,72	32,87	24,99	37,81	18,09	21,10	18,33	34,22	35,69	35,81	29,49	106,01
SKEW	0,84	1,84	1,08	0,95	2,78	1,29	1,18	1,48	2,10	1,42	0,85	1,19	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	186,00
MAX	109,00	181,00	176,00	100,00	207,00	83,00	83,00	83,00	189,00	168,00	142,00	122,00	636,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	30,35	40,45	47,48	30,48	29,07	21,78	24,16	15,28	37,81	44,62	40,41	32,86	394,76
STDV	33,30	36,99	29,36	21,77	25,53	22,37	24,93	16,63	32,18	39,34	36,66	24,81	108,21
SKEW	1,91	1,32	0,82	1,03	1,11	1,81	1,67	1,67	1,24	1,46	2,45	1,17	
MIN	0,00	0,77	0,29	0,02	0,02	0,12	0,00	0,00	0,98	0,28	0,19	0,22	192,83
MAX	183,12	158,99	140,47	104,24	120,63	107,74	114,39	84,31	158,33	193,78	252,63	131,06	723,83

OBSERVED MONTLY RAINFALL (mm) FOR 1921 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,65	45,57	57,78	31,12	32,12	20,90	26,48	25,82	34,08	42,92	45,40	34,90	429,73
STDV	28,76	36,56	43,45	27,21	36,88	21,87	32,58	28,40	37,24	37,24	34,78	35,64	114,58
SKEW	0,91	1,61	1,40	0,95	2,72	2,07	3,61	1,94	2,29	1,30	0,84	1,76	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	186,00
MAX	109,00	196,00	185,00	100,00	207,00	106,00	216,00	133,00	189,00	168,00	142,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1921 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,46	45,37	56,35	30,59	30,09	23,37	28,59	22,48	37,60	44,64	43,34	34,27	429,16
STDV	34,24	40,05	34,77	23,75	25,36	23,57	29,63	23,02	32,13	40,49	34,85	27,05	107,35
SKEW	1,88	1,25	0,88	1,10	0,98	1,76	1,68	1,60	1,19	1,50	2,10	1,24	
MIN	0,01	0,83	0,00	0,11	0,00	0,27	0,00	0,00	0,52	0,01	0,04	0,01	216,96
MAX	189,73	166,22	164,53	111,82	112,21	111,26	134,75	113,51	153,22	201,08	235,88	142,22	745,59

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	33,84	37,17	47,24	34,43	32,81	20,59	21,53	19,63	32,16	39,84	43,36	34,59	397,16
STDV	27,61	29,84	32,48	25,67	36,96	20,07	27,32	21,09	29,77	27,36	36,16	28,67	115,52
SKEW	1,33	1,88	1,04	0,98	2,49	1,29	3,13	1,34	1,63	0,77	0,92	1,15	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	181,00	176,00	110,00	207,00	83,00	176,00	83,00	144,00	118,00	144,00	122,00	722,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,89	37,14	45,29	33,02	30,41	22,66	23,30	17,13	34,35	40,59	41,11	33,61	391,50
STDV	32,82	33,92	29,21	22,96	25,99	24,09	25,95	19,25	28,44	30,87	36,00	24,00	120,17
SKEW	1,74	1,37	0,90	0,95	0,99	1,93	1,80	1,67	1,20	1,34	2,33	1,12	
MIN	0,19	0,32	0,49	0,03	0,02	0,00	0,01	0,00	1,51	0,01	0,01	1,27	108,16
MAX	174,00	144,73	138,45	101,91	123,81	120,24	119,79	96,72	132,82	158,22	248,27	126,87	710,64

OBSERVED MONTLY RAINFALL (mm) FOR 1896 - 1965

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,04	39,56	49,09	31,43	30,29	20,91	21,51	17,81	32,87	42,89	42,69	32,10	393,19
STDV	28,53	32,30	36,65	24,75	35,75	19,78	20,65	17,92	33,93	34,34	36,03	28,38	111,15
SKEW	1,03	1,82	1,25	0,95	2,87	1,36	1,20	1,36	2,02	1,37	0,83	1,24	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	113,00	181,00	176,00	100,00	207,00	88,00	83,00	83,00	189,00	168,00	142,00	122,00	636,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1896 - 1965

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	30,78	39,11	46,49	29,45	27,61	22,91	22,89	15,57	34,62	42,85	39,99	30,47	382,75
STDV	33,57	35,81	31,12	21,59	23,70	23,56	24,33	16,89	31,42	36,90	36,80	24,17	121,55
SKEW	1,81	1,32	0,92	0,89	0,99	1,82	1,69	1,66	1,27	1,49	2,46	1,17	
MIN	0,20	0,70	0,07	0,00	0,01	0,04	0,00	0,00	0,06	0,18	0,14	0,47	37,09
MAX	171,23	151,10	145,42	96,39	113,98	116,75	111,41	85,48	144,62	189,19	255,17	124,52	719,13

OBSERVED MONTLY RAINFALL (mm) FOR 1911 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	33,30	43,71	56,51	32,20	32,37	21,41	25,86	24,79	33,93	41,23	43,96	34,14	423,41
STDV	27,59	34,83	41,62	26,14	35,57	21,24	31,18	27,18	36,25	35,27	33,37	34,57	111,46
SKEW	0,86	1,71	1,39	0,83	2,63	1,90	3,58	1,98	2,23	1,43	0,92	1,71	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	186,00
MAX	109,00	196,00	185,00	100,00	207,00	106,00	216,00	133,00	189,00	168,00	142,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1911 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	33,06	43,48	55,13	31,74	30,32	23,90	27,91	21,52	37,43	42,74	42,00	33,51	422,76
STDV	33,23	37,59	33,92	23,57	25,07	23,48	29,02	22,40	31,71	37,49	32,88	26,56	102,72
SKEW	1,80	1,22	0,89	1,04	0,93	1,72	1,68	1,62	1,18	1,45	2,03	1,25	
MIN	0,09	1,01	0,00	0,00	0,01	0,26	0,00	0,00	0,58	0,02	0,15	0,04	217,70
MAX	183,29	155,35	160,60	110,97	109,72	110,40	132,02	110,26	151,33	186,53	222,09	139,87	722,89

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,39	38,28	46,80	33,43	32,20	19,81	22,38	19,78	34,19	40,74	43,11	33,43	398,51
STDV	29,12	31,93	31,78	25,31	35,74	19,19	26,91	20,38	34,66	32,83	37,01	28,11	113,74
SKEW	1,18	1,80	1,01	0,96	2,50	1,38	2,94	1,33	2,00	1,52	0,97	1,14	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	181,00	176,00	110,00	207,00	83,00	176,00	83,00	189,00	168,00	144,00	122,00	722,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	33,55	38,32	44,96	32,03	29,92	21,81	24,16	17,27	36,61	41,61	40,81	32,42	393,49
STDV	34,91	35,27	28,53	22,52	25,30	22,81	26,17	18,89	31,84	34,68	37,02	23,81	120,58
SKEW	1,81	1,37	0,88	0,96	0,98	1,89	1,75	1,64	1,25	1,45	2,42	1,16	
MIN	0,24	0,34	0,48	0,00	0,00	0,01	0,03	0,01	0,89	0,06	0,17	0,82	104,39
MAX	186,94	150,39	135,51	100,78	119,92	112,97	120,48	94,51	149,34	177,06	256,20	125,91	724,81

OBSERVED MONTLY RAINFALL (mm) FOR 1891 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,16	37,88	49,68	31,85	31,08	22,25	20,49	19,61	34,51	41,05	43,40	32,68	396,63
STDV	28,04	31,71	36,83	24,46	36,18	21,99	20,09	20,13	36,85	33,08	37,40	31,46	107,48
SKEW	0,96	1,89	1,14	0,94	2,63	1,61	1,29	1,82	2,00	1,46	0,96	1,85	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	113,00	181,00	176,00	100,00	207,00	106,00	83,00	108,00	189,00	168,00	144,00	172,00	636,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1891 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31,89	37,72	48,06	31,35	29,07	24,68	22,20	17,10	37,88	42,79	41,31	32,09	396,15
STDV	33,91	34,05	32,14	21,48	25,40	24,95	23,20	17,98	33,44	36,24	37,25	24,66	104,24
SKEW	1,89	1,30	0,94	0,93	1,10	1,77	1,69	1,63	1,26	1,42	2,41	1,19	
MIN	0,02	0,83	0,09	0,00	0,03	0,23	0,00	0,00	0,40	0,13	0,12	0,06	195,41
MAX	188,14	146,60	151,26	102,25	118,76	120,30	105,90	90,64	161,36	177,30	255,32	128,74	710,76

OBSERVED MONTLY RAINFALL (mm) FOR 1901 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31,40	43,56	54,15	31,50	32,33	21,59	23,51	23,01	34,35	40,63	43,71	34,93	414,66
STDV	27,51	36,70	40,94	25,48	36,52	20,87	29,98	26,12	35,92	33,69	33,68	34,24	115,65
SKEW	0,88	1,93	1,36	0,83	2,52	1,75	3,70	2,10	2,11	1,45	0,79	1,68	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	186,00
MAX	109,00	196,00	185,00	100,00	207,00	106,00	216,00	133,00	189,00	168,00	142,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	30,63	43,35	51,94	29,82	30,06	23,75	25,56	19,95	36,82	41,17	41,23	33,46	407,73
STDV	33,76	39,02	34,38	22,76	25,22	24,11	28,21	21,51	32,30	35,95	35,00	26,70	116,97
SKEW	1,90	1,29	0,94	1,03	0,97	1,77	1,79	1,66	1,23	1,50	2,19	1,25	
MIN	0,00	0,25	0,00	0,00	0,04	0,21	0,00	0,01	0,68	0,19	0,00	0,10	65,37
MAX	183,94	165,57	161,49	102,56	118,99	116,21	129,81	108,08	153,07	183,02	237,06	139,94	737,39

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	33,69	37,32	49,67	33,38	32,19	21,47	21,98	21,31	33,93	40,23	43,24	33,57	401,98
STDV	29,33	30,85	35,40	25,14	35,61	21,98	26,17	21,72	35,61	32,13	35,99	31,03	111,95
SKEW	1,19	1,85	1,15	0,96	2,45	1,65	2,89	1,55	2,02	1,49	0,98	1,73	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	181,00	176,00	110,00	207,00	106,00	176,00	108,00	189,00	168,00	144,00	172,00	722,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,85	37,26	47,62	31,94	29,87	23,64	23,72	18,65	36,29	40,96	40,91	32,38	396,09
STDV	34,74	33,75	31,11	22,24	25,02	24,74	25,65	19,91	31,99	34,05	36,07	24,63	120,59
SKEW	1,83	1,34	0,92	0,93	0,95	1,88	1,75	1,60	1,26	1,45	2,34	1,19	
MIN	0,14	0,55	0,20	0,01	0,01	0,01	0,02	0,00	0,70	0,05	0,03	0,52	85,16
MAX	186,34	143,63	146,97	97,75	118,55	122,40	118,16	99,27	149,45	174,00	248,20	129,64	724,91

OBSERVED MONTLY RAINFALL (mm) FOR 1886 - 1975

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,13	39,78	50,94	32,65	31,53	21,23	21,62	22,81	34,63	40,36	43,79	34,63	408,12
STDV	29,66	31,98	37,86	26,06	35,68	21,22	25,50	22,89	37,57	32,11	35,95	32,00	118,49
SKEW	1,13	1,67	1,25	0,94	2,49	1,69	3,03	2,01	1,95	1,49	0,95	1,62	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	181,00	176,00	110,00	207,00	106,00	176,00	133,00	189,00	168,00	144,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1886 - 1975

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,36	39,06	47,96	30,13	28,49	23,22	23,03	19,89	36,19	39,82	40,74	32,61	393,49
STDV	34,07	35,13	31,92	22,84	24,79	23,73	25,13	21,40	33,10	33,61	35,94	25,99	121,34
SKEW	1,70	1,27	0,89	0,91	1,06	1,79	1,70	1,66	1,29	1,46	2,31	1,15	
MIN	0,10	1,00	0,02	0,02	0,00	0,08	0,00	0,00	0,39	0,04	0,00	0,01	49,50
MAX	164,96	147,64	150,15	103,51	118,21	116,68	114,40	109,09	153,90	172,46	245,94	133,36	729,59

OBSERVED MONTLY RAINFALL (mm) FOR 1891 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,78	42,00	51,54	31,82	32,00	21,99	22,10	22,43	34,61	40,13	44,26	33,94	409,61
STDV	28,27	35,97	40,51	25,09	35,56	21,05	28,69	25,23	37,04	32,49	36,30	32,91	117,14
SKEW	0,91	1,93	1,36	0,84	2,47	1,64	3,86	2,14	2,01	1,47	0,91	1,74	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	113,00	196,00	185,00	100,00	207,00	106,00	216,00	133,00	189,00	163,00	144,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1891 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	32,54	41,84	49,84	31,25	29,94	24,38	24,16	19,50	38,01	41,83	42,17	33,33	408,78
STDV	34,42	37,99	33,92	22,68	25,95	24,18	26,77	20,82	33,23	35,72	36,58	25,76	107,57
SKEW	1,88	1,30	0,97	1,01	1,08	1,74	1,80	1,66	1,24	1,43	2,30	1,20	
MIN	0,03	0,79	0,26	0,00	0,05	0,33	0,00	0,00	0,46	0,18	0,00	0,06	199,79
MAX	190,84	162,78	159,21	107,47	120,46	116,24	122,75	104,99	160,04	175,03	249,39	134,54	728,07

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	34,09	41,09	51,35	33,20	32,91	21,31	23,28	23,68	34,08	39,49	44,03	34,62	413,13
STDV	29,38	34,95	38,99	25,63	35,08	21,13	32,09	25,81	35,92	31,67	35,12	32,37	119,53
SKEW	1,12	1,94	1,38	0,86	2,31	1,67	3,56	1,86	2,04	1,50	0,93	1,65	
MIN	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	89,00
MAX	141,00	196,00	185,00	110,00	207,00	106,00	216,00	133,00	189,00	168,00	144,00	172,00	737,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	33,40	41,15	49,35	31,86	30,67	23,46	25,39	20,68	36,71	40,57	41,85	33,61	408,71
STDV	35,10	37,48	32,83	23,29	25,65	24,14	28,53	22,27	32,00	33,94	35,57	25,49	102,72
SKEW	1,83	1,36	0,95	1,04	0,99	1,84	1,82	1,61	1,27	1,44	2,26	1,21	
MIN	0,15	0,48	0,04	0,00	0,03	0,07	0,00	0,00	0,84	0,09	0,00	0,40	143,05
MAX	189,15	160,57	155,87	107,18	120,95	118,54	131,76	111,07	152,12	172,71	243,51	135,58	744,35

APPENDIX G

George observed and generated monthly rainfall data.

OBSERVED MONTLY RAINFALL (mm) FOR 1881 - 1890

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,40	68,70	82,40	71,00	88,80	39,70	47,90	70,30	71,40	64,40	73,10	75,80	829,90
STDV	24,43	37,83	18,74	31,24	85,78	36,83	34,58	54,37	38,30	39,70	29,36	57,21	149,09
SKEW	0,42	0,44	-0,59	-0,09	2,31	1,30	1,44	1,12	0,73	-0,18	-0,08	2,44	
MIN	48,00	14,00	49,00	26,00	13,00	3,00	16,00	8,00	20,00	0,00	20,00	34,00	617,00
MAX	110,00	133,00	103,00	109,00	313,00	119,00	121,00	172,00	159,00	131,00	117,00	227,00	1110,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1890

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	75,76	67,55	82,14	70,64	83,02	43,29	49,60	64,03	76,54	66,55	71,09	76,29	826,52
STDV	27,07	41,94	16,25	27,54	59,30	37,14	32,31	44,65	43,29	54,90	29,60	36,05	138,69
SKEW	0,75	0,95	-0,13	0,41	0,69	1,54	1,08	1,09	0,82	1,38	1,00	0,68	
MIN	16,58	5,35	27,66	14,81	0,01	0,07	1,02	0,57	1,56	0,04	9,39	0,25	596,00
MAX	161,65	188,54	122,94	150,51	266,73	178,11	151,78	222,46	217,14	270,55	205,31	199,60	1242,50

OBSERVED MONTHLY RAINFALL (mm) FOR 1891 - 1900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	96,40	70,90	82,80	66,00	55,30	60,70	31,20	48,20	70,00	67,70	70,60	61,30	781,10
STDV	48,38	24,46	56,63	34,57	25,38	64,47	25,94	43,09	40,76	16,08	49,62	32,03	125,86
SKEW	-0,11	-0,29	0,80	0,00	0,45	2,18	1,74	1,37	1,08	0,87	1,28	-0,54	
MIN	19,00	25,00	12,00	18,00	20,00	13,00	13,00	15,00	27,00	51,00	28,00	0,00	604,00
MAX	160,00	107,00	196,00	115,00	99,00	225,00	86,00	138,00	155,00	96,00	179,00	113,00	970,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1891 - 1900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	93,69	69,74	80,95	65,54	52,90	66,73	32,48	43,47	74,73	68,10	67,69	61,56	777,59
STDV	56,08	28,41	45,79	31,39	23,56	55,77	23,03	32,54	35,81	15,67	42,82	35,55	121,80
SKEW	1,14	0,60	0,71	0,52	0,09	1,48	1,17	1,20	0,67	0,53	1,54	0,88	
MIN	0,05	5,84	0,65	6,07	1,68	0,07	0,00	0,09	5,54	32,91	0,01	2,23	526,36
MAX	311,73	143,09	213,75	159,61	111,00	264,05	108,04	159,44	180,76	114,57	282,64	186,11	1196,63

OBSERVED MONTHLY RAINFALL (mm) FOR 1901 - 1910

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	60,10	140,40	91,90	69,40	52,10	59,30	36,60	63,00	120,30	127,00	75,10	102,70	997,90
STDV	37,85	92,95	32,13	42,62	39,41	85,44	15,07	68,20	135,25	59,37	65,73	65,26	204,35
SKEW	0,86	0,04	0,63	0,11	1,60	2,95	0,45	2,36	2,47	0,67	1,46	0,65	
MIN	15,00	33,00	46,00	18,00	4,00	12,00	18,00	12,00	27,00	52,00	24,00	24,00	776,00
MAX	140,00	251,00	155,00	122,00	148,00	298,00	63,00	241,00	480,00	232,00	220,00	209,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1910

