PROJECTS TCP/SOM/8906 & 0104

FAO TECHNICAL CO-OPERATION/SOMALI GOVERNMENT

HYDROLOGICAL DATA COLLECTION AND UPGRADING OF THE NATIONAL HYDROMETRIC NETWORK ON THE JUBBA AND SHEBELLI RIVERS, AND IN-SERVICE TRAINING OF THE FIELD OPERATIONAL STAFF.

MAIN REPORT

VOLUME .1.

By

Brian A. P. Gemmell
(Consultant Hydrologist)

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VOLUME .I.

MAIN REPORT

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By

BRIAN A.P. GEMMELL

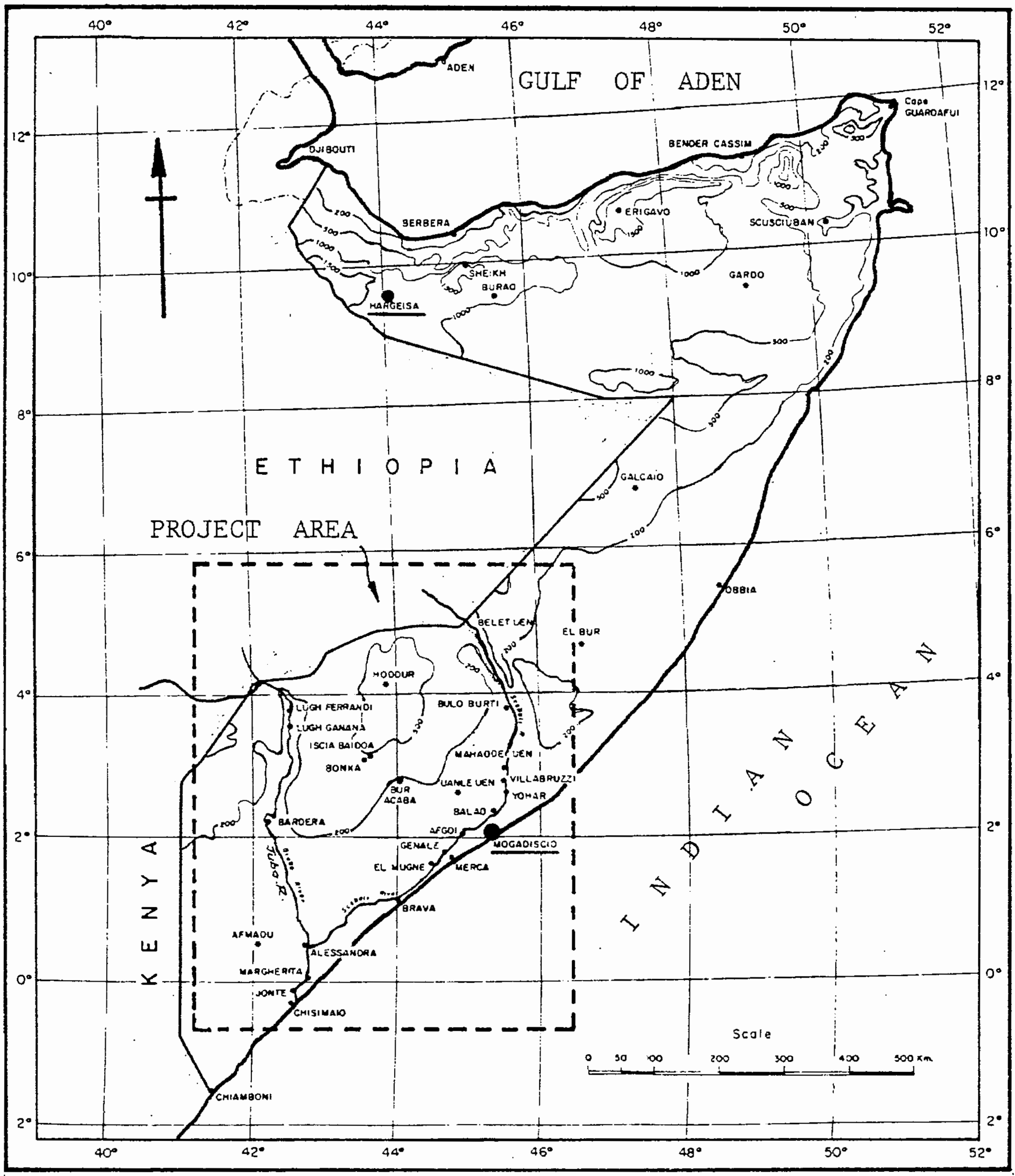
(FAO Consultant Hydrologist)

May 1982

Harrow, Middlesex, England.

TOPOGRAPHICAL MAP

SHOWING PROJECT AREA



F O R E W O R D

This Report has been prepared by the Consultant from data collected during the course of his four missions to Somalia between January 1980 and December 1981, while Managing the 'Water Hydrometry' Project TCP/SOM/8906 & 0104, in conjunction with the Director of the Land and Water Development Department of The Ministry of Agriculture, in Mogadishu.

The recommendations and conclusions appearing in this report are those that were considered appropriate at the time of preparation and maybe modified in the light of further knowledge obtained in the future.

The information and data available for the preparation of this report, was only obtained by close collaboration with personnel from the Ministry of Agriculture.

' IN MEMORIUM '

The success of the Hydrometry Project in Somalia as illustrated by the work which comprises this report, was mainly possible because of the technical knowledge, foresight, personnel awareness and understanding of the late Mr. Douglas Eva, the FAO Senior Projects Officer. It was his determination and support which ensured that the Project duration was extended by way of a phased programme proposed by the Consultant. The phased programme enabled two complete hydrological cycles to be observed, during which both servere drought and unique flood events occurred, thereby ensuring the achievement of the project objectives, which under the normal one year program would not have been possible. He is remembered with respect and affection.

ABBREVIATIONS

mm	-	millimeters
cm	-	centimeters
m	-	meters
m^2	-	meters squared
m^3	-	meters cubed
mcm	-	million cubic meters
$m^3 x\ 10^6$	-	" " "
$m^3 x\ 10^3$	-	thousands of cubic meters
Km	-	Kilometer
Km^2	-	Kilometers squared
m/sec	-	meters per second
m^3/sec	-	meters cubed per second
W.L.	-	water level
R/B	-	right bank
L/B	-	left bank
S/A	-	slope area measurement
WP	-	wetted perimeter
R	-	hydraulic radius
S	-	slope
A	-	area
n	-	roughness factor
BM	-	benchmark
TBM	-	temporary benchmark
CTF	-	cease to flow
R.L.	-	relative level
A.D.	-	assumed datum
WERB	-	waters edge right bank
WELB	-	waters edge left bank
MSL	-	mean sea level
G.Z.	-	gauge zero
'MB'	-	measuring point (bridge)
'MP'	-	measuring point (recorder well)
G.H.	-	gauge height
'MMP'	-	M.MacDonald & Partners .

TERMS OF REFERENCE

After the re-phasing of the Hydrometry Project to three visits which would cover a period of eighteen months instead of the original programme of one year, the Terms of Reference were as follows :-

> ' The Consultant to visit all Hydrometric Stations on the Jubba and Shebelli rivers which comprise the National Hydrological Network, and try to re-activate the stations where possible. Then, initiate regular hydrometric observations such as daily stage records, and a continious river gauging programme to try and re-rate all the stations over the short duration of the Project.
>
> During the field installations and operating activities of the Network, In-service training to be carried out to train staff provided by the Ministry of Agriculture in the various skills required to ensure operational continuity of the hydrological data collection programme.'

Following the exceptional 'GU' flood conditions of April/May 1981, the following additional Terms of Reference were also included :-

> ' To monitor the daily progress of the 'GU' floods and produce a flood report outlining the history of the event, to be used as a data base for the main 'Flood Damage Assessment Study' to be carried out by Sir M. Macdonald & Partners Ltd, in association with Hunting Technical Services Ltd.

On completion of the Hydrometry Project a'Technical Report' is to be submitted to the Government in addition to the Terminal Statement.

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P R E F A C E

The Hydrometry Project TCP/SOM/8906 was born after the visit to Somalia of the Hydrologist Jean C. Henry in 1979, to evaluate irrigation potential along the Jubba and shebelli rivers. During this study the Hydrometric data base was questioned as regards both its validity and representativity. The first steps taken to rectify the situation was the formulation of the Hydrometry Project and its implementation in January 1980.

The main objectives of the Hydrometry Project were to try and re-rate all the National Hydrometric stations on the Jubba and Shebelli rivers. Under the initial 'TCP' time schedule of one year, January to December 1980, the main objectives of the project could not have been achieved due to the level of the floods being below average. Under these circumstances only the lower levels of the rating curves were established. However, under the revised schedule of operating the project in three separate phases a period of eighteen months was covered instead of the original twelve, for no additional cost.

The re-phasing of the project duration was extremely beneficial to the outcome of the project in two major ways. The first benefit was that the extremely low river levels experienced, allowed missing gauge stands to be installed at most of the sites, and the wells and inlet pipes of recorder installations to be cleaned out, of the past ten years silt deposits. With the cleaning of the stilling wells, and cannibalisation of spare parts from damaged recorders found in the Ministry stores, five recording stations were re-activated. Unfortunately two were vandalised soon after they were brought into operation. The long period of low water levels was ideally suited to the training programme especially with regard to the 'Stream Gauging' section. The training began at the 'Grass roots level', so the trainee's would not have been ready had the extreme conditions been experienced soon after the start of the project.

The second major benefit was that two complete hydrological cycles were monitored. Probably the driest period on record Feb/March 1981, with both the Jubba and the Shebelli rivers drying up along their lower reaches. This extreme drought period was immediately followed by the wettest on record, with the highest levels on record being recorded on the upper and middle shebelli, and the lower Jubba.

These extreme conditions enabled discharge ratings at most stations to be achieved over the maximum range, a feat not accomplished since the original hydrological observations were started in Somalia between 1900/1939, during the Italian period of occupation.

In July 1981 the Government of Somalia requested the FAO to extend the project to the end of 1981 to ensure the continuity of the data collection programme, especially after the extreme flood events. This request was granted and a report was produced relating to the event (A History of the'GU' Floods in Somalia on the Jubba and Shebelli rivers March to June 1981).

Throughout the project duration the Government and the United Nations Development Programme Representative, were constantly reminded of the absolute necessity to ensure that continuity with regard to the collection of reliable long term hydrological data, is paramount. It was hoped that the constant reminders would ensure the inclusion of the proposed ' Water Center Project', at the start of the 'IPF' funded five year development plan, scheduled to begin in 1982.

The importance of the Hydrological Studies was identified by the United Nations Multi-Agency Mission on Drought to East Africa, which visited Somalia in early October 1981.

Throughout the Missions final report to the General Assembly in November 1981, it was continiously stressed that the Operational Hydrology Programme, as initiated by the FAO with the Hydrometry Project, must not be allowed to lapse due to the lack of funds, and thereby reverting to the same situation as found prior to the initiation of the Hydrometry Project in 1979.

The damage caused by the 'GU' floods and the insistence for continuity as expressed by the United Nations Mission on Drought, further convinced the Government that the Hydrometry Project had to continue, and so the Ministry of Agriculture once again requested the FAO to maintain the Hydrometry Project for the period leading upto the start of the 'Water Centre Project' in 1984/85.

It is hoped that the FAO will continue to support this most important requirement, especially in a country like Somalia so dependant on agriculture. If the FAO does not agree to finance this extension, the hydrological investigations will most likely be sidelined once again, and there remain for the next decade.

In addition to re-activating the Hydrological Network, the Gauging and In-service training programmes, the Government was advised to maintain a permanent and reliable body of Stream Gauge Observers who could maintain a complete station including a Recorder. At present the major problem is that some stations are left unmanned for months at a time, and this loss of streamflow data is what causes the main errors when the data is analysed.

In-service training was mainly conducted with regard to the field operational requirements and on the basic computations directly relating to the discharge measurements and surveys carried out on site. This was done because the standard of personnel supplied to the project were more practically orientated, rather than academically inclined.

In addition to the In-service training, FAO fellowships were awarded. Three of the Trainee's were sent on three month Operational Hydrology courses in Kenya. This was arranged through the FAO and WMO as an Inter-Agency excercise. The WMO arranged for the acceptance of the trainee's to attend the training programme with the 'Hydromet Surveys Project of Lakes Victoria, Kyoga and Mobutu Sese Seko', and were based in Kisumu.

Unfortunately the level of training recieved does not appear to have been satisfactory. However, the effect of the trip and the course on the overall attitude of the trainee's to the importance of their work, and the added desire to remain within the said field, is in itself successful and benificial to the future continuity of the hydrological activities in Somalia.

This report consists of the data collected by the Consultant and his team over the duration of the Hydrometry Project. All the basic data is included in Volumes '2,3, & 4 ', and is presented in a format usually used in the presentation of ' Hydrological Year Books'. With the training of the field staff and the rating of all the National Network stations, it can be assumed that the Project achieved its main objectives. If the benefits from the work carried out by the Project are to be used in the future, the Hydrological investigations in Somalia must be expanded and not allowed to deteriorate to a derelict state, which has occurred in the past.

1.0. INTRODUCTION

The Somali Democratic Republic covers a territorial area of some 630,000 square kilometers, stretching from the Gulf of Aden (12° 00' N) in the north, round the Horn of Africa at Cape Gardafui, then south along the East African coast to the Kenya border (2° 00' S). The population is in the order of 5.0 million people with an estimated growth rate of 3.2% per annum, as established by the Government in 1980.

The climate is semi arid to arid, with an annual mean precipitation varying from less than 100 millimeters in the north along the Gulf of Aden, and increasing to 500 to 600 millimeters in 'pocketed' area's in the south. In the northern coastal area the mean monthly temperatures vary between 25°and 35°C, with the mean relative humidity between 75 and 50%. In the northern mountain region the mean monthly temperatures vary between 15°and 25°C, with the relative humidity down to between 50 and 60%. The mid-southern inland area has a mean monthly temperature of 30°C, with a range of 4°to 6°C, and a mean relative humidity of 65%. Finally, in the southern coastal area the mean monthly temperature has only a 2°to 4°C variation, with the mean maximum of 28°C being recorded in March/April. The mean relative humidity is about 80% throughout the year, but decreases 10 to 15% further inland.

The Project covers the area of Somalia dependant upon the Jubba and Shebelli rivers for its water. These two rivers drain the eastern slopes of the Ethiopian Plateau to the west of Somalia, and are the only sources of surface water which is available for large scale irrigation development in Somalia. Approximately one third of the river catchments lie within Somalia, and under normal conditions only contribute a very minor percentage of the annual dicharges from local run-off. However, during exceptionally high rainfall periods the timing of the local contribution can, and does have a marked effect on the flood distribution and flood peak levels. It also causes discrepancies in correlation relationships between the observation points downstream, and the inflow stations near the borders.

Because of the low rainfall in Somalia, rainfed agriculture is very unreliable and great efforts are being made to harness the water resources of the two rivers. The 'Offstream Storage Resevoir' on the Shebelli at Johar, which became operational in 1980, and the proposed 'Bardheere Dam' on the Jubba are the two principal ventures to date.

At present irrigated agriculture is practised on land in excess of 50,000 hectares, with proposals in the pipeline to increase this area eventually to more than 250,000 hectares. To increase the irrigated area on the Shebelli to any large degree would require a major revision of the cropping pattern, and substantial improvement of the irrigation efficiency. The situation would deteriorate on the Shebelli if significant irrigation development was undertaken in Ethiopia. Whereas considerable scope is available with regard to the Jubba river basin, to increase the land already under irrigation quite considerably and especially after the completion of the 'Bardheere Dam Project'.

The majority of past and recent reports relating to the water requirements of Somalia indicated that the Hydrological data base was sadly lacking in both continuity and reliability, and that immediate steps should be taken to improve the data base to ensure reliable calculations and planning of such important ventures as the 'Bardheere Dam' and the future of agriculture in Somalia.

The first steps in trying to improve the situation was the formulation of the 'Hydrometry Project' which would carry out the initial spade work, and produce the platform for the proposed longer term 'Water Centre Project'.

1.1. HYDROLOGICAL DATA BACKGROUND

Hydrological investigations have been carried out in Somalia from the early part of this century, although documented data for the period is difficult to locate. The available data starts from the begining of the fifties. In the early sixties Hydrological Investigations were carried out on the Jubba by the Russians (SELCHOZPROMEXPORT), and on the Shebelli by the Water Resources Survey Project, the data appearing in the FAO Report published in 1968. The data for the Jubba river appears in the same report. The Lockwood/FAO Survey was carried out in the mid-sixties and on the completion of the Lockwood/FAO Project the Hydrological Studies were carried on by the newly formed Survey and Mapping Department of the Ministry of Public Works, until the end of 1967. In 1968 and 1969 the Project for the'Water Control and Management of the Shebelli River' was carried out by Hunting Technical Services in association with Sir M. Macdonald & Partners.

In the late sixties and early seventies a number of short term studies were carried out on both the rivers, but the data base used on the Jubba was from the Selchozpromexport and Lockwood/FAO reports. No additional data collection appears to have been carried out, except for occasional discharge observations at Lugh Ganana on the Jubba by the Fanoole Project, inspite of all the stations on the Jubba only being gauged over the lower sector of their rating curves.

Upto the end of 1979 the 'The Water Control and management of the Shebelli River' report was the Bible with regard to Hydrological information on the Shebelli. Apparently additional work was carried out in the early seventies by M.Morgan, but no documentation of the work was available at the Ministry of Agriculture. Sir M.Macdonald & Partners has installed gauging stations on the lower shebelli at Sabun, but only in connection with the 'Offstream Storage Resevoir'. From 1972 the Hydrological activities have been operating on a declining basis by the Ministry of Agriculture. In general all investigations since 1972 have been related to the data collected in the sixties.

1.2. PROJECT OBJECTIVES

In the short term, the Hydrometry Project was formulated because of the urgent need for reliable up-dated streamflow data in connection with the 'Bardheere Dam' proposals, and for the future programming of the irrigation water requirements along the Jubba and Shebelli rivers. Also, the need to train and familiarise staff with the hydrometric skills and proceedures required to ensure that the correct process of data collection and general network operation and instrument maintenance would continue without interruption.

With regard to the long term objectives, it was envisaged that the short term (TCP) project would be the catalyst which would lead to a major follow-on project of longer duration, and would ensure the permanent establishment of a reliable and independant unit, which would also centralise storage of all data relating to Water Resources studies. The data would then be readily available in tabulated form , and published for general circulation.

2.0. GENERAL DESCRIPTION OF THE RIVERS

2.1. JUBBA RIVER

The Jubba river originates in Ethiopia after the confluence at Dollo of the following three rivers, the Uebi Gestro, Genale Doria and the Daua Parmo. The total length of the whole river from the source of the Uebi Gestro the northern most tributary, to the mouth of the Jubba where it flows into the Indian Ocean, just north of the port of Kismayo is 1,306 kilometers. The river flows through Somalia for 800 kilometers from Dolo to the sea. The total catchment area upstream of Dollo is approximately 140,000 square kilometers and mean annual rainfall ranging from 200 to 1,600 millimeters in the highlands.

The river channels upstream of Dollo are far removed from large population centres, and offer little scope for any large scale irrigation, although potential does exist for the development of Hydro-power. Suitable land available for irrigation is mainly situated downstream of Dollo. The lower Jubba area between Dujuuma and the sea also has great potential with regard to irrigation. The mean annual rainfall on the lower Jubba is in the order of 500 millimeters.

Between Dollo and Lugh Ganana the river channel is wide, steep banked with shoals and sandbanks appearing in the channel during low flow periods. From Lugh Ganana to Deores the river channel narrows and becomes more incised with rock banks and stoney bed. A number of intermittent tributaries join the Jubba along this stretch of the river.

From Dujuuma the river valley flattens and the river takes on the characteristics of an aggraded river channel. The river begins to meander and flood waters overspill the banks and fills the 'OXBOW' lakes and depressions known locally as 'desceks'. This overbank spillage occurs as far down stream as Yantoy, where the river is once more contained within it's banks before flowing to the sea.

Discharges in the order of 2,000 m^3/sec at Lugh Ganana and 1,400 m^3/sec at Mareere (Jubba Sugar Project) have been estimated, and minimum flows of 2.0 m^3/sec and totally dry were observed in March 1981 at the same sites.

Just south of Jelib in the area of Kamsuma the Shebelli river channel joins the Jubba river. This channel only carries water from the Shebelli during periods of exceptionally high and extended flood periods. On a number of occassions when the Jelib to Mogadishu road has been breached it has been claimed that the Shebelli waters had reached the Jubba, when infact it was the waters draining from the Inter-riverine area.

2.2. SHEBELLI RIVER

The source of the Shebelli River is in the eastern part of the Ethiopian plateau near the town of Yirgalem. The catchment area covers approximately 300,000 square kilometers, and one third of this area lies in Somalia. The total length of the river from its source in the highlands of Ethiopia to its mouth, after converging with the Jubba and finally onto the Indian Ocean is approximately 1,800 kilometers, with 1,000 kilometers comprising the length of the river within Somalia. The main tributary of the Shebelli in Ethiopia is the Farfan which drains the northern catchments and the 'Far Depression' north east of Callafo. The Farfan joins the Shebelli at Callafo, but the waters of the Farfan do not reach the Shebelli during seasons of low rainfall.

The river enters Somalia at the border town of Ferfar situated 30 Kilometers north of Belet Uen. The river then flows south through Bulo Burti, Mahaddei Uen and Johar onto Balaad, where it turns south west and continues roughly parallel to the coast from which it is seperated by a range of sand hills some 25 kilometers wide. Along this stretch the river flows through some of the main agricultural land in the country at Afgoi, Audegle and Coriole, and then onto the first of three swamp basins which extend to Avai. Downstream of Avai, the river resumes a defined channel, but flows are very much reduced and only in times of exceptional floods, will the Shebelli discharge into the Jubba near Kamsuma,before entering the Indian Ocean north of Kisimayo. Additional flow at times is added to the system from local catchments in the Inter- Riverine area. This water joins the Shebelli water course north east of Jelib and disrupts the road communications, and is usually mistakenly thought to be the waters of the Shebelli river which originated in the highlands of Ethiopia. In exceptional circumstances the water from the Shebelli does reach the Jubba, but only very rarely.

The Shebelli catchment area in Ethiopia is approximately 210,000 square kilometers and under normal conditions contributes 90% of the annual flow credited to the Shebelli in Somalia. The river channel capacity decreases the further the river enters Somalia. At Belet Uen the channel capacity is in the order of 400 m^3/sec, and decreases to 250 m^3/sec by the time it reaches Jalalaqsi and 160 m^3/sec at Mahaddei Uen. By the time it reaches Balaad where the river turns south west the channel capacity has dropped to 106 m^3/sec and below the 90 m^3/sec at Audegle.

The rainfall along the lower and middle Shebelli, Afgoi to Johar area, is in the order of 500 millimeters(mean), and then deceases to 200 millimeters as one moves north to the border area at Belet Uen. Approximately 10% of the annual river discharge is contributed by run-off from local seasonal catchments whose water cources join the Shebelli between Belet Uen and Bulo Burti. The attenuation of flow is mainly due to the overbank spillage during the flood season, and the lack of contributions from the local catchments during the drier periods.

3.0. HYDROMETRIC RIVER GAUGE NETWORK

3.1. GENERAL

At the start of the Hydrometry Project in January 1980 all the National Hydrometric stations were visited by the consultant, to identify the conditions of the stations, the improvement requirements, and the observer availability and reliability.(History notes Vol: 2.& 3.).

After a short period of training in the use of gauging equipment, stage discharge relationships were commenced with a supervised discharge gauging programme at regular intervals when conditions so dictated. During the exceptional 'GU' floods of April/May 1981, flood progress, damage and field observations were monitored from aerial reconnaissance and ground field inspection visits whenever possible. The results of these additional activities have been presented in the consultants report on 'The History of the GU Floods in 1981'.

3.2. HISTORICAL HYDROMETRIC WORK (JUBBA RIVER)

'FANTOLI' published pre 1933 monthly and annual river stage data for the Jubba and Shebelli rivers, which were at the time mainly utilised for flood prediction or warning for the lower Jubba plantations. Useful discharge records did not begin until 1951. The discharge calculations were obtained by theoretical methods rather than actual field gaugings.

The first reliable data for the Jubba was collected by the Lockwood/FAO project 1963/68 when the first available discharge data was obtained by actual field gaugings. Some additional field data was collected by the Fanoole Project (Giprovodhoz), at Kaitoi, Fanoole, Jelib and Jamamme all in the lower Jubba. The gauges at these sites have been changed a number of times which causes difficulties in comparing some of the older data to the present day observations. Another problem was that the staff gauges in many cases were installed with overlaps between the gauges, and the installation data relating to these gauges is not available at the Ministry of Agriculture in Mogadisho. It appears that all reports and desk studies have mainly had to rely on the data collected in the mid sixties, apart from some field observations carried out by Sir M. Macdonald & Partners (MMP) at Kaitoi, the lower Jubba and spot observations at Bardheere, in the later seventies. The data was collected with regard to the studies for the 'Jubba Sugar Project'. Infact, no reliable data was collected by the Hydrological section from 1972 to 1979. This was very unfortunate especially the loss of important data relating to the very high floods experienced in November 1977. Ministry personnel were actually at Lugh Ganana at the time of the peak flood, but no definite marks made as to the peak flood level. Consequently there are a number of different estimated flood peak levels being claimed.

3.3. HISTORICAL HYDROMETRIC WORK (SHEBELLI RIVER)

The situation with regard to the Shebelli is very much the same as the Jubba. The pre 1951 records were conducted at various irregular intervals, with more reliable data being available from 1951. The main rating curves were established during the Lockwood/FAO project in 1964/5, and then adjusted in 1968/69 by M.Morgan during the Project for the Water Control and Management of the Shebelli River.

The original sites at which stage levels were observed during the Italian period were as follows:-

a) Belet Uen bridge.
b) Mahaddei Uen bridge.
c) Johar Bridge.
d) Afgoi bridge.
e) Genale.

All these gauges had been fixed to the various bridge abutments or pillars depending on the bridge structures. The system of attaching the gauge plates to the structures also date the gauges.

The Network was increased and existing stations were upgraded with the installation of Leupold & Stevens strip chart recorders, also additional staff gauges were installed to increase the range of observations, by the Lockwood/FAO Project.The increased Network was as follows :-

a) Belet Uen - Extension of staff gauges, and the installation of a Recorder.
b) Bulo Burti - Installation of staff gauges and a Recorder.
c) Mahaddei Uen - Installed new staff gauges.
d) Balaad - Staff gauges and an Automatic Recorder.
e) Afgoi - Original staff gauges used.
f) Audegle - Temporary staff gauges installed on bridge supports.

The Gauge Observers throughout the duration of the investigations were members of the team and paid by the project. This resulted in an uninterrupted period of good reliable data.

Between 1965 and 1967 the responsibility for the hydrological investigations was given to the Survey and Mapping Section of the Public Works Department. Unfortunately during this period the hydrological activities were greatly curtailed, mainly due to the lack of trained personnel to operate and guide the section, but also due to the lack of finances to carry out efficient field operations.

From February 1968 to April 1969 the operation of the Network was taken over by a project ' The Water Control and Management of the Shebelli River'. During this period the existing gauging stations were upgraded by improving the staff gauges, increasing their range to include low level observations and re-activating the Recorders. At Belet Uen and Bulo Burti new gauge stands were brought into operation apart from the original gauges fixed to the bridges. Additional gauges were also installed at the various barrage sites at Johar, Balaad (proposed site), Genale, Coriole and Falcherio. These gauges were not included in the National Network.

After the completion of the project in 1969, the project hydrologist Mr. M.Morgan was retained to continue operating the hydrological investigations within the framework of the Government. From 1972 the responsibility for the hydrological investigations was handed to the Land and Water Section of the Ministry of Agriculture. A steady decline in the operation of the Network, the continuity and reliability of the data and its notation is clearly illustrated for the period 1973 to the start of the Hydrometry Project in 1980. All the recorders stopped operating and were eventually removed from the stations and dumped in the stores in Mogadishu. All activities with the exception of a fairly continious return of water levels from Lugh Ganana and Belet Uen, virtually came to an end.

4.0 PRESENT HYDROMETRIC NETWORK

The National Hydrometric Network as used for the present hydrological studies is virtually the same as for the previous projects, and are the stations recommended in the report by the Hydrologist J.C.Henry, 'Present and Future Irrigated Agriculture on the Shebelli and Jubba Rivers in Somalia.' It was this report which led to the implementation of the present Hydrometric studies.

4.1. JUBBA RIVER STATIONS

On the Jubba River three stations have been retained for these studies. One at Lugh Ganana the observed point of river input to Somalia, situated some 690 kilometers from the sea. The second station at Bardheere approximately half way between the border and the sea, and only 45 kilometers downstream of the proposed damsite, which is about 500 kilometers from the sea. The third site is in the lower Jubba area only 48 kilometers from the sea at the Jamamme bridge over the Jubba. (FIG. 1.)

Jubba Hydrometric Stations

Location	Latitude	Longitude	Altitude
1. Jubba at Lugh Ganana	03° 47' N	42° 32' E	150 m
2. Jubba at Bardheere	02° 19' N	42° 17' E	115 m
3. Jubba at Jamamme	00° 04' N	42° 44' E	10 m

TABLE .1.

Other stations exist along the lower Jubba valley, but are not included in the National Network, as operated by the Hydrological Section of the Ministry of Agriculture. The sites are situated at Kaitoi, Malenda, Jelib, Mareery and Kamsuma. These sites are maitained by the Fanoole and Jubba Sugar Projects.

JUBBA RIVER

LOCATION OF HYDROMETRIC STATIONS

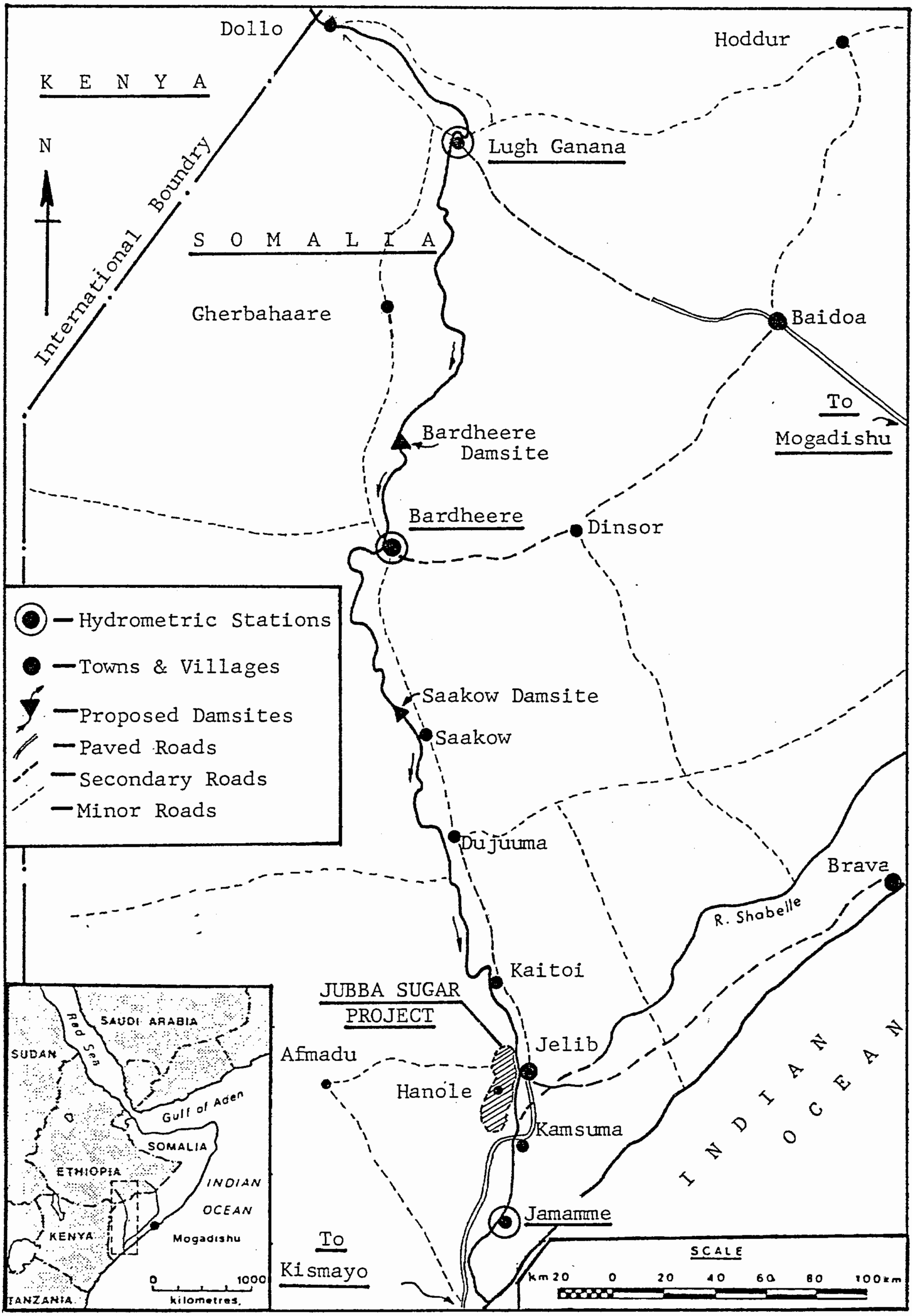


FIG .1.

4.2. SHEBELLI RIVER STATIONS

Similar to the Jubba river the Shebell Hydrometric Network consists of the same stations as utilised in the previous hydrological studies, and then retained by the Hydrological Section of the Ministry of Agriculture. The Shebelli Network consists of six stations, with the main inflow station to Somalia situated at Belet Uen, a distance of 30 kilometers from the international border and about 365 kilometers from Mogadishu at the coast. The second station is at Bulo Burti some 120 kilometers downstream of Belet Uen. This is an important station as the only inflow contribution to the Shebelli from Somalia, comes from the catchments lying upstream of this control point, apart from minor contributions after the lower swamp areas, just before the Shebelli merges with the Jubba. This lower contribution does not affect the major agricultural areas along the main Shebelli river.

The third station is situated at Mahaddei Uen where the discharges indicate the water available for irrigation, after the overbank spillage has taken place between Bulo Burti and Mahaddei Uen, and of importance to the operation of the 'Offstream Storage Resevoir' at Sabun. After Mahaddei Uen there are three stations Balaad (closed), Afgoi east of Mogadishu, and Audegle a further 40 kilometers south. (FIG.2.)

Shebelli Hydrometric Stations

Location		Latitude	Longitude	Altitude
1. Shebelli at	Belet Uen	04° 45'N	45° 12' E	183 m
2. "	Bulo Burti	05° 51'N	45° 34' E	165 m
3. "	Mahaddei Uen	02° 58'N	45° 32' E	112 m
4. "	Balaad(Closed)	02° 22'N	45° 24' E	95 m
5. "	Afgoi	02° 09'N	45° 08' E	90 m
6. "	Audegle	01° 59'N	44° 50' E	76 m

TABLE .2.

SHEBELLI RIVER

LOCATION OF HYDROMETRIC STATIONS

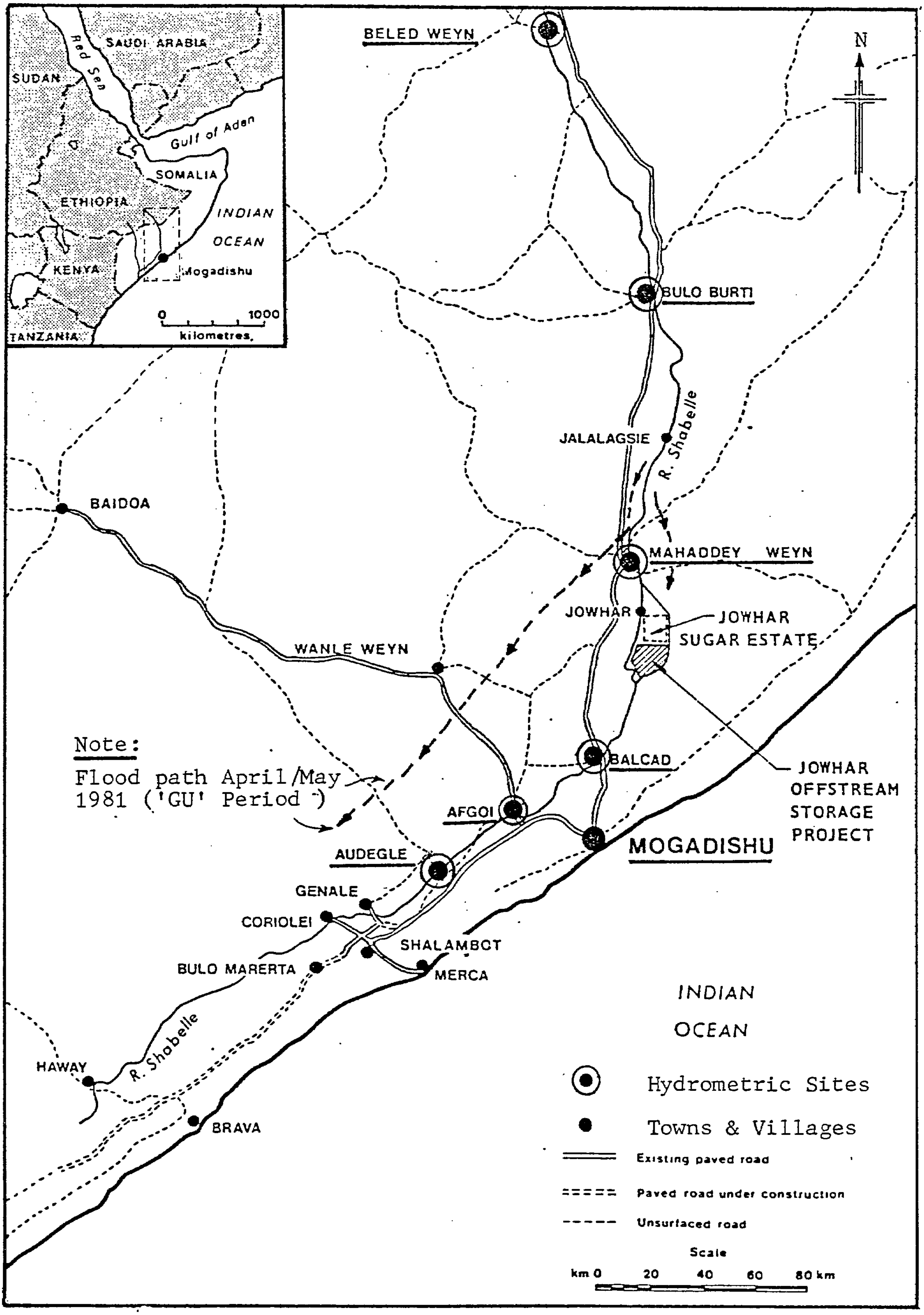


FIG .2.

Other observation stations exist along the Shebelli river at the various weirs and barrages. At Sabun both stage and discharge observations are carried out in relation to the regulation of the 'Offstream Storage resevoir. At Johar weir in connection with the irrigation of the sugar fields and factory operations, and at Balaad, Genale, Coriole and Falcherio barages with regard to irrigation. The only data available at the Ministry of Agriculture is the data from Sabun, where for the moment, data is recorded in a systematic manner.

5.0. REHABILITATION OF GAUGING STATIONS

All the Project Hydrometric Installations were visited as soon as transport became available at the end of February and March 1980. These initial visits to the stations were for orientation purposes and to establish the condition and the operational situation at the stations. All information with regard to the installation and history of the station was collected and noted. All reference points were surveyed and checked with existing data, and where reference points could not be found, new benchmarks were installed. Photographs of all installations were taken to establish a permanent record of the stations, including all benchmarks and other reference points. This was done to ensure that future projects will not have to waste time in building up a dossier of historical data required for the calculations of long term trends and data comparisons , it will be available when required.

5.1. JUBBA RIVER

5.1.1. LUGH GANANA

This station was first visited on the 18/3/80, and the following information and data was collected. The work was interrupted by Ethiopian Air Raids on the town. During later raids on the town a concrete block on the right bank downstream of the bridge was blown up. This block had been used as a TBM when carrying out slope surveys of the water profile of the river.

a) Staff Gauges

The complete range of staff gauges consists of three seperate units. The lower stand consists of a wooden support driven into the ground with a one meter enamelled gauge plate graduated in centimeters attached to the stand. The middle stand is an iron channel embedded in the river bed with concrete and a similar enamel plate attached. The upper unit is a six meter 'I' beam embedded in a large concrete block foundation, supporting four meters of cast iron gauges graduated in two centimeter divisions. The gauges are situated just downstream of the bridge on the left bank. The lower gauge stand was leaning at an angle and probably had been doing so for quite some time. This gauge was straightened and stabalised by fixing a support arm to the remains of the old wooden bridge pillar.

A check survey of the gauges showed that the two lower gauge plates were in level, but that a 0.22 meter overlap occurred between the second and third gauges. Due to this overlap the effective range of the gauges is 5.78 meters and not 6.0 meters. All water levels below the two meter level have to be adjusted by adding 0.22 meters, effectively lowering the zero gauge level into line with the main four meter gauge stand.

Inspection of the gauge structures suggests that the upper four meter gauge unit was the original structure, with the two lower gauges being installed at some later date when the river level had fallen sufficiently to allow their phased installation.

These were the only gauges found at the site, but it is known from an old sketch that these were not the original gauges, also the Russians had installed a set of gauges some 400 meters upstream of the Recorder House, but none of these gauges remain. There is no definite recorded information as to when the gauges were installed, nor when the present set of gauges first came into operation.

b). Recorder Structure

The Recorder Structure was located on the left bank about six meters upstream of the bridge. In between the bridge and the Recorder House is a masonary disused well, which was said to have been submerged during the 1977 flood. The Recorder installation consists of a concrete ring stilling well with a wooden housing structure fixed to the top of the well. Two 10 centimeter pipes let the water into the bottom of the well, placed one above the other. The top pipe is slightly bent and tends to silt up quickly, also making it difficult to clear the silt from the pipe. On the inside of the stilling well the pipes are fitted with 'Stop cocks'.

The original Leupold & Stevens Recorder must have been removed prior to 1978. This was replaced by a 'SIAP' strip chart instrument in October 1978, or maybe even sometime in 1977. These dates are deduced from the chart found on the same type instrument at Bardheere. They were probably installed by 'TECHNITAL SpA' of Rome, who carried out the Feasibility Study for the Bardheere Flood Detention Resevoir in 1977, and the Final Design in 1979.

The 'SIAP' Instrument had been damaged by vandals, and parts were missing. This instrument was removed and immediately replaced with a repaired Leupold & Stevens instrument, with a time scale of 2.4" per/day and a vertical scale of 1:10, which is equal to 2.5 meters of stage change with each traverse of the chart. The duration of the chart being dependant on the depth of the well as the instruments are weight driven. Most of the installations would run for a year.

The water level in the well at the time of inspection was about 0.5 meters above the river level indicating that the system was silted. When analysing the Recorder Charts, it must be remembered that a chart set at a water level below 2.0 meters would be under recording by 0.22 meters, once the water level in the river rose above the 2.0 meter level, and vice versa if initially set at a water level above 2.0 meters. This being due to the 0.22 meter overlap between the two and three meter gauges.

c). Reference Points

i). Benchmarks

The original station Benchmark was located (243-B), a cross cut into the upstream riverside corner of the old ferry concrete anchor block, situated just downstream of the approach road to the bridge on the left bank. At the time the 'MSL' level was not available, so all surveys were related to the assumed datum of RL 100.00. At a later date a survey was carried out to relate the station BM (243-B) to a second BM (243-A) situated on the east facing step of the monument between the District Commissioners and Ministry of Agriculture Offices. BM(243-A) had an 'MSL' level of 153.318 meters (obtained from MMP), and found to be 3.401 meters above the station BM (243-B). This gave the station BM (243-B) an 'MSL' level of 149.917 meters.

This level of 149.917 meters was later also found to be the level as surveyed in 1972, thereby indicating that the concete block had not moved or sunk, at least since 1972. With the confirmation of the 'MSL' level of the station benchmark, the levels of all other reference points were adjusted accordingly.

ii). 'MP' Reference Point.

This is a point marked inside the Recorder Structure from which the water level inside the well can be checked in relation to the outside river water level, and the recording on the recorder chart. This system replaces the more orthodox method of having gauges inside the stilling wells, though not as reliable as fixed gauges. At this station the 'MP' point is the top of the floor boards at the door into the recorder house. The point has an ' MSL ' level of 150.345 meters and a gauge height of 8.923 meters.

iii). 'MB' Reference Point.

The 'MB' point is a reference mark situated on the bridges at a point where depth measurements to water level can be measured when the complete set of staff gauges get submerged in times of exceptional floods, or if and when gauges are destroyed. The point at this site is situated on the downstream side of the bridge pavement, some 16.0 meters from the start of the bridge on the left bank. It is painted white and marked with the letters 'MB'. The 'MSL' level is 150.982 meters, and refers to a gauge height of 9.56 meters. The regular vertical points used during discharge gaugings were also painted white on the downstream pavement deck of the bridge.

iv). Gauge Zero

The Gauge Zero of the 0-2 meter gauges is 141.642 meters (MSL), and the 2-6 meter gauge 143.422 meters (MSL). The adjusted absolute gauge zero is 141.422 meters (MSL), which is obtained by lowering the 0-2 meter zero level by the 0.22 meter overlap between the gauges.

d). Gauging Section

Since the construction of the present bridge in about 1968, all discharge measurements have been taken from the downstream face of the bridge. Earlier measurements were taken from the old ferry. During this project, I believe the first ever wading measurements have been carried out at a point some 400 meters upstream. This method of gauging is far more accurate for the very low water levels, but care must be taken as dangers lurk beneath the water in the form of crocodiles. A number of these reptiles were observed in the vicinity of the bridge, ranging in length from one to five meters.

The build-up of large piles of debris against the upstream pillars during floods, affects the velocities at verticals near the pillars during gaugings. To increase the accuracy of the measurements the number of verticals must be increased thereby reducing the distance between each vertical. Unfortunately this does increase the operational time for each gauging to about three to four hours, and even longer if the 'VVC' method is utilised.

Excessive scouring also takes place during high flows, with scour of upto six meters being recorded at water levels in the order of five to six meters gauge height. From the experience gained during the April/May floods of 1981, gauging winch cables have to be at least 20 meters long.

e). Gauge Observers

Two to three gauge observers were said to be stationed at this site. One by the Ministry of Agriculture, and two by the Fanoole Project from Jelib. This situation would have been acceptable if discharge observations were also carried out by the observers, but this is not the situation at present. Inspite of there being at least two observers on site at any one time, the records are not always reliable as should be expected. It appears that a number of the flood peaks are actually missed, and levels too steady during flood periods, which appear to be unrealistic. The general trends appear to be correct.

Constant negative interference to the recorder by the observers, tended to render the majority of the charts useless when analysed. The difference, or overlap between the gauges confused the observers who tried to adjust the instrument and resulted in the loss of record. On the other hand, the observers are not too keen on recorders because they can keep a check on whether they are cooking the results, leading to assumptions that some of the damage done to the Recorders is calculated. Repeated request were made to the Ministry personnel in Lugh to restrain the observers from playing with the instrument, but these requests constantly went unheaded.

5.1.2. BARDHEERE

This station was first visited between the 22nd and 24th March 1980. The station was in rather a derilict condition with no equipment in working order, and no observations being recorded on a daily basis. No records appear to be available from 1977 to date, at least on a regular basis, nor had the gauges been replaced since they were damaged in the november floods of 1977.

a). <u>Staff Gauges</u>

Only one gauge stand was left intact and upright. This was the 4-6 meter unit situated just downstream of the Recorder House situated on the left bank about 60 meters downstream of the 'Baily Bridge'. About 20 meters upstream of the recorder house were the remains of three twisted sets of gauges. Under normal conditions there would have been large overlaps between the gauges (See photographs Vol.2. - Sect 2B) Local information indicates that the gauges were damaged by the Ferry breaking loose during the november floods of 1977. There is no information as to whether these gauges had been part of the set of gauges related to the one intact stand. Surveyed levels of the two lower twisted gauge stands indicate that there was not much difference between the two lower gauges, and the zero level was almost the same as the zero level four meters below the 4-6 meter gauge stand.

As the water level fell two new gauges were installed at the site. The 2-4 meter gauge was installed on 30/4/80, and the 0-2 meter on 25/2/81. Unfortunately both these two lower sets of gauges were washed out by the high 'GU' floods of April/May 1981, and also the three old twisted gauge stands. Water levels for the lower gauge heights were then obtained by tape measurement from the 'MB' point on the bridge.

b). <u>Recorder Structure</u>

The recorder house and well structure was found to be intact. Both the inlet pipes were above the water level and also in good order, but both the well and the inlet pipes were silted up. The silt from the well was removed by buckets, and the pipes were flushed through by filling the well with water from 'Tanker Trucks'. The five meter head of water in the well flushed the silt from the pipes back into the river. The pipes have to be flushed one at a time using the 'Stop Cocks' on the inlet pipes at the bottom of the well. Once the pipes have been exposed to the air the mud in the pipes drys solid, and the water has to stand in the well for some time before it seeps through the length of the pipe.

A 'SIAP' strip chart float recorder was found in the recorder housing. From the information on the chart the instrument was reset in October 1978, then visited a few days later. The instrument had run for a month or so, then stopped. Our visit in March 1980 was the next visit to the station. The 1978 chart was removed and retained for analysis. The recorder was inspected thoroughly and found to be in working order. It was then serviced and re-installed after the well and inlet pipes had been flushed and cleaned.

The instrument was run by clockwork and only had one months running time which is not suitable to the operational conditions in Somalia, but would act as a temporary measure. The vertical scale was 1:20, and the time scale 2.4" per/day.

This instrument functioned well for a year, but stopped just before the peak of the 'GU' floods in April 1981. Fortunately a temporary observer was on site at the time, and continued to read the staff gauges during the peak period of the flood. The 'SIAP' recorder was replaced by a repaired Leupold & Stevens instrument on the 11/6/81. The masonary wall round the recorder structure was also started on the same date . The reason for this unecessary expenditure was somewhat dubious. The money would have been more benificial if spent on installing more inlet pipes to the recorder well, and employing a permanent gauge reader.

c). Reference Points

i) Benchmarks

The main Benchmark (182-B) was located by levelling from the 'MP' point with a known 'MSL' value to all the concrete blocks in the area until a value corresponded with the known benchmark value. Inspection of the block then revealed the original cross mark cut into the top of the block. The ring bolt value also corresponded. The 'Benchmark was then painted white.

NOTE : This 'benchmark' has since been completely covered with silt deposited during the 'GU' floods of April/May 1981. However, a cross mark on the corner of a concrete wall four meters from the Recorder House door (See photographs Vol.2.). This TBM has a value of 94.835 meters (MSL), which is 0.793 meters higher than the BM value of 94.042 meters (MSL).

ii) 'MP' Reference Point

The 'MP' Point, an arrowhead mark on the top of the concrete well ring, just below the floor boards at the entrance to the recorder house. The relationship between the water level in the well, the water level in the river and the recording on the chart are checked from this point. The 'MSL' value 94.52 meters is equivalent to 5.54 meters gauge height, and the top of the floor boards equals 5.59 meters gauge height.

iii) 'MB' Reference Point

The 'Baily Bridge' was completed in 1978, therefore there was no 'MB' point before that date. A point was selected on one of the crossbeams on the downstream face of the bridge, some 18 meters from the left bank. The point was painted white and inscribed with the letters 'MB'. It has an 'MSL' value of 96.73 meters which equals a gauge height of 7.81 meters. All water levels after the destruction of the lower gauges in April/May were obtained from observations at this point by tape. When converting the taped observations to gauge height, it must be remembered that there is a factor to be added, the length of the weight tied to the bottom of the tape which keeps the tape taught. This will vary from station to station depending on the object used and length of attaching cable.

iv) Gauge Zero

Utilising the one surviving gauge 4-6 meter stand as the master gauge, the gauge zero level is calculated as 88.98 meters (MSL). The previous gauge zero was 89.23 meters (MSL). This level has been mentioned in ('MMP') reports, and probably applied to the old twisted set of gauges, or to any other lower set of gauges which had been washed away, but would have had to have overlaps with that Gauge Zero level. This difference in Gauge Zero has caused confusion in the past and especially in relation to the peak flood level in 1977.

d). Gauging Section

Prior to October 1978 all discharge measurements were taken from the Ferry. Local information indicates that the original ferry was destroyed in november 1977, and present measurements are taken from the downstream side of the bridge which has a foot 'Cat walk' which is ideally suited for the operation of the gauging equipment. The bridge section is approximately 30 meters upstream of the original ferry section.

This is not an ideal section as flood debris builds-up against the bridge pillars and affects the velocities, also a certain amount of backflow effect takes place on the left bank which has to be taken into account when the final discharge calculations are made. The accuracy of such measurements depends entirely on the competance of the operational staff. A fair amount of scour and fill also occurs.

c). Gauge Observer

At the time of the initial visit there was no resident gauge observer, nor had there been one since the early part of 1977. The peak flood level was only recorded because a member of 'MMP' happened to be on site just after the event and recorded the floodmark on the inside wall of the Recorder House. Repeated attempts were made to have a permanent gauge observer stationed, or selected from the local populous, but to no avail. Fortunately on direct orders from the Ministry observations were taken during the peak period of the 'GU' flood in April/May 1981, but then discontinued soon after the main flood had passed. A new observer was finally employed in September 1981, but the observations were not very reliable but may improve with time. The Ministry of Agriculture Office and the District Commissioners Office are situated only one hundred meters from the Gauging Station, and still it is almost impossible to obtain a regular and reliable record of the river levels. With a simple pair of binoculars the gauge could be observed from the office window.

5.1.3. JAMAMME

The initial visit to this station was from 23/3 to 25/3/80. The Ministry of Agriculture Office was visited to check the Observers records book, but no observation book or any other past records were available. The Observer had some figures supposedly for the month of May 1980, but the arrival date of the flood at Jamamme was a month in arreas.

a). Staff Gauges

Three staff gauge supports were intact, each with two meters of cast iron plates. The plates graduated in two certemeter divisions and fixed in level sequence to the bank face of the wooden supports. The gauges are situated on the left bank approximately 60 meters upstream of the bridge, next to the recorder house. Check surveys of the gauges revealed overlaps of 0.25 meters between the lower and middle gauge, and 0.09 meters between the middle and upper gauges. The gauge zero of the present gauges was 1.60 meters above the cease to flow of the river bed at that time.

The top gauge was dislodged sometime between 11/6/80 and 18/10/80, then replaced in level sequence on the 9/11/80 thereby only leaving the 0.25 meter overlap between the two lower gauges. All water levels for the project period have been adjusted accordingly.

b). Recorder Structure

The recorder house is situated on the left bank next to the staff gauges. The construction is the same as the other stations, a wooden housing supported by 1.0 meter diameter well made of concrete rings. The river end of the two inlet pipes was not found, but water was entering the well although with a time lag. At the time of the initial visit, a Leupold & Stevens instrument was found in the recorder house but in a vandalised condition. This instrument had not been attended to for some years. It was removed for repair and servicing, then returned to the site on 9/11/80, but soon fell to the attention of the vandals again and was finally removed from the station on 9/11/81. There were no more spares to make the instrument operational.

c). Reference Points

i) Benchmarks

The original Benchmarks(294-A) and (294-B) with 'MSL' values of 10.64 and 10.495 meters were never identified on site. A new station Benchmark with the assumed datum of 100.00, was installed on the bridge deck where the approach road joins the bridge on the downstream side left bank. The point was painted white and inscribed with the 'BM' sign and assumed datum. All surveys at the station then related to the relative levels and not to sea level.

At a later date a Benchmark on the upstream abutment left bank was located, but did not relate to the original 294-A&B points. This 'BM' appears to be an 'MMP' benchmark and has a relative level value of 98.62 meters, 1.38 meters below the new station benchmark.

ii) 'MP' Reference Point

Normal 'MP' point a arrowhead cut into the top of the concrete well ring just below the floor boards at the recorder house door. It was related to the new benchmark and to the staff gauges. The relative level value is 96.97 meters, and is 6.50 meters above the station gauge zero.

iii) 'MB' Reference Point

The 'MB' Point was pointed out by a memeber of the Ministry staff as being the deck surface of the bridge, on the upstream face at a point 20 meters from the left bank. The spot was repainted white but difficult to find as it gets covered with dirt from passing vehicles and livestock. It has a relative level value of 100.06 meters, and equivalent to a gauge height of 9.58 meters. If low level observations do materialise they will most definitely refer to the 'MB' point because of the large gap between the river bed and the present gauge zero.

iv) Gauge Zero

The station Gauge Zero is RL 90.48 meters, this being the zero point of the present lower gauge. The gauge level adjustments due to the overlaps are corrected at the top end of the observations. It must be assumed that in the past there had been an additional gauge below the present lower gauge stand. A confusing system has been used in the past, of having overlapping gauges and seperate gauge zero's for each gauge, and the daily observations are related to each gauge set individually and then adjusted to the normal sequence later. The confusion was increased as the Russian system of numbering the gauges started at the top, instead of at the lowest gauge.

d) Gauging Section

The gauging section is very good with no pillars to affect the normal flow of water, nor any build-up of debris. The measurements are observed from the downstream face of the bridge. Scour and fill does take place but not to the extent as observed at Lugh Ganana or Bardheere.

e) Gauge Observer

The observer is stationed at the Ministry Office in Jamamme which is twelve kilometers from the gauging site, and he does not have any transport. The quality of the observations are directly related to this rather inadequate situation. No records are maintained at the local office and the observer was never available when the Hydrological field team were on site. The scraps of data that was available appeared to be wrong as indicated by the flood arrival date being almost a month out. The Officer -in-Charge of the Ministry Office was requested to ensure that observations were carried out regularly, this did not produce any startling improvements. Even during the high floods of April/May 1981 the observations were suspect, and only carried out for a short period of time when the countries attention was focused on the area. The daily readings from this station must be treated with caution.

5.2. SHEBELLI RIVER

5.2.1 Belet Uen

The Shebelli River stations were the first to be visited because of their accessibility and closer proximity to Mogadishu. This station was visited from the 26/2/80 to 1/3/80, and being the first observation point after the river enters Somalia from Ethiopia, makes it the most important station on the river, so more time and attention was allocated to this site.

a). Staff Gauges

The present set of gauges consists of six one meter cast alloy gauge plates graduated in two centimeter divisions, attached to the downstream side of the right bank bridge abutment. Due to siltation of the plates at the lower level, an additional two meter gauge was installed at a later date some five meters downstream of the original set. This gauge was set at the same gauge zero level, and has enamelled gauge plates graduated in centimeters. The gauges attached to the bridge are the original gauges used during the Italian period. A second set of gauges fixed to 'I' beam metal supports was installed at the recorder site, probably at the time of the recorder installation. These gauge stands are almost completely silted over, which must have been the reason for the return to use of the gauges on the bridge (Photographs Vol; 3 - sect A).

Latest surveys show a one centimeter difference between the gauge zero of the original gauges on the bridge and the two meter set downstream. The two meter gauge zero is one centimeter higher. Usually there is a three centimeter fall between the water level at the recorder site and the bridge gauge, due to the gauges being set downstream of the bridge, the control point for the recorder levels. Siltation still takes place round the lower levels of the 0-1 meter gauge, and is usually reflected in the observers daily records by a large fall from various low flows to zero levels.

b). Recorder Structure

The Recorder House is located on the right bank of the river, thirty meters upstream of the road bridge. The structure is of the standard design in Somalia, a wooden house set on top of a 1.0 meter diameter concrete ring stilling well. Two 10 cm diameter inlet pipes set at the lower end of the well, one above the other and fitted with 'Stop Cock' valves on the inside of the well to enable regulation of the water level for desilting purposes.

When initially inspected there was no instrument in the housing. The stilling well and inlet pipes were silted and blocked with the water level in the well registering lower than the river level. The well and pipes were cleaned out, first by bucket and spade, then by raising the water level head in the well with the aid of'Water Tanker' trucks loaned by the Police. First attempts to raise the head with a 2" motor pump failed, because the water source, a well near the recorder structure had a rapid drawdown time and a slow recovery period. This suggest that very little recharge takes place from the lower bed levels, but increases as the levels rise.

A re-conditioned Leupold & Stevens recorder was installed on 29/2/80. The Instrument was the 'A-35' model, weight driven with a time scale of 2.4" per/day and vertical scale of 1:10 giving a reversable range of 2.5 meters for each traverse of the chart.

Some water level descrepancies between the inside and and outside levels indicate that the constant pumping from the neighouring well, maybe affecting the water level in the stilling well, causing a drawdown effect. The levels in the well are sometimes lower than the river.

c). Reference Points

Site locations for all the Benchmarks along the Shebelli river were obtained from the survey document ' Vertical Control Points on Bridges Over The Shebelli', carried out in 1963, and checked by M.Morgan , Water Control & Management of the Shebelli

River.(Vol: 3 - Section 'K'). The Benchmark at Audegle on the lower Shebelli has been removed. Levels had to be carried from other Benchmarks in the area.

i). Benchmarks

The original Benchmark (139-A), a cross mark carved into the top of the upstream right bank bridge abutement was located without much trouble, although begining to wear out and should be remarked. All relevant station hydrometric points were related to this Benchmark. The station value is A.D. 100.00 and an 'MSL' of 182.692 meters. The gauge height value of the 'BM' is 6.58 meters.

The South West corner of the concrete water collecting tank situated near the Recorder House is retained as a 'TBM', with an R.L. value of 99.21 meters.

ii).'MP' Reference Point

The 'MP' Point was taken as the top of the floor boards at the entrance to the Recorder House. The old measuring marks were worn into the wood. It's not confirmed whether this was indeed the original measuring point. The R.L. value is 100.025 meters ('MSL' = 182.717 meters), and equal to a gauge height of 6.61 meters. Tapes with weights must be retained at the stations for the observers to measure the water level in the wells, but care must be taken to constantly check the length of the tapes, and the length of the weight from the zero of the tape which must be added to the total depth when calculating the water level. In the past tapes have broken and when rejoined the differences not noted.

iii).'MB' Reference Point

The original 'MB' Point was not located, so a new spot was sighted on the downstream edge of the concrete lip of the bridge deck (R.L. 100.11 meters), and equal to a gauge height of of 6.69 meters. This point mainly used when gauges silted at low levels, and peak flows with water levels above the six meter level.

iv). Gauge Zero

The Gauge Zero of the present set of gauges is equal to an R.L. of 93.42 meters, or 'MSL' 176.11 meters. Some computations of gauge heights by the water section (Ministry of Agriculture), have been obtained utilising a zero of 'MSL' 176.16 meters. It is not known which gauges it relates to, probably the set at the Recorder structure now covered in silt. Local information suggests that the gauges on the bridge were used during the Italian period, and will therefore relate to the pre - 1960 period.

In 1980 and 1981 the water level at the station fell to zero level and minus 0.12 meters. An additional gauge should be installed below the present zero to avoid minus observations. Long periods of zero gauge readings in the past suggest that levels had fallen below the gauge zero level, and not the river ceasing to flow.

d). Gauging Section

This is a stable section under the bridge and no central piers to collect debris and disturb the natural flow in the section. Both upstream and downstream of the bridge section there are deep pools and velocities at low flows are not measureable with the standard meters. Because of the pond situation at low flows, wading measurements have been carried out at a point one kilometer downstream where there is a rock section.

e). Flood Irrigation Canal

One kilometer upstream of the gauging station is an 'Offtake' structure, originally designed for flood irrigation. At present it is used as a flood relief canal, although not very effective as the water comes back to the river about two kilometers downstream. Maximum design flow was 18 m^3/sec, although flows of 25 m^3/sec. were measured utilising floats during the 1981 'GU' floods. The flow which by-passes the

Gauging Station must be added to the total flows to obtain the monthly and annual discharge figures. The flow through the canal before the 'GU' floods 1981 could be started at about the 4.5 meter level. After the floods and breaching of the embankments near the 'Offtake' structure, a flow of 2-3m^3/sec was estimated at a gauge height of 3.75 meters at the gauging station. The floods took place in April/May but no repairs carried out at the Canal headworks by the time the project terminated in December 1981.

f). Gauge Observer

The Observer at this site is one of the 'Old School', and the most reliable observer within the Hydrological section. The initial daily observations are fairly reliable, with most discrepancies appearing in the afternoon observations. Some Gaps in the data are evident, but mainly due to periods of leave absence, and not wilful neglect.

Some problems were initially encountered with the re-installation of the Recorder. In general throughout the system observers are weary of them, because they realise that both a time and data quality check can be maintained. After periods of absence attempts were made to turn the recorders back to insert the requested observation remarks. Fortunately the instruments jam during the attempts, so usually not attempted a second time.

5.2.2. BULO BURTI

Station initially visited and inspected on 29/2/80, and found to be in a derelict state. No recorder house on the well structure, the staff gauges not upright and moveable, including the foundations. Gauges had to be reset, recorder well cleared of dumped rubbish. No observer since the last one enrolled at Agricultural College, sometime in 1978.

This is also an important station with regard to flood warning, as all run-off contributions to the Shebelli from within Somalia is generated from the catchments between Belet Uen and Bulo Burti. It is generally estimated that the Somali contribution is in the order of 10 % of the annual flow, but a higher percentage of the flood flows. Flood peaks, as occurred in March 1981 at Bulo Burti cause concern downstream as the warning was not given due to only relying on Belet Uen returns. Much more attention should be given to the regular monitoring of this station, and the data used in conjunction with the observations from Belet Uen.

a). Staff Gauges

The Staff Gauges are situated on the right bank of the river 220 meters downstream of the road bridge. There were three gauge stands fitted with two meters of enamelled one meter plates graduated in centimeters. An old gauge stand was situated about 40 meters upstream, leaning at an angle of 45^{o}. The gauges were checked and surveyed and only the lower stand was found to be firmly established. With no previous installation data available the zero of the lower gauge was accepted as not having changed since they were installed. It appears that they must have been installed sometime after the publication of the 'Water Control and Management of the Shebelli River' report in 1969.

It is stated in the report that there were no gauge plates at the time of the Project , as the original gauges had been washed out before the start of the project and water levels were being obtained by utilising the 'MB' Point on the bridge. This would also suggest that the gauge heights applied to the discharge measurements and the establishment of the rating curve at the time, would have to be reduced by 0.06 meters if related to the present curve, for comparison purposes.

Both the two upper gauges were slanting over and the concrete block foundations loosely embedded in the silt bank. There was also an overlap of 0.15 meters between the lower and middle gauges. The zero level of the lower gauge plate was R.L. 91.75 meters ('MSL' 134.39 meters).

On the 8/03/80 the 2-4 and 4-6 meter gauges were reset in level sequence to the 0-2 meter base gauge. Then, due to the water levels both in 1980 and 1981 falling below the zero point and producing minus readings, the zero of the station was lowered a further meter, infact changing the gauge range from 6.0 to 7.0 meters. The original zero level would now be recorded as 1.0 meter, and the 6.0 meters as 7.0 meters. This change reduced the gauge zero point to R.L. 90.75 meters or 'MSL' 133.39 meters. The adjustment of the levels obtained at the bridge is due to the slope between the bridge and the gauge site, which is usually about 0.06 meters.

b). Recorder Structure

The remains of the Recorder Structure is located on the left bank 350 meters downstream of the road bridge, next to a slaughter house. The stilling well structure and inlet pipes appear intact, but the wooden recorder house has been removed or demolished, and the metal support base damaged. The well was full of debris, probably used as the slaughter house dump.

The stilling well was cleaned out, and the eventual arrival of ordered Leupold & Stevens spares, enabled one of the 'derelict' instruments to be repaired and installed at the site on 7/04/81, utilising a metal 'SIAP' recorder housing supported by wooden boards set over the top of the stilling well. The recorder was the standard Leupold & Stevens (A-35) model, weight driven with chart scales 1:10 (Vertical) and 2.4" per/day (Horizontal). In October 1981 the 'M.O.A' Office at Bulo Burti constructed a protection wall round the well at great expense, which was unnecessary. The money would have been better spent on repairing the actual structure and ensuring that a good permanet observer was employed for the station.

Unfortunately the recorder was damaged by acts of wilful vandalism, only a few days after it's installation, and missed the peak flood which took place in May 1981. However, the instantaneous peak was obtained by survey. This station must be equiped with a good recording instrument, to offset the poor daily observations.

c). Reference Points

The master Benchmark was located from descriptions given in the survey document "Vertical Control Points on Bridges over the Shebelli - 1963". Problems were encountered at this site with the authorities operating the 'Check Point' established at the bridge, inspite of documentation from various authorities in Mogadishu.

i) Benchmarks

The original Benchmark (114-A), a cross cut into the top surface of the concrete bridge pavement, left bank down-stream face (Photographs Vol: 3 - Section 2), is clearly marked, but only if you know what you are looking for in the first place.

Benchmark (114-B) sited on the wall of the slaughter house was not located. The plaster on the wall has been removed during re-building and the Benchmark destroyed in the process.

Benchmark (114-A) has an 'MSL' value of 142.644 meters, and an assumed datum of R.L. 100.00 meters which is equivalent to a gauge height of 9.25 meters.

To make the normal check surveys which are usually carried out during inspection visits to the gauging stations easier, by reducing the number of change points, a 'TBM' was selected on the downstream left bank bridge abutment. The point chosen was the corner of the ledge supporting the main bridge beams, approximately 1.95 meters below the Benchmark. The R.L. value is 98.055 meters ('MSL' 140.70 meters) and equal to a gauge height of 7.31 meters.

ii). 'MP' Reference Point

The 'MP' point was taken to be the top of the concrete stilling well rings which have an R.L. value of 99.665 meters equivalent to a gauge height of 8.89 meters. The top of the metal frame was also levelled (R.L. 99.725 meters), but later rejected as 'TBM' because it was found to be moveable.

iii). 'MB' Reference Point

The 'MB' Point is situated at the middle of the bridge on the metal strip running the length of the bridge on the downstream side of the bridge pavement. The R.L. value 99.99 meters is equal to 'MSL' 142.634 meters or gauge height of 9.24 meters. Levels observed from this point must be reduced by 0.06 meters to correspond to the staff gauge levels, because of the slope over the 220 meters distance between the points.

iv). Gauge Zero

The Gauge Zero as found on 29/02/80 was at R.L. 91.75 meters ('MSL' 134.39 meters). This level was retained when the gauges were reset, and it was assumed that the zero gauge level had not shifted since those gauges were installed. The two upper gauges were reset in level sequence to the lower gauge.

Water levels both in 1980 and 1981 fell well below the gauge zero, so from 7/04/81 the gauge zero was lowered one meter to avoid the use of minus observations, which are very confusing to the observers. The original Gauge Zero now reads one meter, and the range is increased to 7.0 meters. All back data over the project duration has been adjusted accordingly. The additional 0-1 meter gauge should be installed on the right bank where the flow during low periods tends to concentrate,and judging by the peak flow of May 1981 (9.25 meters), an extra two meters should be installed at the top of the bank to increase the range to 9.0 meters. This would ensure that most exceptional floods would be accommodated.(New G.Z.= RL.90.75 m)

d). Gauging Section

All medium to high level discharge measurements are carried out from the downstream side of the bridge. The section is stable and velocities free flowing without bridge pillar obstructions. Inspite of the record level floods in 1981, there was virtually no change in the section under the bridge.

Low flow measurements are carried out by wading at the gauge site, or wherever the flow is concentrated forming a good section.

e). Gauge Observer

At the time of the initial visit there was no resident observer for the station, nor had there been one for some time since the previous one had gone to agricultural college in Mogadishu, sometime in late 1978. Requests were made to the authorities to employ one as soon as possible, as the gauges had been reset and the floods expected. Unfortunately, there was no response to the request which resulted in the loss of data. In August 1980 the Officer-in-charge of the Bulo Burti office agreed to carry out the observations, but at the end of September there were no returns. Finally a women observer was employed from project funds, on a returnable basis from the Government. In early 1981 a Ministry employee was recruited by the project and regular observations were obtained until the end of April. During the peak flood period in May the observer was given other duties by the Officer-in-charge, and the gauge returns were completely neglected. However, due to the slow rise of the flood spot checks were carried out by the field team from Mogadishu, flights over the station by the consultant, flood peak surveys and local information with regard to dates of events, a very reliable hydrograph was obtained for the month of May. Regular observations started again in June, after further requests to the authorities.

The situation here clearly illustrates the need for a reliable recorder installation, as the problem with the local observers will continue indefinitely, as long as the personnel are controlled by sections other than the Hydrological office. The month of May 1981 had the highest flood levels on record and the highest in living memory and still the observer was moved from his post. This illustrates the negative attitude and lack of understanding with regard to the hydrological requirements and the need for continuity of data. Sadly, this is a problem encountered in all under developed countries.

5.2.3. MAHADDEI UEN

The initial visit to this site was on the 16/02/80, and the station was found to contain only Staff Gauges. No resident gauge observer nor had there been one for some time. Permission to work at the site was obtained from the commander of the area, situated at Mahaddei Uen.

a). Staff Gauges

The present set of staff gauges are situated 10 meters upstrem of the road bridge on either bank. The 0-2 meters on the left bank, and the 2-6 meters on the right bank. The gauge supports are made of 8" steel 'I' beams embedded in concrete foundations. The one meter enamelled plates graduated in centimeters are fixed in pairs to each stand. The two upper gauges are still in good condition, but the lower plate is broken off at the 1.86 meter level, and should be replaced.

Check surveys of the gauges showed an overlap of 0.07 meters between the 2-4 and 4-6 meter gauge plates, but the 0-2 and 2-4 gauges were in level sequence. The lower gauges in the absence of any other installation data, were accepted as being the correct levels indicating the original gauge zero. Having accepted this situation all water levels above the four meter level had to be adjusted by reducing the observed levels by 0.07 meters. An isolated old gauge stand still exists on the right bank under the bridge, this should also be removed as it collects debris and affects velocities during discharge measurements carried out from the downstream side of the bridge.

On the downstream face of the right bank bridge abutment an old set of gauges, similar to the set at Belet Uen, was discovered when old deposited silts were removed by the high water levels experienced in 1981. These gauges appear to be the original gauges utilised during the Italian period, and would refer to any pre- 1960 observations. The plates are of cast alloy and graduated in two centimeter divisions. The plate protruding above the silt was the second plate from the top, as the original fixing points for the top plate are still visable.

Assuming that the old range had the same number of gauge plates, surveyed levels show that there is a difference of 0.53 meters between the levels. The old gauge zero being higher than the present one. As the old plates are fixed to the bridge abutment they would have been in level sequence.

b). Reference Points.

The Reference points were located from information given in the survey document 'Control Points Over The Shebelli River' dated 1963, and then cleaning the concrete surfaces on the bridge in the indicated area's.

i) Benchmark

The original Benchmark, a cross cut into the concrete was located and identified ontop of the pavement of the upstream left bank abutment. It is clearly illustrated in the photographs in(Vol.3.- Sect.3.).

The Benchmark identification mark is 83-A. It has an R.L. value of A.D. 100.00, and an 'MSL' level of 112.079 meters. The 'MSL' value being equal to a gauge height of 7.51 meters.

ii)'MB' Reference Point.

The 'MB' Point has not been utilised during this project. Observations in the past have been taken from the downstream outside lip of the bridge pavement, which is approximately the same level as the Benchmark. This is an estimate and not an actual surveyed result. The bottom of the concrete beam across the bridge has an R.L. level of 99.115 meters, or gauge height 6.62 meters.

iii). Gauge Zero

The value of the present gauge zero is R.L. 92.495 meters, and an 'MSL' value of 104.574 meters. The water level in March 1981 fell below the zero gauge when the river actually dried up, leaving a pool of water near the gauge. The lowest level in the pool was approximately minus 0.10 meters on the 15/03/81, with the 'CTF' level at approximately 0.15 meters gauge height. The overlap of 0.07 meters between the gauges reduces the total range of the gauges to 5.93 meters(R.L. 98.425 m), which is 0.16 meters lower than the top of the flood protection bund. (R.L. 98.585 m).

c). Gauging Section

All medium and high flow measurements carried out from the downstream side of the bridge. The bridge is a single span structure so velocities are not affected by debris collecting piers. Scour and fill of upto 1.5 meters does take place as indicated by sections surveyed during the high flows.