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	58,67	138,86	90,93	68,37	48,84	64,34	37,50	57,53	129,61	130,27	72,24	103,03	1000,20
STDV	38,85	108,77	26,74	36,99	33,57	62,28	15,70	47,20	98,63	61,66	55,73	51,41	230,30
SKEW	1,32	1,21	0,12	0,72	0,74	1,73	0,72	1,19	1,17	0,96	2,06	0,70	
MIN	0,14	7,03	15,48	5,57	0,59	0,06	9,15	0,30	0,16	24,28	0,55	0,26	629,58
MAX	213,36	503,22	163,03	183,48	165,83	309,46	83,73	237,86	502,30	326,09	372,73	277,48	1827,78

OBSERVED MONTHLY RAINFALL (mm) FOR 1921 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	64,70	76,80	90,20	64,30	54,40	49,00	46,60	60,10	86,60	69,60	*****	73,70	837,10
STDV	25,02	51,81	44,54	38,49	27,58	17,96	29,64	23,03	80,74	23,20	73,37	39,92	170,79
SKEW	1,06	1,30	1,05	1,01	0,88	-0,55	1,30	0,42	2,69	-0,20	1,70	0,09	
MIN	29,00	26,00	46,00	17,00	25,00	17,00	20,00	36,00	30,00	36,00	31,00	29,00	571,00
MAX	119,00	180,00	169,00	131,00	107,00	69,00	110,00	94,00	307,00	107,00	273,00	125,00	1089,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1921 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	63,45	75,83	88,66	63,51	51,72	50,90	48,15	57,72	93,05	70,70	97,98	74,43	836,12
STDV	25,30	52,48	35,17	31,28	24,11	19,91	28,84	20,65	58,58	25,43	62,79	32,40	151,35
SKEW	0,89	1,08	0,33	0,67	0,21	0,94	0,98	0,55	0,99	0,76	1,67	0,63	
MIN	8,93	1,43	3,54	6,91	1,53	16,99	2,91	17,46	0,38	22,84	0,04	2,22	550,40
MAX	151,45	236,41	190,20	159,42	121,13	114,74	138,86	121,22	301,90	151,97	421,31	186,87	1232,32

OBSERVED MONTHLY RAINFALL (mm) FOR 1941 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	79,10	53,70	90,40	73,20	62,50	37,50	55,80	44,30	77,90	94,50	90,60	72,90	832,40
STDV	43,52	15,76	51,99	67,64	50,67	24,01	41,90	27,61	33,58	31,75	66,42	46,94	100,04
SKEW	0,09	1,10	0,22	2,25	0,65	0,12	1,43	0,90	0,79	0,28	0,95	0,50	
MIN	19,00	38,00	21,00	17,00	13,00	5,00	24,00	7,00	37,00	49,00	19,00	25,00	642,00
MAX	144,00	86,00	176,00	248,00	146,00	75,00	148,00	99,00	134,00	141,00	201,00	152,00	960,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1941 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,71	52,65	88,94	70,72	59,67	40,33	57,97	40,54	81,55	94,70	85,88	73,09	822,79
STDV	48,37	16,61	44,91	46,53	42,74	28,01	40,25	23,96	30,67	31,15	59,83	36,95	122,53
SKEW	1,21	0,21	0,56	0,86	0,76	1,17	1,14	0,84	0,53	0,58	1,59	0,75	
MIN	0,14	0,87	2,20	0,04	0,23	0,28	0,08	2,76	18,42	28,89	0,01	0,11	370,51
MAX	271,98	92,44	211,54	223,97	184,10	128,16	203,35	119,93	171,21	191,15	381,23	192,68	1057,45

OBSERVED MONTHLY RAINFALL (mm) FOR 1961 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	75,10	70,20	*****	78,80	61,40	51,40	38,40	84,70	72,40	83,70	83,10	67,40	881,20
STDV	39,67	36,65	85,16	78,37	50,35	44,99	20,83	67,25	73,70	50,12	60,82	48,54	180,49
SKEW	-0,11	0,82	2,13	2,63	1,89	1,26	-0,26	1,97	2,43	0,62	1,50	1,00	
MIN	18,00	18,00	30,00	17,00	13,00	20,00	6,00	22,00	15,00	17,00	22,00	18,00	562,00
MAX	130,00	143,00	334,00	291,00	184,00	140,00	70,00	254,00	268,00	178,00	226,00	167,00	1166,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1961 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	72,67	68,95	111,76	75,71	57,96	55,45	39,56	76,90	77,91	84,21	78,94	67,07	867,40
STDV	45,96	39,28	59,86	50,74	37,49	42,24	25,32	51,21	56,65	51,31	53,81	36,28	164,03
SKEW	1,21	0,85	0,67	0,89	0,57	1,33	1,03	0,99	1,00	1,12	1,63	0,83	
MIN	0,08	15,92	2,50	0,01	0,03	0,34	0,61	0,40	0,00	2,29	0,05	0,71	316,35
MAX	254,93	178,68	286,91	240,54	168,84	197,93	122,77	253,30	272,19	265,93	350,62	193,25	1305,92

OBSERVED MONTHLY RAINFALL (mm) FOR 1881 - 1900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	86,40	69,80	62,60	68,50	72,05	50,20	39,55	59,25	70,70	66,05	71,85	68,55	805,50
STDV	38,69	31,03	41,06	32,17	63,92	52,23	30,96	49,08	43,50	29,53	39,70	45,74	136,60
SKEW	0,43	0,22	0,87	-0,06	3,04	2,25	1,51	1,20	0,81	-0,25	0,99	2,20	
MIN	19,00	14,00	12,00	18,00	13,00	3,00	13,00	8,00	20,00	0,00	20,00	0,00	604,00
MAX	160,00	133,00	196,00	115,00	313,00	225,00	121,00	172,00	159,00	131,00	179,00	227,00	1110,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	86,72	68,57	81,70	67,99	67,88	54,88	41,34	53,79	75,60	67,92	69,37	68,91	804,68
STDV	45,74	36,56	34,88	29,70	44,65	47,97	29,29	40,13	39,97	42,36	37,43	36,92	138,23
SKEW	1,32	0,82	0,41	0,49	0,60	1,56	1,17	1,16	0,77	1,12	1,33	0,80	
MIN	3,08	3,09	0,16	10,82	0,47	0,08	0,20	0,02	3,35	2,29	1,90	0,37	543,18
MAX	264,34	173,48	179,15	157,38	207,61	231,64	135,77	200,61	201,14	214,94	248,80	197,69	1194,23

OBSERVED MONTHLY RAINFALL (mm) FOR 1901 - 1920

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	74,35	105,70	90,70	68,65	65,95	54,75	41,45	59,20	93,75	99,95	74,20	88,80	917,45
STDV	47,64	77,39	38,53	41,22	58,69	65,59	19,73	50,49	102,85	54,49	51,35	58,14	184,34
SKEW	0,94	0,93	0,62	0,49	1,94	3,09	0,84	2,69	3,01	1,02	1,44	0,81	
MIN	15,00	25,00	38,00	18,00	4,00	0,00	17,00	12,00	17,00	26,00	23,00	20,00	661,00
MAX	186,00	251,00	174,00	159,00	243,00	298,00	92,00	241,00	480,00	232,00	220,00	209,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1920

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	72,13	105,50	89,14	66,70	62,62	60,29	42,24	53,55	101,47	100,38	70,59	88,68	913,28
STDV	50,39	79,49	33,68	36,47	44,25	54,56	21,27	36,41	77,26	53,58	46,67	45,93	164,45
SKEW	1,33	1,00	0,10	0,65	0,71	1,52	0,77	1,01	1,03	1,01	1,50	0,78	
MIN	1,95	7,70	1,04	3,30	0,02	0,11	0,90	0,34	0,30	7,00	0,18	0,31	389,75
MAX	279,56	337,07	175,25	179,39	195,77	248,56	110,40	179,28	378,77	283,13	294,40	243,61	1485,19

OBSERVED MONTHLY RAINFALL (mm) FOR 1921 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	68,20	85,65	90,45	57,40	53,20	40,85	58,85	59,50	88,85	75,10	98,05	85,05	861,15
STDV	28,66	53,20	39,42	35,42	47,11	21,33	37,99	38,76	68,29	32,25	60,64	94,46	160,47
SKEW	0,36	1,01	0,92	0,87	2,48	0,24	1,20	1,39	2,24	0,66	1,80	3,55	
MIN	23,00	24,00	37,00	16,00	4,00	8,00	20,00	14,00	24,00	17,00	31,00	27,00	571,00
MAX	119,00	216,00	169,00	131,00	219,00	76,00	161,00	159,00	307,00	156,00	273,00	459,00	1185,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1921 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	68,32	84,18	90,19	56,32	50,29	43,08	61,26	55,06	95,74	76,34	94,72	84,80	860,33
STDV	33,51	55,76	31,86	29,46	35,01	23,37	37,90	32,39	54,02	34,54	51,68	52,85	143,81
SKEW	1,21	0,97	0,19	0,67	0,72	1,09	1,06	0,94	0,79	0,88	1,30	0,97	
MIN	4,10	3,18	4,49	4,22	0,00	6,26	2,56	3,65	2,35	12,70	2,28	4,67	566,98
MAX	191,21	250,97	173,16	151,02	165,52	120,54	181,25	168,17	262,21	192,68	339,09	278,25	1250,63

OBSERVED MONTHLY RAINFALL (mm) FOR 1941 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	89,45	64,80	91,35	69,65	70,35	42,65	54,95	69,80	87,20	95,50	84,90	72,30	892,90
STDV	52,74	39,22	48,47	50,27	48,81	26,10	37,72	63,79	41,53	46,89	58,36	40,89	129,77
SKEW	0,28	2,39	0,53	2,44	0,61	0,25	1,01	2,62	0,31	0,72	0,86	0,62	
MIN	18,00	21,00	21,00	17,00	13,00	5,00	3,00	7,00	31,00	15,00	7,00	25,00	642,00
MAX	200,00	203,00	193,00	248,00	155,00	95,00	148,00	300,00	158,00	202,00	201,00	152,00	1121,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1941 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	87,29	63,93	89,62	68,09	66,38	45,72	57,14	62,98	92,10	96,85	81,08	72,87	884,07
STDV	59,70	37,51	41,52	37,54	43,55	30,95	40,46	46,95	39,73	49,44	56,20	32,31	151,22
SKEW	1,34	0,91	0,44	0,69	0,57	1,23	1,14	1,16	0,65	0,94	1,75	0,63	
MIN	1,60	13,99	0,15	3,12	0,13	1,75	0,08	0,10	12,05	9,55	0,24	0,89	517,71
MAX	330,34	170,22	205,92	185,27	193,96	150,09	188,43	231,35	212,79	264,12	372,80	180,81	1269,66

OBSERVED MONTHLY RAINFALL (mm) FOR 1961 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	74,95	76,65	98,85	74,20	68,40	48,60	48,95	80,25	69,85	76,30	83,15	68,90	868,25
STDV	33,35	41,15	66,12	62,02	52,47	32,60	41,63	52,47	57,36	49,36	46,84	40,16	159,65
SKEW	0,17	0,73	2,43	2,53	1,74	1,61	1,85	2,10	2,37	0,93	1,37	0,87	
MIN	18,00	18,00	19,00	15,00	13,00	20,00	6,00	22,00	15,00	17,00	22,00	18,00	562,00
MAX	130,00	156,00	334,00	291,00	216,00	140,00	166,00	254,00	268,00	182,00	226,00	167,00	1166,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1961 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	70,75	74,05	94,08	69,16	62,69	50,79	50,41	72,68	72,83	74,44	78,05	67,19	837,11
STDV	37,68	45,87	49,83	42,14	39,47	32,13	40,45	41,81	48,28	48,95	44,72	33,20	179,63
SKEW	0,74	0,82	0,49	0,55	0,53	1,04	1,32	0,72	0,87	1,10	1,13	0,58	
MIN	0,89	0,02	0,31	0,50	0,00	0,20	0,05	0,84	0,01	1,30	0,08	0,32	27,04
MAX	189,12	201,88	239,88	203,02	179,01	152,20	201,76	207,06	241,07	246,07	278,01	174,23	1221,94

OBSERVED MONTHLY RAINFALL (mm) FOR 1881 - 1910

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,63	93,33	85,70	68,80	65,40	53,23	38,57	60,50	87,23	86,37	72,93	79,93	869,63
STDV	39,80	66,77	38,01	35,24	57,01	63,81	26,47	55,00	86,51	50,19	48,75	54,41	183,56
SKEW	0,46	1,34	0,72	0,03	3,04	2,77	1,63	1,76	3,42	1,24	1,34	1,43	
MIN	15,00	14,00	12,00	18,00	4,00	3,00	13,00	8,00	20,00	0,00	20,00	0,00	604,00
MAX	160,00	251,00	196,00	122,00	313,00	298,00	121,00	241,00	480,00	232,00	220,00	227,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1910

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,74	92,24	84,56	68,35	61,47	58,25	40,11	54,91	94,18	89,21	70,20	80,20	870,43
STDV	44,36	68,65	33,18	32,59	41,71	53,04	25,47	42,42	62,84	58,30	44,07	43,48	172,89
SKEW	1,14	1,12	0,33	0,57	0,65	1,63	1,06	1,18	0,97	1,17	1,61	0,79	
MIN	0,24	9,17	1,82	8,28	0,30	0,00	1,35	0,00	0,01	2,27	0,04	0,47	567,76
MAX	247,41	308,84	176,56	166,85	196,01	258,65	120,23	212,14	306,69	289,72	292,35	231,49	1455,71

OBSERVED MONTHLY RAINFALL (mm) FOR 1901 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	71,13	96,07	90,53	67,20	62,10	52,83	43,17	59,50	91,37	89,83	83,17	83,77	890,67
STDV	41,26	70,35	39,85	39,71	50,24	54,09	23,11	42,84	94,69	48,21	59,70	52,55	181,11
SKEW	1,14	1,11	0,74	0,60	2,16	3,57	1,19	2,78	2,91	1,37	1,64	0,84	
MIN	15,00	25,00	38,00	17,00	4,00	0,00	17,00	12,00	17,00	26,00	23,00	20,00	571,00
MAX	186,00	251,00	174,00	159,00	243,00	298,00	110,00	241,00	480,00	232,00	273,00	209,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	69,95	95,17	89,60	66,83	58,46	57,66	44,39	55,21	99,55	91,64	79,96	84,49	892,91
STDV	42,86	72,46	33,03	34,92	38,69	45,71	23,66	32,51	70,21	48,33	52,06	41,52	162,08
SKEW	1,23	1,12	0,30	0,63	0,56	1,45	0,90	0,94	1,01	0,98	1,65	0,71	
MIN	0,02	7,92	3,15	4,20	0,14	0,09	4,23	3,49	0,02	8,66	0,06	0,01	597,54
MAX	238,85	312,11	180,32	173,49	173,31	220,00	116,14	165,71	339,90	254,05	347,22	228,05	1432,96

OBSERVED MONTHLY RAINFALL (mm) FOR 1921 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	71,83	75,00	90,43	62,66	56,30	39,73	57,83	54,43	85,20	81,56	95,56	81,00	851,57
SYDV	33,96	46,54	43,09	47,96	47,65	21,90	38,63	35,69	58,58	32,88	61,57	81,01	142,01
SKEW	0,38	1,58	0,55	2,21	1,74	0,16	1,20	1,41	2,52	0,45	1,39	3,69	
MIN	19,00	24,00	21,00	16,00	4,00	5,00	20,00	7,00	24,00	17,00	19,00	25,00	571,00
MAX	144,00	216,00	176,00	248,00	219,00	76,00	161,00	159,00	307,00	156,00	273,00	459,00	1185,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1921 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	70,63	74,07	89,26	62,12	52,85	42,43	60,04	50,47	91,08	82,90	92,13	81,17	849,16
STDV	37,44	46,54	36,77	36,15	37,62	25,23	38,87	30,17	46,87	36,07	55,21	47,75	140,22
SKEW	1,10	0,98	0,40	0,74	0,68	1,18	1,07	0,95	0,75	0,86	1,51	0,89	
MIN	1,16	13,86	0,64	1,55	0,00	3,86	1,36	2,81	4,73	15,88	0,36	3,25	558,67
MAX	213,54	209,79	192,75	175,77	169,73	127,25	182,82	153,72	240,44	199,69	368,30	253,88	1207,31

OBSERVED MONTHLY RAINFALL (mm) FOR 1941 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	84,67	66,60	99,10	72,70	67,37	45,57	49,43	74,77	82,27	91,57	84,30	70,67	889,00
STDV	48,56	37,83	62,97	59,84	48,64	33,05	33,61	64,19	53,54	47,45	58,14	42,81	145,52
SKEW	0,31	1,86	1,88	2,59	0,94	1,14	1,19	2,24	1,55	0,62	1,01	0,71	
MIN	18,00	18,00	21,00	17,00	13,00	5,00	3,00	7,00	15,00	125,00	7,00	18,00	562,00
MAX	200,00	203,00	334,00	291,00	184,00	140,00	148,00	300,00	268,00	202,00	226,00	167,00	1166,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1941 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	83,27	65,79	97,42	72,12	63,43	49,31	51,50	68,14	88,31	93,51	80,92	71,34	885,05
STDV	55,26	38,39	47,84	42,51	41,71	34,83	36,05	48,84	47,85	52,12	55,26	33,95	156,39
SKEW	1,30	0,93	0,60	0,74	0,55	1,33	1,15	1,13	0,79	1,02	1,74	0,69	
MIN	1,01	14,49	1,44	1,36	0,18	1,14	0,19	0,33	2,79	6,45	0,14	0,15	581,80
MAX	305,22	174,43	237,52	205,87	185,97	169,51	167,25	241,98	241,74	270,90	369,06	187,91	1310,40