The 'Barrage' fourteen kilometers downstream at Sabun will have an effect on the energy gradient thereby affecting velocities. The low flows will also be affected, depending on the standard of operations of the 'Bypass Penlocks' located in both abutments of the Barrage. The 'Barrage' sill levels are at an 'MSL' level of 105.22 meters, with the Head Regulator sills at 'MSL' 104.50 meters, with the Zero Gauge at Mahaddei Uen 0.65 meters below the 'Barrage' sill level.

During the low flow period of February 1981 the higher water levels recorded at Mahaddei Uen, were probably caused by the closure of the 'penstock' gates at Sabun 'Barrage'.(See Water Level Hydrographs - Vol. 3, Sect.I:2a). The high pond level at the 'Barrage' is 'MSL' 108.50 meters, which is equal to a Gauge Height of 3.43 meters at Mahaddei Uen and would cause backwater effects at Mahaddei gauging station.

d). Gauge Observer

No permanent gauge observer at the station, nor had there been one for quite a long period of time, prior to the start of this project. Low flows at the begining of 1980, and the start of the flood period of April/May were not recorded. With the permission of the Area Commander a guard from the 'Check Point' at the bridge was recruited as the observer, and began observations in June 1980. For the first two months returns were only fair, but then improved to an acceptable standard.

The observer improved with each month and was retained and paid by the project until the end of the Project in December 1981. The Ministry of Agriculture has been requested to retain the observer on the regular Ministry payroll.

5.2.4. BALAAD

This station was inspected and checked on the introductory field trip in Somalia on the 5/02/80. All the installations and reference points were checked and surveyed, and the field office in Balaad was visited to check the past records, and to meet the observer.

After all the work carried out to re-activate the station, installation of a recorder, and the start of re-rating the site, the station was closed when the 'Balaad Barrage' came into operation in April 1980.

a). Staff Gauges

The staff gauges are situated 30 meters upstream of the old 'Wickham Bridge', which is it self situated approximately 60 meters upstream of the present single span main road bridge. The staff gauge range consists of four metal 'I' beam stands embedded in concrete on the left bank, and fitted with two single meter gauge plates, enamelled and graduated in centimeter divisions.

Check surveys of the gauges showed that they had been installed in level sequence except the lower 0-2 meter gauge. The lower gauge overlapped the 2-4 meter gauge by 0.10 meters. As the other gauges are all in level sequence it was assumed that they were all still at the original installation levels, and that past records can confidently be related to the said gauges. All water levels below the 2.0 meter level would have to be adjusted by increasing them by the overlap discrepancy of 0.10 meters, inorder to bring them in sequence to the other observations. This adjustment will also effectively lower the gauge zero point by a similar amount to R.L. 90.45 meters.

b). Recorder Structure

The recorder structure is situated on the left bank between the 'Wickham Bridge' and the staff gauges, next to an irrigation pumping station. It consists of the standard structure used in Somalia of a wooden housing set ontop of a concrete ring stilling well, with the usual two 10 cm. diameter inlet pipes set at the lower level of the stilling well, with 'stop cocks' attached to the inner ends of the pipes to control the inflow and outflow whenever required.

At the time of the visit the housing was empty and the well was completely silted to a depth of almost five meters. The well was desilted by the 29/03/80, and the inlet pipes cleaned out by raising the head of water in the well to over five meters above the water level in the river. On the 3/04/80 a reconditioned Leupold & Stevens recorder was installed at the site. The instrument was the standard A-35 model, weight driven with vertical and horizontal scales of 1:10 and 2.4" per/day. The instrument was set to the slowly rising level after the pipes were cleaned.

Unfortunately the 'Balaad Barrage' built by the Koreans and situated one kilometer downstream of the gauging station, was brought into operation the same day that the recorder was installed. The existance of the Barrage was only known when the water level began rising for no reason at the site when the recorder was being installed, and a recce downstream revealed the structure and the Bulldozers in the process of diverting the water through to the 'Barrage' structure.

The station was affected by the backwater effects of the 'Barrage' and the constant manipulation of the upstream levels, that it was decided to abandon the station.

c). Reference Points.

The Reference points were located fron the data supplied from the Control Points Survey of the Shebelli River, and from information obtained from the Ministry personnel from the local

Ministry of Agriculture Office in Balaad, who were responsible for the daily observations and maintenance of the station.

i) Benchmark

The original Benchmark (31-A) a cross cut into the cement top of the left bank upstream wing wall approach to the bridge, pointed out in the photographs (Vol.3, Sect 'D'). The 'MSL' value of the Benchmark is 96.119 meters, and it was also given a local value of relative level AD. 100.00 meters.

The floor of the Pump House (RL. 96.69) and the top step inside the Pump House (RL. 97.235), were related to the main Benchmark and retained as 'TBM's.

ii). 'MP' Reference Point

In the absence of original installation data the 'MP' point was assumed to be to top of the iron rail floor board support nearest to the door of the recorder house. The local RL. value is 97.79 meters('MSL' 93.91 meters). Depth to the well floor from the 'MP' point is 7.81 meters, giving the well floor an RL. value of 89.98 meters.

iii). 'MB' Reference Point

This point was only located with the help of the Ministry gauge observer. The point from which observations were taken, but not marked is situated near the right bank on the downstream face, the end of a metal cross beam near the upright for the bridge hand rail. It is not very stable or secure and will most definitely fall apart in the near future. The RL. value of the point is 99.135 meters ('MSL' 95.254 meters).

Military authorities controlling the 'Check Point' at the new bridge refused permission to establish a new point on the new bridge, although discharge measurements were permitted to be taken from the said bridge.

The gauge height level of the 'MB' point is 8.685 meters above the adjusted gauge zero point. An attempt should be made to obtain permission to transfer the point to the new bridge.

iv). Gauge Zero

In their present form the gauges have a zero level of R.L. 90.55 meters, but with the adjustment of all readings below 2.0 meters by increasing the observations by 0.10 meters , the absolute gauge zero is infact 90.45 meters. For reasons of check surveys R.L. 90.55 meters will be used to check movement of the stands, but for water level calculations R.L.90.45 meters will apply.

d). Gauging Section

The low flow measurements were carried out by wading at the gauge section, and medium and high flows from the downstream face of the new bridge. The higher measurements will be fairly stable, but the lower ones will be affected by the amount of debris which collects round the central pier of the old bridge.The banks on both sides appear to be fairly stable.

e). Gauge Observer.

At the time of the initial visit a member of the ministry staff at the Balaad office was carrying out the daily readings. Regular observations had been carried out to december 1979, and only continued in 1980 when requested by the project. The observations started again in March 1980,then discontinued when the station was closed because of the backwater effect caused by the closing of the 'Barrage' gates.

It appears that the past observations from this station would be of a higher standard than the stations further afield because of the closer proximity to Mogadishu, and the easier access to the station.

5.2.5. AFGOI

Afgoi is situated on the main trunk road to Baidowa and Lugh Ganana some 25 kilometers south west of Mogadishu. It is the closest Hydrometeric station to the Capital and should be maintained in presentable condition as it is the only station usually visited by visiting dignitaries. The Ministry Office at Afgoi provides the gauge observer and supervises the data collection, and periodic returns made to the hydrological office in Mogadishu.

a). Staff Gauges

The total range of staff gauges originally installed was 6.0 meters. The condition of the gauges when first seen on 7/02/80, was appalling. The 0-1 meter gauge plate was at an angle and not level with the next gauge. The 2-3 meter plate was missing and the upper half of the 4-5 meter plate was boken off. The 3-4 meter plate although still attached to the pillar, had slipped down a few centimeters. The only gauge which was firmly fixed was the 1-2 meter plate, and due to the absence of installation data, these levels were accepted as the remaining link to the original gauge zero level.

The gauges are attached to the upstream support trestle pillar nearer the left bank of the old bridge. Unfortunately due to the type of bridge structure large amounts of flood debris gets trapped round these pillars. Apart from the normal observation problems it also causes irregular scour and fill with the rise and fall of the flood water, and affects the velocities during discharge observations.

On the 27/04/80 the damaged gauges above the two meter level were removed and replaced with two metal frames, each supporting two metal alloy gauges of a meters length and graduated in two centimeter divisions. These gauges were secured to the pillar by steel clamps and bolts, in level sequence to the remaining 1-2 meter gauge, and the 0-1 meter gauge was also reset in level sequence, thereby retaining the probable original zero level. The divisions were repainted in alternate colours to help visual observation from a distance and through the flood debris.

Various reports and local information suggest that these gauges are the original set installed prior to the Lockwood/FAO period, probably by the Italians in the thirties.

b). Reference Points

Mean sea level and site location of the reference points taken from the 'Survey of Control Points on bridges over the Shebelli', and onsite assistance by the local gauge observer. Benchmarks situated on old bridge structure.

i). Benchmarks

Benchmark (15-B) a bolt head embedded into the top of the left bank upstream bridge abutment was the first reference point to be located. The 'MSL' value was 84.93 meters, and was also allocated the local A.D. 100.00 relative level, for local station relationships.

Benchmark (15-A) was located at a later date, only after clearance of overgrowth round the bridge abutment. This point was situated on the downstream left bank abutment, a similar bolt head protruding from the top of the abutment with an 'MSL' value of 84.91 meters and a corresponding R.L. value of 99.98 meters.

For reasons of continuity, should the old bridge ever be destroyed a 'TBM' was selected, a bolt head protruding from the side of the upstream bridge side (new bridge), directly opposite the benchmarks on the old bridge. Local value of bolt head R.L. 101.292 meters ('MSL' 86.222 meters), and the point was painted white with 'TBM' inscription alongside.

ii). 'MB' Reference Point

This point used to obtain water levels if the gauges are destroyed, overtopped or silted up and normal observations impossible. The measuring point is top of the old bridge deck immediately above the gauges on the upstream face. The local R.L. value is 99.98, the same as BM(15-A), or 'MSL' 84.91 meters and equal to a gauge height of 7.49 meters.

iii) Gauge Zero

By utilising the levels from the 1-2 meter gauge the original gauge zero has been retained, so the present levels observed can be directly related to all previous water level observations.

The 'CTF' level on the 15/03/81 was approximately 0.25 meters gauge height, this level was obtained when the river was completely dry (see photographs Vol.3. - Sect 'E'). All observations between 3-4 meters should be adjusted by reducing the levels by 0.02 meters, if observed prior to the replacement of the gauges in April 1980.

c). Gauging Section

The low flow measurements are carried out by wading, usually under the new bridge. The section immediately under the new bridge appears fairly stable due to the rock rubble probably left over from the construction of the new bridge.

The medium and high flow measurements are carried out from the downstream side of the new bridge which was completed in 1969. The plotted cross sections from measurements carried out over the duration of the project show that scour of upto a maximum of one meter does take place just downstream of the bridge section, although a proportion of this could be due to operational error.

The debris brought down by the floods which collects against the old upstream bridge structure does affect the velocities from time to time, and plays a major part in the pattern of scour and fill which takes place at the gauging section.

d). Gauge Observer

The Gauge Observer is a member of the local Ministry of Agriculture office located near by, so there is more daily control of the Observer resulting in more regular and reliable data returns. Due to the close proximity of the station to Mogadishu and it's location on one of the two main trunk roads leading out of Mogadishu frequent 'spot checks' from the main office was possible.

5.2.6. AUDEGLE

This site is situated 42 kilometers downstream of Afgoi and 38 kilometers upstream of Genale Barrage. The station is not accessible for long periods during the wet season due to the rough dirt road across area's of black cotton soil which becomes very sticky when wet. The site was initially visited on the 13/02/80 with the resident observer, who was to become one of the field team working with the project.

a) Staff Gauges

The staff gauge range was 6.0 meters, with the 2-6 meter range attached to the downstream bridge pillar nearest to the left bank. The 0-2 meter plates were attached to a wooden support driven into the river bed one meter from the pillar supporting the other gauges. The 0-2 meter plates are enamelled and graduated in centimeters, and the 2-6 meters metal alloy and graduated in two centimeter divisions.

The 4-5 meter gauge was dislodged during the high water period (April/May - 1980). On 19/03/81 a new four meter set of gauges on two stands, were installed upstream of the bridge (30 meters) on the left bank. The plates were of the enamelled type and graduated in centimeters. The four meter range was set at a level equal to the 1-5 meter range on the gauges at the bridge. This filled the gap of the missing bridge gauge. Although the two sets of gauges are in level, there is a difference of 0.05 meters between the readings due to the build up on the upstream side of the bridge, and the drawdown on the downstream side. The observer has been requested to state which gauges his observations refer to, when forwarding the monthly observation sheets.

b). Reference Points

Data refering to the station reference points and other national Benchmarks in the area obtained from the Survey of the 'Control Points On Bridges Over The Shebelli River', and from the Survey and Mapping Department in Mogadishu. Benchmark 307 was located from old photographs and notes.

i) Benchmarks

The original Benchmark located ontop of the south east corner post of the bridge, has since disappeared together with the other three corner posts. Also the large tree that was near the Benchmark and used as a road sign board as shown in the old photograph, has been destroyed.

From documents located at the Survey and Mapping Department other national benchmarks in the area were identified, and levels carried by traverse survey to the new benchmarks recently installed by the project. The nearest identifiable national Benchmark to the station was 'BM' 307, the south east corner of the concrete base belonging to a pyramid type survey beacon 800 meters from the river, back along the road to Afgoi and also marking the junction point or fork in the road. The value of the Benchmark 307 is 'MSL' 73.894 meters (see photographs in Vol.3.- Section'F').

The initial project Benchmark, the top of the concrete abutment on the downstream left bank was allocated the local reference level A.D. 100.00 meters. Later this was varified at 'MSL' 76.429 meters in relation to 'BM. 307' at the same time illustrating the fact that the immediate river bank area was much higher than the surrounding country. In addition to the principal benchmark on the bridge abutment a second one was selected as a safety measure. The second 'BM' is situated approximately 30 meters upstream from the bridge on the left bank along the footpath leading to the Village houses. The selected point is the lowest iron ring set in a concrete plinth. The higher protruding finger is used as a coconut dehusker, and was also included in the survey (see survey details). The local value of this 'BM' is R.L. 99.70 meters and 'MSL 76.134 meters. This may prove to be the most permanent of the two benchmarks.

ii) 'MB' Reference Point

The point used as the 'MB' is the top of a cross support timber of the bridge deck and situated on the downstream face closer to the right bank. The local reference value is R.L 100.16 meters and an 'MSL' of 76.589 meters, or gauge height 6.55 meters.

iii) Gauge Zero

As the lower gauges were still firmly established and the absence of original installation data it must be assumed that the gauge zero is the original level utilised when the gauges were established. Information indicates that this site was not used during the earlier Italian period, but was first used by the Land and Water Surveys Project in about 1963/64. The R.L. value of the zero gauge is 93.62 meters, which also applies to the new upstream range, and an 'MSL' value of 70.05 meters.

c). Gauging Section

Low flow discharge measurements are carried out by wading upstream of the bridge opposite the new gauges. The higher flows are measured from the downstream face of the bridge by winch suspension. The low trestle type bridge with numerous trestle piers, supports and diagonal members interfere with the streamflow, and traps even the smaller pieces of flood debris brought down by the flood waters. This trapping of logs and tree's makes it hazardous for gauging purposes, as the equipment could get damaged, or lost by getting tangled up amongst the debris and breaking the suspension cable. The silt deposit shift under the bridge depends on which set of piers builds up the largest breakwater round it, causing the silt deposition immediately behind the debris wall, and increases the scour through the clear passages. The site is definitely not conducive to good discharge measurement operations.

d) Gauge Observer.

The resident observer for this station at the begining of 1980 was draughted into the Hydrometric Team which was attached to the project, and were infact also the entire Hydrological Section. Temporary observers were recruited for the earlier part of 1980 with unsatisfactory results. In May an observer was employed by the project, and after repeated coaching and patience acceptable results were eventually produced. He was recommended to be retained by the Ministry.

6.0. STAGE DATA

6.1. General

On both the Jubba and Shebelli rivers the measurement of stage levels has mainly been carried out by the daily observation of Staff Gauges, graduated in meters and centimeters, installed on the river banks. Some of the gauges were set in overlapping sequence(Russian system) with the number one gauge at the top of the bank, and some with the more conventional level sequence system adopted by most countries, with the number one gauge being the lowest gauge in the set.

Observations are carried out twice daily, at 0800 and 1400 hours with the mean of the two being the daily reading. The observer should also make additional observations of flood peak levels and times, and also during periods of drought the date and times when rivers stop flowing (cease to flow), as did occur both in 1980 and 1981 along the lower reaches of the two rivers. However, the system does not work as efficiently as it should because data is constantly being lost due to various incompetance with regard to the staff, and inefficient operational proceedures.

Information obtained from investigations on site during the initial orientation visits to the stations, showed that not all the stations had resident observers at the time, and in some cases there had been no observers for a considerable time.

Gauging Station Observers

Jubba River		
1. Lugh Ganana	-	Manned (fair to Good returns)
2. Bardheere	-	Unmanned (No daily returns)
3. Jammame	-	Unmanned (No regular returns)
Shebelli River		
4. Belet Uen	-	Manned (Good fairly reliable returns)
5. Bulo Burti	-	Unmanned (No daily returns)
6. Mahaddei Uen	-	Unmanned (" " ")
7. Balaad	-	Station closed April 1980
8. Afgoi	-	Manned (Good returns)
9. Audegle	-	Unmanned (Observer with project field team)

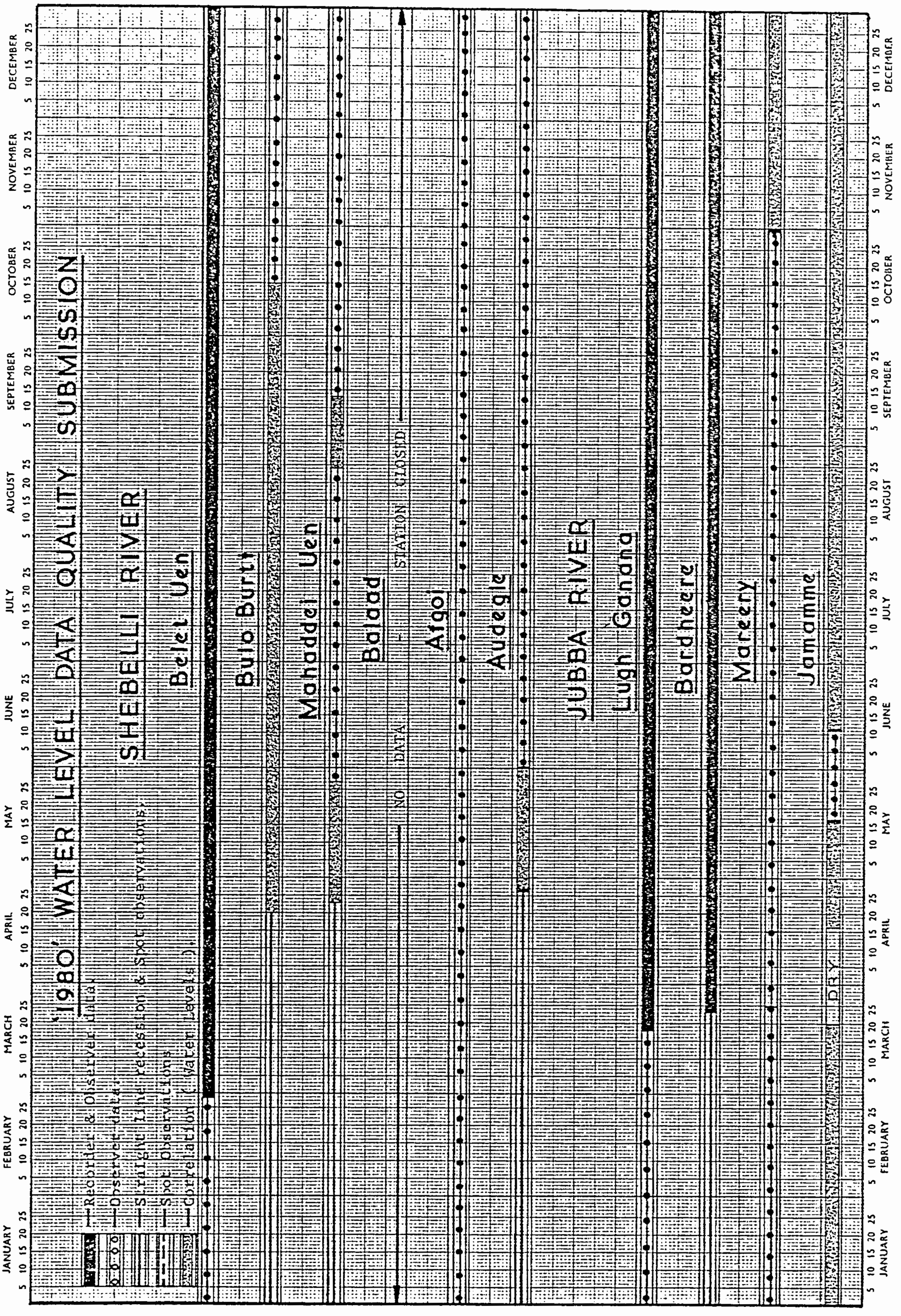
TABLE .3.

Recording instruments were initially installed by the LOCKWOOD/FAO project in 1963/65 at six major stations within the network. The three stations on the Jubba and at Belet Uen, Bulo Burti and Balaad on the Shebelli. These were apparently maintained in operable condition through to the early seventies, to the departure of M.Morgan. Sometime between 1973 and the start of the Water Hydrometry project in 1980, all the recorders were removed and dumped in the stores at Mogadishu. In 1978 two recorders 'SIAP' were installed at Lugh Ganana and Bardheere on the Jubba, probably by the Italian Company 'TECHNITAL SpA'. The chart found on the instruments showed that the charts had been installed on the 10th October 1978, then never visited again until March 1980 by the FAO Consultant (TCP Project). It appears that not very much success was achieved with the instruments. Very few old charts are available at the Hydrological Office in Mogadishu for scutiny, and if available no information as to which station the chart came from.

6.2. Stage Data Collection 1980/81

Prior to the employment of new observers and the reactivation of recorders the baseflow recession was monitored by regular 'spot observations' carried out by the field teams from Mogadishu on routine gauging trips. By the middle of the year (1980) observers had been obtained for most of the stations, except on the Jubba at Bardheere and Jamamme. The observers were employed by the project and paid from project funds, but on a refundable basis from the Ministry. This system ensured that observers were employed when needed without having to undergo the long delays usually experienced through normal Ministry channels.

Unfortunately observers were not supplied for the Jubba stations at Bardheere and Jamamme until 1981, and then only for irregular periods. Fortunately the recorder found at the Bardheere gauging station was serviced and made operable at the time of initial visit, and functioned well throughout 1980, thereby avoiding any loss of data for the period inspite of no resident observer being at the station.



'1980' WATER LEVEL DATA QUALITY SUBMISSION
Recorder & Observer data.
Observer data.
Straight line recession & Spot observations.
Spot Observations
Correlation (Water Levels).
SHEBELLI RIVER
Belet Uen
Bulo Burti
Mahaddei Uen
Balaad
NO DATA - STATION CLOSED
Afgoi
Audegle
JUBBA RIVER
Lugh Ganana
Bardheere
Mareery
Jamamme
DRY
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIG .3.

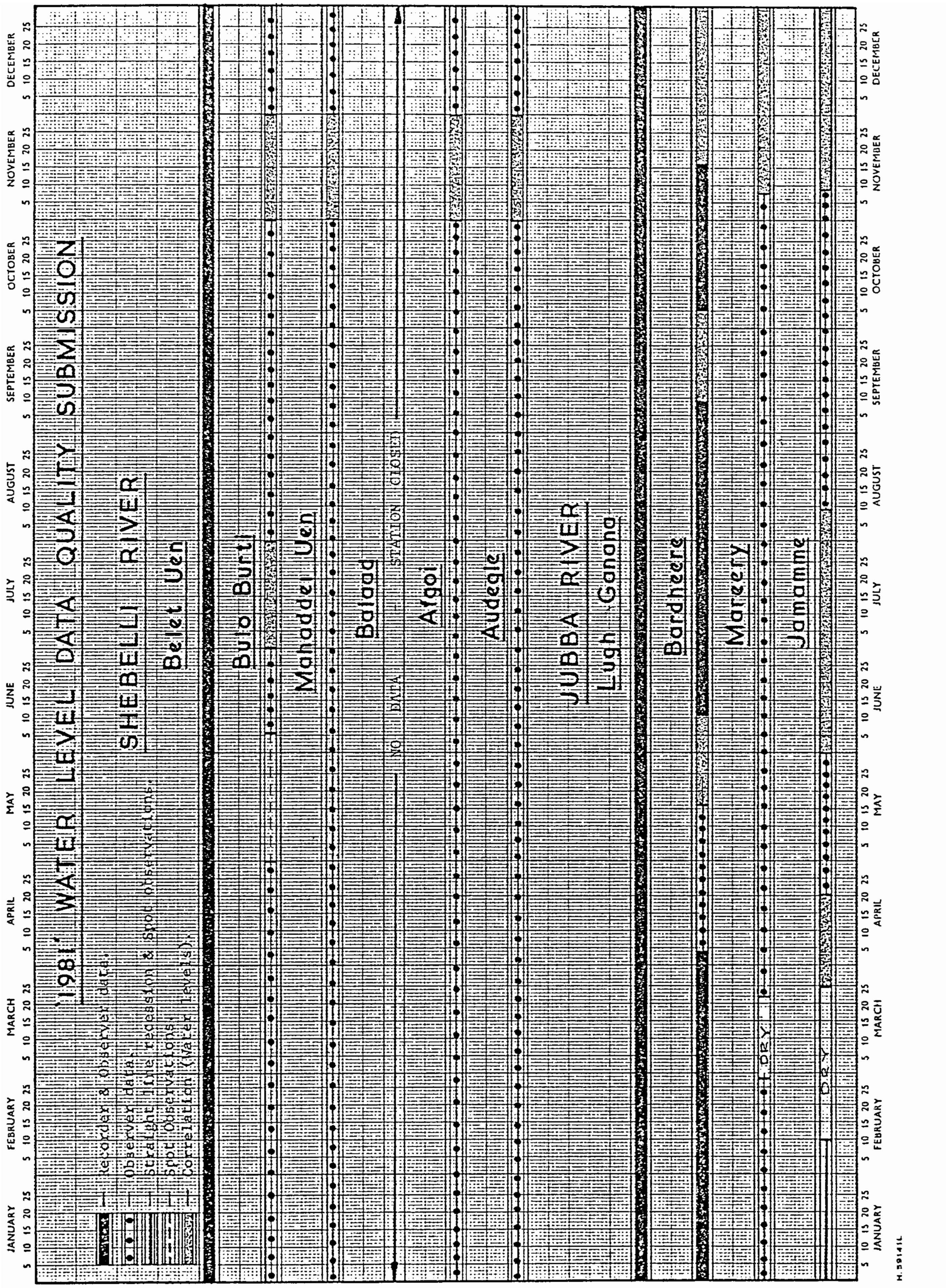

'1981' WATER LEVEL DATA QUALITY SUBMISSION
Recorder & Observer data.
Observer data.
Straight line recession & Spot observations.
Spot Observations.
Correlation (Water levels).
SHEBELLI RIVER
Belet Uen
Bulo Burti
Mahaddei Uen
Balaad
NO DATA
STATION CLOSED
Afgoi
Audegle
JUBBA RIVER
Lugh Ganana
Bardheere
Mareery
Jamamme
DRY
DRY
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
H.5914 L

FIG .4.

Before the arrival of the project vehicles at the start of the project in February 1980, time was spent on trying to repair derilict Leupold & Stevens recorders found under cement bags in the stores. From a total of twelve instruments found six were made operable by cannibalisation and improvisation, and eventually installed at the three Jubba stations of Lugh Ganana, Bardheere and Jamamme, and the Shebelli at Belet Uen, Bulo Burti and Balaad. The instruments installed at Bulo Burti and Jamamme were vandalised soon after being installed, but were unable to be repaired due to the lack of spares. The station at Balaad was closed soon after being installed because the 'Barrage' downstream became operable and the station was within the area affected by backwater. The data collection methods and quality are illustrated with the 'Bar Charts' for 1980/81 (Figs 3 & 4).

The daily baseflow recession levels for the period January to April 1980, were obtained by producing straight line recession curves from 'spot observations', at stations without observers. Missing data from Bardheere has been synthesised by correlation with Lugh Ganana, and the majority of data at Jamamme by similar correlation with the independant Jubba Sugar Project station at Mareery (See Vol.2.-Section'D').

On the Shebelli missing data was also synthesised utilising simple linear correlation of the water levels. Data for both Bulo Burti and Mahaddei Uen correlated to Belet Uen, and Audegle to Afgoi and Afgoi to Mahaddei Uen. (See Vol.3.-Section'G'). The final mean daily water levels are illustrated in Figs 5-8, as mean annual hydrographs.

During the high flood period of May 1981 on the Shebelli at Bulo Burti, the observer was given other tasks by the Officer In-Charge of the local 'M.O.A' office, and neglected to take any observations inspite of the flood being the highest in living memory. However, because of the large resevoirs which were caused by the bottlenecks at Giglei and Elo Geibo the two proposed damsites, the water level rise and fall was very much slower and steadier than usual with any minor rises or falls being absorbed by the resevoir conditions upstream. The flood

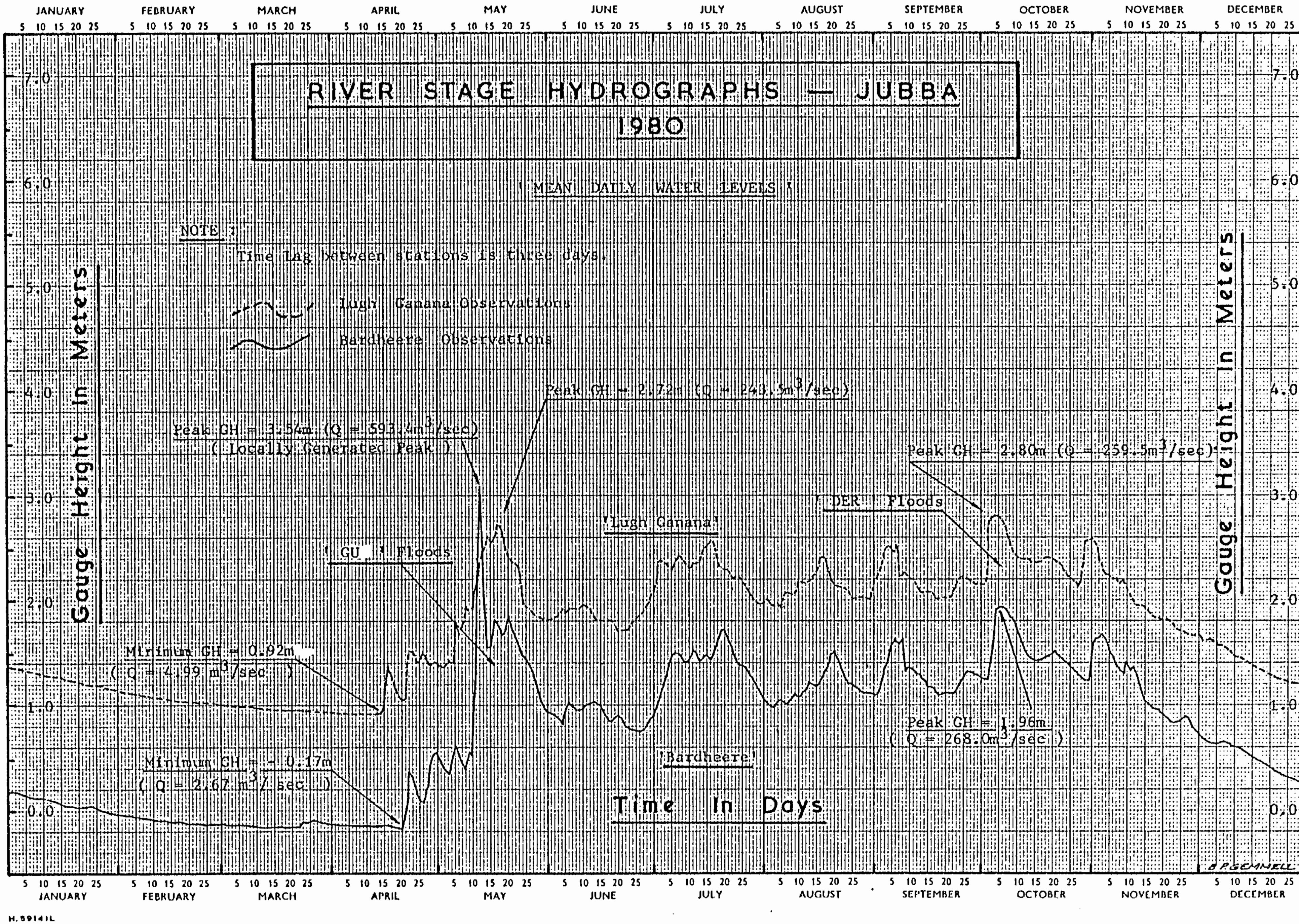
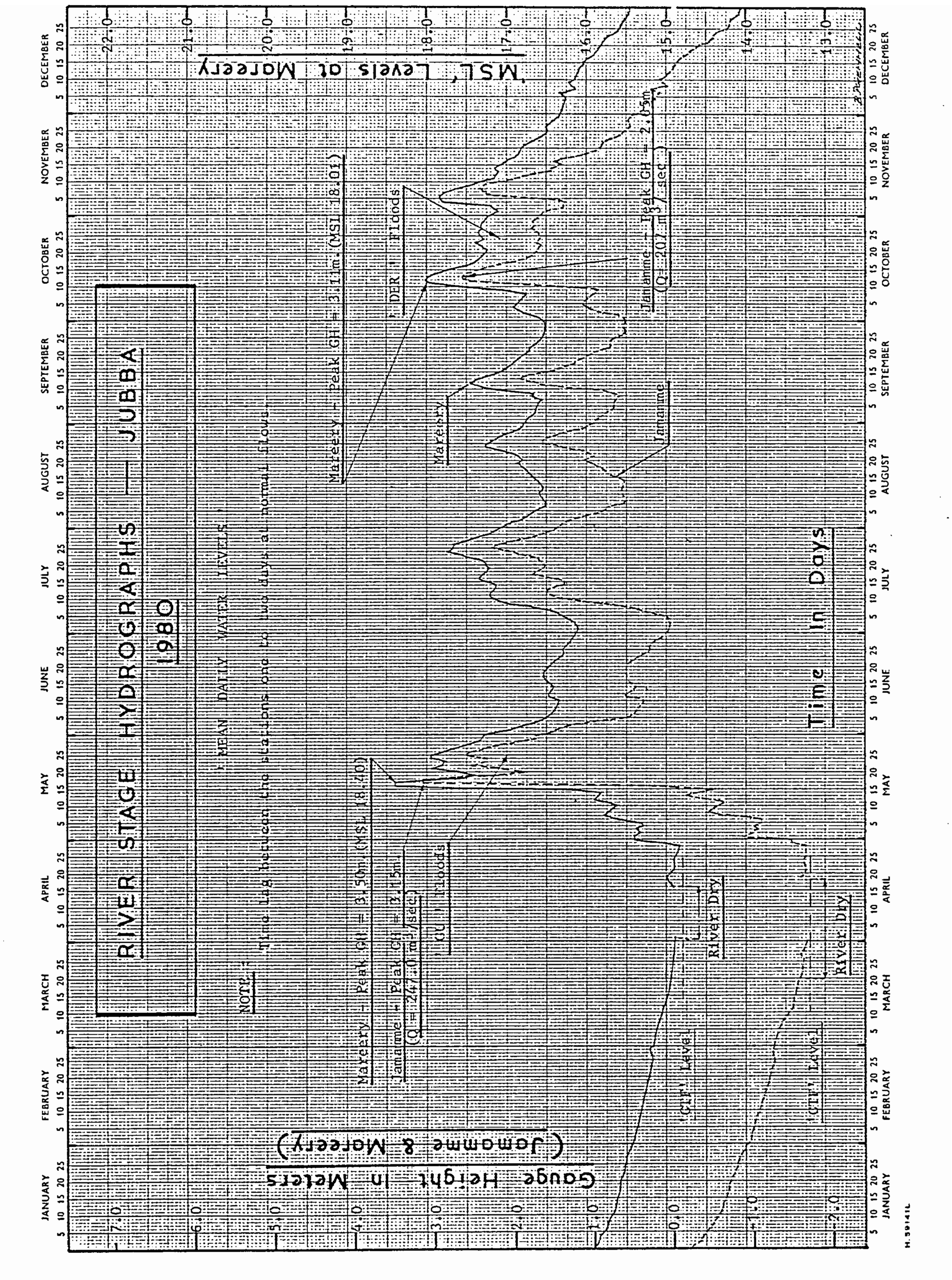

RIVER STAGE HYDROGRAPHS — JUBBA
1980
(MEAN DAILY WATER LEVELS)
NOTE :
Time Lag between stations is three days.
Lugh Ganana Observations
Bardheere Observations
Peak GH = 3.54m (Q = 593.4m³/sec)
(Locally Generated Peak)
Peak GH = 2.72m (Q = 243.5m³/sec)
Peak GH = 2.80m (Q = 259.5m³/sec)
Peak GH = 1.96m
(Q = 268.0m³/sec)
' GU ' Floods
' DER ' Floods
'Lugh Ganana'
'Bardheere'
Minimum GH = 0.92m
(Q = 4.99 m³/sec)
Minimum GH = - 0.17m
(Q = 2.67 m³/ sec)
Gauge Height In Meters
Time In Days
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
B.P.GEMMELL
H.59141L

FIG .5.



RIVER STAGE HYDROGRAPHS — JUBBA
1980
MEAN DAILY WATER LEVELS
NOTE: Time Lag between the stations one to two days at normal flows
Gauge Height in Meters (Jamamme & Mareery)
'MSL' Levels at Mareery
Time In Days
Mareery - Peak GH = 3.50m (MSL 18.40)
Jamamme - Peak GH = 3.15m (Q = 247.0 m3/sec)
'GU' Floods
Mareery - Peak GH = 3.11m (MSL 18.01)
'DER' Floods
Jamamme - Peak GH = 2.65m (Q = 207 m3/sec)
Mareery
Jamamme
'GII' Level
River Dry

FIG .6.

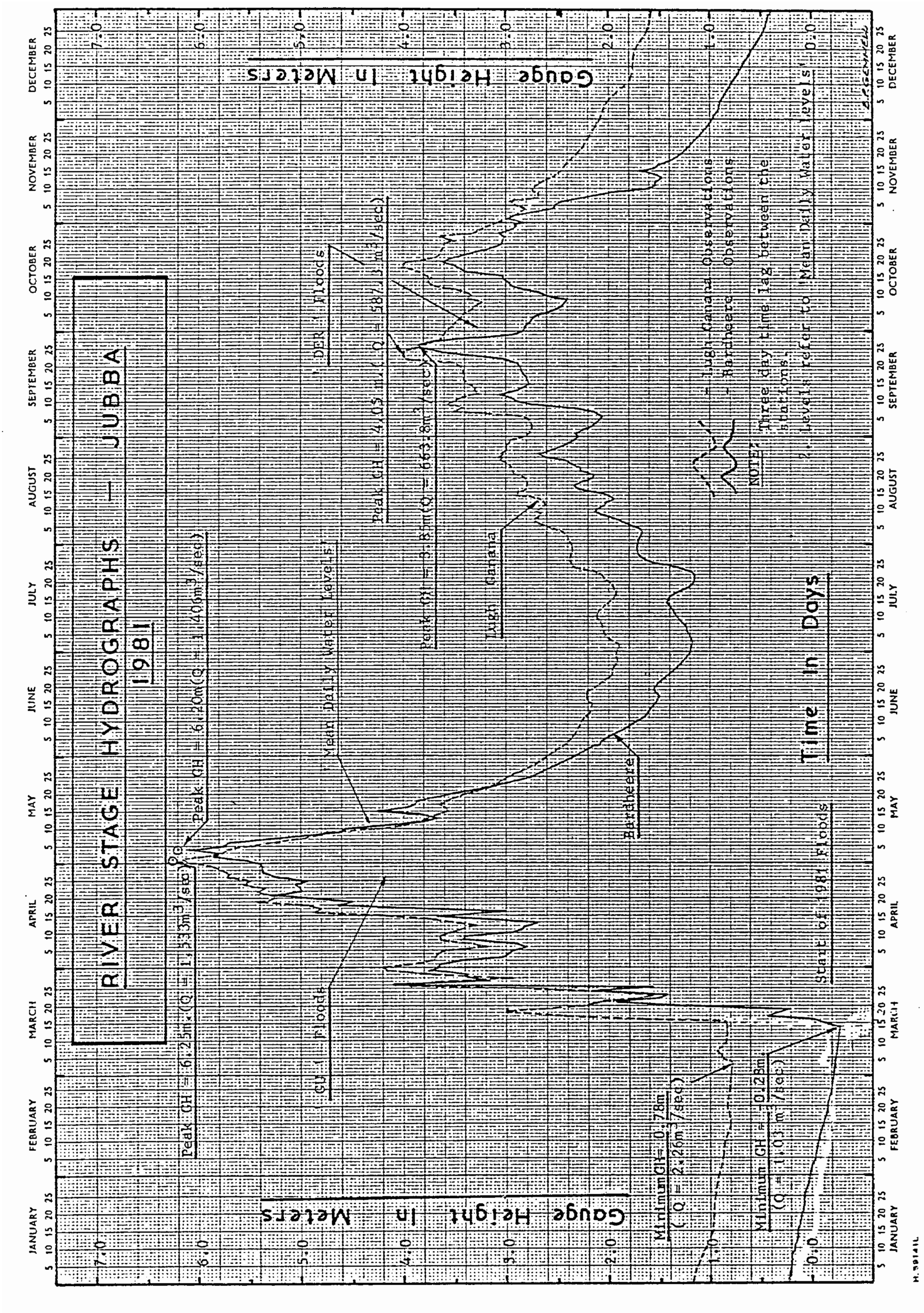
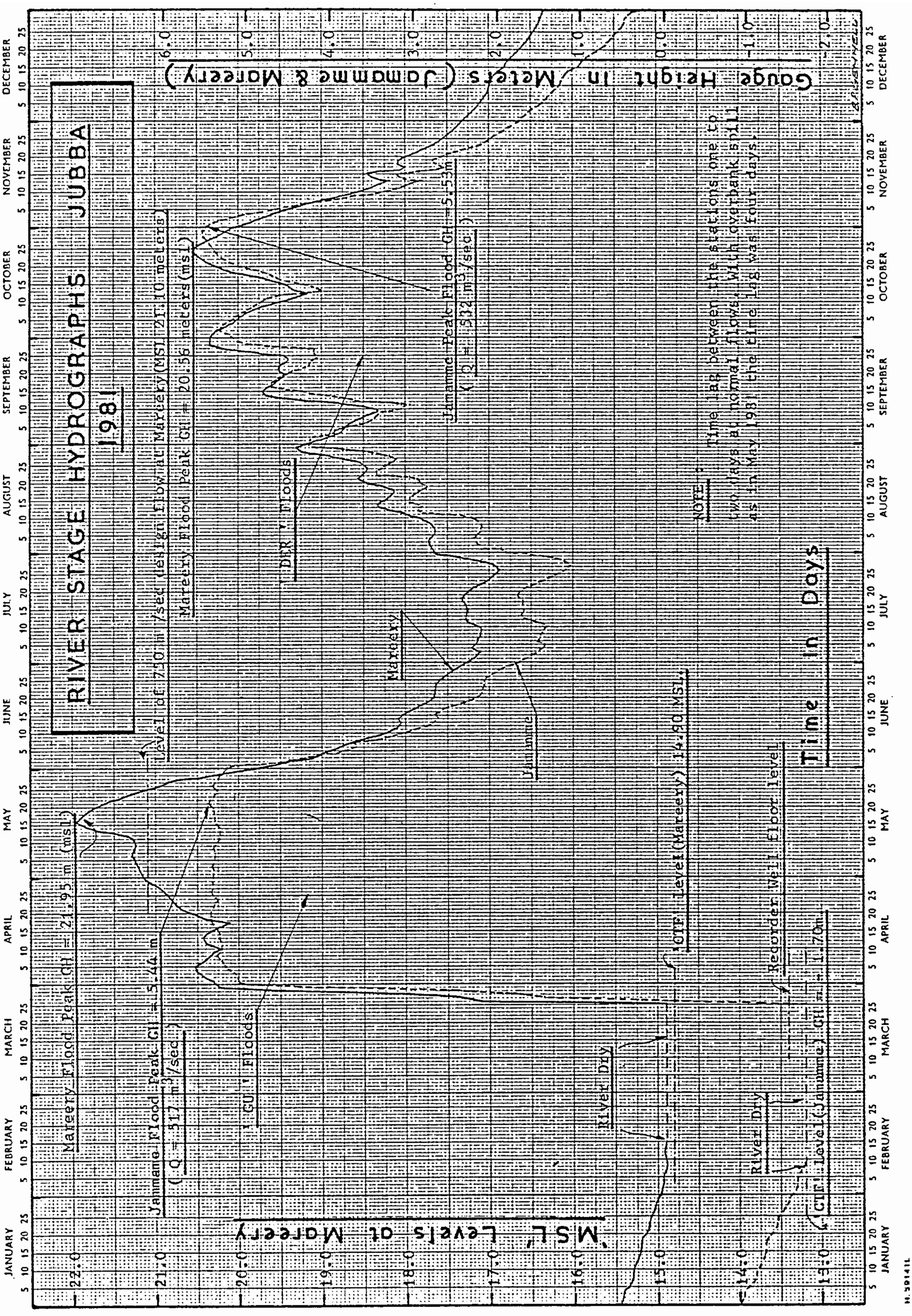

RIVER STAGE HYDROGRAPHS — JUBBA
1981
Gauge Height In Meters
Time In Days
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
Peak GH = 6.25m (Q = 1,533m 3/sec)
Peak GH = 6.20m (Q = 1,406m 3/sec)
Mean Daily Water Levels
'GU' Floods
'DER' Floods
Peak GH = 4.05 m (Q = 587.3 m3/sec)
Peak GH = 3.8m (Q = 663.8m 3/sec)
Lugh Ganana
Bardheere
Minimum GH = 0.78m (Q = 2.26m 3/sec)
Minimum GH = -0.28m (Q = 1.03 m 3/sec)
Start of 1981 Floods
- Lugh Ganana Observations
- Bardheere Observations
NOTE: Three day time lag between the stations.
2. Levels refer to Mean Daily Water Levels.

FIG .7.



RIVER STAGE HYDROGRAPHS JUBBA
1981
Mareery Flood Peak GH = 21.95 m (msl)
Jannamme Flood Peak GH = 5.44 m
(Q = 517 m³/sec)
Level of 750m³/sec design flow at Mareery (MSL 21.10 meters)
Mareery Flood Peak GH = 20.56 meters (msl)
Jannamme Peak Flood GH = 5.53m
(Q = 532 m³/sec)
'GU' Floods
'DER' Floods
Mareery
Jannamme
River Dry
'CTF' Level (Mareery) 14.90 MSL
Recorder Well Floor level
'CTF' Level (Jannamme) GH = -1.70m
NOTE : Time lag between the stations one to two days at normal flows. With overbank spill as in May 1981 the time lag was four days.
'MSL' Levels at Mareery
Gauge Height in Meters (Jamamme & Mareery)
Time in Days
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIG .8.

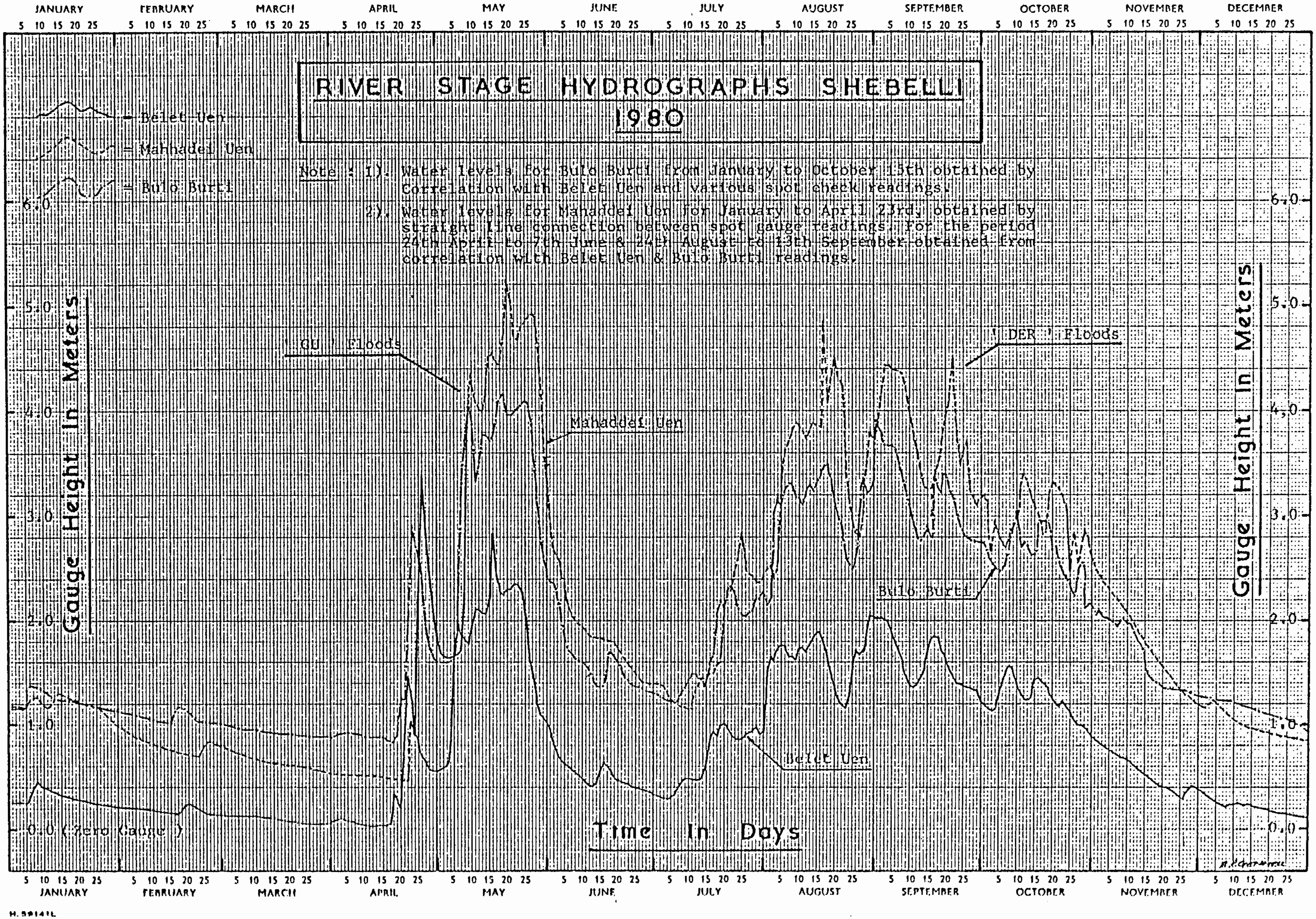

RIVER STAGE HYDROGRAPHS SHEBELLI
1980
= Belet Uen
= Mahhadei Uen
= Bulo Burti
Note : 1). Water levels for Bulo Burti from January to October 15th obtained by correlation with Belet Uen and various spot check readings.
2). Water levels for Mahaddei Uen for January to April 23rd, obtained by straight line connection between spot gauge readings. For the period 24th April to 7th June & 24th August to 13th September obtained from correlation with Belet Uen & Bulo Burti readings.
'GU' Floods
'DER' Floods
Mahaddei Uen
Bulo Burti
Belet Uen
Gauge Height In Meters
Time In Days
0.0 (Zero Gauge)
1.0
2.0
3.0
4.0
5.0
6.0
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
H. 59141L

FIG .9.

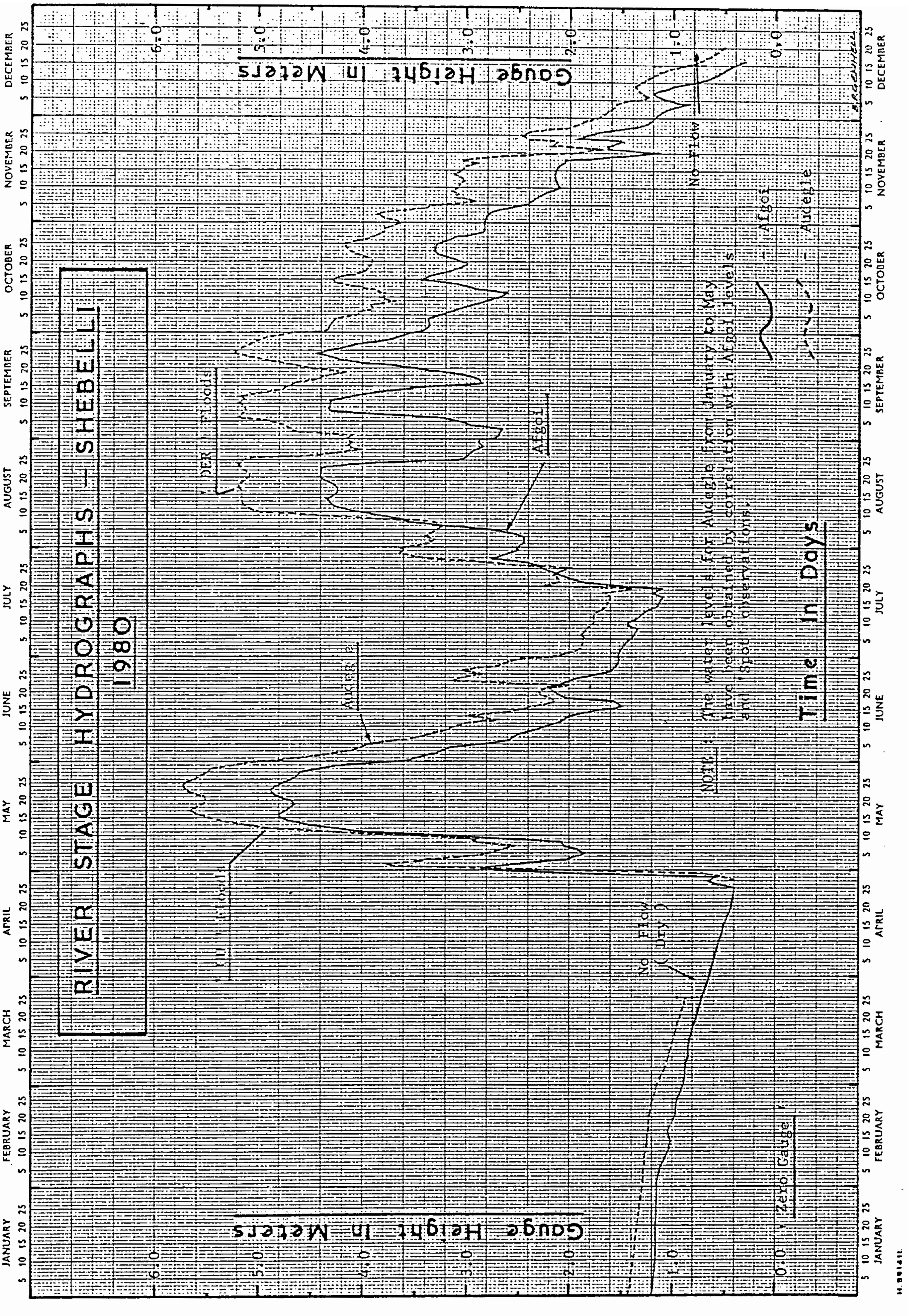

RIVER STAGE HYDROGRAPHS — SHEBELLI
1980
Gauge Height in Meters
Time in Days
NOTE: The water levels for Audegle from January to May have been obtained by correlation with Afgoi levels and Spot observations.
Afgoi
Audegle
No Flow (Dry)
No Flow
Zero Gauge

FIG .10.

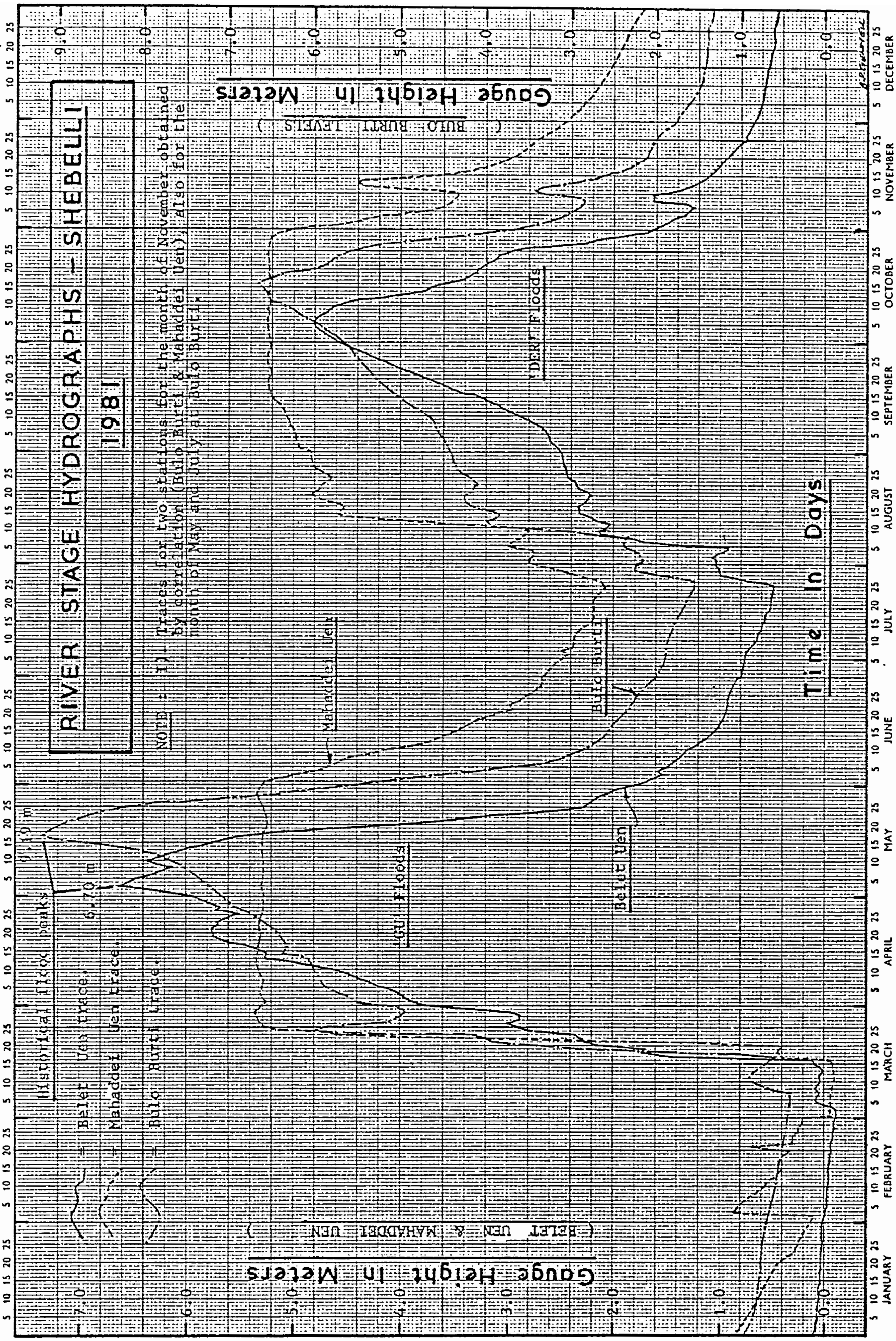
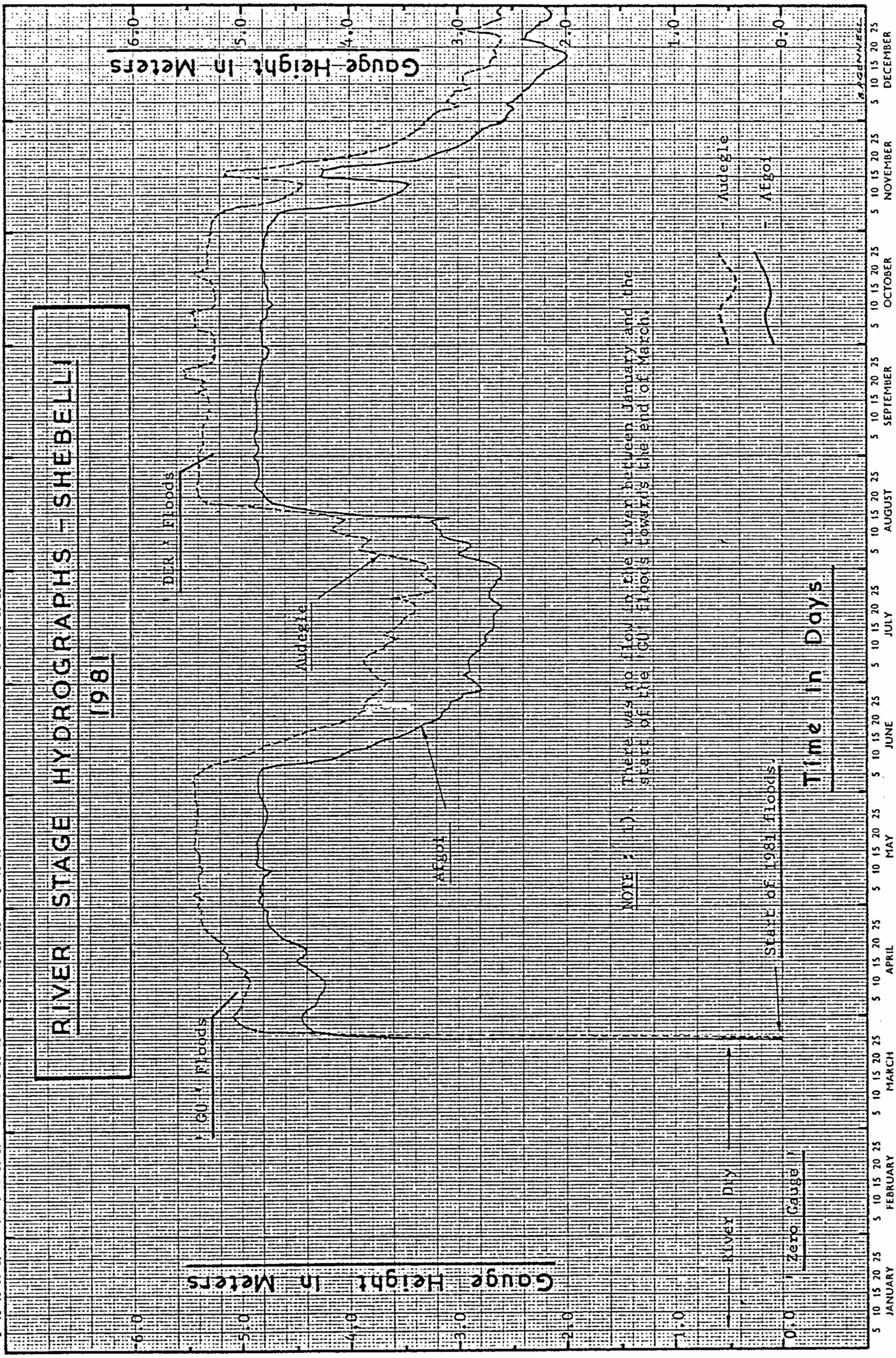

RIVER STAGE HYDROGRAPHS - SHEBELLI
1981
NOTE : 1) - Traces for two stations for the month of November obtained by correlation (Bulo Burti & Mahaddei Uen). Also for the month of May and July at Bulo Burti.
Historical flood peaks
= Belet Uen trace.
= Mahaddei Uen trace.
= Bulo Burti trace.
9.19 m
6.70 m
'GU' Floods
'DERI' Floods
Mahaddei Uen
Bulo Burti
Belet Uen
Gauge Height In Meters
(BELET UEN & MAHADDEI UEN)
Gauge Height In Meters
(BULO BURTI LEVELS)
Time In Days
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIG .11.



RIVER STAGE HYDROGRAPHS - SHEBELLI
1981
Gauge Height in Meters
Time in Days
GU Floods
DER Floods
Audegle
Afgoi
NOTE: 1). There was no flow in the river between January and the start of the GU floods towards the end of March.
Start of 1981 floods.
River Dry
Zero Gauge
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIG .12.

peak travel time between Belet Uen and Bulo Burti is in the order of two days under normal conditions, but during these floods the peaks occurred fourteen days apart. The peak at Belet Uen was recorded on the 3/05/81, and at Bulo Burti on the 17/05/81, illustrating the resevoir conditions experienced upstream. Under these conditions the five observations obtained at the isolated site were sufficient to plot a very reliable hydrograph for the period. Three on site observations obtained by the Hydrological Field Team with the date of the peak being obtained from the authorities controlling the 'Check Point' at the bridge, and two flights over the sight by the consultant before and after the peak, with photographs to retain the evidence to be checked when the flood peak levels were surveyed. Without these 'spot checks' all the data would have been lost because of inefficiency and the general misguided belief, that Hydrological Investigations are of a low priority, or treated as such.

6.3. Stage Data Collection Problems

6.3.1. Personnel Attitudes

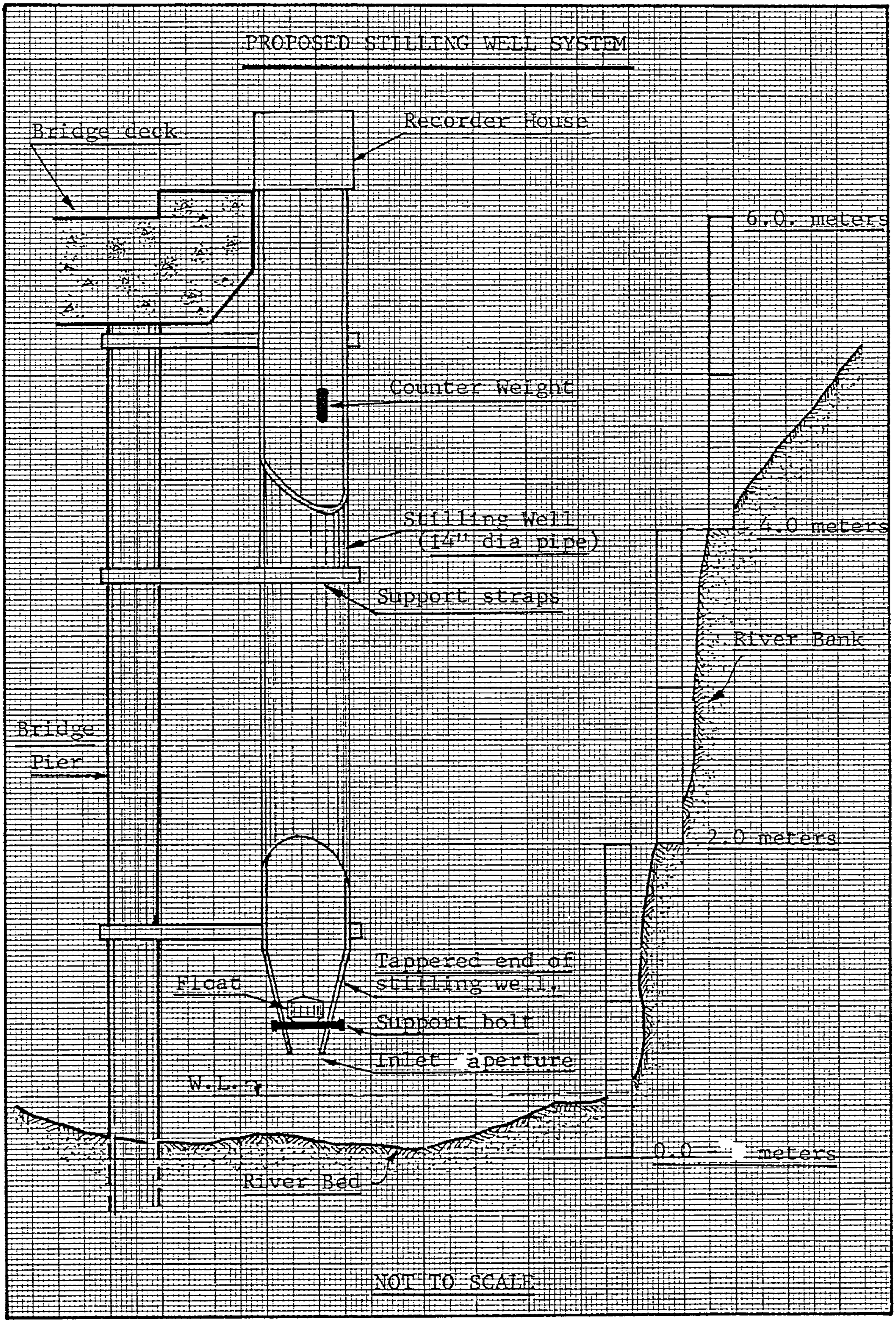
The initial and major problems are mainly concerned with the people who are responsible for the organisation of the work, and those responsible for carrying out the work in the field. The first hurdle to overcome is to ensure that the people selected to carry out this work fully understand the importance and necessity of the work, and that continuity is the paramount requirement. The present attitude appears to be, throughout the country, that only extreme conditions are of any importance such as the high 'GU' floods of 1981. This point is clearly illustrated from the gaps in the stage data which are largest during recession periods. However, to achieve better results the authorities will have to improve the field operation conditions such as field allowances, to replace the supplementary allowances paid by the Expatriate Companies and International Organisations. It is impossible for field teams to operate in the field without imprest accounts to pay for emergency repairs and recruitment of labourers. Infact, more control of operations and field operational flexability freedom to make and alter decisions in the field, without having to return to Mogadishu at great expense, and loss of time and probably important data because no operational funds are available on site. To improve this situation more staff of a higher level are required in the Hydrological Section, and at least one qualified Hydrologist/Engineer would be required to head the section on a permanent basis.

If the appreciation and enthusiasm does not come from the higher levels within the organisation, it is unrealistic to expect the people at the grass roots level to appreciate the importance of the work and to produce disciplined results. Good and reliable Hydrological Data prepares the way for reliable agricultural planning for the future. A most important and necessary requirement for the future of Somalia.

6.3.2. Recording Problems

The recorder wells in use at present were constructed in the early sixties, and consist of concrete ring stilling wells, with two 0.10 meter diameter inlet pipes set at the lower end of the well, approximately 0.50 meters above the well bottom allowing a silt trap area. This type of stilling well structure has proved very successful in silt free rivers. They have and do work well under silt conditions, but only with first class field maintenance proceedures, and personnel who are willing to carry out the work to a high standard under difficult conditions. Unfortunately these standards are not available in Somalia at present.

Similar conditions were encountered in the middle east countries, with similar operation conditions and standards and the problems were countered by changing the design of the structures. With regard to flash flood type wadi's, additional pipes were added to the structures at varying intervals of between 25 to 50 centimeters above the lowest pipe. This system ensured that the flood levels would always be recorded, especially the higher levels. The recorder pipes and wells were then immediately desilted after the flood in preparation for the next one.



PROPOSED STILLING WELL SYSTEM
Bridge deck
Recorder House
6.0. meters
Counter Weight
Stilling Well
(14" dia pipe)
4.0 meters
Support straps
River Bank
Bridge
Pier
2.0 meters
Tappered end of
stilling well.
Float
Support bolt
Inlet aperture
W.L.
0.0 meters
River Bed
NOT TO SCALE

FIG. 13.

Under the conditions found in Somalia where the whole flood duration takes place over a period of months rather than days, a more practical system with an improved inlet system, and less maintenance requirements is essential. The additional pipe system will work, but will require a lot of attention with regard to desilting the structure after each flood peak. Therefore the best system for the conditions found in Somalia would be the open ended stilling well type, which would be attached to bridge piers or abutments.(See 'FIG.13').

The structure consists of a large diameter pipe fitted to a stable support at a point where the lower tappering end of the pipe will be in contact with the water, at least to a level 0.50 meters above the low water bed level. This would apply to stations where there are possibilities of the river drying up. At stations with permanent water even at extreme low periods, the end of the pipe can be extended to be in the water at all times. The end of the stilling well pipe is brought to a tappered end to minimise the surge action inside the pipe. It must not be too small or will tend to silt up, the normal opening should be about three to four inches. A bolt is fixed through the bottom of the pipe for the float to rest on, and act as the zero level for the recorder without affecting the inlet.

With this type of installation the recorded stage levels would be unbroken, thereby reducing the immense amount of work required to synthesise data because of large gaps found in the daily observed records. If the installations are made to work efficiently the work load on the field teams is also greatly reduced.

Other types of recording systems can be considered, such as 'Pressure Type' or 'Bubble Type' instruments. These systems are good but require much more technical knowledge and related requirements, such as gas for the bubble type instrument, which is not always available when required. The cost of rebuilding the recorder structures would be greatly outweighed by the improvement in data quality, and reduced maintenance costs.

DETAILS OF MAXIMUM AND MINIMUM DISCHARGE MEASUREMENTS

(Jubba and Shebelli Rivers)

HYDROMETRIC STATION	LOW STAGE			HIGH STAGE			METHOD OF OBS	TOTAL NO: GAUGINGS
	DATE	GH (m)	Q (m /sec)	DATE	GH (m)	Q(m /sec)		
Jubba								
Lugh Ganana	22.02.81	0.56	2.59	1.05.81	6.12	1,463.6	C.M.M	35
Bardheere	22.02.81	- 0.20	2.13	4.05.81	6.20	1,395.0	Slope/Area	23
				28.09.81	3.35	482.5	C.M.M	
				9.11.77	6.72	1,640.8	Slope/Area	
Jamamme	11.06.80	0.48	70.48	21.05.81	5.48	529.7	C.M.M	16
Note: River dried up Mar/Apr 1980 & Feb/Mar 1981.							TOTAL	74
Shebelli								
Belet Uen	15.04.80	0.01	2.00	15.04.81	5.29	359.0	C.M.M	42
				3.05.81	6.70	1,395.3	CMM & S/A	
Bulo Burti	8.03.81	0.69	0.36	8.05.81	7.51	351.0	C.M.M	30
				17.05.81	9.19	530.0	Slope/Area	
Mahaddei Uen	18.04.80	0.46	1.51	12.10.81	5.19	167.6	C.M.M	25
Balaad	29.03.80	0.35	2.08	6.04.81	6.15	84.0	C.M.M	6
Afgoi	7.02.80	1.06	1.27	8.09.81	4.88	99.3	C.M.M	14
Audegle	13.02.80	1.26	0.54	3.08.81	5.36	94.4	C.M.M	14
Note: River dry at Afgoi & Audegle Mar/Apr 1980 & Feb/Mar 1981.							TOTAL	131
River also dry Mahaddei Uen March 1981.						GRAND	TOTAL	205

C.M.M = Current Meter Measurement. S/A = Slope Area Measurement.

TABLE .4.

7.0. STAGE DISCHARGE RELATIONSHIPS

7.1. General

Throughout the project discharge measurements were continiously carried out at all the hydrometric stations which formed the National Network. The extremely low flows in 1980 and 1981, and the record high flows on the upper Shebelli and lower Jubba in 1981, enabled the establishment of the station rating curves over their near maximum ranges, a previously unaccomplished feat.

A total of 205 current meter discharge measurements were carried out on both the rivers with only one operational field team, under extremely rough and difficult conditions. Maximum flood discharges were obtained by slope area methods at Bardheere on the Jubba, and Belet Uen on the Shebelli. A total of 73 measurements were made on the Jubba and 132 on the Shebelli. Details of the maximum and minimum levels, dates and discharges are tabulated in 'TABLE. 4.'.

7.2. EQUIPMENT

The initial low flow measurements of 1980 were carried out with equipment that was available at the Ministry of Agriculture Water Department. The recorders and current meters were the instruments remaining from the 1963 to 1972 period.

Two current meters were available, an 'OTT' Pygmy and 'OTT' C.31 (Magnetic contact). The condition of the meters was doubtful with regard to their ratings, but were made operable and surficed to train the staff, and to commence the initial low level establishment of the rating curves. Later on they were calibrated against the new project meters and found to be within acceptable limits, but required constant attention and maintenance to the electric cables and counters. The initial training measurements were carried out by wading as the old winches were not repairable due to the lack of replacement parts, especially electrical suspension cable and connecting plugs.

The Project supplied to new Current Meter Assemblys 'OTT' Dosse Models(magnetic contacts), complete with gauging winches, cables, sinkers(25 kgs), and revolution counters. During the project one of the new meters had to be returned to Germany for repair due to an internal contact failure, and on three seperate occasions the suspension cables became entangled with flood debris resulting in the loss of the equipment in the deep flood water. However, on two occasions the trainee's under extremely dangerous conditions, not only from the flood water, but also from crocodiles braved the waters and retrieved the equipment. If this had not been done, the gauging programme would have come to an end before the job had been completed. Unfortunately one complete 'Assembly' was lost leaving the section without means of continuing the gauging programme on that occasion.