OBSERVED MONTHLY RAINFALL (mm) FOR 1951 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	83,23	76,40	96,13	71,50	71,67	48,33	50,67	85,27	78,73	83,03	81,83	69,83	896,63
STDV	45,07	44,22	59,77	52,55	50,48	30,76	39,09	61,94	55,13	53,07	47,76	38,34	154,17
SKEW	0,57	1,09	2,26	2,73	1,39	1,26	1,48	2,14	1,55	0,85	1,04	0,84	
MIN	18,00	18,00	19,00	15,00	13,00	6,00	3,00	17,00	15,00	15,00	7,00	18,00	562,00
MAX	200,00	203,00	334,00	291,00	216,00	140,00	166,00	300,00	268,00	202,00	226,00	167,00	1166,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1951 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	81,73	75,39	94,48	70,93	67,56	51,61	53,03	78,83	84,59	85,25	78,83	70,50	892,76
STDV	49,50	47,34	44,35	38,35	41,53	31,16	40,11	48,09	48,66	55,64	46,73	30,35	155,87
SKEW	1,22	0,98	0,54	0,66	0,47	1,19	1,24	0,97	0,84	1,15	1,49	0,59	
MIN	0,00	14,09	0,34	3,61	1,48	4,33	0,01	3,78	1,38	1,56	0,42	1,55	599,12
MAX	276,35	213,30	223,15	189,25	188,94	156,62	184,45	244,10	243,40	280,05	311,81	172,07	1344,52

OBSEVED MONTHLY RAINFALL (mm) FOR 1881 - 1920

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	80,37	87,75	86,65	68,57	69,00	52,47	40,50	59,22	82,22	83,00	73,02	78,67	861,47
STDV	43,27	60,97	39,51	36,50	60,65	58,56	25,64	49,15	78,82	46,54	45,32	52,64	169,88
SKEW	0,63	1,50	0,70	0,31	2,47	2,76	1,35	1,89	3,47	1,27	1,30	1,31	
MIN	15,00	14,00	12,00	18,00	4,00	0,00	13,00	8,00	17,00	0,00	20,00	0,00	604,00
MAX	186,00	251,00	196,00	159,00	313,00	298,00	121,00	241,00	480,00	232,00	220,00	227,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1920

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	81,11	86,63	85,95	67,98	64,87	57,71	41,91	54,02	89,21	85,04	70,44	79,15	864,04
STDV	52,32	61,97	33,87	33,25	44,49	51,50	25,69	38,43	59,01	52,56	41,56	41,89	160,15
SKEW	1,55	1,05	0,37	0,58	0,62	1,59	1,02	1,12	0,95	1,10	1,49	0,78	
MIN	0,00	1,43	1,16	6,14	0,00	0,00	1,58	0,31	0,04	2,78	0,41	0,39	575,04
MAX	299,17	269,30	181,15	169,11	198,99	245,99	122,09	190,66	288,96	267,18	277,89	226,88	1385,47

OBSERVED MONTHLY RAINFALL (mm) FOR 1895 - 1934

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	78,02	91,97	84,55	65,52	57,55	48,65	43,32	59,70	86,52	86,37	78,62	87,45	868,27
STDV	43,78	62,17	38,51	38,34	45,44	48,44	26,34	43,18	87,36	46,27	54,55	77,16	183,41
SKEW	0,75	1,36	0,73	0,57	2,40	3,85	1,13	2,27	2,97	1,32	1,76	3,12	
MIN	15,00	25,00	12,00	17,00	4,00	0,00	13,00	12,00	17,00	17,00	23,00	20,00	571,00
MAX	186,00	251,00	174,00	159,00	243,00	298,00	110,00	241,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1895 - 1934

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,65	90,90	83,53	65,11	54,21	52,85	44,78	55,23	93,98	88,17	75,65	87,75	868,80
STDV	47,01	63,09	32,80	33,91	34,67	40,42	26,86	33,64	64,65	47,04	47,42	49,46	156,42
SKEW	1,23	1,05	0,36	0,63	0,52	1,42	1,00	0,97	0,99	0,99	1,59	0,84	
MIN	0,02	12,09	1,44	4,30	0,53	0,36	2,14	2,69	0,02	8,05	0,02	1,85	580,55
MAX	262,02	277,70	174,88	168,75	156,84	195,82	128,23	170,75	314,32	246,23	316,16	264,64	1386,51

OBSERVED MONTHLY RAINFALL (mm) FOR 1911 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,02	74,00	90,20	63,97	62,17	42,35	54,95	54,67	80,70	79,40	90,00	79,47	847,92
STDV	39,78	43,82	43,19	46,09	54,92	27,89	35,51	33,30	56,44	32,80	56,58	73,84	136,51
SKEW	0,78	1,50	0,56	1,95	1,81	1,58	1,31	1,35	2,22	0,38	1,54	3,65	
MIN	19,00	24,00	21,00	16,00	4,00	0,00	17,00	7,00	17,00	17,00	19,00	20,00	571,00
MAX	186,00	216,00	176,00	248,00	243,00	154,00	161,00	159,00	307,00	156,00	273,00	459,00	1485,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1911 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	74,01	72,94	89,17	63,62	58,42	45,86	56,78	50,71	86,87	80,41	86,61	79,92	845,31
STDV	43,16	44,26	36,76	36,10	41,87	31,02	35,52	28,43	47,51	35,57	50,07	45,30	127,76
SKEW	1,14	0,90	0,40	0,67	0,66	0,27	1,04	0,93	0,76	0,83	0,37	0,87	
MIN	0,13	6,85	0,34	1,54	0,07	1,29	0,99	4,80	2,14	13,03	0,78	2,21	576,88
MAX	240,36	194,34	189,03	175,16	178,53	149,93	168,54	144,74	231,78	196,49	331,43	239,97	1183,67

OBSERVED MONTHLY RAINFALL (mm) FOR 1925 - 1966

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	81,64	72,88	97,00	60,98	61,90	40,43	55,02	70,48	89,50	88,07	90,74	77,38	886,02
STDV	42,93	44,46	56,37	40,37	47,65	25,85	35,92	59,59	63,17	44,80	60,75	70,68	142,14
SKEW	0,51	1,77	1,94	2,49	1,36	0,81	1,18	2,19	1,79	0,67	1,34	4,00	
MIN	18,00	21,00	21,00	16,00	4,00	5,00	3,00	7,00	15,00	15,00	7,00	21,00	571,00
MAX	200,00	216,00	334,00	248,00	219,00	144,00	161,00	300,00	307,00	202,00	273,00	459,00	1185,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1925 - 1966

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	79,35	71,80	95,32	60,25	58,35	43,46	57,11	63,98	96,41	89,65	87,03	77,85	880,56
STDV	48,44	44,48	44,22	31,15	39,83	28,08	37,93	45,68	54,85	48,55	55,72	42,72	143,46
SKEW	1,16	0,91	0,43	0,62	0,59	1,21	1,09	1,15	0,80	0,98	1,58	0,82	
MIN	0,00	3,48	0,27	3,73	0,01	2,08	0,38	0,52	1,59	6,38	0,00	1,20	593,34
MAX	269,17	196,93	217,33	156,06	173,33	137,58	179,53	225,91	267,82	252,65	368,52	225,88	1287,68

OBSERVED MONTHLY RAINFALL (mm) FOR 1941 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	82,20	70,25	94,70	71,92	69,37	45,62	51,95	75,02	78,52	85,90	84,02	70,60	880,57
STDV	44,17	40,13	57,33	55,77	50,03	29,31	39,33	57,89	50,20	48,50	52,24	40,04	144,14
SKEW	0,47	1,41	1,92	2,46	1,18	1,17	1,40	2,29	1,55	0,72	1,02	0,71	
MIN	18,00	18,00	19,00	15,00	13,00	5,00	3,00	7,00	15,00	15,00	7,00	18,00	562,0
MAX	200,00	203,00	334,00	291,00	216,00	140,00	166,00	300,00	268,00	202,00	226,00	167,00	1166,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1941 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	80,89	69,83	93,11	71,34	65,35	48,95	54,38	69,02	84,15	88,00	80,91	71,30	877,23
STDV	49,39	41,84	44,59	40,84	42,38	31,14	40,37	45,19	45,01	52,38	50,38	32,10	152,44
SKEW	1,22	0,95	0,56	0,72	0,54	1,24	1,22	1,03	0,78	1,07	1,58	0,63	
MIN	0,01	14,77	0,68	2,12	0,43	3,01	0,00	1,68	3,15	4,10	0,04	0,79	583,17
MAX	275,26	190,46	223,09	199,13	191,42	154,85	186,03	226,88	228,63	267,90	335,88	179,83	1292,80

OBSERVED MONTHLY RAINFALL (mm) FOR 1881 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,24	85,56	87,36	67,72	66,08	51,78	41,72	59,40	83,10	80,32	78,64	77,68	856,60
STDV	40,56	58,92	40,11	36,54	55,70	52,83	26,29	44,95	78,39	43,04	52,46	50,02	168,59
SKEW	0,80	1,48	0,75	0,42	2,65	3,0	1,30	1,95	3,22	1,40	1,67	1,23	
MIN	15,00	14,00	12,00	17,00	4,00	0,00	13,00	8,00	17,00	0,00	20,00	0,00	571,00
MAX	186,00	251,00	196,00	159,00	313,00	298,00	121,00	241,00	480,00	232,00	273,00	227,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1930

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	75,92	84,62	86,32	67,40	62,19	56,65	43,17	54,61	90,11	82,20	75,74	78,24	857,19
STDV	43,77	59,85	34,22	33,15	41,18	46,76	26,46	35,88	59,06	48,01	46,61	40,16	153,27
SKEW	1,17	1,06	0,37	0,57	0,57	1,50	1,02	1,04	0,94	1,06	1,55	0,75	
MIN	0,16	10,28	1,27	6,13	0,17	0,00	1,70	1,29	0,01	4,35	0,09	0,09	573,64
MAX	246,06	261,97	181,76	167,34	185,17	224,70	125,72	179,94	288,66	246,64	310,77	218,45	1350,18

OBSERVED MONTHLY RAINFALL (mm) FOR 1891 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,30	90,72	89,02	63,62	58,72	50,38	46,36	57,12	87,04	83,56	83,02	81,80	867,66
STDV	41,71	60,93	42,16	37,31	48,48	51,71	30,90	43,96	79,34	42,33	55,28	71,19	169,20
SKEW	0,73	1,32	0,67	0,56	2,21	3,25	1,52	2,04	3,11	1,52	1,56	3,31	
MIN	15,00	24,00	12,00	16,00	4,00	0,00	13,00	12,00	17,00	17,00	23,00	0,00	571,00
MAX	186,00	251,00	196,00	159,00	243,00	298,00	161,00	241,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1891 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	74,15	89,62	87,62	62,76	55,32	54,96	48,03	52,30	94,32	84,93	79,77	82,08	865,87
STDV	46,06	62,35	36,72	32,92	37,55	43,94	30,93	34,49	60,38	42,07	49,16	47,54	147,98
SKEW	1,18	1,02	0,31	0,65	0,59	1,43	1,06	1,06	0,90	0,92	1,53	0,87	
MIN	0,01	11,10	0,43	3,62	0,00	0,03	0,74	1,40	0,01	9,67	0,13	3,02	580,18
MAX	255,20	270,79	187,08	164,70	164,92	209,64	146,42	172,40	290,64	224,23	325,88	250,37	1327,49

OBSERVED MONTHLY RAINFALL (mm) FOR 1906 - 1955

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	80,00	78,12	87,42	65,18	62,86	47,24	54,24	60,84	82,30	81,82	88,82	83,36	872,20
STDV	44,54	51,18	40,80	44,28	53,15	45,32	34,68	48,56	54,22	35,80	55,41	72,20	145,53
SKEW	0,76	1,58	0,66	1,70	1,70	3,79	1,26	2,75	1,98	0,54	1,39	3,14	
MIN	18,00	21,00	21,00	16,00	4,00	0,00	17,00	7,00	17,00	15,00	19,00	20,00	571,00
MAX	200,00	244,00	176,00	248,00	243,00	298,00	161,00	300,00	307,00	185,00	273,00	459,00	1234,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1906 - 1955

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,85	77,02	86,24	64,61	59,00	51,36	56,17	55,89	88,14	83,28	85,64	83,70	868,92
STDV	48,41	51,57	34,58	35,75	41,62	39,56	35,11	36,94	46,86	39,63	50,41	46,76	149,00
SKEW	1,21	1,00	0,36	0,69	0,66	1,42	1,04	1,04	0,78	0,91	1,48	0,84	
MIN	0,01	3,69	1,16	2,63	0,01	0,28	1,86	1,21	3,47	12,08	0,55	1,51	576,57
MAX	267,29	227,91	182,54	175,95	186,99	191,38	166,18	185,19	238,29	213,72	336,41	250,54	1285,02

OBSERVED MONTHLY RAINFALL (mm) FOR 1931 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL MEAN
MEAN	80,10	75,48	93,90	67,64	65,90	43,04	55,78	71,80	81,04	84,84	86,22	75,76	881,50
STDV	42,06	44,12	53,45	52,40	52,55	28,30	40,35	56,52	51,39	46,57	51,23	67,08	144,68
SKEW	0,49	1,37	1,93	2,51	1,38	1,22	1,24	2,13	1,59	0,72	1,12	4,00	
MIN	18,00	18,00	19,00	15,00	4,00	5,00	3,00	7,00	15,00	15,00	7,00	18,00	562,00
MAX	200,00	216,00	334,00	291,00	219,00	140,00	166,00	300,00	268,00	202,00	226,00	459,00	1185,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1931 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	78,71	74,54	92,46	67,07	61,91	46,20	58,28	65,85	86,78	86,85	83,15	76,18	877,98
STDV	47,07	46,21	41,99	38,76	43,08	29,67	42,10	44,53	45,88	50,59	49,15	41,07	153,16
SKEW	1,21	0,97	40,50	0,73	0,64	1,25	1,19	1,06	0,77	1,06	1,49	0,80	
MIN	0,01	14,40	0,04	1,79	0,01	2,68	0,09	1,02	3,61	4,75	0,48	0,61	577,03
MAX	263,23	208,62	213,28	188,65	193,94	147,30	194,68	222,71	233,70	259,82	329,97	221,32	1298,06

OBSERVED MONTHLY RAINFALL (mm) FOR 1881 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,32	87,05	87,92	64,85	63,73	48,60	46,62	59,32	84,43	80,37	81,37	80,80	861,37
STDV	39,19	58,05	39,19	36,23	56,59	49,44	31,23	45,61	74,95	42,20	51,80	68,66	165,43
SKEW	0,74	1,39	0,75	0,46	2,49	3,19	1,46	1,79	3,13	1,28	1,63	3,24	
MIN	15,00	14,00	12,00	16,00	4,00	0,00	13,00	8,00	17,00	0,00	20,00	0,00	571,00
MAX	186,00	251,00	196,00	159,00	313,00	298,00	161,00	241,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1940

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	75,05	86,07	86,90	64,49	59,86	53,06	48,38	54,45	91,31	82,26	78,47	81,11	861,41
STDV	42,65	59,93	33,53	32,71	41,83	43,12	31,16	36,57	57,73	47,30	46,48	45,79	154,55
SKEW	1,16	1,06	0,34	0,60	0,65	1,48	1,07	1,05	0,91	1,05	1,49	0,84	
MIN	0,29	11,38	1,93	5,05	0,01	0,02	?117	0,93	0,09	4,97	0,43	1,73	569,40
MAX	240,28	264,22	179,96	163,91	188,73	207,97	146,69	183,14	284,01	243,41	310,14	244,86	1345,76

OBSERVED MONTHLY RAINFALL (mm) FOR 1901 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,33	85,38	90,83	65,23	63,17	46,08	51,75	62,83	89,93	90,18	85,72	82,05	890,50
STDV	44,41	60,16	41,66	42,39	51,43	42,31	33,24	51,38	73,97	46,02	56,81	67,46	158,74
SKEW	0,74	1,43	0,64	1,60	1,62	3,91	1,32	2,55	3,07	1,05	1,33	3,23	
MIN	15,00	21,00	21,00	16,00	4,00	0,00	3,00	7,00	17,00	15,00	7,00	20,00	571,00
MAX	200,00	251,00	193,00	248,00	243,00	298,00	161,00	300,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,16	84,48	89,78	64,83	59,35	50,07	53,65	57,62	97,07	91,99	82,48	82,56	890,05
STDV	48,28	60,73	35,39	35,09	41,38	37,46	34,19	38,90	58,10	48,48	52,41	44,36	157,69
SKEW	1,25	1,07	0,37	0,66	0,64	1,39	1,06	1,07	0,87	0,98	1,61	0,80	
MIN	0,24	9,41	1,41	3,13	0,03	0,50	1,35	0,96	0,70	8,70	0,00	0,65	587,62
MAX	267,71	264,01	188,36	172,91	184,79	181,29	161,18	194,18	287,94	254,94	349,48	239,47	1370,91

OBSERVED MONTHLY RAINFALL (mm) FOR 1921 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,53	75,70	93,28	67,08	63,98	44,03	54,25	69,85	81,97	82,30	88,70	75,42	874,10
STDV	39,98	45,01	51,74	50,08	49,28	26,82	38,70	52,48	56,49	43,78	55,07	63,09	148,70
SKEW	0,62	1,32	1,86	2,45	1,48	1,10	1,29	2,30	2,02	0,84	1,34	3,97	
MIN	18,00	18,00	19,00	15,00	4,00	5,00	3,00	7,00	15,00	15,00	7,00	18,00	562,00
MAX	200,00	216,00	334,00	291,00	219,00	140,00	166,00	300,00	307,00	202,00	273,00	459,00	1185,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1921 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,23	74,77	91,91	66,56	60,19	47,09	56,62	64,39	87,94	84,16	85,50	75,91	871,27
STDV	44,06	47,11	40,84	37,61	40,46	28,65	40,09	41,27	48,19	47,08	51,51	39,75	149,25
SKEW	1,17	0,98	0,48	0,71	0,59	1,20	1,17	1,01	0,80	1,03	1,52	0,77	
MIN	0,15	13,85	0,00	2,29	0,08	3,80	0,21	1,97	2,63	6,01	0,28	0,23	575,02
MAX	247,57	212,07	208,85	183,90	182,67	143,79	185,87	207,89	243,52	243,70	343,57	215,26	1282,74