Inorder to continue the programme, the old current meter 'body' piece was used with the impellers for the meter which was sent to Germany. In this way one complete set of equipment was available to continue the programme. This meter was still operational at the close of the project in december 1981, but would not last for very much longer without a complete overhaul and replacement spares.

When, and if, new equipment is ordered it is essential that the stronger all steel suspension cable with the strongest breaking strength is purchased, or more equipment will be lost in similar situations. The copper platted plastic covered cable which was supplied with the winches is not robust enough to cope with the rather rough and careless treatment equipment undergoes in Somalia.

The winches were supplied with 15 meter suspension cables which were sufficient for all the sites on both rivers under normal conditions, but not for the Jubba during extreme flood conditions, especially at Lugh Ganana. The mean low water bed level at Lugh Ganana is approximately 15 meters below the bridge deck, but 21 meters during high flows due to the scour which occurs. In April/May 1981 with gauge heights above six meters, extension cables had to be made on site to enable the depths to be measured. As the extension cables were not electric, the process of plumbing the depths had to be duplicated, thereby increasing the operational time of a single measurement from the normal four to five hours, to almost seven hours when the Vertical Velocity (VVC) method was used. In future some cables will have to be at least 25 meters long to cope with all the conditions encountered.

Water levels inside the stilling wells and from the 'MB' points on bridges were measured with ordinary cloth tapes which were weighted with heavy objects to keep them taut. Numerous errors were always made by observers forgeting to add to the measurement the extra length of the weighting object, and on some occasions using broken tapes. This problem was solved by the purchase of 'Electrical Contact Meters', which light up when the weight comes in contact with the water surface.

In December 1981 at the end of the 'Hydrometry Project', the available equipment and spares were sufficient to probably last the Hydrological Section for a further six months. Thereafter the gauging programme would probably stop due to equipment malfunctioning. This point was strongly emphasised in the Consultants final progress report, and again in the preliminary draft Project Document for the considered 'TCP' funded extension of the Hydrometry Project into 1982/83.

7.3. RATING CURVES

All the newly established rating curves have been plotted on both natural and Log/Log scaled paper, and rating tables tabulated. Cross sections also plotted to illustrate the full extent of the scour and fill which occurs throughout the flood and recession cycles.(Volume .3). Only the natural scale curves are included in this volume of the report for comparison with historical data.

7.3.1. JUBBA RIVER RATINGS

7.3.1.1. Lugh Ganana

a) 1980/81 Rating Curve

The stage discharge rating curve has been established from a total of 35 gaugings which were observed between March

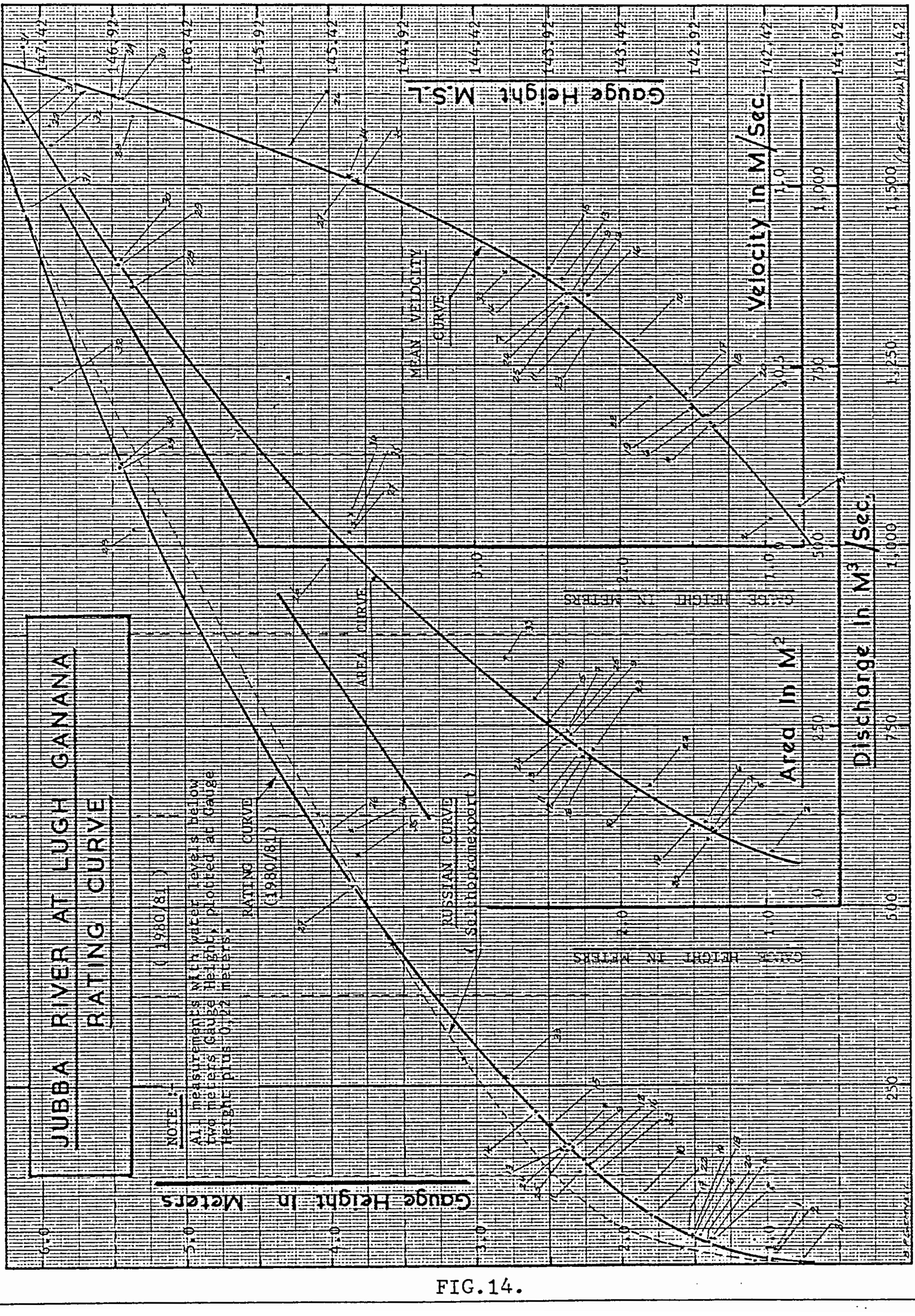

JUBBA RIVER AT LUGH GANANA
RATING CURVE
(1980/81)
NOTE :
All measurements with water levels below two meters Gauge Height, plotted at Gauge Height plus 0.22 meters.
RATING CURVE (1980/81)
RUSSIAN CURVE (Selchozpromexport)
AREA CURVE
MEAN VELOCITY CURVE
Gauge Height In Meters
Gauge Height M.S.L
GAUGE HEIGHT IN METERS
Velocity In M/Sec
Area In M²
Discharge In M³/Sec

FIG.14.

1980 and December 1981, the duration of the project (Fig.14). During the low flood period of 1980 a total of 20 gaugings were taken between gauge heights 0.97 meters and 2.59 meters with discharges ranging from 5.35 to 213 m^3/sec. The minimum flow in 1980 was approximately 5.0 m^3/sec (0.92m GH) and a maximum of 260 m^3/sec (2.80m GH.).

In 1981 the range was more extreme with a total of 15 gaugings being observed, from a minimum of 2.26 m^3/sec(0.78m GH) to a maximum of 1,464 m^3/sec (6.12m GH.). The flood peak on 1.5.81 was 6.25 meters with a flood peak discharge of about 1.533 m^3/sec. This peak level was approximately one meter lower than the flood in November 1977.

The discharge measurements were mainly carried out by using the well proven 0.2/0.8 method of gauging, where the mean of the velocities at the two points is accepted as the mean velocity for the vertical. On a few occasions the five point Vertical Velocity Method was used with the results being computed graphically. This method is more accurate than the two point method but very much more time consuming, and can almost double the time required to carry out an observation. On the Jubba at Lugh Ganana this increases the observation time for a single measurement from three hours to six hours. The results obtained by using the longer method indicated less water than the results obtained by the 0.2/0.8 method.

The decrepancies observed appeared to be more apparent with measurements observed during a rapid recession period, and probably caused by the larger spread of water level variance between the start and end of the measurement. Vertical velocity measurements taken during steady periods tended to produce similar results to the two point method. However, in the future Vertical Velocity measurements must be continued to be utilised on both the rising and falling stages, to enable a far more comprehensive comparison to be made, inorder to continue acceptance of the point two method as the standard method of flow measurement in Somalia. The sites with velocity interference from bridge pillars may well require more accurate methods to obtain the true velocity curves.

b). Rating Comparisons 1963 to 1981

Most Consultants reports over the last decade suggest that the rating at Lugh Ganana was never extended over the 400 m^3/sec. level, and therefore based all their assumptions and calculations on the Lockwood/FAO (1968), and the Russian Selchozpromexport(1965) rating curve presentations. Both the curves lower ratings were established from the original seventeen Lockwood measurements taken from the ferry at Lugh Ganana. A search through the files at the Fanoole Project (Hydrological) Office in Jelib, produced a file with data refering to the observation of 200 measurements which had been taken at Lugh Ganana between 1963 and 1977. From 1972 to 1977 a total of 180 measurements had been taken mainly by the Fanoole Project staff. Information refering to the measurements are included in the following TABLE. 5.

Discharge Measurements (1963 - 1977)

Jubba River at Lugh Ganana

(TABLE.5.)

Year	Gauge Height Min.	Max.		Discharge Min.	Max.		Total No:
1963	2.35	3.03	meters	136.4	391.0	m^3/sec	8
1964	0.95	3.41	"	4.6	399.0	"	9
1965	0.73	2.41	"	13.0	110.8	"	2
1969		2.45	"		195.1	"	1
1972	1.40	3.18	"	42.6	369.5	"	17
1973	0.88	4.15	"	39.1	374.4	"	33
1974	1.22	3.85	"	36.5	557.4	"	48
1975	0.82	3.80	"	Trace	556.0	"	51
1976	0.92	3.54	"	5.5	518.0	"	17
1977	1.14	5.30	"	20.0	966.0	"	14
							200

Note: Some measurements are still missing, as the numbers of the measurements were not consecutive. For details refering to the individual measurements see Volume 2 - Section'I'(1 & 2).

The Selchozpromexport Report (1965) states that there were 34 measurements used in establishing the curve, details are not available.

The 1963/64 Lockwood/FAO and Russian (Selchozpromexport) curves have similar levels below the original 'MSL' value of 144.75 meters. Above this level the Lockwood curve indicates a change in river regime which increases the gauge height with an attenuation in discharge, whereas the Russian(Selchozpromexport) extension using the site cross section and Chezy -Basin formula, shows a normal progressive increase in discharge with an attenuation in gauge height, which is more akin to the present rating curve(Fig.14.).

RATING CURVES FOR THE JUBBA RIVER (LUGH GANANA)
(1963/64)

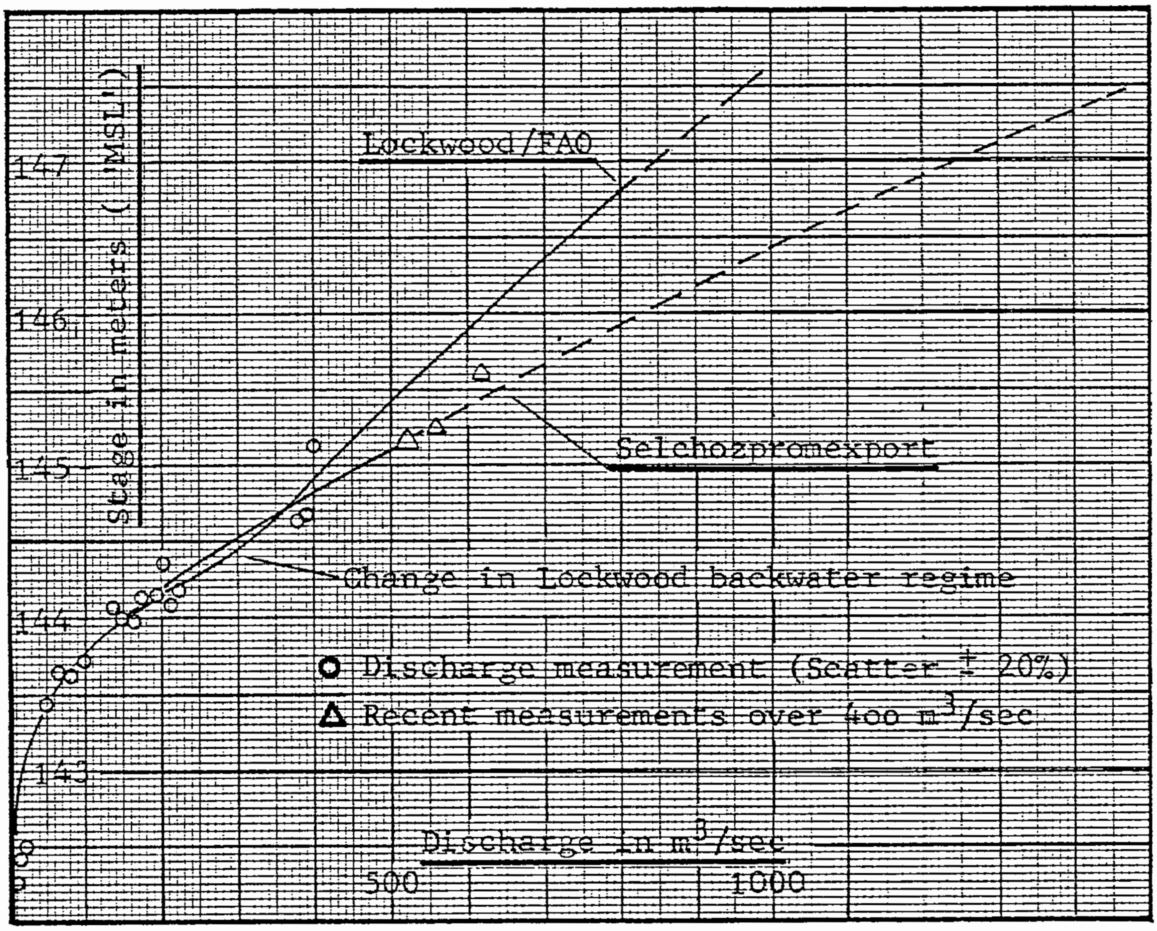


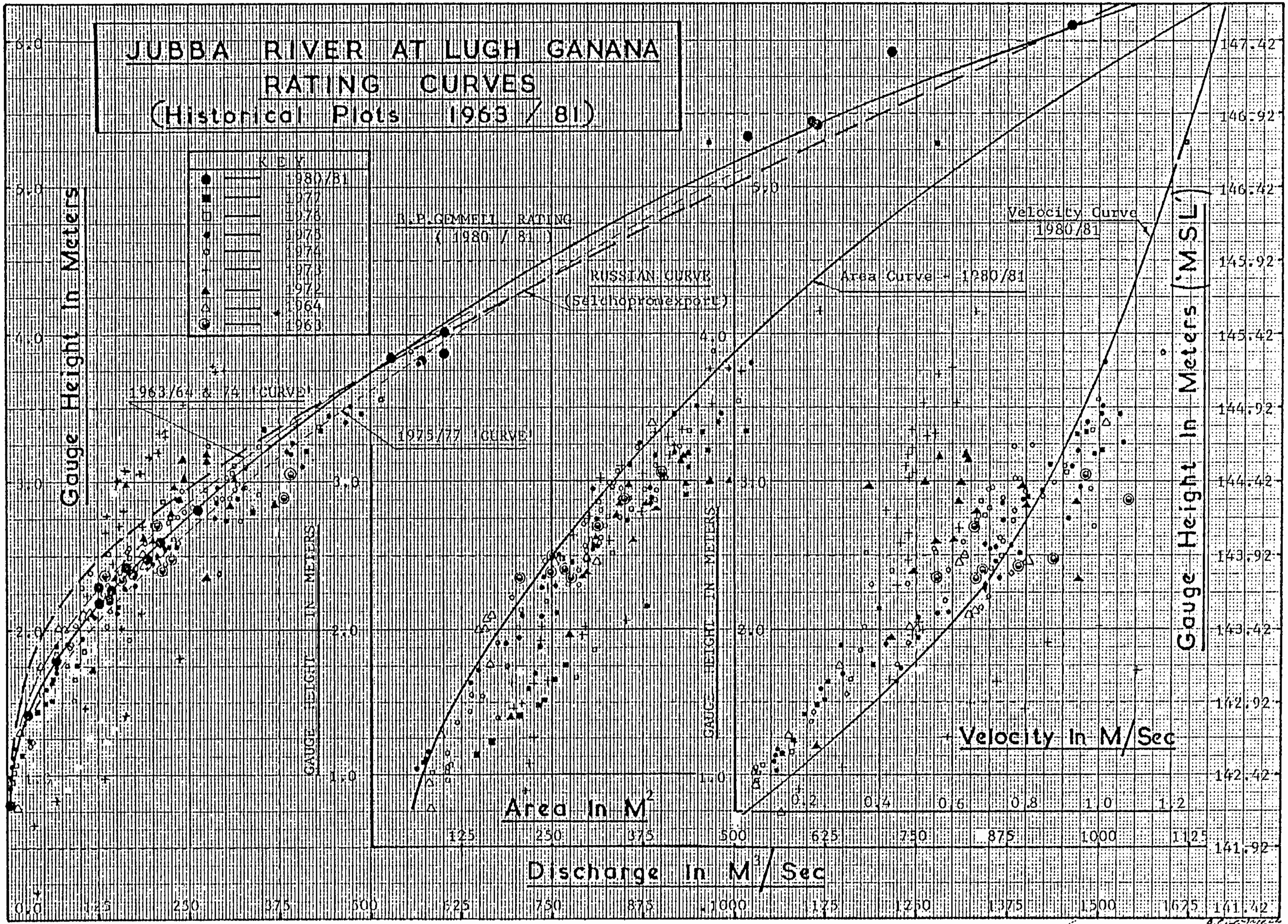
FIG. 15.

The original Lockwood/FAO extension to the rating curve should be ignored and discarded, as there is no data or logical explaination to support the backwater assumption. It is evident that Lockwood/FAO had adopted a compound rating with an abrupt transition at a discharge of about 300 m^3/sec. Such transitions are fairly common at bankful discharge, above which overbank spillage tends to attenuate the natural rise of the river stage with its discharge. However, the Lockwood/FAO changes slope at half bankful discharge and in the opposite direction to that normally encountered between the low and high controls (FIG.15.) The slope of the Lockwood/FAO curve suggest that at a discharge above the 300 m^3/sec. a low flow control is drowned out by the backwater of a severe downstream constriction, which is infact not true.

All historical measurements of discharge and the Russian (Selchozpromexport) rating curve plot have been superimposed on the recently established rating curve (FIG.16.). Between the zero and 3.5 meter gauge heights the Selchozpromexport curve returns half the discharge of the present curve (50m^3/sec as to 100 m^3/sec at GH. 2.0 meters.). The curves are similar again at GH 3.80 meters the crossover point,with the Selchozpromexport extension increasing to 7.5% more discharge at GH.5.0 meters before coinciding again at GH.6.10 meters or 1,475 m^3/sec, the peak area of the 1981 flood.

Careful examination of the old installation data sheets reproduced in this report (see volume 2 - sect H.2c & d), shows that the Benchmark 'MSL' elevation was corrected after the first seventeen measurements used to plot the 'Selchozpromexport' and Lockwood/FAO curves had been carried out. The original Benchmark value 'MSL'. 150.174 meters established in May 1963 was corrected to 'MSL' 149.917 meters in the later part of September 1964, some 0.25 meters lower. Therefore, after application of the 0.25 meter correction to the 1964 disharge measurments stage levels, all the gaugings plot within ± 20% below the 2.0 meter level and within ± 10% above that level. The area's and velocities also plot on either side of the recent curves.

The measurements from the other years also plot within ± 20%, with a number of wild plots which is to be expected cosidering the situation in Somalia. The exception to this trend are the measurements taken in the latter part of 1972 and the whole of 1973. These measurements plot in a totally different pattern to all the others, either being observed at a different



JUBBA RIVER AT LUGH GANANA
RATING CURVES
(Historical Plots 1963 / 81)
KEY
1980/81
1977
1976
1975
1974
1973
1972
1964
1963
B.P. GEMMELL RATING (1980 / 81)
RUSSIAN CURVE (Selchoproexport)
1963/64 & 74 CURVE
1975/77 CURVE
Area Curve - 1980/81
Velocity Curve 1980/81
Gauge Height In Meters
GAUGE HEIGHT IN METERS
Gauge Height In Meters ('MSL')
Area In M²
Velocity In M/Sec
Discharge In M³/Sec

FIG. 16

site or a different set of gauges with different 'MSL' levels. The Russian 'Selchozpromexport' adjustment to their earlier flow data in their revised 1973 report may shed some light on the matter, but unfortunately no working data from the Russian period is available at the Ministry of Agriculture Hydrological office in Mogadishu.

The large scatter of the early measurement plots can be attributed to a various number of reasons. The lack of training and inefficient standard of the field operational staff and the office computation and analysis follow-up, inadequate and old equipment requiring re-calibration and general repairs, and the general attitudes, proceedures and discipline when measurements are carried out. Probably the main single factor responsible for the slight general increase in discharges for the period 1976/77, was the small number of verticals (12-18) and their positioning in the cross section. Most of the recent gaugings were carried out with (30-32) verticals over the river flood width of 148.0 meters. The verticals were placed at both high and low velocity points inorder to obtain a representative mean velocity for the section. The older measurements however, tended to concentrate on the points which gave the highest and quickest response from the meter, thereby returning slightly higher discharges than normal.

The final conclusion is that this recent curve is the only time that the curve has been established by actual field gaugings above the medium range, and therefore the most reliable. The curve also appears to be the mean with regard to the past data, therefore can be used to recalculate all historic data. The past data for 1977 has been recalculated for comparison with 1980/81. The majority of the extreme scatter experienced is probably due to operational error rather than any great change or shift in section. However, due to the nature of the river bed, wide and sandy, a slight amount of shift can be expected in the lower section of the curve. The recent lower measurements have been more reliable because they were obtained by wading, rather than suspension which is not really suitable for low flow gauging, due to the suspended weight below the meter.

7.3.1.2. Bardheere

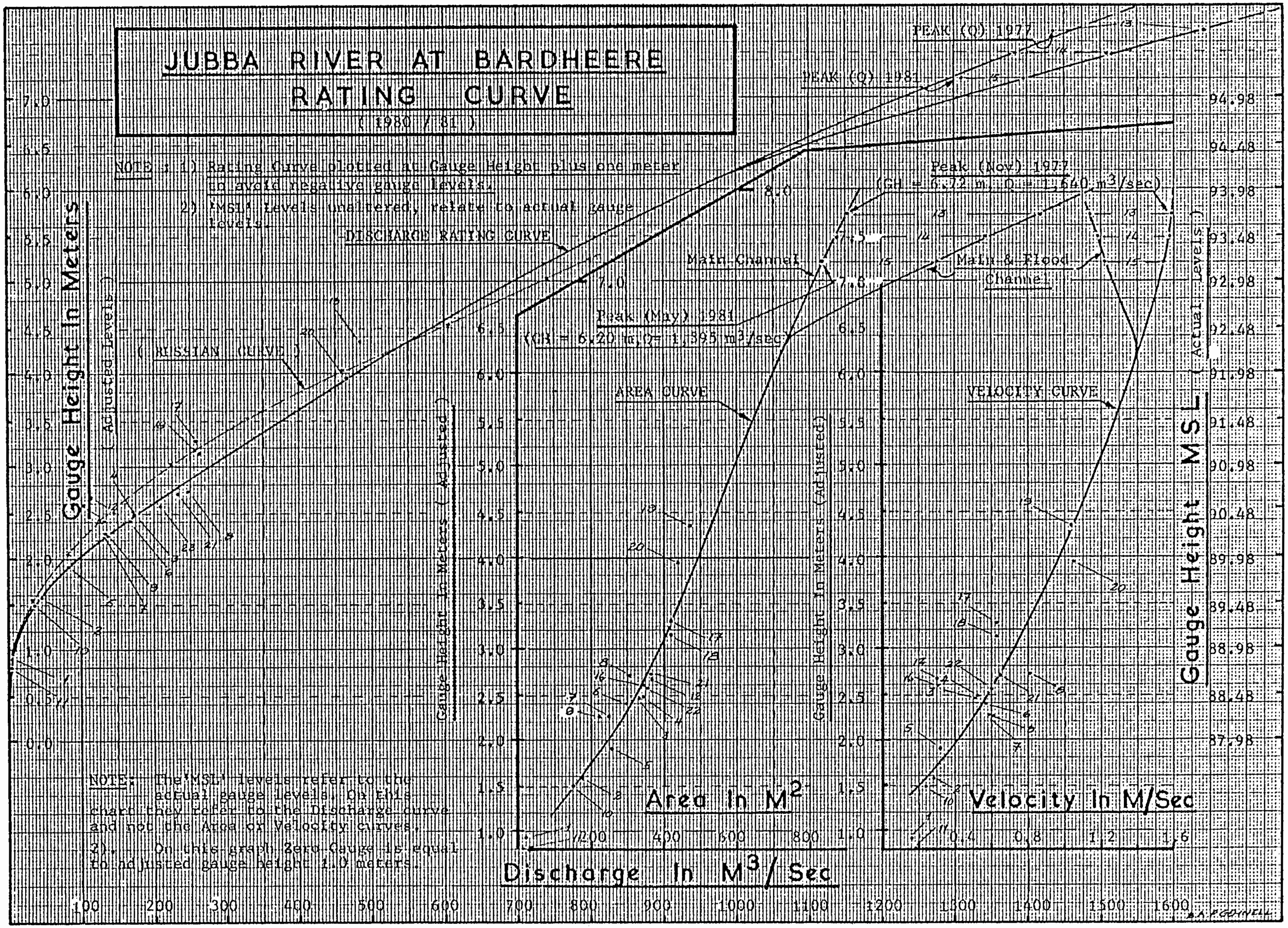
a) 1980/81 Rating Curve

Due to the difficult accessability of this station during the rainy season, only 22 discharge measurements were carried out over the duration of the project, and only to a maximum of 500 m^3/sec. The flood peaks were obtained with the usual 'Mannings' Slope Area method ($Q=\frac{A.R^{2/3}.S^{1/2}}{'n'}$), utilising the surveyed cross sections after the flood events and the slope of the water at the time of the flood. The slope is obtained by identifying the debris marks immediately after the event, or by installing 'Griffin Type' gauges.

In 1980 a total of 10 discharge gaugings were carried out between gauge heights -0.11 meters (4.31 m^3/sec), and gauge height 1.71 meters (247.8 m^3/sec). The absolute minimum and maximum levels were -0.17 meters (2.67 m^3/sec) and 3.54 meters (593.3 m^3/sec). The maximum flood was generated locally and did not come from Lugh Ganana.

In 1981 a further 12 measurements were carried out, nine current meter and three by Slope Area methods. The 1977 flood-mark was included in the cross section survey and the discharge recalculated with the revised flood level of 6.72 meters. The extremely low dry season and following exceptional 'GU' flood period produced an extreme spread of stage level, allowing the full range of the rating to be established. In March 1981 the water level dropped to a minimum of -0.28 meters (1.12 m^3/sec), and reached a maximum level of 6.20 meters (1,310.0 m^3/sec). The flood peak was only 0.52 meters below the highest level on record of 6.72 meters recorded in November 1977, and 330m^3/sec less discharge.

The rating curve has been plotted with a bias towards the measurements carried out by the consultant or under his direct observation, as dictated by discrepancies with regard to the surveyed water levels and measurement observation by the local field staff (Fig.17.). The trestle type 'Baily Bridge' pillar structure obstructs and affects the velocity pattern in the



JUBBA RIVER AT BARDHEERE
RATING CURVE
(1980 / 81)
NOTE : 1) Rating Curve plotted at Gauge Height plus one meter to avoid negative gauge levels.
2) 'MSL' Levels unaltered, relate to actual gauge levels.
DISCHARGE RATING CURVE
(RUSSIAN CURVE)
PEAK (Q) 1977
PEAK (Q) 1981
Peak (Nov) 1977
(GH = 6.72 m, Q = 1,640 m3/sec)
Peak (May) 1981
(GH = 6.20 m,Q= 1,595 m3/sec)
Main Channel
Main & Flood Channel
AREA CURVE
VELOCITY CURVE
Gauge Height In Meters
(Adjusted Levels)
Gauge Height In Meters (Adjusted)
Gauge Height In Meters (Adjusted)
Gauge Height M S L
(Actual Levels)
Area In M2
Velocity In M/Sec
Discharge In M3/ Sec
NOTE: The'MSL' levels refer to the actual gauge levels. On this chart they refer to the Discharge curve and not the Area or Velocity curves.
2). On this graph Zero Gauge is equal to adjusted gauge height 1.0 meters.

FIG.17.

section. The velocities are also affected by the amount of flood debris that collects around the pillars. There is also a certain amount of backwater on the left bank which has to be taken into account when the discharge calculations are carried out, and the quality of the measurement will depend on the skill of the observer at the time.

The 1977 flood mark was clearly marked inside the wooden recorder house at the station, by 'MMP' personnel who were in the area at the time, and documented in their 'Jubba Sugar Report 1978'(page 3, para 2.3.). In the report the 'MSL' level of the 1977 flood is given as 95.70 meters, and gauge height 6.47 meters. The 'MSL' value is common to the present and the 1965 staff gauge levels, but not to the actual gauge heights, due to the difference of the gauge zero levels. The gauge height 6.47 meters applies to the 1965 zero gauge ('MSL' 89.23 meters), whereas the equivalent gauge height in relation to the present gauge zero ('MSL' 88.98 m) is 6.72 meters, as plotted on the rating curve.

Note that the rating curve has been plotted at actual gauge height plus one meter in-order to avoid minus gauge heights. The 'MSL' levels on the rating curve graph apply only to the rating curve and not the area and velocity curves. The rating table has been tabulated to the actual gauge levels.

b)Rating Comparisons 1963 to 1981.

The 'Selchozpromexport' (1965) report states that the 1963/64 rating curve was established with 15 measurements taken by Lockwood/FAO project. Unfortunately the details of those measurements were not available at the Ministry of Agriculture in Mogadishu, nor any information on any additional measurements which may have been observed between 1964 and 1979. The rating curve presented in the 'Selchozpromexport' report has been copied and superimposed over the present curve (1980/81), before any adjustment to its levels.(Fig.17.). The 1963/64 curve was only varified to between 300 and 400 m^3/sec by current metering, but then theoretically extended to 800 m^3/sec using the cross-sectional data.

The 1963/64 curve was plotted to the 1965 zero gauge datum of 'MSL' 89.23 meters, which was 0.25 meters higher than the present zero datum at 'MSL' 88.98 meters. This accounts for the higher gauge levels below the 3.20 meter level on the old curve (Fig. 17.). After applying the -0.25 meter correction factor to the old curve comprising the section of the curve established by the Lockwwood/FAO gaugings, the 1963/64 and 1980/81 curves are very similar (Fig. 18.). The older curve shows 20% more water at the very low levels, and only 5% at the one meter level when the flow is in the 100m^3/sec stage. Between 1.0 and 3.0 meter gauge level the two curves are similar with differences of between ± 2-5%, which is probably operational error rather than a rating curve shift. The theoretical extension to the old curve shows an increase in discharge from gauge height 2.75 meters(adjusted levels) of 7.0% upto bankfull level.

RATING CURVES FOR THE JUBBA RIVER (BARDHEERE)
(1963/64 & 1980/81)

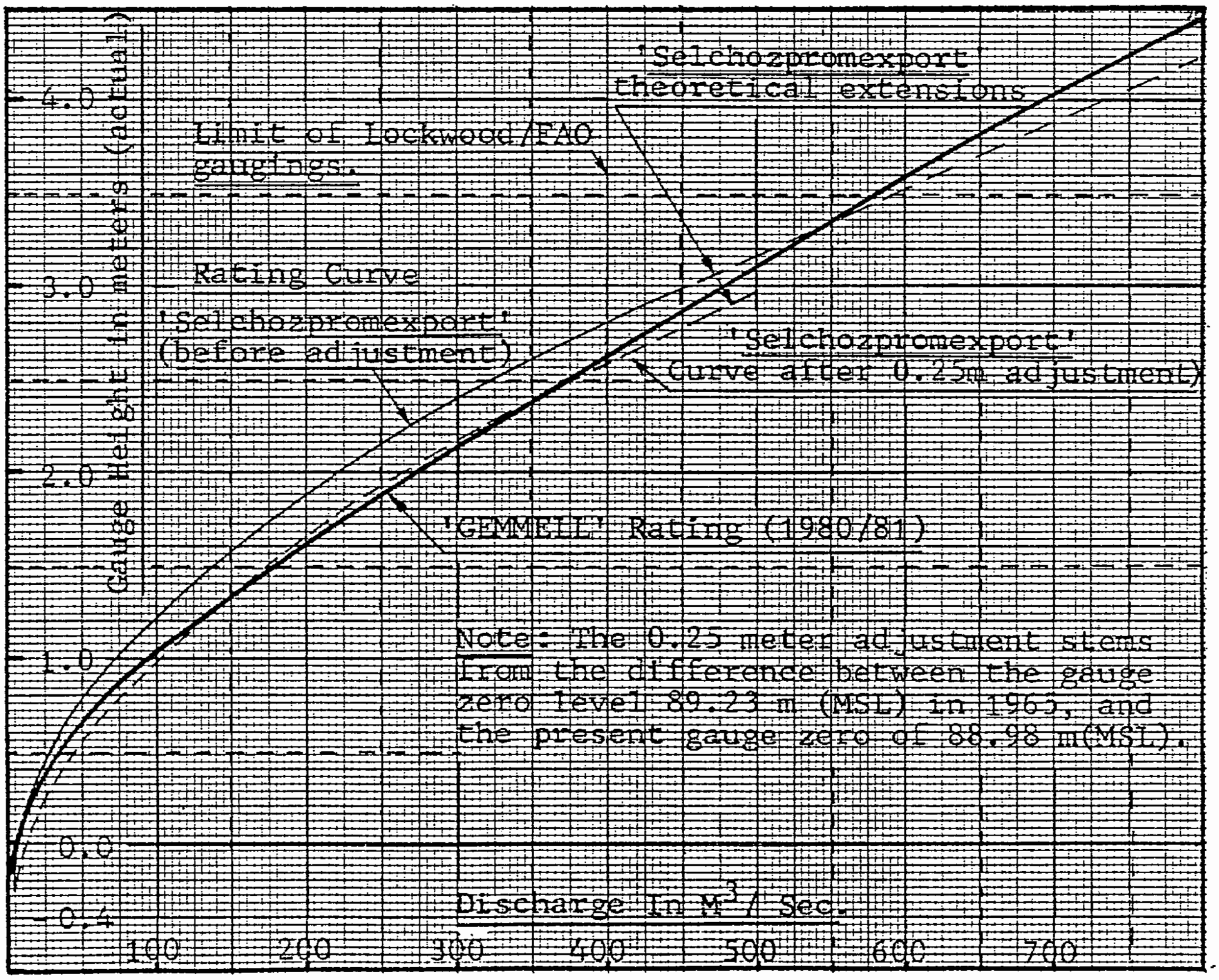


FIG. 18.

The old rating would return more water at the levels above 2.75 meters than the 1980/81 rating, but no decision should be taken to alter the past computations until at least one or two discharge measurements have been taken at the higher stages, which would illustrate which extension is the most accurate. Present data indicates that the new curve is the most reliable, although the flood discharges were obtained by the theoretical 'Slope Area' method.

The overall conclusion is that there has not been any drastic change in the section or rating since 1963, except in the very low range probably due to the scour and fill differences before and after the large flood events. In the absence of any additional gauging data between 1965 and 1979, it must be assumed that the present rating curve is the most accurate and reliable, and that the curve can be applied to the whole period from 1965 to 1981.

7.3.1.3. Jamamme

a) *1980/81 Rating Curve*

This rating was established with 17 discharge measurements observed between March 1980 and November 1981. In 1980 nine measurements were observed including one float observation, with the remaining eight measurements including the peak flood gaugings observed throughout 1981. The 1980 gaugings covered a water level and discharge range of 2.02 meters and 107.5m^3/sec. The gauging spread was from gauge height 0.48 meters(70.5m^3/sec) to gauge height 2.50 meters (178.0 m^3/sec).

In 1981 due to the drought at the begining of the year and the extremely high following 'GU' flood levels the gauging spread was more extreme, from gauge height 1.92 meters(144.6m^3/sec) to gauge height 5.48 meters (530 m^3/sec).

The peak discharge of 530 m^3/sec. recorded on the 21/5/81 only applies to the water which passed the gauging site and under the bridge at the Jamamme road junction. The total flood consisting of the flow in the main channel and the flow over

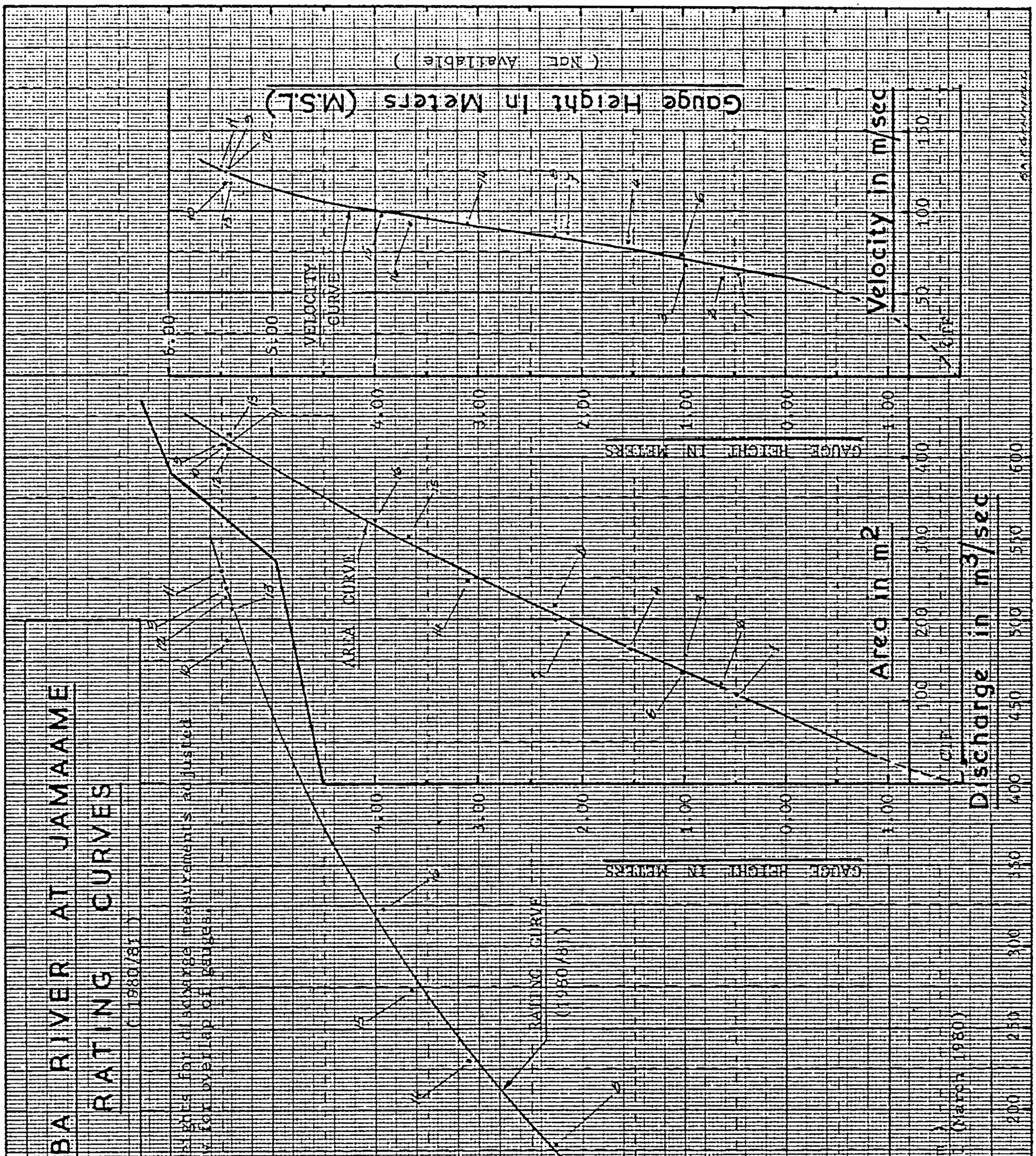

JUBBA RIVER AT JAMAAME
RATING CURVES
(1980/81)
NOTE: Gauge Heights for discharge measurements adjusted to allow for overlap of gauges.
Gauge Height in Meters
RATING CURVE (1980/81)
AREA CURVE
VELOCITY CURVE
GAUGE HEIGHT IN METERS
Gauge Height in Meters (M.S.L)
(Not Available)
Discharge in m3/sec
Area in m2
Velocity in m/sec

FIG. 19.

the flood plain, must have been in the order of 1,300 m^3/sec. On the 16/5/81 the flow in the Jubba river at Mareery(Jubba Sugar Project site), was reported to have reached a maximum level of 21.97 meters('MSL') and a discharge of 950 m^3/sec, with an additional peak flow of 400 m^3/sec flowing down the 'Snake River', or Far Schebelli to Scorpion lake to the south west of the Jubba Sugar Project cane fields. Additional flow also joined the system from the main Shebelli River channel, which only flows on rare occasions with the major contribution being from the Madagoi wadi originating in the Dinsor area, and not from the Shebelli.

The gauge levels at Jamamme station (flood levels),are controlled by the situation upstream. Whether the river flood protection bunds remain intact, and if breached to what extent. Also, whether the flood relief canals are in operation or not. The peak discharge at Jamamme is not a true indicator as to the magnitude of the flood in the lower Jubba.

The recent rating curve established with the 17 discharge measurements plots extremely well, with only a 5% scatter either side of the curve (Fig. 19.). The 'C.T.F' levels were established by survey as the river dried up completely, both in 1980 and 1981.

b) Rating Comparisons 1963 to 1981.

Unfortunately no previous data relating to the earlier rating of this station was available in Mogadishu, so no comparisons are possible. The 'Selchozpromexport' report (1965) states that the 1961 flood peak level at the Jamamme bridge was 7.54 meters 'MSL', and 7.13 meters in 1963. Assuming that the Benchmark located on the upstream left bank bridge abutment is indeed 'BM' 294-B ('MSL' 10.495 meters), then the peak water level in 1961 was 2.955 meters below the 'BM' and 4.40 meters below the 'MB' point on the bridge. The 'MB' point has a gauge height value of 9.58 meters, therefore the 1961 level of 7.54 meters('MSL') equals a present gauge height of 5.18 meters, and 1963 a gauge height of 4.77 meters. The 1961 level would have been 0.30 meters lower than the 1981 peak.

The Chief Engineer of the Chinese construction team working on the 'Fanoole Headwork Structure' at Maleenda said that the 1981 flood was higher than both the 1961 and 1977 floods(MMP notes of visit to Fanoole 24/5/81 - W.Sim & Calverley). In another report by the Chinese Team to the Director of the Fanoole Project Dr. Hassan Mohamed Ali, and dated June 14th 1981, it is claimed that the 1961 level was the historical peak, therefore higher than the 1977 flood.

The same report (14/6/81) put the Lugh Ganana 1981 flood peak at 'MSL' 147.45 meters (6.03 meters G.H.). From this statement it appears that they are using the zero from the 0-2 meter gauges as the absolute gauge zero and correcting the 2-6 meter gauge readings by subtracting the 0.22 meter overlap, infact raising the 2-6 meter gauge post by 0.22 meters. Whereas, the 2-6 meter gauge post was the original gauge and the 0-2 meter being added later. The data for 1980/81 has been plotted and calculated by accepting the 2-6 meter levels as standard, then adding 0.22 meters to all levels below 2.0 meters. infact lowering the 0-2 meter gauges to level sequence with the original 2-6 meter gauge. Before any realistic comparisons can be made it must be established which system was adopted. The chinese must of obtained their data from the Russian files in their care. The actual peak gauge height at Lugh was 6.25 meters related to G.Z. 141.42 meters 'MSL'.

Data relating to this station must be available somewhere, and only when this data is located can any reliable form of comparison be carried out. All the construction and river control and training,must have caused variations in the higher stages (overbank) to occur, but the rating within the river channel probably remains the same without much change, except in the very low levels because of the very sandy nature of the river bed material.

In the absence of any past data refering to earlier rating curves, the new curve must be assumed to surfice for all water level data to date, not yet converted to river flow volume discharges.

7.3.2. SHEBELLI RIVER RATINGS

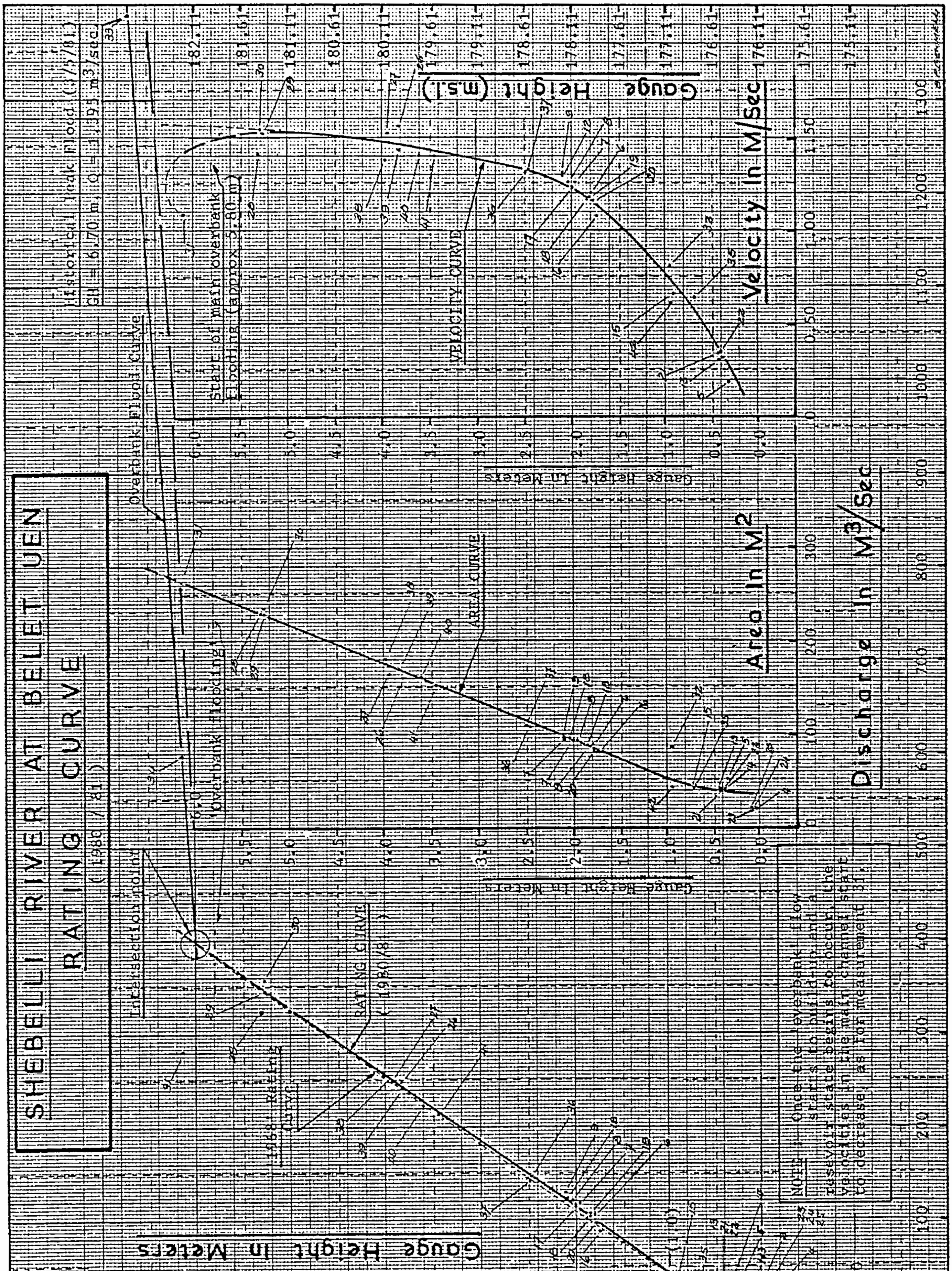
7.3.2.1. Belet Uen

a) 1980/81 Rating Curve.

A total of 42 discharge measurements were taken between March 1980 and November 1981 with which the present rating curve has been established (Fig.20.). During 1980 a total of 22 gaugings were taken between gauge heights 0.01 meters (2.00 m^3/sec) and gauge height 2.11 meters (130.0 m^3/sec). The minimum annual water level was 0.01 meters and the maximum a low peak of 2.83 meters (172.0 m^3/sec).

In 1981 the range of water levels was much higher than the previous year, thereby increasing the discharge measurement spread to the possible maximum because of the drought at the begining of the year, which was immediately followed by the highest recorded levels in living memory on the upper and middle shebelli. A total of 20 discharge measurements were carried out between gauge heights 0.07 meters (3.15 m^3/sec), and gauge height 6.70 meters (1,395.0 m^3/sec), the flood peak level. The minimum level was recorded in March at - 0.12 meters (0.43 m^3/sec).

The rating is straight forward upto a level of about 5.50 meters, after which overbank spillage and by-pass flows cause backwater effects. Overbank spillage returning to the river downstream at a high level would have direct effects on the slope and consequently the discharge. This situation was illustrated during the flood of May 1981, when the majority of the flood was bypassing the station on the left and right banks then rejoining the main river one kilometer downstream. The velocity measured at the station at a water level of 5.29 meters (1.54 m/sec) was much higher than the velocity at water level 6.14 meters (1.08 m/sec). The discharge also fell by 21.5% from 359 m^3/sec to 282 m^3/sec. An additional factor affecting the velocities at overbank flood levels is the position of the station. The station is situated on the return leg of a large meander so the flow in the channel would be directly opposite



SHEBELLI RIVER AT BELET UEN
RATING CURVE
(1980 / 81)
Intersection point
Overbank Flood Curve
Overbank flooding
RATING CURVE (1980/81)
1968 Rating Curve
AREA CURVE
VELOCITY CURVE
Start of main overbank flooding (approx 5.80 m)
Historical Peak Flood (1/5/81)
Gauge Height In Meters
Gauge Height (m.s.l.)
Area In M2
Velocity In M/Sec
Discharge In M3/Sec

FIG. 20.

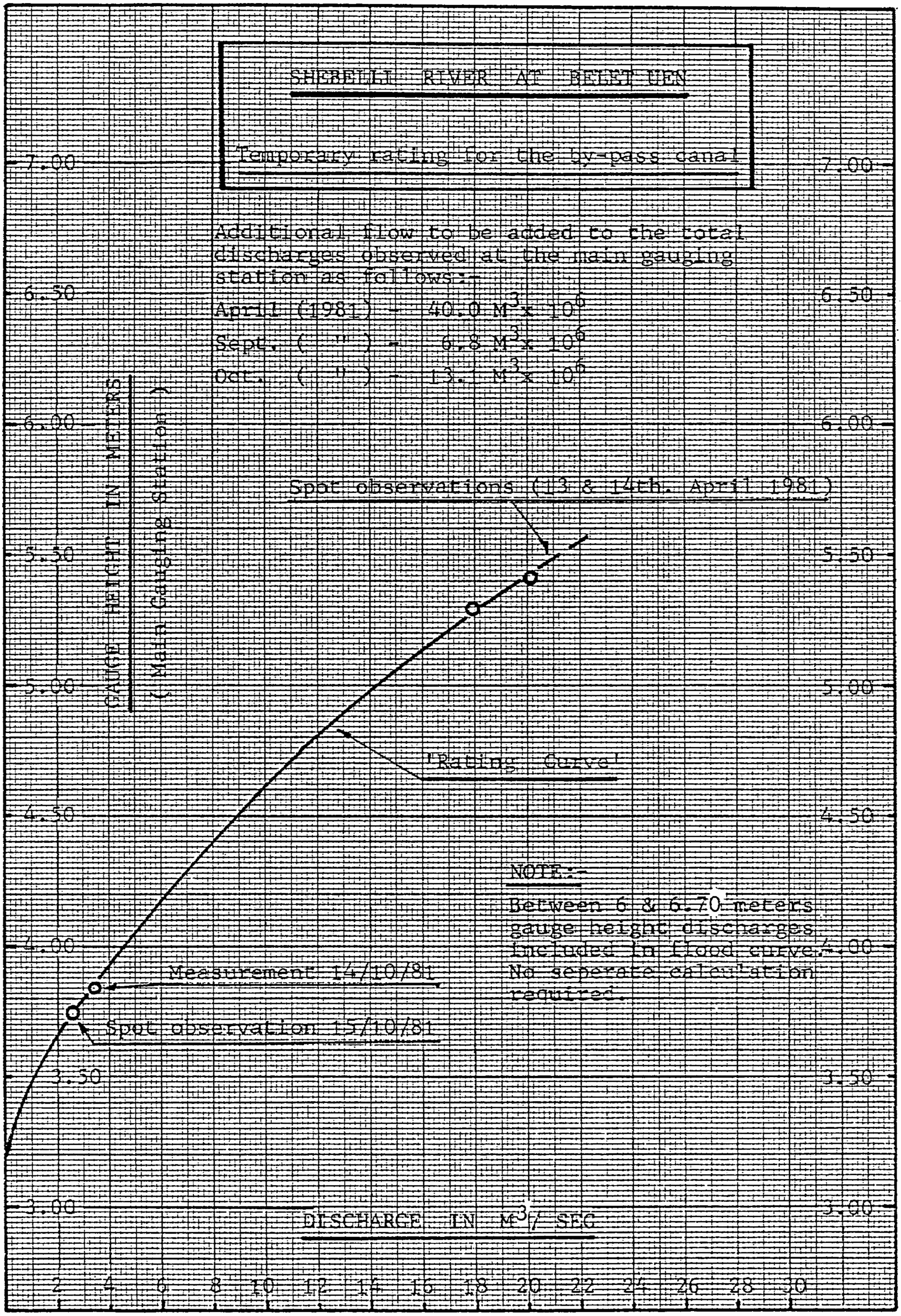

SHEBELLI RIVER AT BELET UEN
Temporary rating for the by-pass canal
Additional flow to be added to the total discharges observed at the main gauging station as follows:-
April (1981) - 40.0 M³x 10⁶
Sept. (") - 6.8 M³x 10⁶
Oct. (") - 13.1 M³x 10⁶
GAUGE HEIGHT IN METERS
(Main Gauging Station)
Spot observations (13 & 14th. April 1981)
'Rating Curve'
NOTE:-
Between 6 & 6.70 meters gauge height discharges included in flood curve. No seperate calculation required.
Measurement 14/10/81
Spot observation 15/10/81
DISCHARGE IN M³/ SEC
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

FIG. 21.

to the general flood flow across the land. The station site is illustrated in the following sketch in relation to the high overbank flow:

SKETCH MAP OF BELET UEN SHOWING EXTENT OF FLOOD

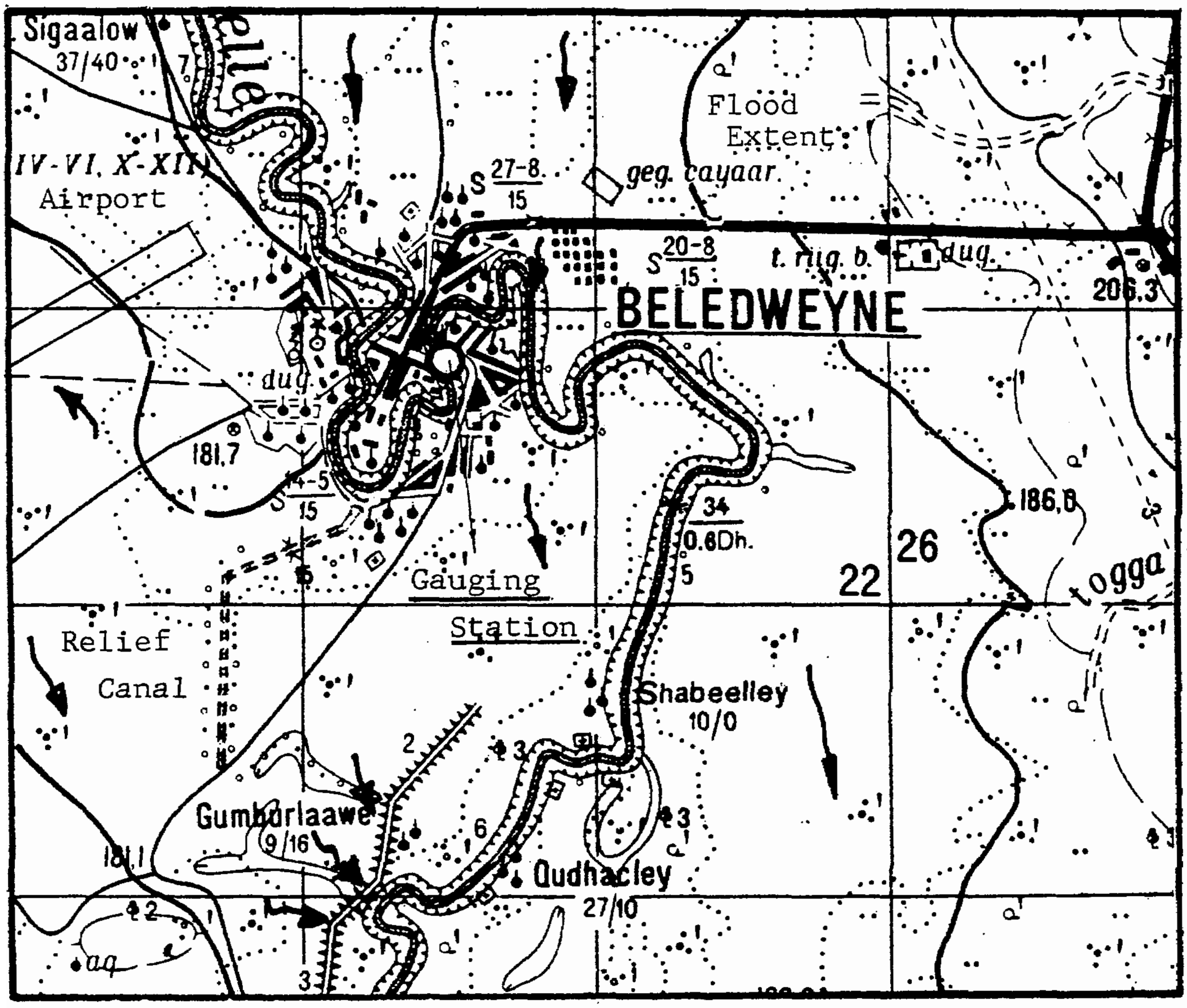


FIG. 22.

The rating curve for the main channel above 5.50 meters probably forms a loop curve. A more suitable way of plotting the rating would be the Slope/Stage/Discharge relationship, but would require at least two sets of gauges to establish the slope of the water at each gauging, which would be affected by the intersecting flow from the overbank spillage and the by-pass flow returning to the main channel, one kilometer downstream of the station.

Flow through the relief canal before the on set of the flood started at approximately 4.0 meters gauge height, and after the flood the 'CTF' level was 3.75 meters. A seperate rating curve was established for the relief canal by utilising the design flow, float measurements, and current meter gaugings for the low flow. (Fig.21)

The overbank flood discharges were obtained by current meter gauging at the main channel, and applying the 'Slope Area Method' to the breach on the right bank at the relief canal offtake. On the left bank the overflow extended for a distance of three kilometers causing major breaches in the main approach road to the town. At water level 6.70 meters(flood peak), the road embankment was used as a 'Broadcrested Weir', with a head differential of 0.33 meters between U/S and D/S water levels. The flow through the breaches was calculated by cross sectional survey after the flood, and float observations during the flood on 12/5/81. The velocities through the town were estimated from site observations and estimates. The final discharges for the flood peak and discharge for 12/5/81 are as follows :

Flood Peak Details (Discharges) - 3/5/81

		m^3/sec
i)	Flow through breaches and culverts along approach road to Belet Uen (Breached 1/5/81) -	319.0
ii)	Flow over the road -	635.0
iii)	Flow at Gauging station (main channel - 6.70m)-	282.0
iv)	Flow at Relief canal & breaches(breached 3/5)-	159.0
	Total Q =	1,395.0

TABLE .6.

Details of Discharge on 12/5/81

		m^3/sec
i)	Flow through culvert & breaches along approach road to Belet Uen.	200.0
ii)	Flow at Relief Canal & breaches (R/B)	116.0
iii)	Flow at Gauging station (WL.6.14 m)	282.0
	Total Q =	598.0

TABLE .7.

Details from report on 'History of the 'GU' Floods' on the Jubba & Shebelli Rivers - Sept 1981. (B.A.P.Gemmell).

b) Rating comparisons 1965/68 & 1980/81

The 1980/81 curve plots almost exactly over the 1965/68 cuves upto a discharge of 355 m^3/sec. Above this level the effects of the 'overbank' spillage begins to take place, with the total discharge increasing rapidily but with an attenuated rate of increase in the water level. Simultaneously the flow in the main channel decreases forming a'Hysteresis' or loop curve. This hysteresis effect will only take place if wide spread flooding occurs resulting with a 'resevoir state' from backwater, and 'intersection' flow downstream of the gauging station.

Therefore, due to the similarity of the rating curves and the absence of any additional gauging data between 1968 and 1980, it must be assumed that no change in rating has occurred since the establishment of the rating in 1965. All past data related to the original curve does not require recalculation, and the latest curve can be applied to any flow calculations required from pre - 1980 stage data.

The 'overbank' flood extension to the normal rating curve (above 355 m^3/sec), and the 'Hysteresis' loop effect for the decreased flow on the recession leg, only applies to the overbank stages of the 1981 flood. (Fig.23). Under normal conditions the rising stage of the 1980/81 curve would be applicable to about gauge height 5.80 meters (390 m^3/sec), only if the flood levels are achieved without the exceptional flood plain inundation and resulting 'backwater effects'.

The 1980/81 curve appears to agree more closely with the very low level discharges observed in 1965 rather than with 1968. The lower gaugings observed in 1965 would suggest more accuracy, but at these low levels the variations in flow would be more related to operational differences rather than rating changes.

The observation of the minimum flow discharges at the downstream site by wading methods, is far more accurate than suspension gauging from the bridge with very slow velocities and minimum depth restrictions due to bulky equipment.

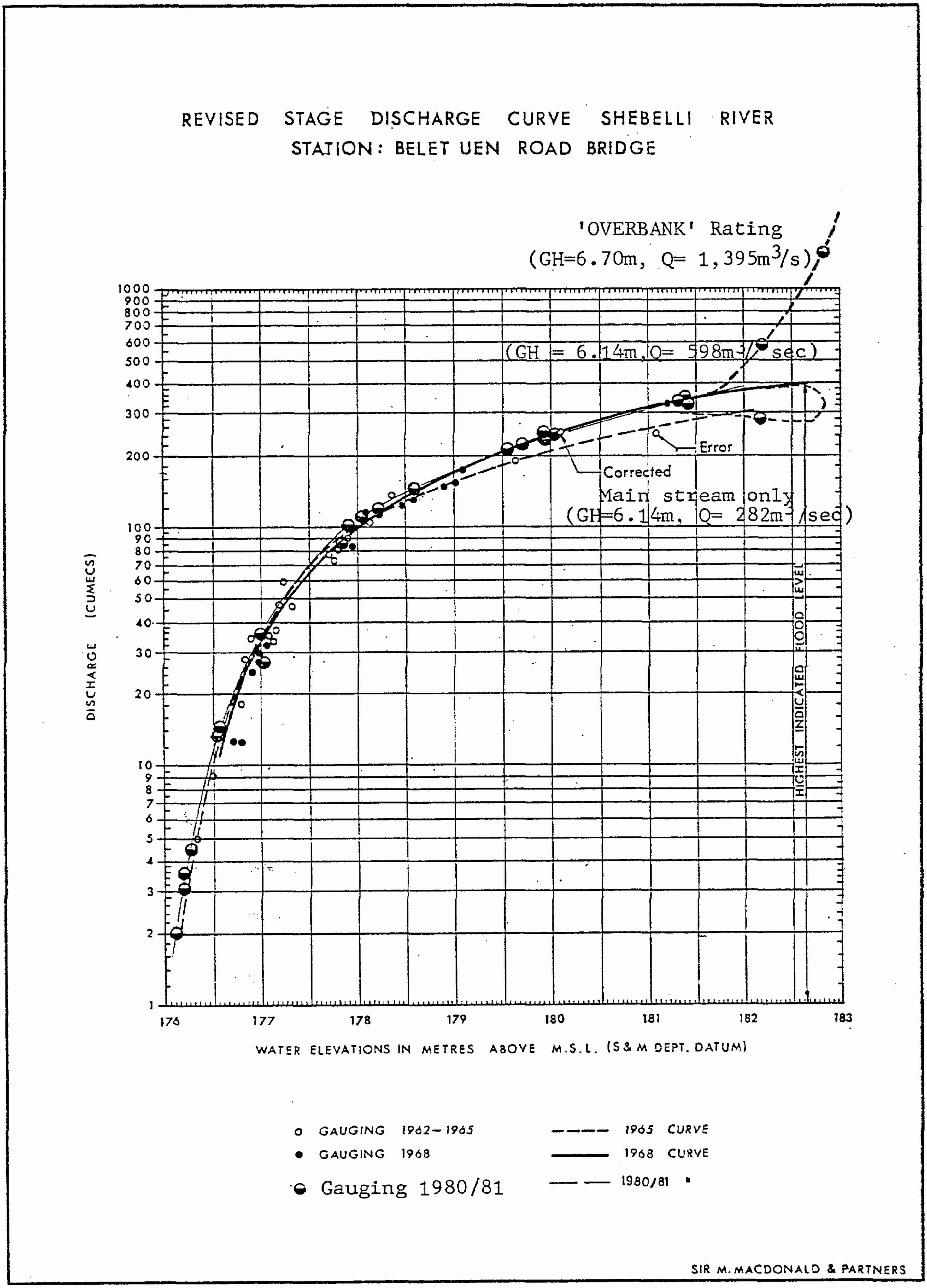
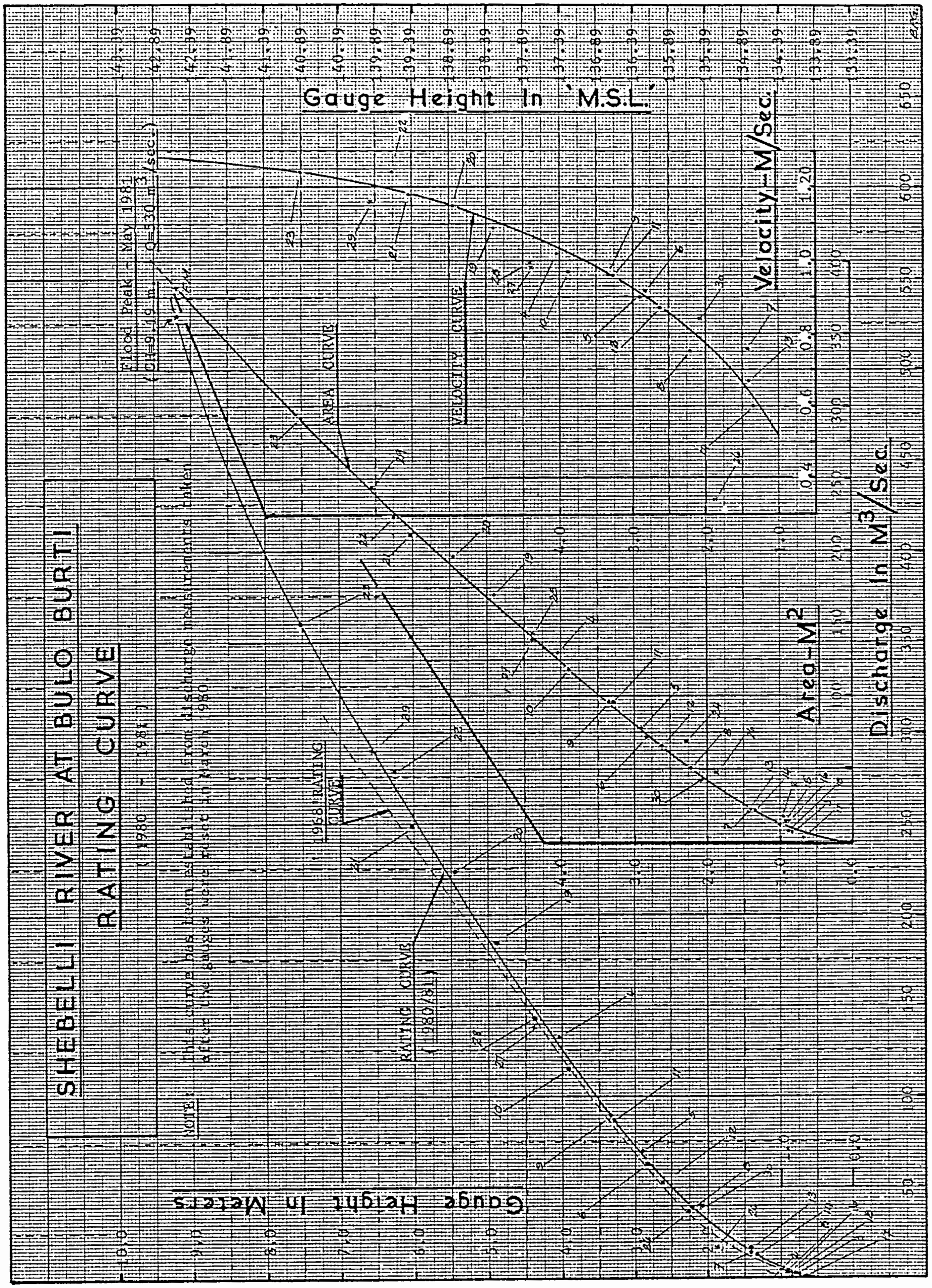

REVISED STAGE DISCHARGE CURVE SHEBELLI RIVER
STATION: BELET UEN ROAD BRIDGE
'OVERBANK' Rating
(GH=6.70m, Q= 1,395m3/s)
(GH = 6.14m, Q= 598m3/sec)
Error
Corrected
Main stream only
(GH=6.14m, Q= 282m3/sec)
HIGHEST INDICATED FLOOD LEVEL
DISCHARGE (CUMECS)
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
176
177
178
179
180
181
182
183
WATER ELEVATIONS IN METRES ABOVE M.S.L. (S & M DEPT. DATUM)
GAUGING 1962—1965
GAUGING 1968
Gauging 1980/81
1965 CURVE
1968 CURVE
1980/81
SIR M. MACDONALD & PARTNERS

FIG. 23



SHEBELLI RIVER AT BULO BURTI
RATING CURVE
(1980 - 1981)
NOTE: This curve has been established from discharge measurements taken after the gauges were reset in March 1980
Flood Peak - May 1981
(GH=9.19 m, Q=530 m3/sec.)
Gauge Height In 'M.S.L.'
Gauge Height In Meters
AREA CURVE
VELOCITY CURVE
1968 RATING CURVE
RATING CURVE (1980/81)
Velocity-M/Sec.
Area-M2
Discharge In M3/Sec.

FIG. 24

7.3.2.2. BULO BURTI

a) 1980/81 Rating Curve.

The rating curve has been established with 30 discharge measurements taken between February 1980 and November 1981. The 14 measurements taken in 1980 were observed over a gauge height spread of 3.19 meters, between gauge height 0.85 meters (1.72 m^3/sec) and gauge height 4.04 meters (133.4 m^3/sec). The annual minimum gauge height was 0.84 meters with a maximum of 4.65 meters (171.0 m^3/sec).

The 16 measurements observed in 1981 covered a wider spread, or range of water level because of the drought at the begining of the year and the exceptional floods which followed soon after in the 'GU' period. The minimum gauging was carried out at a gauge height of 0.69 meters(0.36 m^3/sec), and the highest at gauge height 7.51 meters(360.0 m^3/sec). The flood peak discharge was obtained by the 'Slope Area Method'(Mannings) at a gauge height of 9.19 meters(530.0 m^3/sec). The peak level at the bridge was 9.24 meters but has been adjusted the 0.05 m fall in slope to the gauge site situated downstream. The minimum flow was below the lowest gauging level, probably only a trickle. At the time of the gauging on 8/03/81 at 1600 hrs. the initial clear water rise which heralds the arrival of the new flood season had just occurred an hour beforehand.(Fig.24)

The discharge measurements were carried out by wading during the low levels at the best sections available at the time, both upstream and downstream of the bridge and the gauge site. All medium and high flow measurements carried out from the downstream face of the bridge deck by suspension methods, using the point two, point three, and VVC methods of gauging the velocities in the verticals.

The single span bridge is a very good discharge gauging section with none of the usual velocity interference from pillars or abutments. Inspite of the record flood levels there was only slight scour and fill differences before and after the flood (see cross sections - Vol.3.,Sect.B.).

The discharge measurements observed, all plot within ± 5% of the curve in the medium to high range. Due to the very sandy bed conditions at the gauge site there will most definitely be a shifting rating over a period of time in the lower sector of the curve (see rating comparisons). The major overbank spillage takes place from gauge height 8.0 meters or 'MSL' 141.40 meters (397 m^3/sec).

b) Rating Comparisons 1962/65, 1968 & 1980/81

There is a difference between the three ratings throughout the whole range, with the largest differences occurring in the lower sector of the curves. The 1980/81 curve returns more water throughout the range than both the other curves. The 1962/65 curve fluctuates between the 1968 & 1980/81 curves. The percentage differences between the 1980/81 and 1968 curves are illustrated in TABLE.8., also the percentage differences after the adjustment for the slope difference in gauge height(0.05m) between the two sites.

TABLE .8.

1980/81-68 Rating Curve Percentage Differences

'MSL' meters	G.H. meters	Q(1980/81) m^3/sec	Q(1968) m^3/sec	% DIF *(Before)	% DIF (After)
135.0	1.61	19.0	12.0	-- 37.0	- 26.0
135.5	2.11	35.0	27.0	- 28.0	- 17.7
136.0	2.61	54.0	50.0	- 8.0	- 3.7
137.0	3.61	135.0	124.0	- 8.0	- 6.5
138.0	4.61	167.0	153.0	- 8.4	- 6.5
139.0	5.61	222.0	208.0	- 6.3	- 4.5
140.0	6.61	290.0	270.0	- 6.9	- 4.8

* Before & After slope adjustment.

The 1962/65 rating is similar to the 1968 curve at a discharge of 25.0 m^3/sec(G.H. 2.06 m), then converges with the 1980/81 curve at discharge 105 m^3/sec(G.H. 3.61 m) and finally reverts to being similar to the 1968 curve at a discharge of 260 m^3/sec (G.H. 6.61 m.). At the lower levels the projected 1962/65 curve returns 65% less water than the present 1980/81 rating.

It is not absolutely clear whether the ratings refer to the same gauge sites. However, it is indicated in the 1969 report 'Water Control and Management of The Shebelli River', that the water levels at that time were being observed from the 'MB' point on the bridge, as there were no gauge plates on the gauge stands. This would account for the fairly large differences between the curves even after the adjustment of gauge height for the slope factor. It would also stand to reason that the 1962/65 curve would have been related to the recorder site which is downstream of the present station, but has a section similar to the gauge site. Whether any adjustments for slope were ever carried out is not known. (Fig. 25).

There is a 0.05 meter slope difference between the bridge and gauge section, and similarly a further difference of 0.02 meters between the recorder site and the gauge site, making an overall difference between the bridge and the recorder site of 0.07 meters.

Any curve related to the bridge section would probably have the most stable low level rating, more-so than the present staff gauge and recorder site. It may be advantageous in the long term to establish the gauges on the bridge which would give a more stable section, and the gauges would have more chance of long term survival. At the present site the gauges are more apt to be washed away, and probably never replaced at the same levels.

With the uncertanties of which sections the various curves refer to, and whether the water levels were observed on the staff gauges or obtained from bridge depth observations, it is difficult to judge how far back the present rating curve should be applied with reliable accuracy. With the absence of any intermediate data (gaugings) from 1968 to 1979, and that gaugings have been carried out at much lower levels in the 1980/81 period, the recent curve must be accepted as the most accurate and utilised for volume calculations throughout the seventies decade, as long as adjustments are made to stage levels observed from the bridge deck.