OBSERVED MONTHLY RAINFALL (mm) FOR 1881 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,71	82,29	88,27	66,04	63,56	47,01	47,93	57,17	83,50	82,39	82,69	79,67	857,23
STDV	39,51	55,24	40,82	41,57	55,44	46,69	32,77	43,66	70,40	40,98	53,67	65,77	157,52
SKEW	0,63	1,59	0,62	1,43	2,31	3,30	1,46	1,85	3,26	1,14	1,47	3,18	
MIN	15,00	14,00	12,00	16,00	4,00	0,00	13,00	7,00	17,00	0,00	19,00	0,00	571,00
MAX	186,00	251,00	196,00	248,00	313,00	298,00	161,00	241,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	75,46	81,35	87,16	65,63	59,69	51,32	49,77	52,49	90,12	84,17	79,67	80,05	856,90
STDV	43,45	55,67	35,28	35,00	41,91	41,18	32,53	35,07	54,48	46,25	48,48	44,53	151,09
SKEW	1,17	1,04	0,39	0,65	0,66	1,47	1,08	1,05	0,87	1,01	1,54	0,83	
MIN	0,17	11,29	0,89	3,63	0,02	0,05	0,97	0,99	0,53	6,53	0,17	1,34	565,96
MAX	244,24	245,28	186,04	173,16	188,08	198,37	152,69	175,50	269,73	240,61	323,33	238,81	1313,11

OBSERVED MONTHLY RAINFALL (mm) FOR 1901 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	79,93	83,66	93,71	65,64	61,64	45,41	49,57	64,53	86,60	89,40	85,24	79,90	885,24
STDV	43,98	56,20	49,73	40,53	48,80	40,66	32,16	54,60	74,06	45,60	56,48	63,88	155,47
SKEW	0,63	1,58	1,87	1,54	1,71	3,85	1,36	2,37	2,89	1,06	1,37	3,31	
MIN	15,00	21,00	21,00	16,00	4,00	0,00	3,00	7,00	15,00	15,00	7,00	20,00	571,00
MAX	200,00	251,00	334,00	248,00	243,00	298,00	161,00	300,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,67	82,73	92,10	64,45	58,15	49,09	51,32	58,59	93,49	90,72	81,68	80,31	880,29
STDV	48,95	55,81	39,92	33,79	39,41	36,17	33,34	41,07	58,82	46,76	51,66	42,33	148,19
SKEW	1,21	1,01	0,32	0,65	0,61	1,31	1,05	1,11	0,89	0,94	1,57	0,78	
MIN	0,07	11,50	0,02	3,99	0,00	0,58	0,63	0,66	0,12	8,34	0,04	0,49	532,16
MAX	271,92	244,22	200,47	168,93	173,54	172,87	158,62	203,57	284,80	248,00	341,33	226,28	1332,37

OBSERVED MONTHLY RAINFALL (mm) FOR 1911 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	79,11	75,03	92,74	67,20	66,24	44,91	53,11	67,79	79,86	80,96	86,50	75,34	868,80
STDV	41,97	43,69	50,64	48,74	52,90	29,09	36,87	49,72	55,49	42,37	52,77	61,01	145,30
SKEW	0,68	1,29	1,75	2,32	1,58	1,40	1,34	2,41	1,91	0,84	1,40	3,79	
MIN	18,00	18,00	19,00	15,00	4,00	0,00	3,00	7,00	15,00	15,00	7,00	18,00	562,00
MAX	200,00	216,00	334,00	291,00	243,00	154,00	166,00	300,00	307,00	202,00	273,00	459,00	1185,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1911 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,39	74,08	91,48	66,77	62,29	48,35	55,24	62,51	85,93	52,56	83,36	75,91	865,87
STDV	46,00	45,73	40,21	37,38	42,34	31,46	38,02	38,91	48,15	45,23	49,01	39,39	143,32
SKEW	1,21	0,95	0,48	0,68	0,59	1,25	1,14	1,00	0,81	1,00	1,46	0,77	
MIN	0,02	13,76	0,00	2,24	0,00	2,33	0,27	2,74	1,78	6,06	0,51	0,20	579,67
MAX	257,00	203,67	205,50	182,59	186,83	154,57	176,58	195,79	239,98	236,23	326,61	213,87	1265,09

OBSERVED MONTHLY RAINFALL (mm) FOR 1881 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	79,60	81,49	88,77	66,05	65,39	47,11	48,70	61,94	85,13	84,15	82,25	78,68	869,25
STDV	43,00	54,59	41,40	39,91	54,53	44,68	32,92	50,53	67,91	43,61	53,16	62,74	157,09
SKEW	0,64	1,57	0,68	1,39	2,14	3,28	1,32	2,23	3,11	1,10	1,38	3,24	
MIN	15,00	14,00	12,00	16,00	4,00	0,00	3,00	7,00	17,00	0,00	7,00	0,00	571,00
MAX	200,00	251,00	196,00	248,00	313,00	298,00	161,00	300,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1960

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	78,22	80,57	87,68	65,68	61,46	51,33	50,62	56,57	91,74	86,06	79,21	79,13	868,34
STDV	47,27	55,32	35,51	34,03	42,34	40,22	33,62	39,31	54,09	48,70	49,05	42,71	154,09
SKEW	1,22	1,04	0,39	0,62	0,63	1,44	1,10	1,09	0,85	1,03	1,57	0,80	
MIN	0,00	11,07	0,88	4,44	0,00	0,16	0,79	0,57	0,96	5,64	0,06	0,67	574,98
MAX	263,96	243,76	187,21	169,53	190,25	194,21	157,38	195,93	269,05	251,72	327,01	230,16	1335,97

OBSERVED MONTHLY RAINFALL (mm) RAINFALL (mm) FOR 1891 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	79,44	81,67	92,80	67,03	61,96	48,58	47,51	63,74	85,25	86,56	83,50	77,63	875,66
STDV	44,29	54,46	50,63	46,88	48,42	45,45	31,76	52,78	70,44	44,20	56,01	62,02	160,12
SKEW	00,56	1,59	1,60	2,20	1,69	3,13	1,36	2,32	2,99	1,11	1,31	3,25	
MIN	15,00	18,00	12,00	16,00	4,00	0,00	3,00	7,00	15,00	15,00	7,00	0,00	562,00
MAX	200,00	251,00	334,00	291,00	243,00	298,00	161,00	300,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1891 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,23	80,66	91,14	65,95	58,36	52,79	49,32	58,08	92,04	88,09	80,13	78,04	871,84
STDV	49,87	54,77	41,46	36,49	39,33	40,66	32,94	40,37	55,90	45,87	51,52	42,73	150,50
SKEW	1,23	1,01	0,40	0,71	0,58	1,39	1,09	1,11	0,86	0,96	1,61	0,82	
MINZ	0,23	11,13	0,03	2,52	0,01	0,22	0,44	0,71	0,43	8,13	0,00	1,09	579,97
MAX	275,21	239,55	206,20	180,57	173,52	194,92	154,50	200,62	272,52	241,71	341,84	227,59	1322,90

OBSERVED MONTHLY RAINFALL (mm) FOR 1901 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,74	83,20	92,64	67,48	64,48	46,71	51,05	67,19	84,91	86,71	85,08	78,76	884,94
STDV	41,73	55,90	48,55	47,77	51,41	39,92	35,26	51,88	70,39	46,95	54,21	61,80	158,25
SKEW	0,70	1,44	1,75	2,15	1,61	3,62	1,48	2,32	3,00	0,95	1,34	3,26	
MIN	15,00	18,00	19,00	15,00	4,00	0,00	3,00	7,00	15,00	15,00	7,00	18,00	562,00
MAX	200,00	251,00	334,00	291,00	243,00	298,00	166,00	300,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1901 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	75,43	82,28	91,39	66,99	60,62	50,54	53,12	61,82	91,69	88,66	81,95	79,30	883,79
STDV	45,77	57,08	38,88	37,74	41,48	36,08	35,92	40,34	55,77	49,93	50,37	41,46	156,26
SKEW	1,22	1,05	0,44	0,69	0,62	1,35	1,12	1,03	0,88	1,03	1,55	0,77	
MIN	0,00	10,83	0,22	2,53	0,00	1,10	0,60	1,58	0,45	5,97	0,10	0,23	581,75
MAX	255,40	250,81	201,54	183,21	186,29	176,01	167,63	202,51	275,81	258,36	335,86	224,72	1353,21

OBSERVED MONTHLY RAINFALL (mm) FOR 1881 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	79,10	80,23	91,64	67,47	64,94	47,59	47,56	64,47	83,71	84,10	82,34	77,42	870,58
STDV	42,45	52,86	48,18	45,29	53,82	44,48	31,88	52,68	68,26	44,07	53,69	61,20	158,79
SKEW	0,59	1,60	1,71	2,14	2,10	3,05	1,34	2,16	2,96	1,01	1,37	3,16	
MIN	15,00	14,00	12,00	16,00	4,00	0,00	3,00	7,00	15,00	0,00	7,00	0,00	562,00
MAX	200,00	251,00	334,00	291,00	313,00	298,00	161,00	300,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1970

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,72	79,31	90,39	67,03	61,05	51,83	49,43	48,97	90,35	86,03	79,28	77,87	869,26
STDV	47,08	53,74	38,76	36,16	41,86	40,47	32,84	41,03	54,62	49,26	49,56	42,07	155,17
SKEW	1,22	1,03	0,44	0,66	0,62	1,44	1,10	1,09	0,88	1,04	1,58	0,80	
MIN	0,00	11,46	0,15	3,41	0,00	0,18	0,76	0,55	0,54	5,24	0,02	0,68	571,18
MAX	262,85	237,40	200,39	178,46	188,11	195,47	153,72	204,43	270,45	253,99	330,40	226,70	1338,07

OBSERVED MONTHLY RAINFALL (mm) FOR 1886 - 1975

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	78,98	82,47	91,72	67,44	62,31	47,98	48,34	66,50	82,63	82,77	83,11	77,39	871,64
STDV	42,71	52,46	48,36	45,76	47,18	43,31	33,90	53,22	68,65	44,17	53,47	61,45	157,83
SKEW	0,60	1,56	1,68	2,09	1,62	3,25	1,49	2,07	2,95	1,08	1,36	3,12	
MIN	15,00	18,00	12,00	15,00	4,00	0,00	3,00	7,00	15,00	0,00	7,00	0,00	562,00
MAX	200,00	251,00	334,00	291,00	243,00	298,00	166,00	300,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1886 - 1975

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	77,59	81,48	90,44	66,96	58,65	52,02	50,35	60,94	89,22	84,73	80,06	77,79	870,23
STDV	47,20	53,53	38,93	36,57	38,86	38,61	34,39	41,81	54,82	48,74	49,47	42,40	155,56
SKEW	1,22	1,01	0,45	0,67	0,58	1,39	1,13	1,07	0,89	1,05	1,57	0,81	
MIN	0,00	13,34	0,14	3,18	0,20	0,68	0,49	0,72	0,35	5,14	0,08	0,80	571,06
MAX	263,37	239,10	201,11	180,10	175,94	187,97	160,31	208,95	271,08	250,71	329,83	227,95	1339,83

OBSERVED MONTHLY RAINFALL (mm) FOR 1891 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	78,92	81,83	91,54	67,31	63,46	48,27	48,84	65,08	83,26	84,60	83,47	76,82	873,40
STDV	42,68	53,38	49,26	46,33	49,19	43,06	34,80	51,11	67,74	44,93	53,65	59,37	157,82
SKEW	0,60	1,53	1,57	2,09	1,68	3,28	1,49	2,26	3,05	1,09	1,32	3,32	
MIN	15,00	18,00	12,00	15,00	4,00	0,00	3,00	7,00	15,00	15,00	7,00	0,00	562,00
MAX	200,00	251,00	334,00	291,00	243,00	298,00	166,00	300,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1891 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	76,71	80,78	89,88	66,23	59,74	52,24	50,83	59,56	89,77	86,22	80,24	77,29	869,48
STDV	47,92	54,35	40,70	36,40	39,99	38,60	35,35	39,92	53,82	46,68	49,71	41,07	150,97
SKEW	1,19	1,00	0,40	0,71	0,57	1,35	1,14	1,07	0,86	0,99	1,55	0,79	
MIN	0,02	10,94	0,00	2,76	0,06	0,65	0,20	1,22	0,62	6,71	0,08	0,49	579,29
MAX	264,73	238,81	203,43	180,54	177,59	186,33	163,87	199,37	264,46	244,06	330,43	220,75	1316,27

OBSERVED MONTHLY RAINFALL (mm) FOR 1881 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	78,67	80,52	90,63	67,68	65,99	47,41	48,75	65,60	82,07	82,58	82,43	76,72	869,05
STDV	41,14	52,03	47,13	44,94	53,87	42,39	34,61	51,19	65,95	44,67	51,73	58,87	156,79
SKEW	0,62	1,53	1,65	2,04	2,04	3,16	1,47	2,12	3,01	1,01	1,36	3,22	
MIN	15,00	14,00	12,00	15,00	4,00	0,00	3,00	7,00	15,00	0,00	7,00	0,00	563,00
MAX	200,00	251,00	334,00	291,00	313,00	298,00	166,00	300,00	480,00	232,00	273,00	459,00	1409,00

100 YEAR SERIES GENERATED FROM MONTHLY RAINFALL (mm) FOR 1881 - 1980

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	78,49	79,41	89,47	67,15	62,05	51,42	50,81	60,20	88,45	84,61	79,42	77,20	868,69
STDV	47,03	53,57	38,12	35,98	42,23	38,63	34,99	40,52	52,86	49,45	48,06	40,67	154,44
SKEW	1,19	1,01	0,44	0,65	0,62	1,40	1,14	1,06	0,87	1,06	1,53	0,78	
MIN	0,07	5,27	0,19	3,72	0,04	0,54	0,43	0,98	0,74	4,61	0,23	0,28	571,90
MAX	254,37	237,81	197,58	178,50	191,60	187,89	162,84	203,09	261,83	253,59	320,00	219,72	1328,99

APPENDIX H

Alicedale 'observed' and generated monthly streamflow data.

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 10

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1	8	527	64	343	138	10	0	57	7	0	2	1158
STDV	3	16	503	146	794	360	33	0	179	18	1	6	1762
SKEW	3,0	2,1	3,1	3,0	2,5	2,9	3,2	1,3	3,2	2,7	3,2	2,6	1,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	10	47	4786	473	2411	1140	103	0	567	56	2	17	5260

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 10

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1	8	561	67	343	134	10	0	55	8	0	2	1191
STDV	2	11	752	83	513	181	13	0	78	11	0	3	1006
SKEW	2,9	2,8	2,4	1,9	3,0	2,4	2,3	1,2	2,8	2,5	2,4	3,4	1,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	55
MAX	15	113	5391	504	3900	1286	102	0	725	75	2	40	7053

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 210

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	2	1	401	40	0	0	0	0	0	0	0	20	464
STDV	6	2	167	115	0	0	0	0	0	0	0	62	1342
SKEW	3,2	2,8	3,1	3,1	1,4	0,8	0,5	0,6	0,7	0,3	1,0	3,2	3,1
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	19	8	3711	367	0	0	0	0	0	0	0	195	4273

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 210

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	2	1	430	42	0	0	0	0	0	0	0	20	496
STDV	3	1	570	54	0	0	0	0	0	0	0	0	595
SKEW	3,0	2,7	2,3	2,2	1,4	0,8	0,6	0,7	0,7	1,0	1,3	3,6	2,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	1
MAX	26	14	3960	371	0	0	0	0	0	0	0	381	4075

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 410

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	13	6	1	0	5	1	0	1	219	22	1	0	269
STDV	43	19	1	1	16	2	0	3	692	68	4	0	825
SKEW	3,2	3,2	3,0	3,2	3,2	3,2	0,8	3,2	3,2	3,2	3,1	3,1	3,2
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	134	59	5	2	50	5	0	11	2188	216	11	1	2615

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 410

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	12	6	1	0	5	0	0	1	214	23	1	0	265
STDV	18	9	1	0	8	1	0	2	305	34	2	0	317
SKEW	2,9	2,8	2,4	2,0	3,2	2,5	1,3	2,4	2,8	2,6	2,4	3,2	2,9
MIN	0	0	0	0	0	0	0	0	0	0	0	0	5
MAX	167	89	6	1	64	5	0	11	2942	233	13	2	3219

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 610

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1	149	23	12	1	0	0	0	0	35	29	13	265
STDV	3	423	47	40	4	0	0	0	0	109	79	34	471
SKEW	3,2	3,1	2,0	3,2	3,2	2,7	1,9	2,1	1,6	3,2	3,1	2,9	2,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	11	1347	133	125	12	0	0	0	0	344	251	107	1480

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 610

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1	156	24	13	1	0	0	0	0	37	31	13	277
STDV	1	223	32	17	2	0	0	0	0	53	42	19	250
SKEW	3,0	3,1	2,2	2,3	3,1	1,7	1,4	1,4	1,4	2,7	2,4	3,7	2,5
MIN	0	0	0	0	0	0	0	0	0	0	0	0	10
MAX	14	2388	197	128	14	0	0	0	0	439	321	253	2611

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 810

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	6	0	45	4	0	0	0	1	0	0	1	60	118
STDV	19	0	142	14	0	0	0	2	0	0	4	190	344
SKEW	3,2	3,2	3,2	3,2	1,6	0,3	0,2	3,2	3,2	2,2	3,2	3,2	3,1
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	60	1	449	44	0	0	0	6	1	0	14	602	1095