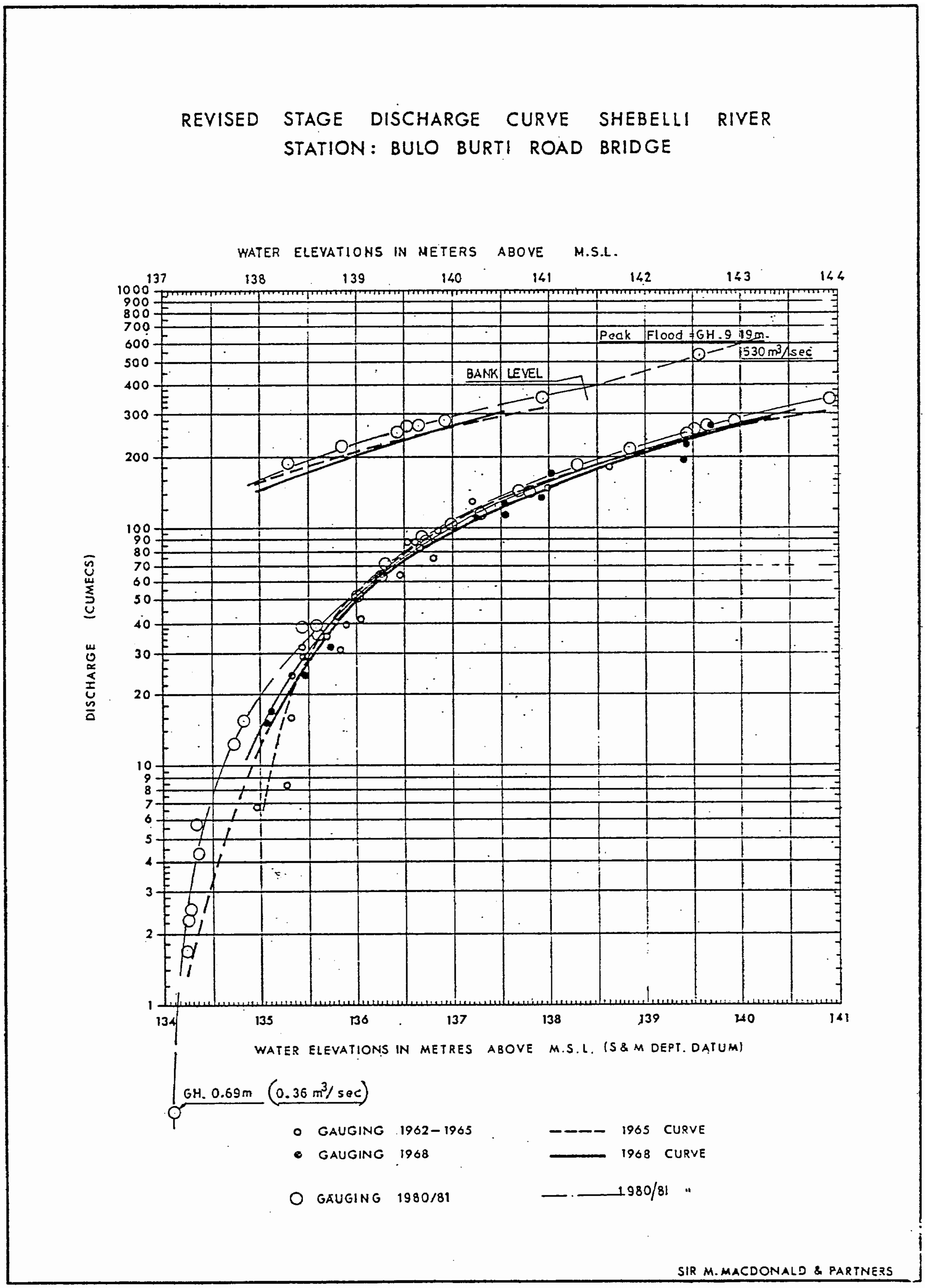

REVISED STAGE DISCHARGE CURVE SHEBELLI RIVER
STATION: BULO BURTI ROAD BRIDGE
WATER ELEVATIONS IN METERS ABOVE M.S.L.
137 138 139 140 141 142 143 144
DISCHARGE (CUMECS)
1000 900 800 700 600 500 400 300 200 100 90 80 70 60 50 40 30 20 10 9 8 7 6 5 4 3 2 1
Peak Flood = GH. 9.19m.
530 m³/sec
BANK LEVEL
134 135 136 137 138 139 140 141
WATER ELEVATIONS IN METRES ABOVE M.S.L. (S & M DEPT. DATUM)
GH. 0.69m (0.36 m³/sec)
GAUGING 1962–1965
GAUGING 1968
GAUGING 1980/81
1965 CURVE
1968 CURVE
1980/81 "
SIR M. MACDONALD & PARTNERS

FIG. 25.

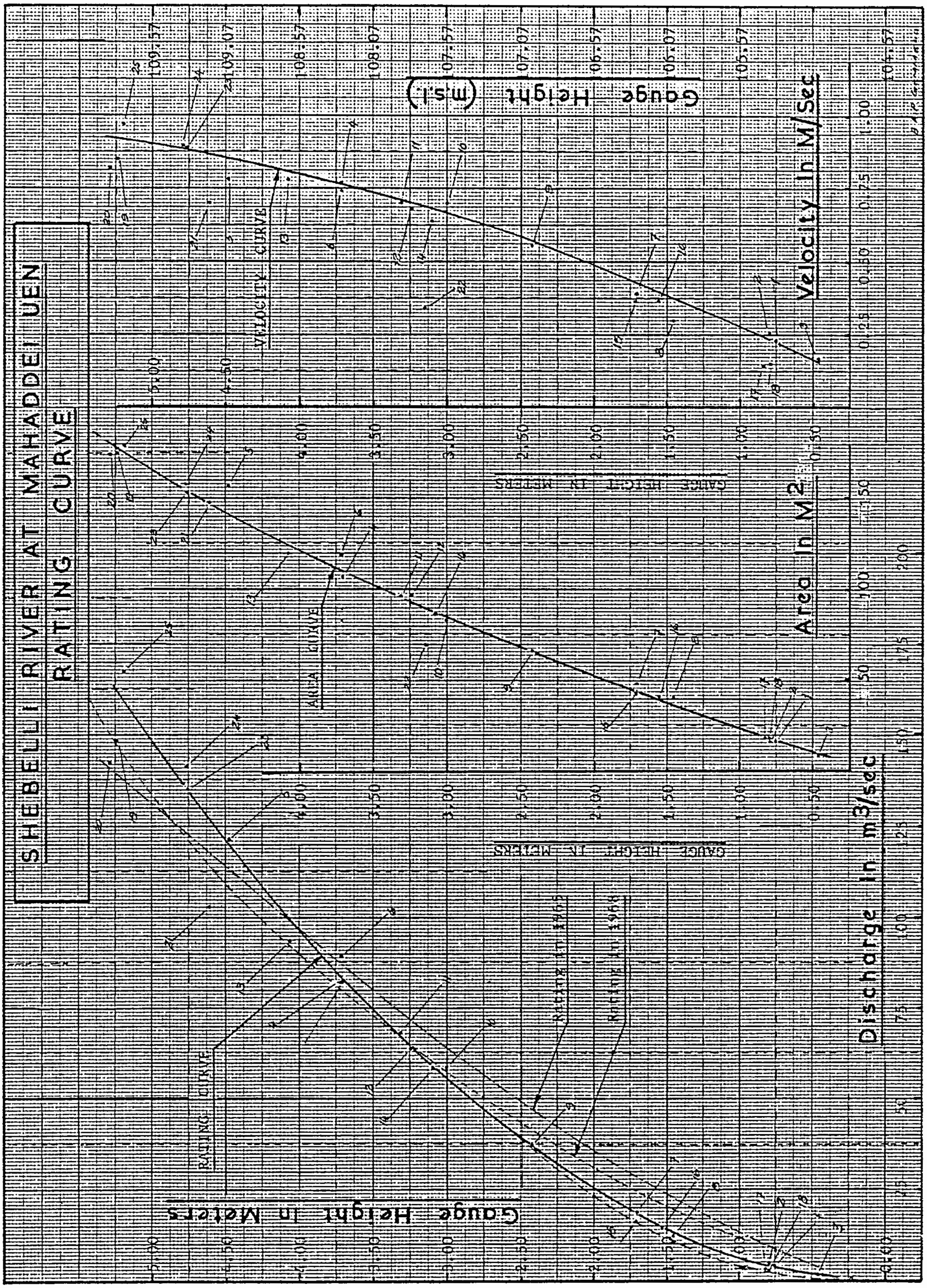

SHEBELLI RIVER AT MAHADDEI UEN
RATING CURVE
VELOCITY CURVE
AREA CURVE
RATING CURVE
Rating in 1965
Rating in 1968
Gauge Height (m.s.l.)
GAUGE HEIGHT IN METERS
GAUGE HEIGHT IN METERS
Gauge Height in Meters
Velocity in M/Sec
Area in M2
Discharge in m3/sec

FIG. 26.

7.3.2.3. MAHADDEI UEN

a) 1980/81 Rating Curve.

This rating curve was established from 25 discharge measurements taken between February 1980 and November 1981, over a range of 4.82 meters from gauge height 0.46 meters ($1.51m^3/sec$) to gauge height 5.28 meters ($148.5m^3/sec$).

In 1980 a total of 16 gaugings were taken, mainly in the lower sector of the curve between gauge height 0.46 meters ($1.51m^3/sec$) and gauge height 4.47 meters ($121.7m^3/sec$). The minimum annual water level was 0.44 meters ($0.61m^3/sec$) and the maximum 4.94 meters ($144.0m^3/sec$).

In 1981 an additional 9 measurements were carried out between gauge heights 0.79 meters ($2.60m^3/sec$) and 5.28 meters ($148.5m^3/sec$), and a maximum annual flood level of 5.29 meters with the river running dry in March the same year (Fig.26)

It appears that the 'Barrage' installation downstream at Sabuun probably affects the discharge at Mahaddei Uen, both at high and low levels. The present 1980/81 rating curve returns less water below gauge height 3.30 meters ($66.0m^3/sec$), and more water in the upper section of the rating curve.

The flood peak levels are controlled by the 'overbank' spillage which occurs upstream of Mahaddei Uen. This is illustrated by the peak water level at Mahaddei Uen in 1981 (5.29m) being only 0.10 meters higher than the much smaller floods in 1980 which peaked at 5.19 meters, inspite of the exceptional record floods which produced gauge heights in excess of one and two meters above the normal flood levels at Belet Uen and Bulo Burti.

The flood levels at Mahaddei Uen are controlled or regulated by the extent of flood bank breaching and bank over topping, which occurs upstream of Mahaddei Uen and downstream of Jalalaqsi. In 1981 intentional breaching of the flood bunds occurred prior to the arrival of the main floods in May.

The excess overbank and flood relief discharges collected in the low depression nothwest of Mahaddei Uen, then began to flow in a southward direction away from the river, parallel to the old river channels. The water breached the main asphalt northern trunk road to Belet Uen, ten kilometers west of Mahaddei Uen on about the 20/4/81. The water continued southwards for a further 80 kilometers, and breached the Mogadishu to Baidowa road on the 11/6/81, near the village of War Maxan. The loss of this water from the main river system maintains a very steady flood level at Mahaddei Uen, as illustrated by the flat topped hydrographs(Fig.1

The low flows at 'Sabuun Barrage' are theoretically supposed to be maintained at natural river flow discharges. However, if the operation of the 'Penlock Gates' in the headworks are not operated according to the planned schedule, varying results in rating can be expected at Mahaddei Uen. The Sill level of the 'Sabbun Barrage' has an 'MSL' value of 105.29 meters, which is 0.65meters higher than the gauge zero level at Mahaddei Uen ('MSL' 104.57 m), therefore making the gauging site at Mahaddei Uen susceptible to backwater effects.

This situation can also be expected to act in reverse during the periods of high flow. Under normal flooding situations, 'overbank' flooding downstream of Mahaddei Uen would tend to cause backwater effects due to reduced energy gradients, thereby reducing the discharge through the bottle neck at the station. However, with the extraction of $50m^3$/sec from the main river channel into the 'Offstream Storage Resevoir' the water level is maintained within the main channel, so the energy gradient is increased thereby increasing the discharge at Mahaddei Uen gauging station.

Measurements observed prior to the peak flood, when the Barrage gates were partially closed in order to increase the upstream pool level, were found to have lower discharges than the observations taken with free flow through the Barrage and offtake structure. Observations in April 1981 at gauge height

5.29 meters had a discharge of $142.5m^3/sec$, while later measurements returned a discharge of $167m^3/sec$ at a lower gauge height of 5.12 meters. This constitutes an increase in discharge of about 18% for a 0.10 meter fall in gauge height.

b) Rating Comparisons (1965/68 & 1980/81)

The new rating curve returns much less water over the lower reaches of the rating but agree's with the other curves in the upper range, except when the "Offtake" at the Sabuun Barrage downstream of the station is operating at high discharges (40 - $50m^3/sec$), and there is free flow through the Barrage, with the river levels maintained within the river banks. Therefore, it is impossible to compare the old and new rating, or decide whether any siltation of the channel has occurred. Under the present circumstances the present rating will have to be used for all comparisons relating to data collected during and after the construction of the Sabuun Barrage to date. The 1968 curve will have to surfice for all data collected between 1970 and 1979. (Fig.27)

Regular gauging will have to be carried out at this site, in order to maintain reliable discharge information. All future gaugings should be related to the operational situation at the Barrage, mainly by having copies of the daily operation schedules carried out at the Barrage, with which to correlate the discharge measurements.

It appears that a certain amount of siltation has occurred on the right bank near the bridge, as illustrated by the old set of gauges fixed to the right bank bridge abutment being completely silted over. The gauges were only located by the consultant while carrying out flood work investigations along the river bank. These gauges are not mentioned in other reports so it would appear that the gauges were silted over a long time ago. They must relate to the Italian data mentioned in the report on "Control and management of the Shebelli river", when the gauges were used only for flood warning purposes.

7.3.2.4. BALAAD.

a) 1980/81 Rating Curve.

Unfortunately no complete rating curve was established because the station was closed, due to the "Korean Barrage" coming into operation on the same day the recorder was installed at the station. The presence of the 'Barrage' was only discovered when the water level at the station started rising for no apparent reason, when the Recorder was installed. A recce downstream of the station revealed the presence of the 'Barrage' and the re-direction of the river flow through the Barrage channel.

Prior to the diversion of the river through the Barrage, only two low level discharge measurements were taken and four additional measurements taken later on at high levels only as 'Spot discharge' checks. However, the measurements obtained have been plotted over the old 1965/68 curve, and is explained in the following rating comparisons section.

b) Rating Comparisons (1962/65, 1968 & 1980/81

The Six measurements plotted over the old curves (Fig.28) indicate that the initial two low gaugings fit the 1965 curve, and were the two lowest points ever gauged. Only three high level measurements were taken in 1968, therefore the low curve was not established, or checked against the previous curve.

The present low level gaugings suggest that there has not been any significant change to the section with regard to siltation of the low control.

The high level gaugings have no significance or relation to the rating as they were affected by the backwater effects in the Barrage resevoir.

The high level discharges clearly illustrate the fall in velocities at the station, which will present siltation problems in the future. The installation of this Barrage and the 'Johar Offstream Storage Resevoir' will render the old Lockwood/FAO correlations obsolete.

REVISED STAGE DISCHARGE CURVE SHEBELLI RIVER
STATION : MAHADDEI UEN ROAD BRIDGE

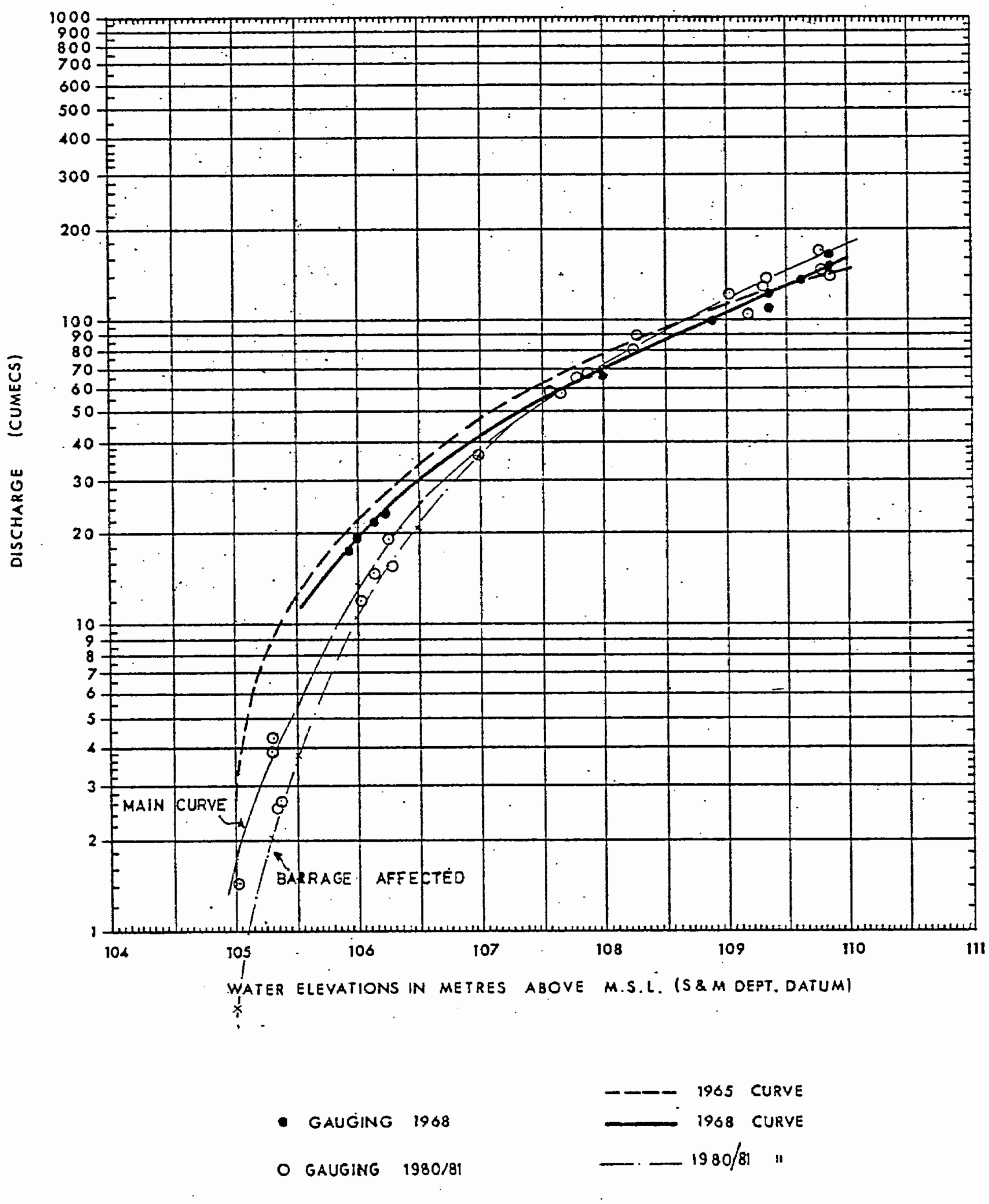


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FIG. 27.

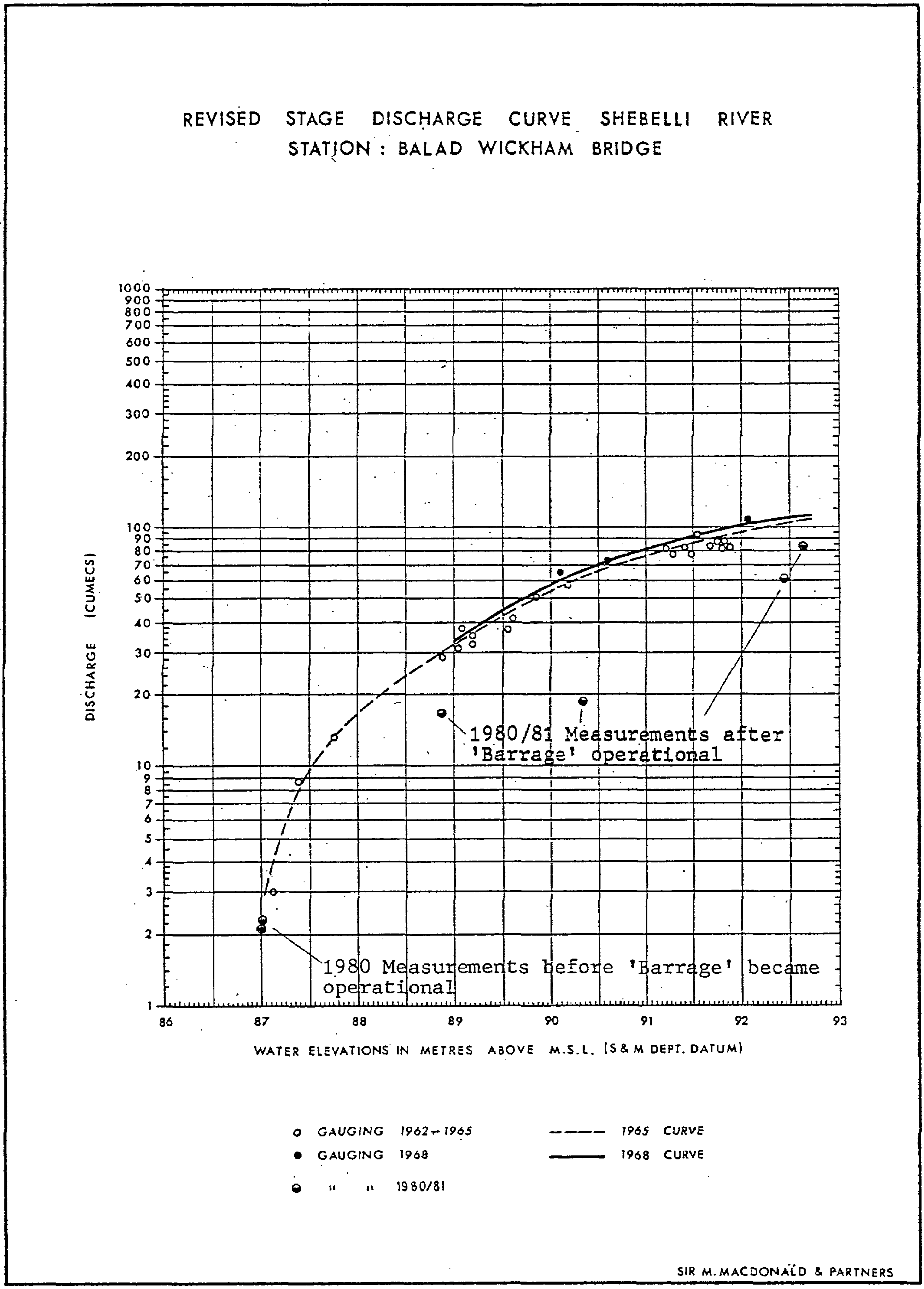

REVISED STAGE DISCHARGE CURVE SHEBELLI RIVER
STATION : BALAD WICKHAM BRIDGE
DISCHARGE (CUMECS)
WATER ELEVATIONS IN METRES ABOVE M.S.L. (S & M DEPT. DATUM)
1980/81 Measurements after 'Barrage' operational
1980 Measurements before 'Barrage' became operational
GAUGING 1962 - 1965
GAUGING 1968
" " 1980/81
1965 CURVE
1968 CURVE
SIR M. MACDONALD & PARTNERS

FIG. 28.

7.3.2.5. AFGOI.

a) 1980/81 Rating Curve.

A total of 14 discharge measurements were carried out over the Project period February 1980 to November 1981. The observation water levels ranged from cease-to-flow levels, only standing pools in the river bed to a peak gauge height of 4.88 meters.

The 9 measurements observed in 1980 were from gauge height 1.06 meters ($1.27m^3/sec$) to gauge height 3.82 meters ($61.6m^3/sec$). The maximum annual water level was 4.88 meters ($99.01m^3/sec$), with a minimum level of 0.40 meters with no flow recorded.

An additional 5 measurements were carried out in 1981 between gauge heights of 1.50 meters ($6.54m^3/sec$), and 4.88 m ($99.01m^3/sec$) the same level recorded in 1980. (Fig.29.)

The river dried up completely from mid December in 1980 until the onset of the 'GU' floods on the 25th March 1981. The cease-to-flow level at the gauging station was approximately 0.25 meters gauge height (See photograph-Vol.3, Sect.E.)

The gauging section under the new bridge downstream face is fairly stable, but velocities are subject to disturbance caused by the variable amounts of flood debris which gets trapped against the trestle support pillars of the derelict bridge, situated 10 - 15 meters upstream. The collection of this debris also influences the amount of scour and fill which takes place during the cycle of the flood. The removal of this old bridge and hindering pillars would greatly improve the standard and quality of the discharge gaugings and water level observations.

Although only 14 measurements were carried out to establish the rating, they did cover the maximum range possible over the duration of the Project, and with the flow in the lower Shebelli now being maintained within the river banks, because of the controlled extraction of a maximum of $50m^3/sec$ upstream at Sabuun, the flood peak at Afgoi will not exceed a gauge height much in excess of 5.0 meters.

The measurements are fairly well distributed over the rating range, although additional measurements between 3.50 and 5.00 meters would be appreciated to show whether there is a reduced discharge effect above the 3.50 meter level, as indicated in the 1962/65 and 1968 ratings. The present data does not confirm the old concept, but indicates the opposite of a natural progressive curve.

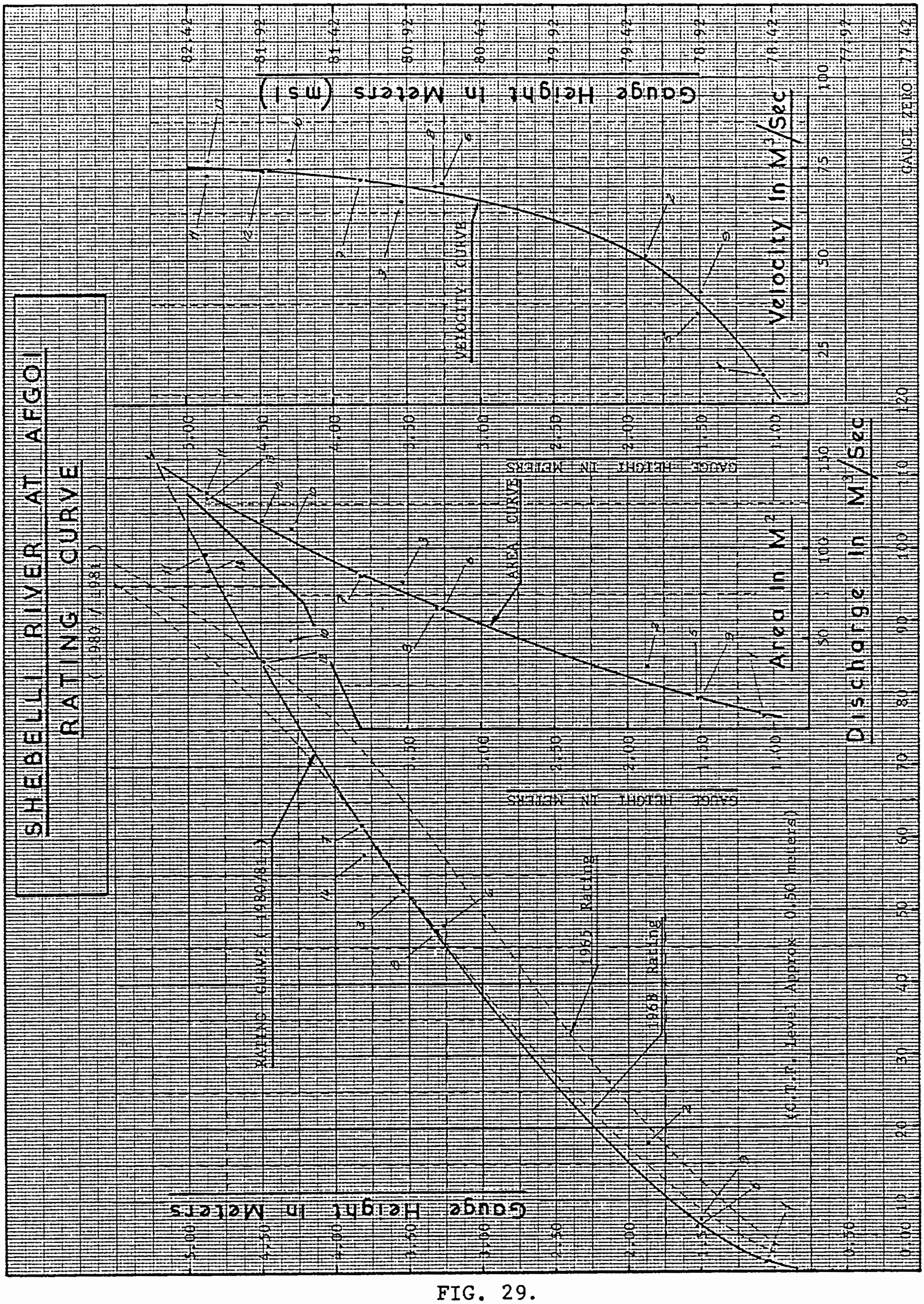
b) Rating comparisons (1962/65-1968 & 1980/81)

The 1980/81 rating is similar to the 1968 rating below a 70m $^3/$sec discharge level, but indicates more discharge above that level (4.08meters). Throughout the discharge range of the 1962/65 rating it has an average of 19.5% more discharge over the 1968 curve, with a maximum difference of 43% more water at gauge height 1.58 meters (7.73m$^3/$sec), to a minimum of 4.0% difference at gauge height 5.58 meters (100m$^3/$sec). The 1980/81 curve diverges from the 1968 curve at a gauge height of 4.08 meters, becoming similar to the 1962/65 curve at a gauge height of 4.55 meters (86.0m$^3/$sec), reaching a discharge of 106m$^3/$sec at a gauge height of 5.08 meters.(Fig.30).

Three additional measurements were observed between 1965 and 1967, but all between the 80 - 90m$^3/$sec range, and in general tend to confirm the 1968 high level rating, although a fairly large scatter would tend to suggest rather unreliable observations.

The present high and medium level measurements taken from the downstrean face of the new bridge, would tend to be more accurate than the measurements carried out by suspension means, from either the upstream or downstream face of the old bridge. The observation meter would not be affected as much by the large amounts of flood debris that builds up around the pillars of the old bridge.

When the two older curves are plotted on natural scale paper, there is a distinct attenuation of discharge in



SHEBELLI RIVER AT AFGOI
RATING CURVE
(1980 / 1981)
Gauge Height in Meters (msl)
Velocity in M/Sec
VELOCITY CURVE
GAUGE HEIGHT IN METERS
AREA CURVE
Area in M²
Discharge in M³/Sec
RATING CURVE (1980/81)
1965 Rating
1968 Rating
(C.T.P. Level Approx 0.50 meters)
Gauge Height in Meters
GAUGE ZERO 77.42

FIG. 29.

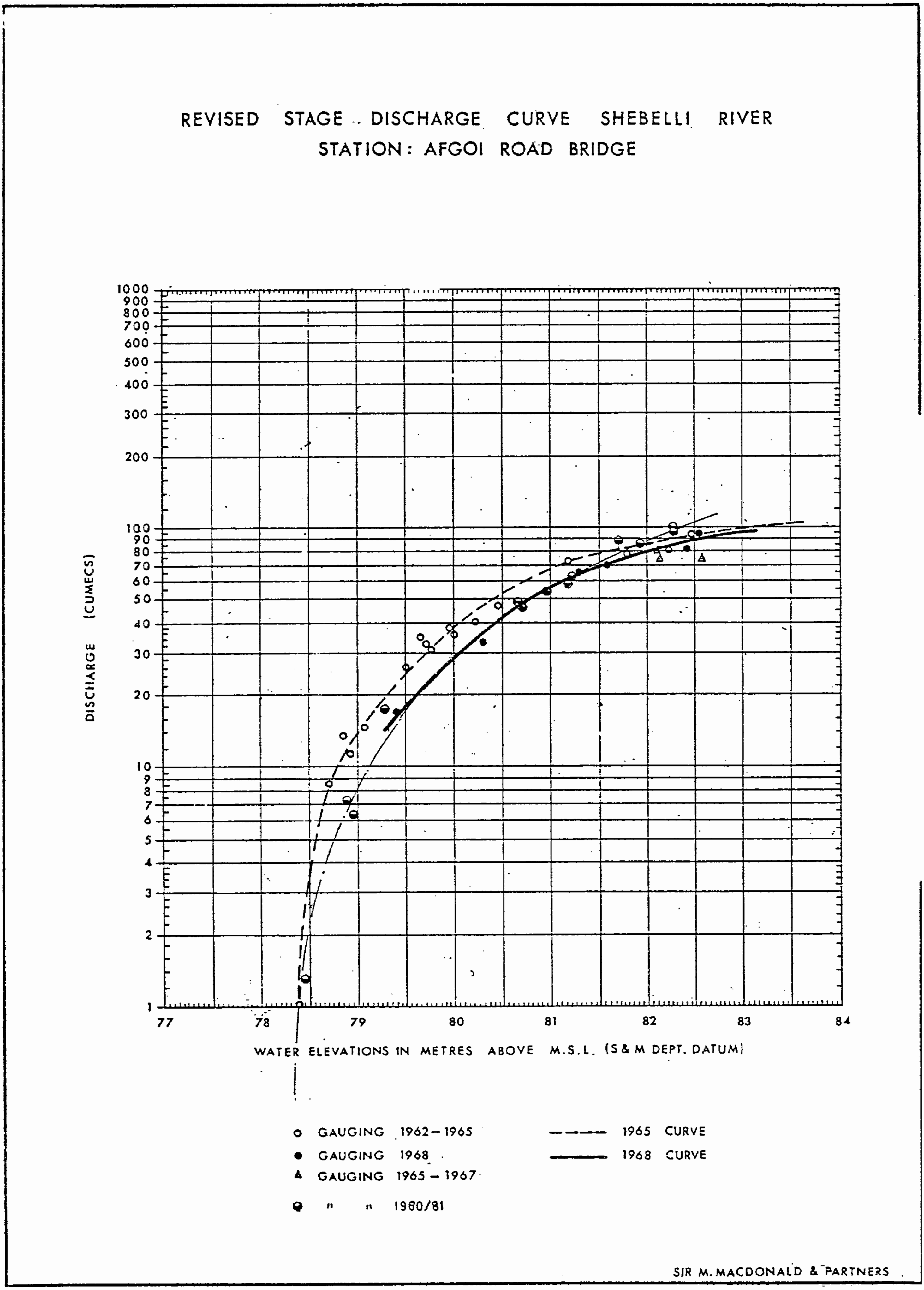

REVISED STAGE - DISCHARGE CURVE SHEBELLI RIVER
STATION: AFGOI ROAD BRIDGE
DISCHARGE (CUMECS)
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
77
78
79
80
81
82
83
84
WATER ELEVATIONS IN METRES ABOVE M.S.L. (S & M DEPT. DATUM)
GAUGING 1962 – 1965
GAUGING 1968
GAUGING 1965 – 1967
" " 1980/81
1965 CURVE
1968 CURVE
SIR M. MACDONALD & PARTNERS

FIG. 30 .

relation to increase in water level above a gauge height of 3.75 meters. This would suggest a restriction, or intersecting inflow immediately downstream of the station. None of these factors actually apply and the Genale Barrage is too far downstream to effect this station, so at present there is no valid data to support the older supposition. However, it is possible that with the flow now being contained within the channel banks, the flood gradient is retained, thereby maintaining the higher velocities and increased discharge, as illustrated by the recent curve. To resolve this point satisfactoraly, additional gaugings should be taken as soon as possible.

In the meantime, and with the absence of intermediate gauging data (1969-79), the 1968 curve would have to apply to all data collected prior to the building of the offstream storage resevoir at Johar and the 'Korean Barrage ' at Balaad, which would be pre - 1980. The 1980/81 curve will relate to all future data, until proved otherwise in the light of additional information..

7.3.2.6 AUDEGLE.

a) 1980/81 Rating Curve.

A total of 14 discharge measurements were taken between February 1980 and November 1981, from gauge height 1.26 meters ($0.54m^3/sec$) to gauge height 5.36 meters ($94,42m^3/sec$). In 1980 the eleven measurements were gauged between gauge heights 1.26 and 5.20 meters ($72.10m^3/sec$). The three observations carried out in 1981 were all in the top half of the curve between gauge heights 4.90 meters ($84.3m^3/sec$) and 5.36 meters ($94.6m^3/sec$) (Fig.31).

The river ceased-to-flow in 1980 and 1981, with Jan/March 1981 being the most severe case of drought for seven years and the river being absolutely bone dry. Water was only located by sinking two to three meter wells in the river beds. The low flow rating section being affected in the process.