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 810

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	5	0	49	5	0	0	0	1	0	0	1	59	120
STDV	8	0	66	6	0	0	0	1	0	0	2	86	111
SKEW	2,9	2,7	2,4	2,1	1,4	0,9	1,0	2,3	2,7	1,6	2,4	3,4	2,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	1
MAX	74	1	491	36	0	0	0	6	1	0	15	1057	1098

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 20

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1	9	264	33	199	72	5	1	42	5	9	3	642
STDV	2	20	1069	106	578	257	23	5	137	14	40	7	1332
SKEW	4,1	2,4	4,4	4,2	3,4	4,2	4,5	4,5	3,5	3,1	4,5	2,9	2,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	10	75	4786	473	2411	1140	103	22	567	56	177	25	5260

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 20

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1	10	280	34	196	69	5	1	40	5	10	3	654
STDV	1	13	382	43	299	94	7	2	57	8	14	4	526
SKEW	2,9	2,9	2,4	2,1	3,1	2,4	2,4	2,3	2,9	2,4	2,5	3,4	1,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	43
MAX	9	139	2618	270	2220	610	62	10	522	49	89	43	3606

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 220

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	5	220	24	131	13	0	0	0	0	1	38	436
STDV	13	19	828	82	580	57	0	0	0	1	5	124	1112
SKEW	3,4	4,4	4,4	4,3	4,5	4,5	0,6	1,2	4,5	4,5	4,5	3,8	3,0
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	53	87	3711	367	2595	265	0	0	0	6	20	532	4273

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 220

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	5	234	24	129	13	0	0	0	0	1	37	447
STDV	6	7	317	32	201	17	0	0	0	0	2	53	395
SKEW	3,0	3,0	2,4	2,1	3,3	2,4	0,5	0,8	2,6	2,5	2,5	3,5	1,9
MIN	0	0	0	0	0	0	0	0	0	0	0	0	16
MAX	53	78	2239	195	1768	114	0	0	0	4	11	669	2722

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 420

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	7	15	57	6	3	0	1	1	109	12	1	0	211
STDV	30	56,1	186	18	11	1	2	2	489	48	3	0	603
SKEW	4,5	4,1	3,6	3,6	4,5	4,5	3,9	4,4	4,5	4,4	4,3	4,4	3,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	134	248	785	78	50	5	8	11	2188	216	11	1	2615

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 420

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	6	16	60	6	3	0	1	1	105	12	1	0	210
STDV	9	23	81	8	4	0	1	1	150	18	1	0	184
SKEW	3,0	3,0	2,4	2,1	3,2	2,5	2,3	2,3	2,9	2,6	2,4	3,6	2,4
MIN	0	0	0	0	0	0	0	0	0	0	0	0	9
MAX	85	245	572	49	33	2	5	6	1346	135	7	1	1500

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 620

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	8	267	50	11	1	0	0	0	64	95	32	8	535
STDV	35	895	119	34	3	0	0	0	285	323	81	24	1347
SKEW	4,4	3,8	2,5	3,0	3,6	2,1	2,0	1,9	4,5	4,1	2,7	4,0	3,6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	155	3848	389	125	12	0	0	0	1273	1422	275	107	5862

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 620

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	7	284	53	11	1	0	0	0	62	99	33	8	557
STDV	11	399	70	15	1	0	0	0	88	143	45	11	475
SKEW	2,9	2,8	2,3	2,1	3,1	1,6	1,1	1,2	2,8	2,6	2,4	3,2	2,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	35
MAX	102	3954	519	89	10	0	0	0	832	1060	342	130	4737

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 820

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	10	12	58	6	9	1	0	3	0	4	1	30	134
STDV	24	46	177	18	41	4	1	12	1	20	4	135	291
SKEW	2,4	4,3	3,1	3,1	4,5	4,5	4,5	4,4	4,4	4,5	3,2	4,5	2,6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	82	205	679	67	181	18	3	54	5	88	14	602	1095

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 820

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	9	13	61	6	9	1	0	3	0	5	1	29	137
STDV	13	18	83	8	14	1	0	4	0	7	2	42	103
SKEW	3,0	3,2	2,5	2,2	3,2	2,4	2,4	2,3	2,8	2,6	2,5	3,8	2,0
MIN	0	0	0	0	0	0	0	0	0	0	0	0	9
MAX	114	203	624	48	119	8	2	26	4	52	10	563	871

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 30

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	16	9	341	38	133	48	4	2	67	34	9	158	859
STDV	80	19	1049	104	478	211	19	10	235	129	34	809	1780
SKEW	5,4	2,2	3,6	3,5	4,2	5,1	5,5	4,5	4,1	5,1	4,6	5,4	3,0
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	438	75	4786	473	2411	1140	103	51	1159	699	177	4433	8050

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 30

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	15	9	359	39	131	46	4	3	63	36	9	153	866
STDV	21	13	484	50	202	63	5	3	91	51	13	222	616
SKEW	3,0	2,9	2,4	2,1	3,2	2,4	2,4	2,3	2,9	2,5	2,5	3,8	1,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	201	136	3266	324	1605	410	42	22	804	341	89	2945	4394

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 230

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	3	3	149	16	87	9	0	0	0	16	2	26	312
STDV	10	16	678	67	474	47	2	0	0	88	9	102	923
SKEW	4,3	5,4	5,3	5,3	5,5	5,5	5,5	5,5	5,4	5,5	4,5	4,7	3,7
MIN	-27	-47	0	-215	0	-151	-7	-1	0	0	0	0	0
MAX	53	87	3711	367	2595	256	10	1	0	482	48	532	4273

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 230

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	3	3	135	16	90	6	0	0	0	14	2	27	297
STDV	10	16	691	67	466	45	2	0	0	91	9	99	840
SKEW	-0,1	0,0	0,0	-0,1	0,0	0,0	-0,1	-0,1	0,1	-0,1	0,0	0,1	-0,1
MIN	0	0	0	0	0	0	0	0	0	-296	-31	-279	0
MAX	37	68	2347	200	1547	133	5	1	0	282	30	455	2950

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 430

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	5	10	38	6	2	0	5	1	73	30	3	0	173
STDV	25	46	153	19	9	1	23	3	399	116	11	0	504
SKEW	5,5	5,1	4,5	3,3	5,4	5,5	5,1	3,5	5,5	4,7	5,2	5,0	4,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	134	248	785	78	50	5	125	12	2188	605	60	1	2615

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 430

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	11	40	6	2	0	5	1	69	31	3	0	173
STDV	6	16	55	8	3	0	7	1	100	45	4	0	134
SKEW	3,0	3,2	2,4	2,2	3,2	2,4	2,4	2,3	2,9	2,5	2,5	3,5	2,4
MIN	0	0	0	0	0	0	0	0	0	0	0	0	13
MAX	57	172	384	52	24	1	61	8	851	310	26	1	1181

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 630

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	6	202	87	16	2	0	0	1	43	95	25	5	483
STDV	28	737	275	39	6	1	0	6	232	310	69	20	1139
SKEW	5,4	4,6	4,5	2,4	4,1	5,5	1,4	5,5	5,5	3,7	3,2	5,0	4,0
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	155	3848	1445	143	31	3	0	35	1273	1422	275	107	5862

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 630

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	5	215	92	17	2	0	0	1	41	99	26	5	503
STDV	7	303	123	22	3	0	0	2	59	144	35	7	394
SKEW	2,9	2,8	2,4	2,0	3,1	2,4	1,1	2,5	2,9	2,6	2,4	3,3	1,9
MIN	0	0	0	0	0	0	0	0	0	0	0	0	13
MAX	66	3003	922	126	22	1	0	13	572	984	249	87	3621

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 830

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	7	78	56	5	60	6	0	2	2	82	9	24	329
STDV	20	275	150	15	297	29	1	10	8	335	33	111	644
SKEW	3	4,1	3,3	3,5	5,4	5,4	5,5	5,4	5,3	4,8	4,7	5,3	2,5
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	82	1356	679	67	1621	160	3	54	42	1760	174	602	2704

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 830

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	6	82	58	5	59	6	0	2	2	87	9	23	338
STDV	9	118	79	6	92	8	0	3	2	125	13	33	218
SKEW	3,0	3,1	2,5	2,1	3,2	2,3	2,3	2,4	2,9	2,5	2,5	3,6	1,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	14
MAX	80	1260	571	40	793	55	1	18	21	929	81	414	1409

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 40

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	15	11	258	29	100	36	3	2	50	26	52	123	703
STDV	72	27	917	91	416	183	16	9	205	112	267	700	1583
SKEW	5,6	3,5	4,2	4,1	4,9	5,9	6,3	5,2	4,7	5,8	6,2	6,3	3,4
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	438	143	4786	473	2411	1140	103	51	1159	699	1686	4433	8050

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 40

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	14	11	272	30	98	35	3	2	48	27	54	118	710
STDV	20	16	368	38	152	47	3	3	68	39	76	172	480
SKEW	3,0	3,0	2,4	2,1	3,2	2,4	2,5	2,3	2,9	2,5	2,5	3,7	1,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	64
MAX	188	163	2519	240	1275	304	33	17	614	277	515	2243	3376

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 240

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	2	3	112	15	66	6	0	0	0	13	9	21	246
STDV	9	14	589	60	410	41	2	0	0	76	43	89	807
SKEW	4,9	6,2	6,2	5,5	6,3	6,3	6,3	6,3	6,3	6,3	6,0	5,4	4,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	53	87	3711	367	2595	256	10	1	0	482	268	532	4273

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 240

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	2	3	118	15	65	6	0	0	0	14	9	20	252
STDV	3	4	161	20	101	9	0	0	0	20	13	29	203
SKEW	3,0	3,1	2,4	2,1	3,3	2,4	2,4	2,2	2,4	2,6	2,5	3,7	1,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	17
MAX	29	42	1078	126	920	57	3	0	0	159	87	380	1325

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 440

	JAN	FEB	MAR	APR	MAY	JUN	JU	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	3	8	47	6	1	0	4	1	55	24	2	4	155
STDV	21	40	154	18	8	1	20	3	346	101	10	25	447
SKEW	6,3	5,9	3,8	3,0	6,2	6,3	5,9	4,1	6,3	5,4	5,9	6,3	4,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	134	248	785	78	50	5	125	12	2188	605	60	158	2615

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 440

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	3	8	50	6	1	0	4	1	54	26	2	4	160
STDV	5	12	68	8	2	0	5	1	77	37	3	6	119
SKEW	3,0	3,1	2,4	2,1	3,2	2,4	2,4	2,3	2,9	2,5	2,5	3,8	2,1
MIN	0	0	0	0	0	0	0	0	0	0	0	0	12
MAX	44	129	456	54	19	1	49	6	674	262	22	76	948

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 640

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	155	66	13	2	0	0	1	32	105	71	9	458
STDV	24	641	240	34	5	0	0	6	201	336	332	35	1124
SKEW	6,3	5,3	5,2	2,8	4,8	6,3	1,2	6,3	6,3	3,4	6,0	4,7	3,6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	155	3848	1445	143	31	3	0	35	1273	1422	2086	193	5862

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 640

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	168	71	14	2	0	0	1	32	111	76	9	486
STDV	6	235	95	17	2	0	0	1	45	162	104	13	363
SKEW	2,9	2,8	2,4	2,0	3,1	2,5	1,1	2,5	2,8	2,6	2,4	3,2	1,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	37
MAX	50	2293	718	104	18	1	0	11	438	1151	779	151	3043

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 840

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	5	58	64	6	46	5	0	2	2	61	7	18	273
STDV	17	239	188	19	257	25	0	9	10	291	29	96	583
SKEW	3,6	4,8	3,5	3,5	6,2	6,2	6,3	6,2	4,3	5,5	5,5	6,1	2,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	82	1356	894	88	1621	160	3	54	46	1760	174	602	2704

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 840

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	5	61	67	6	45	4	0	2	2	65	7	17	281
STDV	7	89	92	8	70	6	0	2	3	94	10	25	181
SKEW	3,0	3,1	2,5	2,1	3,2	2,3	2,3	2,4	3,0	2,6	2,5	3,6	1,2
MIN	0	0	0	0	0	0	0	0	0	0	0	0	14
MAX	61	945	662	48	611	42	1	14	30	726	62	307	1068

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 50

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	12	8	207	23	82	29	2	1	40	20	41	99	565
STDV	64	25	824	82	373	164	15	8	184	101	239	627	1440
SKEW	6,3	4,0	4,8	4,6	5,5	6,7	7,1	5,8	5,3	6,5	6,9	7,0	3,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	438	143	4786	473	2411	1140	103	51	1159	699	1686	4433	8050

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 50

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	11	9	218	24	80	28	2	2	38	21	43	94	571
STDV	16	13	296	31	125	38	3	2	54	31	61	138	386
SKEW	3,0	3,0	2,4	2,1	3,2	2,4	2,5	2,4	2,9	2,6	2,5	3,7	1,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	54
MAX	152	132	2035	195	1062	248	26	14	490	232	429	1802	2658

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 250

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	2	4	115	14	57	6	0	0	7	11	60	22	298
STDV	8	21	550	56	367	36	1	0	52	68	377	87	861
SKEW	5,5	5,0	6,1	5,5	7,2	7,0	7,1	7,1	7,1	7,0	7,0	4,9	3,6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	53	118	3711	367	2595	256	10	1	365	482	2660	532	4273

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 250

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	2	5	122	15	55	5	0	0	7	12	63	21	306
STDV	2	7	165	19	87	7	0	0	10	17	88	31	221
SKEW	3,0	3,0	2,4	2,1	3,3	2,4	2,3	2,2	2,9	2,6	2,5	3,6	1,5
MIN	0	0	0	0	0	0	0	0	0	0	0	0	24
MAX	23	70	1180	117	801	50	2	0	92	136	640	390	1333

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 450

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	6	37	5	1	0	3	1	45	19	28	6	154
STDV	19	36	139	16	7	1	18	2	309	90	181	28	442
SKEW	6,7	6,6	4,3	3,5	6,9	7,0	6,6	4,7	7,1	6,0	7,0	4,9	4,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	134	248	785	78	50	5	125	12	2188	605	1277	158	2615

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 450

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	3	7	39	5	1	0	3	1	42	20	29	6	156
STDV	5	10	54	7	2	0	4	1	61	29	41	8	104
SKEW	3,0	3,1	2,4	2,2	3,2	2,4	2,5	2,3	3,0	2,5	2,5	3,7	1,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	15
MAX	43	103	376	42	15	1	40	5	532	213	295	105	790

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 650

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	3	124	53	10	1	0	0	1	26	84	58	8	368
STDV	22	576	216	31	5	1	0	6	180	303	298	31	1020
SKEW	7,0	6,0	5,9	3,3	5,3	4,9	6,8	5,1	7,1	3,8	6,7	5,2	4,1
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	155	3848	1445	143	31	4	0	35	1273	1422	2086	193	5862

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 650

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	3	131	56	11	1	0	0	1	25	88	60	7	383
STDV	4	186	75	14	2	0	0	2	35	128	83	11	283
SKEW	3,0	2,9	2,4	2,1	3,1	2,5	1,8	2,4	2,8	2,6	2,4	3,5	1,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	23
MAX	41	1890	549	86	15	1	0	13	327	905	617	135	2436

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 850

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	47	138	13	37	4	0	1	2	49	5	14	315
STDV	16	215	601	59	230	23	0	8	9	261	26	86	807
SKEW	4,1	5,4	6,3	6,3	6,9	6,9	7,1	6,9	4,2	6,2	6,1	6,8	3,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	82	1356	4130	408	1621	160	3	54	46	1760	174	602	4540

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 850

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	49	145	13	36	4	0	1	2	52	6	14	326
STDV	5	71	199	18	56	5	0	2	3	76	8	20	241
SKEW	3,0	3,1	2,5	2,1	3,2	2,3	2,3	2,4	2,9	2,6	2,5	3,5	1,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	21
MAX	49	755	1436	110	498	35	1	12	29	596	50	245	1673

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 100

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	19	30	120	13	44	15	1	1	25	11	28	66	374
STDV	100	152	602	60	266	116	10	6	134	72	178	460	1067
SKEW	7,3	6,4	6,4	6,2	7,8	9,4	9,9	6,5	7,1	9,2	8,6	9,0	5,1
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	876	1096	4786	473	2411	1140	103	51	1159	699	1686	4433	8050

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 100

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	17	32	127	14	43	14	1	1	24	12	30	63	377
STDV	25	45	173	18	67	20	2	2	34	17	42	92	238
SKEW	3,0	3,0	2,4	2,1	3,3	2,4	2,5	2,4	2,9	2,6	2,5	3,6	1,6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	48
MAX	235	474	1207	113	600	129	14	11	311	129	286	1183	1624

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 300

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	7	9	111	13	30	3	0	0	16	7	34	54	283
STDV	28	46	505	51	260	26	3	3	120	50	269	254	754
SKEW	4,7	7,8	5,7	5,4	9,9	9,9	9,0	9,8	8,8	9,2	9,6	5,6	3,5
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	180	418	3711	367	2595	256	31	25	1149	482	2660	1824	4273

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 300

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	6	9	117	13	29	3	0	0	16	7	35	51	287
STDV	9	13	160	17	45	4	1	0	22	11	50	75	202
SKEW	3,0	3,0	2,4	2,1	3,3	2,3	2,5	2,4	3,0	2,6	2,5	3,5	1,8
MIN	0	0	0	0	0	0	0	0	0	0	0	0	26
MAX	82	134	1132	103	419	26	5	3	207	85	358	930	1411

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 500

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	9	21	80	10	10	1	2	0	24	13	62	34	266
STDV	50	160	341	35	92	10	13	2	219	72	416	300	844
SKEW	6,8	9,6	5,3	4,7	10,0	8,3	9,4	5,7	9,9	6,9	8,5	9,9	5,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	415	1580	2419	239	923	91	125	13	2188	605	3916	2997	6913

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 500

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	8	22	84	10	10	1	2	0	23	14	65	32	271
STDV	12	32	114	13	15	2	2	0	33	20	92	47	176
SKEW	3,0	3,1	2,4	2,1	3,3	2,4	2,5	2,3	3,0	2,6	2,5	3,7	1,5
MIN	0	0	0	0	0	0	0	0	0	0	0	0	33
MAX	110	333	780	80	143	12	21	3	299	155	659	604	1246

OBSERVED MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 700

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	18	69	109	13	78	8	1	2	61	50	72	15	495
STDV	128	412	391	42	468	46	8	15	335	219	341	54	1078
SKEW	9,1	8,3	4,5	3,7	7,1	7,1	10,0	8,9	7,2	5,4	5,7	4,9	3,0
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	1236	3848	2495	247	3984	394	81	142	2930	1422	2373	392	5862

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 700

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	16	73	114	14	76	7	1	2	57	52	75	14	502
STDV	24	105	154	18	119	10	1	3	82	75	105	21	299
SKEW	3,0	3,1	2,4	2,1	3,3	2,4	2,5	2,4	2,9	2,5	2,5	3,6	1,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	30
MAX	221	1111	1061	112	1071	66	10	21	740	546	714	264	1911

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	2	28	83	13	26	3	0	1	2	30	8	8	203
STDV	11	157	438	65	169	17	2	5	8	190	27	61	596
SKEW	5,9	7,1	8,3	6,5	8,8	8,2	9,4	9,8	4,5	8,1	4,6	9,5	5,1
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	82	1356	4130	492	1621	160	24	54	46	1760	174	602	4540

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	2	29	87	13	25	3	0	1	2	32	8	8	210
STDV	3	43	120	17	39	4	0	1	3	46	11	11	148
SKEW	3,0	3,1	2,5	2,2	3,2	2,3	2,5	2,4	3,0	2,6	2,5	3,5	1,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	16
MAX	26	450	874	111	343	27	4	6	25	364	73	138	1032

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 150

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	13	21	121	13	31	10	1	2	17	15	72	53	370
STDV	82	125	595	60	218	95	8	12	110	101	436	380	1042
SKEW	8,9	7,8	6,2	6,1	9,6	11,5	12,0	9,5	8,7	8,7	7,7	10,6	4,6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	876	1096	4786	473	2411	1140	103	131	1159	1013	4043	4433	8050

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 150

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	12	23	128	13	30	10	1	2	17	15	75	51	376
STDV	18	32	175	18	47	13	1	2	24	22	106	74	244
SKEW	3,0	3,0	2,4	2,1	3,3	2,4	2,5	2,4	3,0	2,6	2,5	3,6	1,6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	42
MAX	161	341	1204	112	424	92	11	16	219	177	718	939	1715

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 350

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	5	9	95	11	20	2	1	0	22	12	41	38	256
STDV	23	48	429	43	212	21	7	2	166	90	243	209	664
SKEW	5,8	7,2	6,4	6,1	12,1	12,1	10,2	9,3	8,6	9,4	9,2	6,9	3,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	180	418	3711	367	2595	256	78	25	1642	980	2660	1824	4273

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 350

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	9	99	11	19	2	1	0	21	13	42	36	260
STDV	6	14	136	14	30	3	1	0	30	19	60	53	176
SKEW	3,0	3,0	2,4	2,1	3,3	2,3	2,5	2,4	3,0	2,6	2,5	3,6	1,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	25
MAX	57	144	936	88	284	18	10	3	276	155	401	667	1201

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 550

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	9	23	69	9	8	1	1	3	17	16	46	23	266
STDV	52	144	291	32	76	8	10	29	179	79	340	245	703
SKEW	6,7	9,3	5,9	4,8	11,8	9,9	11,5	11,9	12,1	5,8	10,4	12,2	6,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	415	1580	2419	239	923	91	125	358	2188	605	3916	2997	6913

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 550

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	9	24	72	9	8	1	1	3	16	17	48	22	231
STDV	12	35	99	12	12	1	1	4	24	25	68	32	145
SKEW	3,0	3,0	2,5	2,1	3,3	2,3	2,6	2,4	3,0	2,5	2,5	3,5	1,5
MIN	0	0	0	0	0	0	0	0	0	0	0	0	27
MAX	110	369	683	75	109	9	15	32	216	190	450	392	907

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 750

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	12	50	76	9	59	6	1	2	44	36	55	11	362
STDV	104	341	323	34	390	39	7	15	275	181	283	45	906
SKEW	11,1	9,9	5,5	4,7	8,3	8,3	12,2	7,7	8,7	6,6	6,8	6,0	3,7
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	1236	3848	2495	247	3984	394	81	142	2930	1422	2373	392	5862

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 750

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	11	53	80	9	57	6	1	2	42	38	57	10	367
STDV	16	77	109	12	89	8	1	3	60	55	81	15	217
SKEW	3.0	3,1	2,4	2,1	3,3	2,4	2,5	2,4	2,9	2,5	2,5	3,6	1,3
MIN	0	0	0	0	0	0	0	0	0	0	0	0	24
MAX	150	810	748	78	813	50	7	24	541	405	541	193	1380

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	3	33	65	15	24	3	0	0	5	26	16	9	198
STDV	13	175	365	72	151	15	2	4	31	163	77	54	523
SKEW	5,5	6,0	9,7	6,5	8,9	8,4	11,5	11,9	9,2	8,9	7,4	9,7	5,2
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	91	1356	4130	582	1621	160	24	54	331	1760	763	602	4540

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	2	35	68	15	23	2	0	0	5	27	17	8	204
STDV	3	51	94	20	36	3	0	1	7	39	24	12	129
SKEW	3,0	3,0	2,5	2,2	3,2	2,3	2,5	2,4	3,0	2,6	2,6	3,4	1,4
MIN	0	0	0	0	0	0	0	0	0	0	0	0	15
MAX	32	524	660	125	310	23	3	4	61	310	161	138	822

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 200

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	31	21	119	16	24	8	1	7	16	14	65	43	363
STDV	294	116	549	61	189	82	7	71	96	90	397	330	1029
SKEW	13,0	7,8	6,3	5,2	11,0	13,3	13,7	13,7	9,7	9,2	8,0	12,2	4,5
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	4041	1096	4786	473	2411	1140	103	1000	1159	1013	4043	4433	8050

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 200

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	28	22	125	16	23	7	1	7	15	15	68	41	368
STDV	41	32	171	21	36	10	1	9	21	21	96	59	232
SKEW	3,0	3,0	2,5	2,1	3,3	2,4	2,5	2,5	3,0	2,6	2,5	3,6	1,6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	40
MAX	363	335	1173	132	324	72	9	69	195	163	637	745	1687

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 400

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	9	123	14	24	2	1	2	29	10	36	33	288
STDV	21	45	546	55	210	21	6	27	214	80	215	188	747
SKEW	6,3	6,9	6,5	6,2	10,8	10,8	11,7	13,9	8,7	10,3	10,1	7,4	4,1
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	180	418	5097	502	2595	256	78	379	2268	980	2660	1824	5598

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 400

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	9	129	14	23	2	1	2	27	11	38	32	292
STDV	5	14	177	18	36	3	1	3	39	16	53	46	210
SKEW	3,0	3,0	2,5	2,1	3,3	2,3	2,6	2,5	3,0	2,6	2,5	3,6	1,9
MIN	0	0	0	0	0	0	0	0	0	0	0	0	28
MAX	48	143	1218	114	332	22	8	24	355	132	345	570	1485

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 600

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	8	18	54	7	9	1	1	3	13	14	37	17	182
STDV	47	125	253	28	78	8	9	26	155	70	296	212	616
SKEW	7,2	10,7	6,8	5,3	10,2	9,1	12,5	13,1	14,0	6,4	11,9	14,0	7,6
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	415	1580	2419	239	923	91	125	358	2188	605	3916	2997	6913

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 600

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	7	19	56	8	9	1	1	3	12	15	39	17	186
STDV	11	28	77	10	14	1	1	4	18	21	55	24	115
SKEW	3,0	3,0	2,5	2,1	3,3	2,3	2,6	2,4	3,0	2,6	2,5	3,5	1,4
MIN	0	0	0	0	0	0	0	0	0	0	0	0	22
MAX	93	288	531	61	129	10	13	27	163	162	358	298	713

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 800

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	16	40	65	8	45	4	0	2	63	40	63	11	359
STDV	125	296	287	31	338	33	6	13	483	194	294	43	964
SKEW	9,3	11,4	6,0	5,1	9,7	9,6	14,1	8,9	10,5	6,4	6,1	5,7	4,5
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	1236	3848	2495	247	3984	394	81	142	5968	1538	2373	392	7599

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 800

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	15	42	69	8	44	4	0	2	60	42	66	11	362
STDV	22	61	93	10	68	6	1	3	86	61	93	15	213
SKEW	3,0	3,1	2,4	2,1	3,3	2,4	2,5	2,4	2,9	2,5	2,5	3,6	1,4
MIN	0	0	0	0	0	0	0	0	0	0	0	0	21
MAX	195	642	641	66	627	39	5	18	774	448	616	194	1390

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 1000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	35	60	12	18	2	0	3	6	24	40	11	217
STDV	25	169	324	63	131	13	2	38	39	150	273	56	547
SKEW	7,6	5,9	10,5	7,4	10,3	9,8	12,7	13,9	8,7	9,0	10,9	7,8	4,9
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	229	1356	4130	582	1621	160	24	533	405	1760	3501	602	4540

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 1000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	4	34	58	11	16	2	0	3	5	24	38	9	204
STDV	5	48	79	15	25	2	0	4	8	34	54	13	124
SKEW	3,0	3,0	2,5	2,1	3,2	2,3	2,4	2,5	3,0	2,6	2,6	3,4	1,2
MIN	0	0	0	0	0	0	0	0	0	0	0	0	13
MAX	49	501	555	91	217	16	2	29	72	262	364	158	714

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 1000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	13	25	84	11	24	3	1	3	25	21	48	23	282
STDV	145	172	413	50	209	41	6	40	251	126	300	197	805
SKEW	22,9	14,1	7,7	7,0	12,7	22,3	14,9	19,2	16,9	9,1	9,4	16,2	5,1
MIN	0	0	0	0	0	0	0	0	0	0	0	0	0
MAX	4041	3848	5079	582	3984	1140	125	1000	5968	1760	4043	4433	8050

APPENDIX I

George 'observed' and generated monthly streamflow data.

'OBSERVED' MONTLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 10

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1382	1859	2902	2742	2493	1621	1152	1472	2797	1914	1549	1795	23677
STDV	1032	1492	2913	2006	2359	1536	593	1030	2506	1229	868	1469	7342
SKEW	1,1	1,0	1,8	1,6	2,0	2,7	1,4	1,3	2,0	1,0	0,7	0,9	1,0
MIN	266	486	307	1006	889	661	535	525	501	385	584	320	0
MAX	3576	4338	9919	7395	8206	5791	2468	3634	9139	4446	3271	4474	39201

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 10

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1343	1877	2900	2777	2482	1577	1129	1444	2772	1886	1565	1782	23532
STDV	866	1365	2500	1675	1803	1085	509	891	1986	1152	825	1332	6980
SKEW	1,0	1,1	1,3	0,7	1,3	1,0	0,4	0,8	1,2	1,0	0,8	1,3	0,4
MIN	0	0	0	1	0	0	20	0	0	2	12	0	6947
MAX	5800	9740	15364	8753	11444	6208	2928	4857	14682	6485	4706	10533	50515

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 210

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1180	1821	2952	1389	1718	1623	1216	857	1175	1191	941	2108	18173
STDV	947	1354	3005	732	570	443	421	340	556	656	500	2208	5583
SKEW	1,0	0,5	1,9	0,7	-0,6	-0,7	0,5	1,3	1,0	0,1	1,1	1,5	0,8
MIN	197	220	333	292	765	898	631	514	540	327	226	285	0
MAX	2809	4009	10425	2729	2485	2206	1869	1598	2186	2101	2066	7124	29124

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 210

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1149	1842	2968	1407	1722	1608	1200	848	1172	1180	953	2107	18155
STDV	794	1367	2559	708	579	441	396	307	496	664	479	1871	4951
SKEW	1,1	1,2	1,3	0,6	0,6	0,3	0,3	0,4	0,6	0,9	0,7	1,6	0,5
MIN	0	0	0	12	134	510	176	92	86	0	7	0	7110
MAX	5589	10048	15440	3754	4055	3148	2536	1930	3562	3767	2829	16498	37135

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 410

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1043	832	1213	1387	1704	1012	974	1987	2640	1423	1612	1036	16864
STDV	1440	1460	847	1080	1416	416	430	1572	3779	480	1090	762	7320
SKEW	3,0	3,1	0,9	1,0	2,2	-0,6	-0,5	2,2	3,0	0,2	0,9	1,4	2,0
MIN	386	180	198	125	472	300	306	587	910	618	498	293	8629
MAX	5091	4960	2999	3650	5344	1628	1525	6001	13273	2296	3711	2707	35500

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 410

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1014	863	1218	1423	1715	1001	960	1965	2640	1414	1648	1041	16901
STDV	851	899	828	1018	1132	434	442	1248	2310	483	1022	651	4935
SKEW	1,4	1,7	1,0	0,9	1,2	0,6	0,4	0,9	1,5	0,5	0,9	1,1	0,6
MIN	0	0	1	0	0	80	11	1	0	171	0	0	5699
MAX	6027	7183	4930	5226	7021	2627	2522	6892	17547	3084	5749	5162	38322

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 610

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1406	2085	1585	1383	1566	1250	1129	1279	1115	2377	2619	2147	19941
STDV	994	3016	1148	1843	1319	618	543	1041	736	1993	1501	1973	6049
SKEW	1,0	2,0	0,9	2,7	1,9	0,2	0,2	2,5	1,0	2,0	1,8	1,7	1,2
MIN	367	240	326	167	368	529	374	152	173	648	1177	624	0
MAX	3135	9300	3923	6414	4791	2195	2100	4077	2603	7288	6297	6823	33818

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 610

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1375	2153	1584	1419	1568	1230	1108	1259	1112	2353	2654	2144	19958
STDV	836	2303	1101	1249	1071	588	531	840	667	1638	1314	1620	5724
SKEW	1,0	1,8	1,0	1,2	1,3	0,6	0,5	0,9	0,9	1,1	0,7	1,3	0,5
MIN	1	0	2	0	0	47	3	0	0	0	42	0	6980
MAX	5636	18586	6556	6492	6602	3466	2980	4594	4783	9116	7674	13099	44262

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 810

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	870	879	1258	1169	1237	1165	1015	1411	1219	1120	1453	1720	14517
STDV	356	894	1467	716	370	658	468	1454	618	526	869	2513	4771
SKEW	0,6	1,9	3,0	1,4	-0,6	1,4	0,3	2,6	0,6	0,2	2,0	2,9	0,8
MIN	337	54	326	570	555	395	278	421	391	404	750	489	8499
MAX	1568	3013	5366	2638	1602	2698	1907	5357	2395	1868	3637	8697	22903

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 810

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	843	864	1213	1156	1219	1118	977	1340	1189	1084	1438	1626	14066
STDV	317	736	985	597	361	559	441	1011	562	509	712	1527	3718
SKEW	0,5	1,3	1,2	0,6	0,5	0,6	0,4	1,1	0,7	0,7	0,7	1,6	0,5
MIN	51	0	0	23	162	14	21	0	39	19	47	0	4987
MAX	2185	5262	6080	3180	2692	3204	2510	5760	4186	3014	4267	11513	28397

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 20

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1209	1701	1803	2389	2389	1450	1314	1714	2850	1813	2002	1875	22510
STDV	955	1506	2322	1604	2270	1121	595	1530	2357	1149	1255	1393	6284
SKEW	1,4	1,2	2,6	1,8	2,0	3,3	0,8	2,1	1,8	1,5	1,4	0,8	0,8
MIN	266	317	191	806	685	399	535	525	501	385	584	320	0
MAX	3576	4918	9919	7395	8217	5791	2584	6584	9139	4695	5755	4493	39201

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 20

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1175	1722	1806	2418	2373	1416	1290	1681	2830	1786	2028	1860	22385
STDV	771	1328	1720	1364	1747	817	549	1202	1918	1028	1152	1288	6220
SKEW	1,0	1,2	1,5	0,7	1,4	0,8	0,4	1,0	1,1	0,9	0,9	1,2	0,4
MIN	0	0	0	0	0	0	39	0	1	0	4	2	7216
MAX	5116	9430	10800	7238	11122	4617	3138	6414	14221	5862	6594	9658	46456

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 220

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1370	1571	2282	1346	2350	1477	1178	836	1653	1616	1205	2144	19028
STDV	1076	1315	2390	1086	2591	533	474	342	1020	1174	798	2506	6080
SKEW	1,1	1,3	2,4	2,6	3,4	0,2	1,1	0,8	1,2	1,5	2,1	1,6	0,3
MIN	197	220	333	292	640	625	631	435	540	327	226	285	0
MAX	3928	4832	10425	5191	12444	2513	2420	1598	4142	4918	3842	8979	30047

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 220

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1332	1585	2285	1365	2353	1458	1159	825	1643	1598	1220	2134	18958
STDV	898	1198	1896	848	1756	516	431	323	893	1056	692	2028	5459
SKEW	1,1	1,2	1,2	0,8	1,4	0,5	0,4	0,5	0,9	1,0	0,8	1,8	0,5
MIN	0	0	0	4	0	277	108	62	5	2	4	0	6145
MAX	6364	8859	11329	4402	11141	3354	2668	1990	6233	6039	4072	18558	40784

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 420

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	979	1086	1538	1284	1628	904	1156	1543	2298	1580	1545	896	16437
STDV	1057	1578	1680	1011	1388	437	744	1233	2822	1263	885	666	6664
SKEW	3,4	2,6	2,2	1,0	1,7	0	1,2	2,7	3,4	3,0	0,7	1,8	1,1
MIN	184	91	198	125	334	190	306	289	350	441	421	293	5417
MAX	5091	6022	6800	3650	5344	1652	3110	6001	13273	6334	3711	2707	35500

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 420

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1400	2131	1517	1470	1519	1082	1113	1543	2099	2605	2573	1714	20765
STDV	991	2331	1071	1174	922	464	472	986	1689	1899	1411	1289	6230
SKEW	1,1	1,9	1,0	1,0	1,1	0,6	0,4	0,9	1,3	1,2	0,8	1,3	0,6
MIN	0	0	0	0	1	89	34	0	0	0	1	0	6939
MAX	6771	19035	6385	6046	5710	2806	2736	5414	12583	10560	8086	10441	50097

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 620

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1448	2083	1527	1449	1526	1103	1135	1576	2126	2648	2547	1729	20897
STDV	1245	3485	1188	1598	1091	501	487	1125	2456	2438	1514	1583	8032
SKEW	1,6	2,6	1,4	2,4	1,7	0,8	0,4	1,4	3,1	2,5	1,2	2,0	1,4
MIN	269	240	326	167	368	448	374	152	173	648	468	393	9308
MAX	5130	13589	4687	6414	4791	2195	2100	4077	11376	10785	6297	6823	44575

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 620

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1400	2131	1517	1470	1519	1082	1113	1543	2099	2605	2573	1714	20765
STDV	991	2331	1071	1174	922	464	472	986	1689	1899	1411	1289	6230
SKEW	1,1	1,9	1,0	1,0	1,1	0,6	0,4	0,9	1,3	1,2	0,8	1,3	0,6
MIN	0	0	0	0	1	89	34	0	0	0	1	0	6939
MAX	6771	19035	6385	6046	5710	2806	2736	5414	12583	10560	8086	10441	50097

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 820

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1204	1232	1379	1026	1530	1186	1219	1840	1642	1510	1757	1462	16988
STDV	1212	1619	1443	585	1279	752	750	1748	802	1388	732	1878	5721
SKEW	2,6	2,3	2,2	1,6	3,4	2,0	2,5	2,1	0,4	3,4	0,8	3,4	0,6
MIN	242	54	326	340	519	369	278	421	391	404	750	489	8499
MAX	5124	6262	5366	2638	6529	3518	3881	7179	3300	6954	3637	8697	29185

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 820

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1157	1250	1365	1032	1512	1154	1187	1790	1626	1475	1764	1430	16741
STDV	817	1204	1120	507	910	622	606	1351	777	1019	713	1187	4811
SKEW	1,0	1,5	1,3	0,6	1,1	0,7	0,5	1,1	0,7	1,1	0,6	1,4	0,5
MIN	0	0	0	42	1	1	2	0	46	0	206	0	5189
MAX	5322	8876	6959	2710	5946	3510	3375	7832	5816	5781	4493	8520	38157

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 30

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1208	1570	2249	2020	2230	1465	1304	1925	2710	1994	1829	2360	22864
STDV	916	1471	2580	1446	1957	1020	566	1725	2242	1694	1196	2788	7602
SKEW	1,3	1,3	1,8	2,1	2,1	2,8	0,5	2,3	1,6	2,2	1,3	3,1	0,5
MIN	199	99	191	391	638	399	535	525	501	385	276	80	9509
MAX	3576	4918	9919	7395	8217	5791	2584	7894	9139	8166	5755	14475	39650

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 30

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1169	1587	2238	2039	2206	1427	1277	1880	2678	1954	1848	2314	22615
STDV	757	1315	2091	1204	1525	801	538	1335	1869	1399	1131	2076	6788
SKEW	1,0	1,3	1,4	0,7	1,3	0,7	0,4	1,0	1,1	1,1	0,9	1,6	0,5
MIN	0	0	0	2	0	0	46	0	0	0	1	0	6663
MAX	5001	9410	13124	6330	9778	4529	3091	7306	14003	7909	6468	16038	48556

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 230

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1328	1484	2126	1289	2062	1419	1274	1011	1790	1706	1277	1793	18559
STDV	988	1237	2022	1016	2198	577	622	586	1024	1598	822	2217	5843
SKEW	1,0	1,2	2,7	2,5	3,9	0,8	1,4	1,2	1,0	3,0	1,8	1,9	0,4
MIN	197	156	333	292	640	625	488	249	540	327	226	285	0
MAX	3928	4832	10425	5191	12444	2944	3161	2791	4341	8359	3842	8979	30047

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 230

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1287	1495	2114	1303	2051	1396	1247	992	1776	1678	1289	1769	18398
STDV	850	1163	1608	795	1448	540	554	536	930	1211	720	1675	5133
SKEW	1,1	1,2	1,1	0,7	1,3	0,5	0,4	0,7	0,8	1,1	0,8	1,7	0,4
MIN	0	0	0	0	0	194	29	2	14	0	0	0	5836
MAX	5835	8498	9665	4118	9056	3395	3227	3026	6658	6710	4121	14602	38666

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 430

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1039	1057	1279	1241	1451	925	1331	1607	2242	2064	1666	989	16892
STDV	1072	1404	1458	1191	1193	585	992	1383	2380	1839	866	736	6232
SKEW	2,6	2,5	2,6	1,8	2,0	2,0	1,5	2,2	3,7	2,2	0,6	1,4	0,8
MIN	184	91	197	81	334	190	306	289	350	441	421	293	5417
MAX	5091	6022	6800	5263	5344	3199	4010	6001	13273	8393	3711	2924	35500

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 430

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1004	1077	1275	1260	1442	904	1295	1574	2219	2028	1683	981	16743
STDV	737	1040	1111	987	972	504	829	1104	1582	1497	862	617	5273
SKEW	1,1	1,5	1,3	1,0	1,2	0,7	0,7	1,0	1,2	1,2	0,7	1,1	0,5
MIN	0	0	0	0	0	1	1	1	0	0	38	0	4407
MAX	4873	7842	6904	5093	6282	2903	4556	5880	11854	8421	4980	4600	39963

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 630

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1316	2242	1745	1590	1618	1170	1118	1588	2015	2822	2301	1475	21001
STDV	1068	3183	1486	1678	1160	548	436	1330	2082	2330	1422	1362	7165
SKEW	1,9	2,2	2,0	2,0	1,4	0,7	0,4	2,1	3,4	2,3	1,3	2,4	1,2
MIN	269	240	326	167	368	363	374	152	173	648	468	393	9308
MAX	5130	13589	7022	6414	4791	2568	2100	6318	11376	10785	6297	6823	44575

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 630

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1276	2288	1733	1613	1608	1147	1097	1554	1993	2776	2327	1462	20874
STDV	840	2392	1278	1274	1003	516	425	1071	1475	1884	1318	1054	6065
SKEW	1,0	1,7	1,1	1,0	1,2	0,6	0,3	1,0	1,2	1,1	0,8	1,3	0,6
MIN	0	0	0	0	0	67	65	1	0	1	0	0	6848
MAX	5587	18915	7646	6606	6225	3056	2501	5765	10905	10553	7607	8266	48211

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 830

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1121	1819	1710	1373	1970	1368	1158	1659	1929	1920	1659	1671	19358
STDV	1019	2484	1479	924	2264	968	675	1576	1472	2523	809	1890	8119
SKEW	3,0	2,0	1,5	1,1	3,6	1,8	2,3	2,1	2,3	2,9	0,6	2,5	0,8
MIN	242	54	326	340	519	369	278	215	391	401	278	385	7227
MAX	5124	9688	5366	3385	12084	4543	3881	7179	7618	11646	3637	8697	39374

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 830

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1085	1857	1694	1385	1943	1329	1130	1616	1907	1879	1670	1639	19135
STDV	695	1919	1300	823	1483	801	567	1239	1176	1697	819	1347	6128
SKEW	0,9	1,7	1,2	0,7	1,4	0,8	0,5	1,1	1,0	1,5	0,7	1,4	0,6
MIN	0	0	0	0	0	1	3	0	0	0	62	0	5051
MAX	4507	14623	7983	4270	9760	4496	3177	7037	8784	9771	4908	9863	46413

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 40

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1183	1481	2014	1842	2046	1326	1261	1796	2375	1926	2069	2006	21328
STDV	1004	1514	2328	1379	1753	938	578	1581	2047	1497	1826	2494	7454
SKEW	1,8	1,5	2,1	1,9	2,4	3,0	0,5	2,4	1,9	2,4	2,8	3,5	0,6
MIN	199	68	103	147	340	262	327	482	390	385	276	80	9316
MAX	4674	5790	9919	7395	8217	5791	2584	7894	9139	8166	10341	14475	39650

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 40

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1143	1500	2004	1860	2025	1291	1234	1754	2347	1888	2094	1967	21105
STDV	774	1317	1853	1209	1355	740	555	1229	1644	1240	1466	1748	6552
SKEW	1,0	1,4	1,4	0,8	1,2	0,8	0,4	1,0	1,1	1,1	1,1	1,5	0,5
MIN	0	0	0	1	0	0	26	2	0	2	0	0	5778
MAX	5077	9543	11675	6262	8771	4185	3165	6798	12381	7021	8416	13343	46833

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 240

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1293	1373	1967	1322	1863	1322	1161	964	1690	1693	1359	1673	17680
STDV	923	1133	1820	1255	1981	585	614	531	1067	1562	1069	2041	6137
SKEW	1,0	1,4	2,9	3,0	4,2	0,7	1,4	1,4	1,2	2,6	2,7	2,0	0,4
MIN	197	156	333	292	557	389	466	249	538	327	226	285	7923
MAX	3928	4832	10425	6644	12444	2944	3161	2791	4383	8359	5998	8979	30047

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 240

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1255	1382	1955	1337	1851	1299	1135	947	1674	1663	1374	1649	17520
STDV	795	1032	1439	904	1313	550	539	484	945	1221	858	1533	5010
SKEW	1,0	1,2	1,1	0,8	1,3	0,6	0,5	0,7	0,9	1,2	0,9	1,7	0,4
MIN	0	0	0	1	0	125	10	0	1	0	0	0	5313
MAX	5399	7436	8666	4654	8315	3376	3097	2738	6807	6797	4844	13075	37127

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 440

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1005	974	1364	1108	1288	959	1266	1417	2111	1904	1591	1106	16093
STDV	999	1272	1618	1075	1089	773	922	1260	2208	1826	843	1183	6420
SKEW	2,6	2,7	2,2	2,1	2,3	2,4	1,5	2,5	3,7	2,1	0,6	3,5	0,7
MIN	184	37	197	81	279	190	302	261	350	283	276	199	5417
MAX	5091	6022	6800	5263	5344	4042	4010	6001	13273	8393	3711	7031	35500

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 440

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	976	999	1370	1131	1286	938	1237	1394	2100	1881	1613	1100	16027
STDV	698	944	1240	876	870	610	783	990	1520	1471	853	825	5127
SKEW	1,1	1,5	1,4	1,0	1,3	0,9	0,7	1,0	1,2	1,3	0,8	1,3	0,5
MIN	0	0	0	0	0	2	3	0	0	0	21	0	4233
MAX	4628	7089	7750	4525	5597	3477	4294	5251	11386	8289	4872	6335	38202

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 640

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1215	2146	1600	1623	1650	1221	1135	1523	2240	2911	2385	1559	21209
STDV	955	2856	1316	1599	1165	604	497	1243	1952	2396	1598	1327	7184
SKEW	2,2	2,4	2,4	1,8	1,4	0,7	1,1	2,2	2,9	2,0	1,6	2,1	1,1
MIN	269	240	326	167	368	363	374	152	173	648	468	393	9308
MAX	5130	13589	7022	6414	4791	2660	2754	6318	11376	10785	7679	6823	44575

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 640

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1181	2186	1589	1646	1641	1196	1114	1491	2218	2861	2413	1545	21080
STDV	736	2183	1097	1254	1012	567	460	999	1525	1976	1432	1069	6062
SKEW	1,0	1,6	1,0	1,0	1,1	0,6	0,4	0,9	1,1	1,1	0,9	1,2	0,5
MIN	1	0	1	0	0	49	43	0	0	0	0	1	6965
MAX	4867	16855	6569	6502	6348	3328	2662	5365	11211	11092	8182	8270	46661

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 840

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1113	1488	1649	1197	1885	1294	1179	1542	2072	1932	1579	1539	18468
STDV	1033	2224	1587	878	2116	897	690	1397	1645	2214	786	1707	7528
SKEW	2,5	2,4	1,7	1,3	3,4	1,8	1,9	2,5	2,0	3,2	0,6	2,7	0,9
MIN	76	54	208	158	328	369	278	215	391	401	278	95	6268
MAX	5124	9688	6631	3385	12084	4543	3881	7179	7618	11646	3637	8697	39374

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 840

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1071	1517	1633	1207	1857	1257	1149	1503	2045	1887	1589	1508	18223
STDV	751	1583	1346	775	1442	746	590	1081	1327	1555	794	1234	5866
SKEW	1,1	1,7	1,2	0,8	1,4	0,8	0,5	1,0	1,0	1,4	0,7	1,4	0,5
MIN	0	0	0	0	0	0	1	0	0	0	50	0	4774
MAX	4873	12160	8341	3991	9518	4219	3309	6044	9940	8837	4721	9142	43844

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 50

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1185	1466	1959	1733	2010	1326	1255	1630	2190	1827	1884	1757	20221
STDV	1010	1409	2117	1309	1770	906	635	1494	1881	1398	1711	2293	7337
SKEW	1,8	1,6	2,3	2,0	2,2	2,6	0,6	2,5	2,2	2,5	2,9	3,9	0,7
MIN	199	68	103	147	340	260	229	104	327	385	276	80	7928
MAX	4674	5790	9919	7395	8217	5791	2889	7894	9139	8166	10341	14475	39650

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 50

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1143	1480	1944	1749	1987	1290	1224	1589	2161	1789	1905	1720	19981
STDV	780	1244	1695	1136	1393	754	614	1170	1482	1158	1363	1546	6392
SKEW	1,0	1,3	1,3	0,8	1,3	0,8	0,5	1,0	1,1	1,0	1,1	1,5	0,5
MIN	0	0	0	1	0	0	4	0	1	0	0	0	4837
MAX	5039	8918	10605	5844	9126	4287	3472	6487	11159	6547	7856	11804	46033

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 250

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1205	1399	1980	1281	1907	1263	1113	983	1780	1661	1516	1612	17700
STDV	873	1214	1832	1168	2115	628	601	530	1483	1465	1625	1868	6487
SKEW	1,2	1,6	2,6	3,0	3,6	0,7	1,3	1,1	2,6	2,6	4,1	2,2	0,6
MIN	197	156	274	124	316	232	365	249	342	327	226	285	7923
MAX	3928	5446	10425	6644	12444	2944	3161	2791	8897	8359	10486	8979	32861

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 250

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1169	1411	1966	1295	1889	1236	1087	965	1760	1630	1536	1586	17531
STDV	729	1088	1488	860	1422	595	531	496	1164	1166	1110	1396	5360
SKEW	0,9	1,2	1,1	0,8	1,4	0,6	0,5	0,7	1,1	1,2	1,1	1,5	0,5
MIN	0	0	0	2	0	41	7	0	0	0	0	0	4733
MAX	4800	7752	9077	4436	9289	3527	3041	2727	8615	6538	6205	11104	38027

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 450

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1119	1032	1458	1183	1304	983	1269	1309	2046	1781	1763	1058	16304
STDV	1024	1226	1482	1025	1012	711	854	1152	2104	1688	1306	1064	5996
SKEW	2,1	2,4	2,1	1,8	2,3	2,4	1,5	2,8	3,5	2,3	3,1	4,0	0,6
MIN	184	37	197	81	279	190	302	261	317	283	276	199	5417
MAX	5091	6022	6800	5263	5344	4042	4010	6001	13273	8393	8600	7031	35500

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 450

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1082	1049	1451	1200	1295	958	1236	1282	2026	1750	1786	1047	16164
STDV	763	953	1214	876	823	578	733	878	1478	1343	1091	728	4932
SKEW	1,1	1,4	1,3	0,9	1,2	0,8	0,6	1,0	1,2	1,2	0,9	1,2	0,5
MIN	0	0	0	0	0	1	1	1	0	0	1	1	4547
MAX	5048	7019	7460	4534	5280	3268	3974	4738	11134	7593	6192	5419	36861

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 650

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1211	1914	1473	1471	1541	1247	1065	1505	2194	2686	2179	1583	20071
STDV	907	2608	1214	1485	1131	732	485	1351	1794	2235	1564	1339	6939
SKEW	2,0	2,7	2,7	2,1	1,5	1,4	1,1	2,3	3,0	2,2	1,6	1,9	1,3
MIN	269	237	326	167	368	356	374	152	173	648	468	393	9308
MAX	5130	13589	7022	6414	4791	4037	2754	6318	11376	10785	7679	6823	44575

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 650

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1178	1952	1464	1493	1532	1219	1045	1474	2176	2643	2209	1569	19955
STDV	726	1919	990	1130	963	652	448	1054	1413	1815	1381	1103	5718
SKEW	0,9	1,6	1,0	1,0	1,2	0,7	0,4	1,0	1,0	1,1	0,9	1,2	0,5
MIN	2	0	2	0	0	9	29	0	1	0	0	1	6642
MAX	4794	14652	5935	5868	6067	3739	2562	5601	10363	10212	7852	8444	42902

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 850

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1148	1402	1900	1168	1733	1221	1136	1451	2079	1815	1643	1557	18253
STDV	1000	2011	1979	805	1932	877	622	1281	1718	2028	872	1628	7058
SKEW	2,3	2,7	2,2	1,4	3,8	1,9	1,8	2,7	1,8	3,4	0,4	2,5	1,0
MIN	76	54	208	158	266	262	278	215	391	401	278	95	6268
MAX	5124	9688	10248	3385	12084	4543	3881	7179	7618	11646	3637	8697	39374

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 850

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1108	1425	1884	1178	1710	1186	1107	1415	2052	1775	1655	1530	18025
STDV	748	1422	1624	718	1298	722	573	981	1390	1418	894	1213	5653
SKEW	1,0	1,6	1,3	0,8	1,4	0,8	0,5	1,0	1,1	1,3	0,8	1,3	0,5
MIN	0	0	0	0	0	0	0	1	0	0	18	0	5068
MAX	4879	10774	10092	3740	8481	4083	3193	5381	10407	8038	5197	9095	41917

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 100

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1314	1455	1715	1529	1803	1218	1191	1535	2058	1755	1775	1668	19017
STDV	1252	1679	1705	1148	1596	838	634	1429	1843	1338	1566	2092	6676
SKEW	2,4	2,6	2,8	2,1	2,5	2,4	0,9	2,3	2,3	2,0	2,6	3,6	0,7
MIN	199	68	103	147	336	233	229	104	225	134	276	80	7252
MAX	7572	8914	9919	7395	8315	5791	2889	7894	9139	8166	10341	14475	39650

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 100

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1266	1474	1702	1545	1785	1185	1163	1499	2034	1721	1798	1638	18810
STDV	916	1300	1351	987	1227	694	587	1123	1424	1165	1274	1423	5739
SKEW	1,1	1,4	1,2	0,8	1,3	0,8	0,5	1,1	1,1	1,1	1,1	1,5	0,5
MIN	0	0	0	0	0	0	1	0	0	0	0	0	5123
MAX	6062	9451	8268	5128	7922	3920	3261	6168	10698	6586	7273	10880	41835

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 300

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1224	1535	2112	1326	1743	1246	1106	1186	1938	1551	1472	1574	18014
STDV	933	1382	1833	1110	1689	682	591	966	1799	1216	1351	2131	6464
SKEW	1,7	1,5	2,2	2,4	3,8	1,3	1,7	2,4	2,8	2,7	4,1	3,1	0,7
MIN	197	109	239	124	262	232	334	228	342	327	226	264	7923
MAX	5121	6995	10425	6644	12444	3862	3615	5808	11759	8359	10486	12008	37199

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 300

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1186	1550	2094	1340	1724	1217	1081	1160	1914	1521	1489	1543	17818
STDV	758	1258	1594	890	1194	620	514	777	1362	995	977	1393	5287
SKEW	1,0	1,2	1,1	0,8	1,3	0,7	0,4	0,9	1,2	1,0	1,0	1,6	0,4
MIN	0	0	0	0	0	16	8	0	0	1	1	0	5119
MAX	4959	8982	9702	4614	7701	3575	2894	4231	10248	5624	5555	10848	38037

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 500

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1268	1250	1672	1339	1414	1108	1159	1370	2010	1780	1900	1213	17484
STDV	1111	1476	1695	1161	1199	810	693	1187	1899	1471	1759	1535	6260
SKEW	2,0	2,9	2,2	1,7	3,7	2,5	1,7	2,2	3,0	2,3	3,8	5,4	0,4
MIN	184	37	197	81	219	164	264	218	289	283	276	199	5142
MAX	6063	9717	8662	5454	9362	5497	4010	6001	13273	8393	13147	13021	35500

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 500

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1226	1267	1663	1357	1404	1079	1131	1340	1987	1748	1925	1198	17326
STDV	853	1134	1372	978	902	660	608	949	1424	1224	1319	927	5314
SKEW	1,1	1,4	1,2	0,9	1,2	0,8	0,5	1,0	1,2	1,1	1,0	1,3	0,5
MIN	0	0	0	0	0	0	2	0	0	0	0	0	4706
MAX	5650	8380	8411	5059	5773	3768	3372	5045	10631	6877	7324	7184	39185

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 700

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1414	1618	1819	1316	1851	1244	1107	1455	2251	2278	2072	1533	19959
STDV	1259	2103	1686	1151	2196	803	585	1337	2334	2004	1811	1543	7092
SKEW	2,7	3,1	2,3	2,5	3,4	2,1	2,0	2,6	2,9	2,1	2,4	2,3	0,8
MIN	269	185	326	167	368	189	294	152	173	377	234	308	8952
MAX	8400	13589	8202	6414	13091	5343	4099	7925	14486	10785	10652	8176	44575

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 700

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1367	1639	1806	1332	1833	1213	1083	1422	2225	2239	2102	1517	19777
STDV	938	1525	1361	882	1475	681	508	1023	1687	1657	1473	1165	5727
SKEW	1,1	1,5	1,1	0,8	1,5	0,8	0,4	1,0	1,2	1,2	1,1	1,3	0,5
MIN	0	0	0	0	0	1	3	0	0	0	2	0	6453
MAX	6319	11576	8101	4580	9063	3841	2799	5478	12464	9263	8486	9238	41369

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1070	1276	1805	1337	1689	1198	1165	1301	1945	1817	1780	1482	17865
STDV	860	1691	1680	1117	1718	820	668	1075	1583	1824	1157	1447	6122
SKEW	2,4	2,9	2,1	2,6	3,5	2,2	1,6	3,0	1,8	3,1	1,3	2,3	0,9
MIN	76	54	208	158	266	262	278	215	354	233	278	95	6268
MAX	5124	9688	10248	7651	12084	5062	3881	7179	7618	11646	5601	8697	39374

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 900

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1036	1294	1789	1350	1668	1165	1136	1271	1921	1778	1797	1458	17662
STDV	649	1220	1437	900	1210	681	583	828	1291	1370	1076	1115	5223
SKEW	0,9	1,5	1,2	0,8	1,3	0,8	0,5	0,9	1,1	1,2	0,9	1,3	0,5
MIN	1	0	0	0	0	0	0	2	0	0	0	0	5378
MAX	4273	9063	8775	4679	7780	3838	3207	4524	9617	7752	6149	8349	38848

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 150

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1287	1369	1751	1528	1742	1203	1187	1457	1992	1732	1962	1525	18736
STDV	1126	1507	1727	1159	1530	806	647	1379	1718	1422	1922	1876	6607
SKEW	2,3	2,7	2,7	2,0	2,5	2,2	1,2	2,5	2,2	2,4	3,1	3,8	0,6
MIN	199	68	103	147	228	233	229	104	225	134	276	80	5642
MAX	7572	8914	9919	7395	8315	5791	3931	7894	9139	9658	12631	14475	39650

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 150

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1243	1385	1736	1543	1723	1171	1159	1422	1970	1697	1988	1497	18534
STDV	852	1179	1372	987	1176	673	587	1063	1354	1194	1474	1253	5565
SKEW	1,0	1,3	1,2	0,8	1,3	0,8	0,5	1,1	1,1	1,1	1,2	1,4	0,5
MIN	0	0	0	0	0	0	0	0	0	0	0	0	5227
MAX	5648	8464	8379	5137	7564	3784	3230	5894	10156	6754	8465	9407	40799

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 350

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1243	1518	2088	1375	1675	1238	1070	1267	1938	1595	1756	1517	18281
STDV	947	1412	1729	1081	1514	877	615	1032	1892	1326	1638	1881	6443
SKEW	1,6	1,6	2,1	2,1	3,9	2,8	2,1	2,0	2,9	3,0	2,7	3,2	0,7
MIN	185	109	239	124	262	176	180	228	327	258	226	221	7824
MAX	5121	7058	10425	6644	12444	6234	4383	5808	12006	9387	10486	12008	37199

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 350

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1205	1532	2070	1389	1661	1205	1045	1238	1914	1565	1779	1493	18097
STDV	766	1261	1518	896	1091	702	524	853	1395	1052	1280	1278	5311
SKEW	1,0	1,3	1,1	0,8	1,2	0,8	0,5	1,0	1,2	1,1	1,1	1,5	0,5
MIN	0	0	0	0	0	0	0	1	0	0	0	0	5393
MAX	5043	9139	9158	4667	6927	4005	2915	4545	10416	5919	7174	10182	38428

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 550

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1261	1415	1726	1308	1464	1092	1128	1561	2008	1938	1928	1177	18007
STDV	1150	1628	1631	1159	1229	713	634	1507	1783	1628	1642	1311	6184
SKEW	2,1	2,3	2,0	2,0	3,2	2,5	1,7	2,6	2,8	2,1	3,3	5,8	0,5
MIN	184	37	165	81	219	164	263	218	272	283	276	199	5142
MAX	6419	9717	8662	6337	9362	5497	4010	8875	13273	8556	13147	13021	36835

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 550

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1218	1435	1715	1324	1454	1066	1102	1525	1985	1903	1951	1164	17840
STDV	867	1319	1366	941	946	604	564	1149	1374	1357	1305	830	5418
SKEW	1,1	1,5	1,2	0,9	1,2	0,8	0,5	1,1	1,1	1,1	1,0	1,2	0,5
MIN	0	0	0	0	1	1	0	0	0	0	1	0	4878
MAX	5794	9869	8321	4868	6032	3478	3154	6161	10165	7616	7261	6415	40752

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 750

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1323	1453	1680	1286	1732	1168	1065	1443	2149	2133	1958	1447	18836
STDV	1167	1870	1527	1034	2007	774	569	1416	2188	1844	1724	1415	6787
SKEW	2,6	3,4	2,3	2,5	3,5	2,2	1,9	2,6	2,8	2,2	2,4	2,4	0,7
MIN	241	85	209	105	135	116	146	79	141	360	234	241	5447
MAX	8400	13589	8202	6414	13091	5343	4099	7980	14486	10785	10652	8176	44575

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 750

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1279	1471	1668	1300	1714	1138	1041	1409	2123	2095	1985	1430	18654
STDV	874	1339	1253	832	1356	650	499	1069	1608	1522	1393	1077	5506
SKEW	1,1	1,5	1,1	0,8	1,5	0,8	0,5	1,1	1,2	1,1	1,1	1,3	0,5
MIN	0	0	0	0	0	0	2	0	0	0	0	0	5774
MAX	5836	10012	7515	4340	8503	3690	2763	5714	11993	8546	7954	8434	40117

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1144	1370	1771	1483	1679	1172	1125	1306	1984	1831	1839	1468	18172
STDV	920	1733	1528	1282	1647	755	598	1049	1676	1722	1319	1434	5977
SKEW	2,2	2,9	2,2	2,6	3,5	2,2	1,6	2,7	1,9	2,9	2,0	2,4	0,7
MIN	76	54	179	158	266	223	264	215	354	233	278	95	6268
MAX	5124	9688	10248	8568	12084	5062	3881	7179	9284	11646	8277	8697	39374

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 950

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1108	1389	1755	1498	1660	1141	1099	1278	1963	1794	1859	1446	17992
STDV	702	1276	1324	1020	1159	636	529	825	1343	1335	1151	1094	5102
SKEW	0,9	1,4	1,1	0,9	1,3	0,7	0,4	0,9	1,1	1,2	0,9	1,3	0,5
MIN	0	0	0	0	0	0	3	3	0	0	1	0	5842
MAX	4688	9332	8002	5306	7376	3554	2893	4581	10034	7561	6606	8023	38130

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 200

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1362	1418	1846	1634	1750	1230	1172	1507	2027	1775	1886	1563	19170
STDV	1332	1484	1730	1317	1439	789	644	1501	1741	1518	1858	1822	6777
SKEW	3,4	2,5	2,4	2,2	2,4	2,0	1,4	2,8	2,0	2,3	3,1	3,4	0,7
MIN	126	7	103	147	228	233	229	104	225	134	276	80	5642
MAX	11569	8914	9919	8276	8315	5791	4019	10386	9139	9658	12631	14475	45121

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 200

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1313	1434	1831	1651	1733	1198	1144	1470	2004	1739	1911	1536	18964
STDV	943	1202	1419	1081	1132	669	575	1121	1401	1260	1416	1275	5689
SKEW	1,1	1,3	1,2	0,8	1,2	0,7	0,5	1,1	1,1	1,2	1,1	1,4	0,5
MIN	0	0	0	1	0	0	0	0	0	0	0	0	5293
MAX	6275	8620	8639	5622	7265	3782	3170	6162	10510	7125	8086	9636	41896

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 400

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1218	1510	2122	1384	1667	1174	1050	1325	1927	1587	1803	1530	18297
STDV	926	1414	1895	1080	1597	842	616	1287	1934	1258	1616	1834	6345
SKEW	1,6	1,7	2,2	2,0	3,7	2,7	1,9	2,9	3,2	2,8	2,4	3,1	0,7
MIN	185	109	239	124	262	176	180	147	263	152	226	66	6464
MAX	5121	7058	11585	6644	12444	6234	4383	9882	13697	9387	10486	12008	37199

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 201 - 400

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1180	1524	2105	1398	1651	1143	1024	1293	1903	1557	1827	1505	18110
STDV	749	1244	1615	899	1137	676	533	981	1385	1031	1300	1268	5368
SKEW	1,0	1,3	1,1	0,8	1,3	0,8	0,5	1,1	1,2	1,0	1,1	1,5	0,5
MIN	0	0	0	0	0	0	1	0	0	1	1	0	5298
MAX	4929	8983	9776	4691	7216	3841	2937	5206	10347	5809	7309	10016	38977

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 600

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1225	1378	1659	1341	1489	1117	1119	1503	1906	1897	1927	1162	18110
STDV	1124	1515	1510	1147	1294	767	637	1470	1692	1580	1606	1199	5905
SKEW	2,1	2,3	2,1	2,0	3,3	2,2	1,6	2,6	2,7	2,1	2,9	5,8	0,5
MIN	184	37	98	81	219	112	263	218	272	237	276	199	5142
MAX	6419	9717	8662	6337	9362	5497	4010	8875	13273	8556	13147	13021	36836

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 401 - 600

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1181	1394	1647	1356	1477	1087	1092	1466	1882	1861	1949	1149	17542
STDV	840	1245	1280	950	977	647	566	1109	1304	1317	1316	797	5250
SKEW	1,1	1,4	1,1	0,9	1,2	0,8	0,5	1,1	1,1	1,1	1,0	1,2	0,5
MIN	0	0	0	0	0	0	0	0	0	0	1	1	5142
MAX	5614	9239	7759	4919	6206	3703	3144	5945	9640	7389	6138	39634	38130

'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 800

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1341	1498	1722	1331	1727	1218	1072	1422	2212	2183	2017	1438	19182
STDV	1226	1742	1484	1053	1846	799	561	1305	2374	1883	1842	1393	6747
SKEW	2,8	3,3	2,2	2,3	3,5	2,0	1,5	1,0	1,3	1,2	1,1	1,3	0,5
MIN	241	85	185	83	135	116	146	79	141	360	234	212	5222
MAX	8400	13589	8202	6414	13091	5343	4099	7980	18575	10785	10652	8176	44575

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 601 - 800

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1296	1516	1709	1345	1709	1186	1048	1389	2184	2143	2046	1420	18991
STDV	898	1323	1253	858	1291	684	508	1016	1682	1587	1485	1080	5666
SKEW	1,1	1,4	1,1	0,8	1,4	0,8	0,5	1,0	1,3	1,2	1,1	1,3	0,5
MIN	0	0	0	0	1	0	2	0	0	0	0	0	5717
MAX	5993	9715	7529	4486	8159	3872	2809	5382	12671	8935	8444	8353	41420

'OBSERVED' MONTLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 1000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1185	1469	1787	1468	1684	1168	1097	1257	1945	1855	1869	1495	18279
STDV	1022	1805	1544	1212	1562	785	618	1092	1679	1711	1574	1433	6312
SKEW	2,4	2,5	1,9	2,4	3,3	2,2	1,6	2,9	2,0	2,7	2,9	2,3	0,8
MIN	76	34	179	139	122	223	264	215	326	233	278	95	5346
MAX	6029	9688	10248	8568	12084	5062	3881	7469	9284	11646	11972	8697	43946

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 1000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1144	1486	1768	1481	1663	1136	1070	1227	1919	1815	1888	1470	18068
STDV	753	1378	1341	994	1144	648	540	830	1328	1341	1257	1106	5385
SKEW	1,0	1,5	1,1	0,8	1,3	0,8	0,5	0,9	1,1	1,2	1,0	1,3	0,5
MIN	0	0	0	0	0	0	20	0	0	0	0	5281	6947
MAX	4965	10155	8155	5155	7363	3653	2980	4559	9957	7587	7185	8179	39793

'OBSERVED' MONTLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 1000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1266	1455	1827	1432	1664	1181	1102	1403	2003	1850	1900	1438	18530
STDV	1135	1597	1645	1169	1558	796	616	1340	1902	1612	1702	1560	6437
SKEW	2,8	2,6	2,2	2,2	3,4	2,2	1,6	2,8	3,0	2,4	2,7	3,3	0,7
MIN	76	7	98	81	122	146	79	141	134	226	66	5142	5346
MAX	11569	13589	11585	8568	13091	6234	4383	10386	18575	11646	13147	14475	45121

'OBSERVED' MONTLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 1000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1185	1469	1787	1468	1684	1168	1097	1257	1945	1855	1869	1495	18279
STDV	1022	1805	1544	1212	1562	785	618	1092	1679	1711	1574	1433	6312
SKEW	2,4	2,5	1,9	2,4	3,3	2,2	1,6	2,9	2,0	2,7	2,9	2,3	0,8
MIN	76	34	179	139	122	223	264	215	326	233	278	95	5346
MAX	6029	9688	10248	8568	12084	5062	3881	7469	9284	11646	11972	8697	43946

1000 YEAR SERIES GENERATED FROM 'OBSERVED' MONTHLY STREAMFLOW ($m^3.10^3$) FOR YEARS 801 - 1000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1144	1486	1768	1481	1663	1136	1070	1227	1919	1815	1888	1470	18068
STDV	753	1378	1341	994	1144	648	540	830	1328	1341	1257	1106	5385
SKEW	1,0	1,5	1,1	0,8	1,3	0,8	0,5	0,9	1,1	1,2	1,0	1,3	0,5
MIN	0	0	0	0	0	0	20	0	0	0	0	5281	6947
MAX	4965	10155	8155	5155	7363	3653	2980	4559	9957	7587	7185	8179	39793

'OBSERVED' MONTLY STREAMFLOW ($m^3.10^3$) FOR YEARS 1 - 1000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
MEAN	1266	1455	1827	1432	1664	1181	1102	1403	2003	1850	1900	1438	18530
STDV	1135	1597	1645	1169	1558	796	616	1340	1902	1612	1702	1560	6437
SKEW	2,8	2,6	2,2	2,2	3,4	2,2	1,6	2,8	3,0	2,4	2,7	3,3	0,7
MIN	76	7	98	81	122	146	79	141	134	226	66	5142	5346
MAX	11569	13589	11585	8568	13091	6234	4383	10386	18575	11646	13147	14475	45121