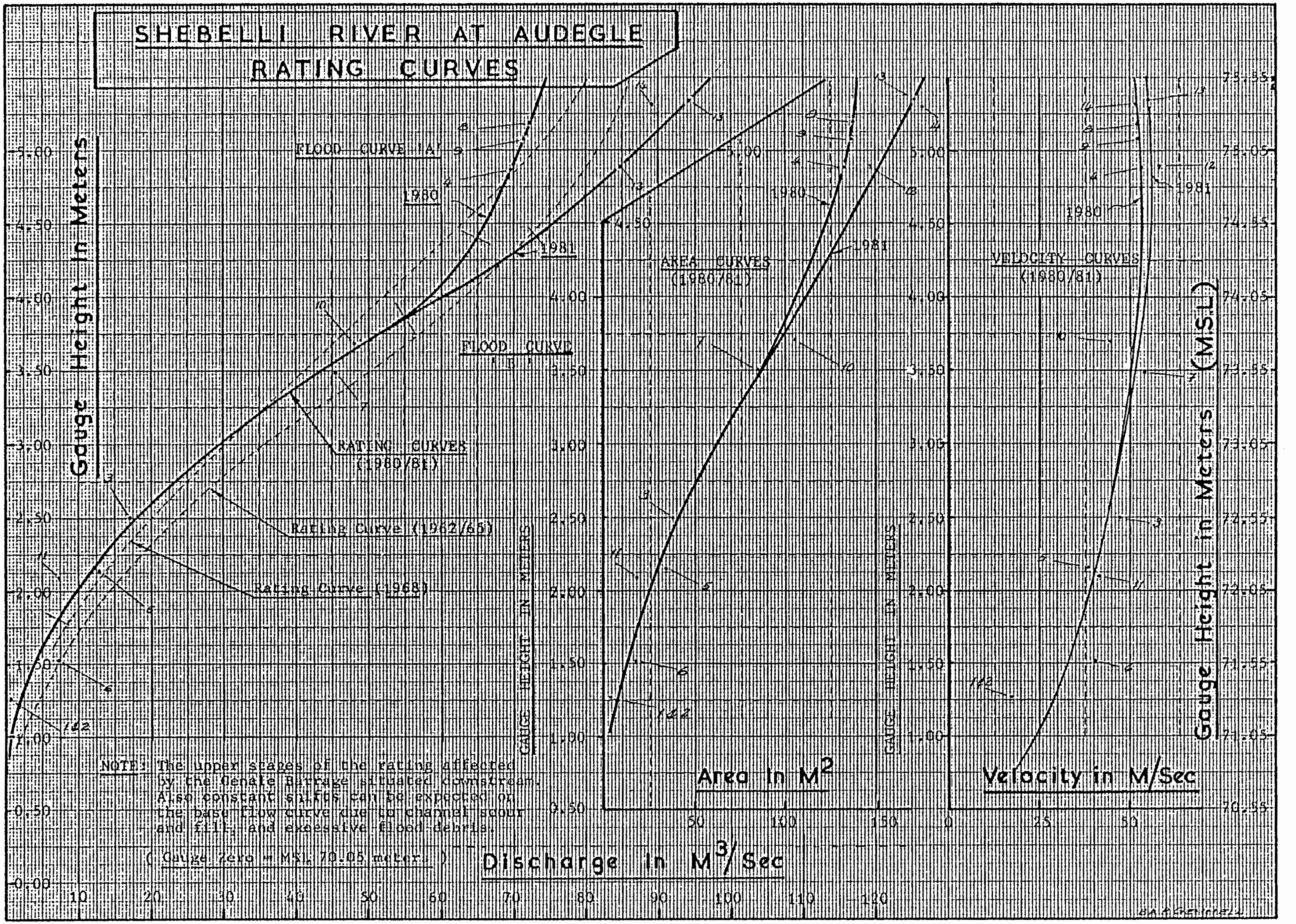
The peak flood level in 1980 was 5.72 meters ($76.6m^3/sec$), and slightly lower at 5.56meters in 1981 (98.5m^3/sec). It is interesting to note that a fall of 0.16 meters in peak level water in the 1981 rating returns a 28.7% increase in discharge.Inspite of the record floods in the upper and middle Shebelli in 1981, the flood peak at Audegle was higher in 1980. The malfunction of the 'Genale Barrage' gates must be mainly responsible for this situation, and the 'Overbank' flooding which reduced the energy gradient of the river in the Audegle area.

The measurements clearly illustrate the fact that there can be a variable rating curve depending on the 'Cverbank' flooding accuring downstream. In the future the flow will be more controlled on the lower Shebelli due to the inauguration of the "Johar Offstream Storage Reservoir" and the 'Balaad Barrage'. In 1981 a breach in the flood retention bund at Dar-es-Salaam between Audegle and Genale, would have increased the outflow of water from the channel system which would have helped in increasing the energy gradient at Audegle, and therefore an increased discharge for a lower gauge level.

The gauging section is not good because of the trestle type bridge pillars which are excellent flood debris traps, which due to the effects on the velocities by the varying amount of debris trapped round the pillars, tends to cause scour and fill at different points in the section. This constant change in deposits causes substantial shift in the lower stages of the rating curve, as illustrated by the differences between the 1980 and 1981 stage ratings. Regular gaugings must be continued indefinitely if the collection of reliable representative data is to be maintained.

b) <u>Rating Comparisons (1962/65,1968 & 1980/81)</u>

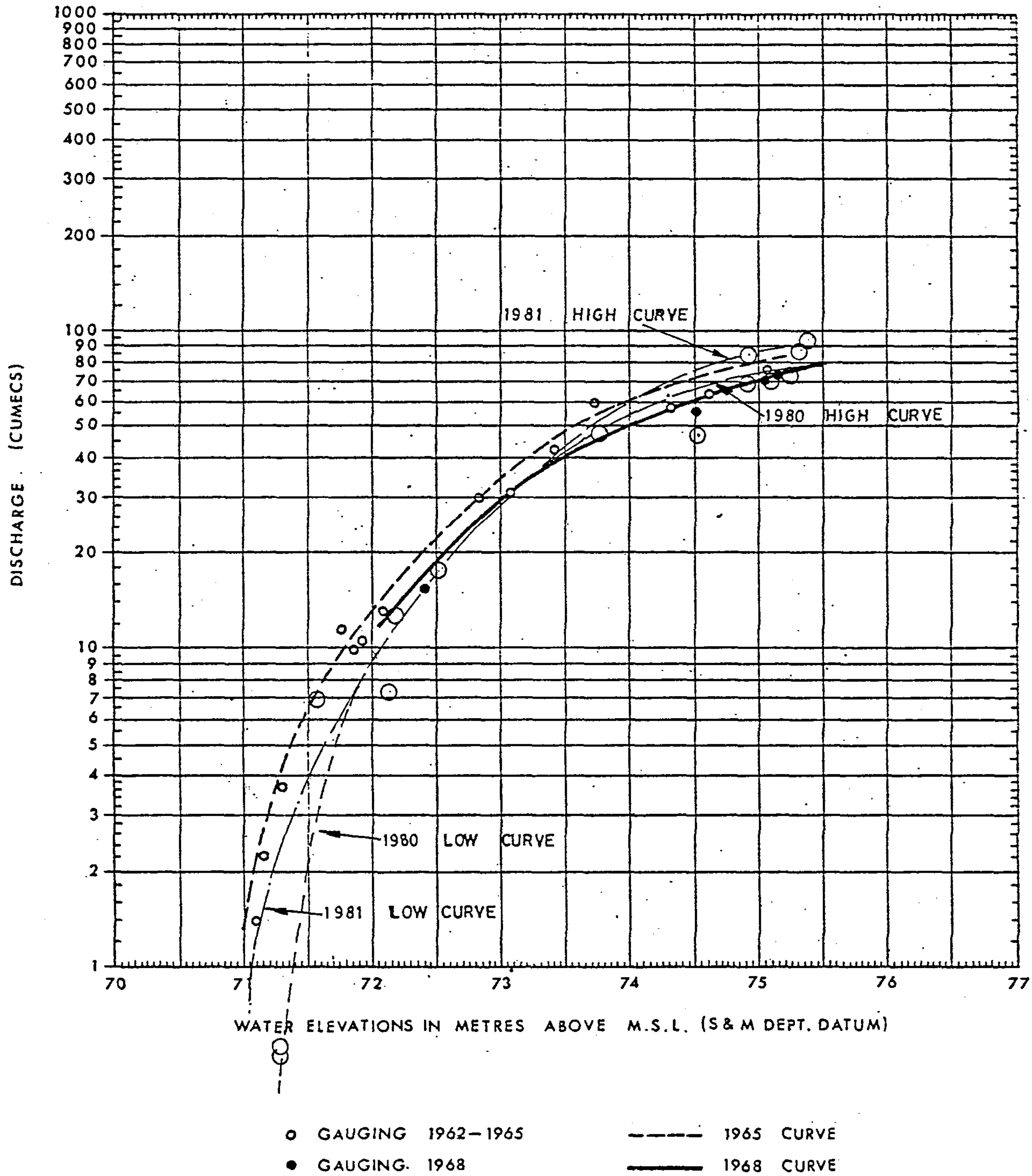
The 1980/81 rating has been superimpossed over the original 1961/65 and 1968 rating curves (<u>Fig.32.</u>) and shows that both recent low ratings return less water than the 1962/65 and 1968 curves.It then becomes common with the 1968 curve at a discharge in the order of 35m^3/sec. The 1980 high curve tends to fall



SHEBELLI RIVER AT AUDEGLE
RATING CURVES
FLOOD CURVE (A)
1980
1981
FLOOD CURVE (B)
RATING CURVES (1980/81)
Rating Curve (1962/65)
Rating Curve (1968)
AREA CURVES (1980/81)
VELOCITY CURVES (1980/81)
Gauge Height In Meters
GAUGE HEIGHT IN METERS
Gauge Height in Meters (M.S.L)
Area In M2
Velocity in M/Sec
Discharge In M3/Sec
NOTE: The upper stages of the rating affected by the Genale Barrage situated downstream. Also constant shifts can be expected of the base flow curve due to channel scour and fill, and excessive flood debris.
(Gauge zero = MSL 70.05 meter.)

FIG. 31

REVISED STAGE DISCHARGE CURVE SHEBELLI RIVER
STATION: AUDEGLE ROAD BRIDGE



SIR M. MACDONALD & PARTNERS

FIG. 32.

between the 1962/65 and 1968 rating curves, with the higher discharge curve of 1981 returning the highest discharges to-date above the 70 m^3/sec gauge height.

In the lower stages both the 1980 and 1981 curves return less water than the 1965 curve, with the 1981 low curve moving back closer to the 1965 discharges. It appears that there are a number of factors which affect the rating at this station at varying times, thereby causing shifts in the rating curve in both the high and low stages. This situation can only be countered by the regular and reliable observation of discharge at the site.

The original local benchmark with accompanying 'MSL' value was destroyed sometime in the seventies. The present 'MSL' value has been transferred by traverse survey from National Benchmark NO: 307, situated one kilometer away. It is assumed that the levels are similar and related to the same sea level datum.

The overall conclusion is that the present 1981 curve is representative of the present and future discharges, until additional gaugings dictate otherwise. The 1981 curve should also be used to update the flow data from 1977 to-date, as done at Belet Uen and Lugh Ganana in this report.

The large differences found between the 1980/81 curves suggest that the changes in rating occur rather rapidly, rather than gradually over a long period of time. If change takes place it is probably over a single flood event, brought on by some uncontrolled situation like excessive buildup of debris round the bridge pillars, or reduced velocities during low flow periods due to 'Barrage' gates being closed, causing an excess of sediment deposits at various sites.

Maximum and minimum boundry ratings can be established to accomodate all the rating curve variations to-date, with the mean curve being used to calculate the volume flows over the past decade .

8.0. SEASONAL RIVER COURSES (Somali Catchments)

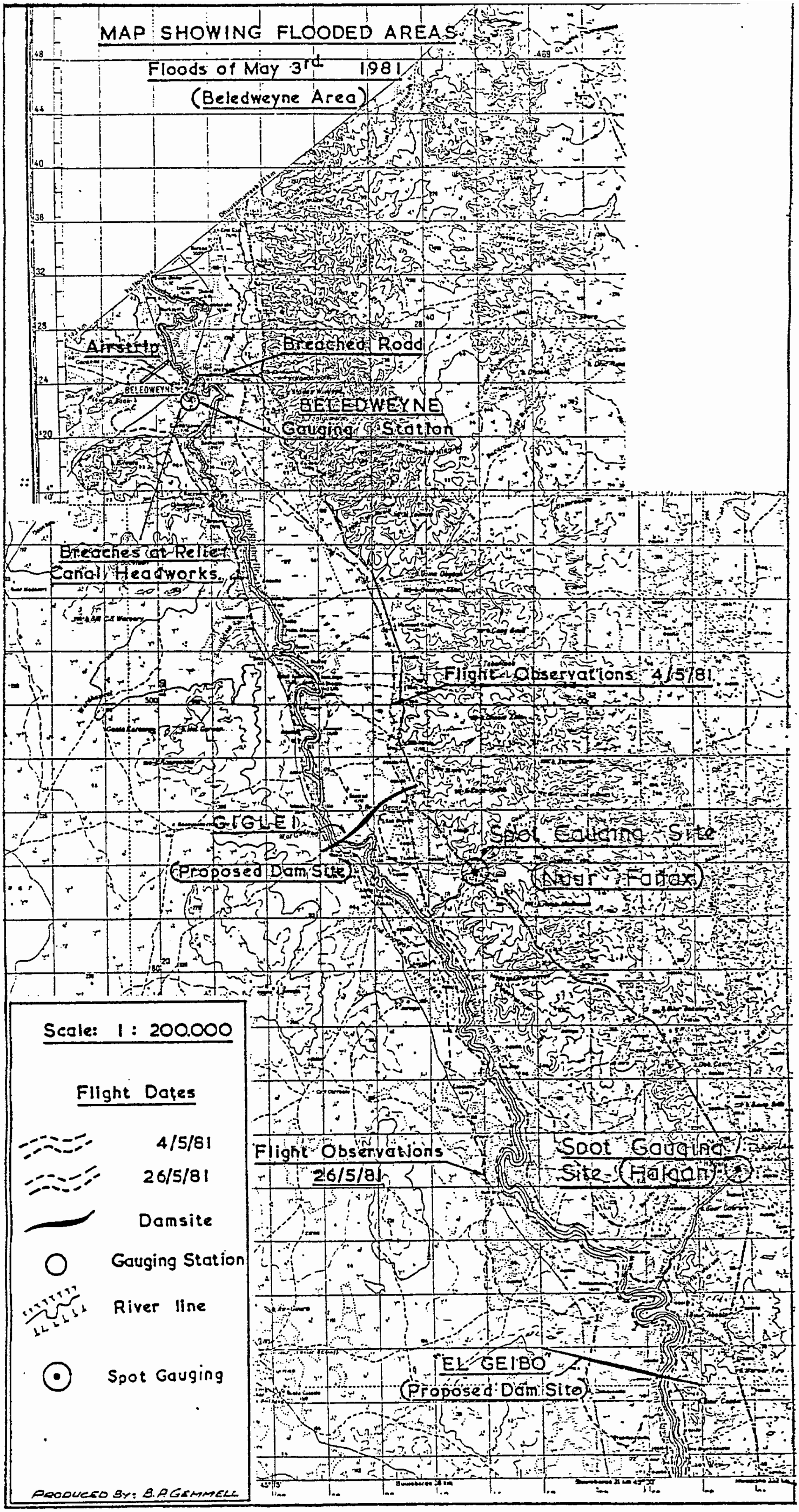
The shortage of operational field staff, equipment and time, prevented any detailed work being carried out with regard to the seasonal 'flash flows' which contribute to the Shebelli River annual discharge, from catchments situated between Bulo Burti and Belet Uen (Fig.33). However, spot observations were carried out by the consultant, whenever flood occurances were noted during field operations at selected sites. The selected sites on the Shebelli River were at Halgan (Quarant Uno) on the Wadi Kelli Gurat, and at Nurr Fanax on the Wadi Kelli Carro. Observations were also taken near Bur Acaba, on the Wadi Bur Acaba in the Inter-Riverine area.

Slope area measurements were carried out of peak flood marks, and calculations of flood volumns made in relation to duration information obtained from local inhabitants, and some field observations. (See Appendices G,H & I, for details)

Close inspection of the bridges at these sites indicated that staff gauges had been attached to the abutments sometime in the past.Unfortunately none of the gauges remain intact, nor is any installation data available at the Ministry of Agriculture in Mogadishu. Although this information is not available in Mogadishu, it must be available from some other source. In the (MMP./HTS) report "Water Control and Management of the Shebelli River" reference's are made to calculations being made of the local run-off contributions from local catchments within Somalia to the Shebelli river, estimated at 10% of the annual flow in normal years. Presumeably this data was obtained from observations carried out at these sites. All efforts must be made to retrieve this valuable data for inclusion to the Ministries permanent records.

8.1. Wadi Kelli Gurat at Halgan (Quarant Uno)

This 'togga' (Wadi) drains the low hills which lie to the east of the Wadi Kelli Carro and Boho watersheds, and east of the main road from Bulo Burti to Belet Uen. (Fig.34.)



MAP SHOWING FLOODED AREAS
Floods of May 3rd 1981
(Beledweyne Area)
Airstrip
Breached Road
BELEDWEYNE
Gauging Station
Breaches at Relief Canal Headworks
Flight Observations 4/5/81
GIGLEI
(Proposed Dam Site)
Spot Gauging Site
(Nuur Fanax)
Flight Observations 26/5/81
Spot Gauging Site (Halgan)
EL GEIBO
(Proposed Dam Site)
Scale: 1 : 200.000
Flight Dates
4/5/81
26/5/81
Damsite
Gauging Station
River line
Spot Gauging
PRODUCED BY: B.A.GEMMELL

FIG. 33.

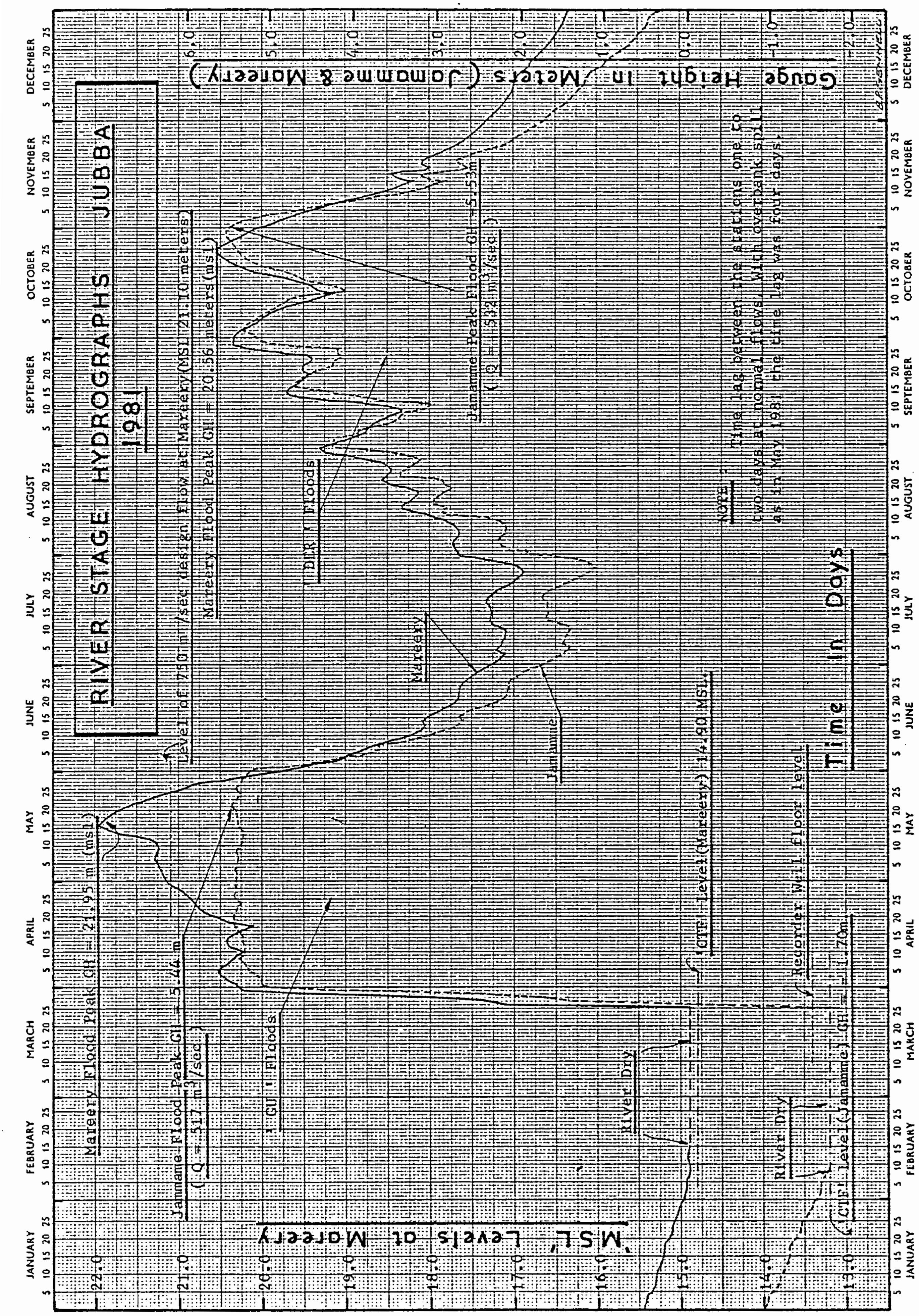

RIVER STAGE HYDROGRAPHS JUBBA
1981
Mareery Flood Peak GH = 21.95 m (msl)
Jamamme Flood Peak GH = 5.44 m
(Q = 517 m3/sec)
'GU' Floods
Level of 750 m3/sec design flow at Mareery (MSL 21.10 meters)
Mareery Flood Peak GH = 20.56 meters (msl)
'DER' Floods
Mareery
Jamamme
Jamamme Peak Flood GH = 5.53m
(Q = 532 m3/sec)
NOTE: Time lag between the stations one to two days at normal flows. With overbank spill as in May 1981 the time lag was four days.
River Dry
River Dry
'CTE' Level (Mareery) 14.90 MSL
Recorder Well floor level
'CTE' Level (Jamamme) GH = 1.70m
'MSL' Levels at Mareery
Gauge Height in Meters (Jamamme & Mareery)
Time in Days
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIG .8.

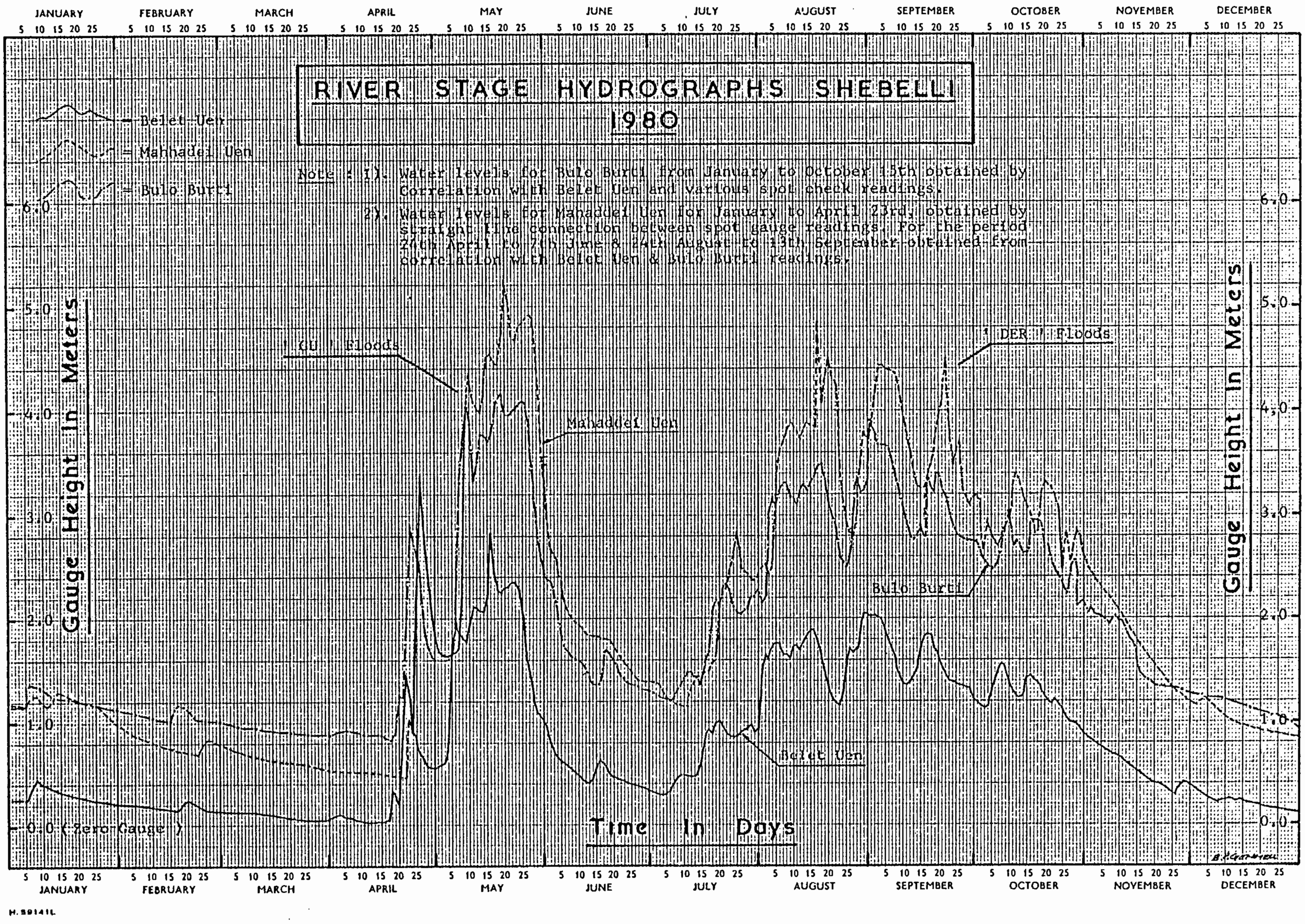
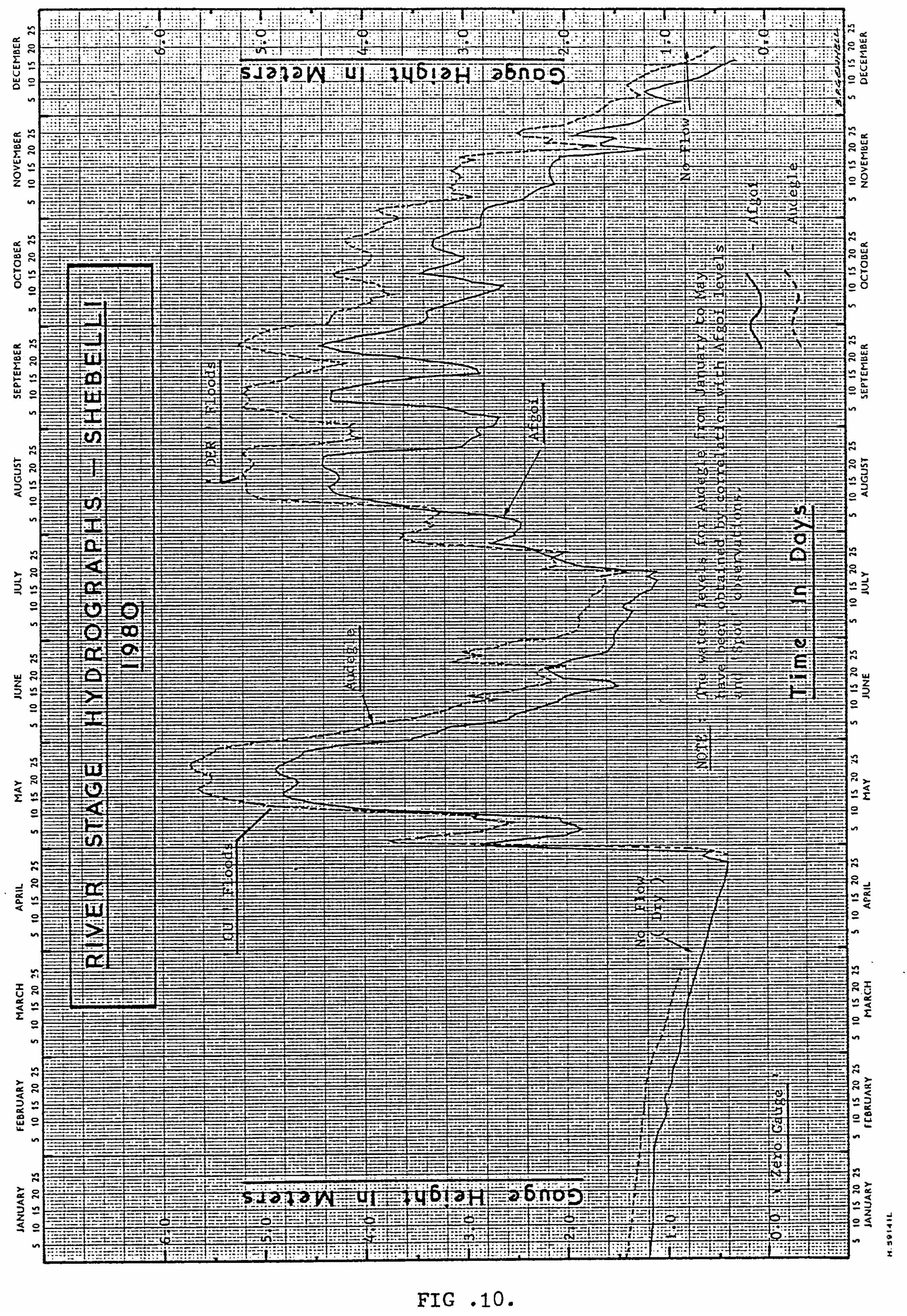
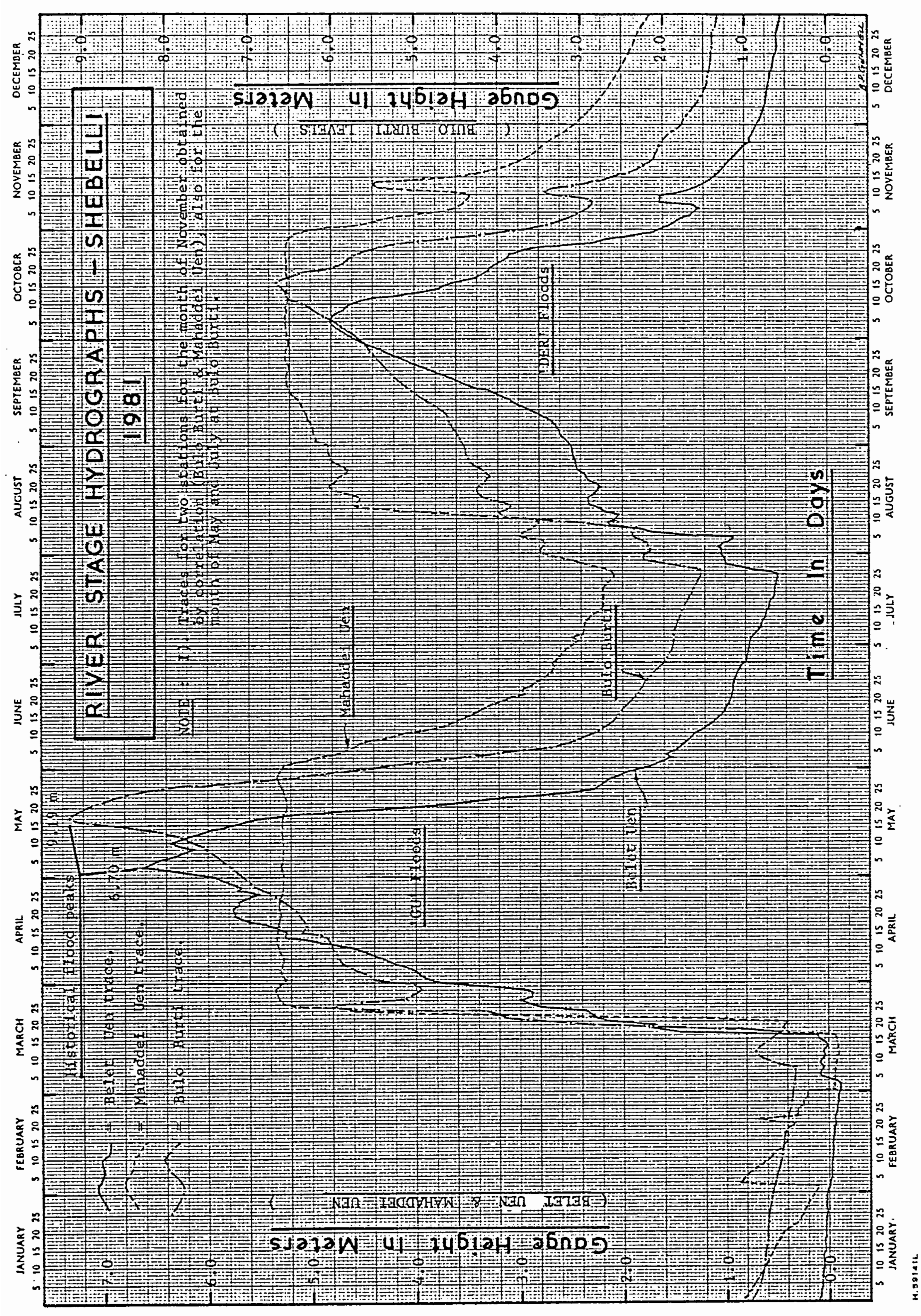

RIVER STAGE HYDROGRAPHS SHEBELLI
1980
= Belet Uen
= Mahhadei Uen
= Bulo Burti
Note : 1). Water levels for Bulo Burti from January to October 15th obtained by correlation with Belet Uen and various spot check readings.
2). Water levels for Mahaddei Uen for January to April 23rd, obtained by straight line connection between spot gauge readings. For the period 26th April to 7th June & 24th August to 13th September obtained from correlation with Belet Uen & Bulo Burti readings.
' GU ' Floods
' DER ' Floods
Mahaddei Uen
Bulo Burti
Belet Uen
Gauge Height In Meters
0.0 (Zero Gauge)
1.0
2.0
3.0
4.0
5.0
6.0
Time In Days
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25
H. 59141L

FIG .9.



RIVER STAGE HYDROGRAPHS — SHEBELLI
1980
Gauge Height in Meters
Time in Days
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Zero Gauge
No Flow (Dry)
CU Floods
Audegle
Afgoi
DER Floods
No Flow
NOTE: The water levels for Audegle from January to May have been obtained by correlation with Afgoi levels and spot observations.

FIG .10.



RIVER STAGE HYDROGRAPHS – SHEBELLI
1981
NOTE:- 1). Traces for two stations for the month of November obtained by correlation (Bulo Burti & Mahaddei Uen). Also for the month of May and July at Bulo Burti.
Historical flood peaks
9.19 m
6.70 m
= Belet Uen trace.
= Mahaddei Uen trace.
= Bulo Burti trace.
GU Floods
DER Floods
Mahaddei Uen
Bulo Burti
Belet Uen
Gauge Height In Meters
(BELET UEN & MAHADDEI UEN)
(BULO BURTI LEVELS)
Time In Days
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

FIG .11.

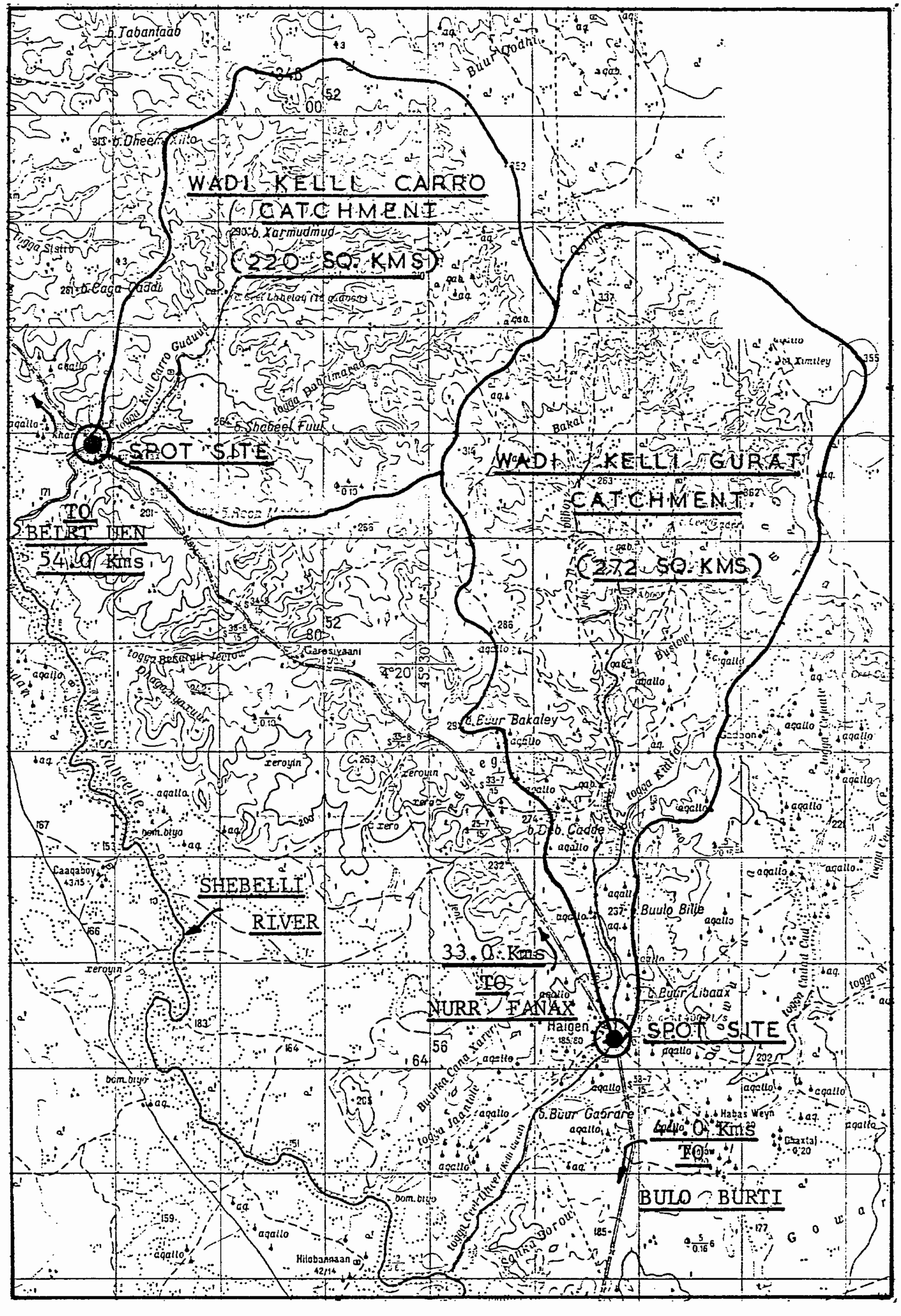

WADI KELLI CARRO CATCHMENT
(220 SQ. KMS)
SPOT SITE
TO BELET UEN 54.0 Kms
WADI KELLI GURAT CATCHMENT
(272 SQ. KMS)
SHEBELLI RIVER
33.0 Kms TO NURR FANAX
SPOT SITE
44.0 Kms TO BULO BURTI

FIG. 34.

In 1980 a minimum of three floods occured at this site, the largest occuring between the 8th and 10th of May. The duration of the whole flood was noted and recorded, as the consultant was in the area at the time. Flood surveys were carried out downstream of the road bridge, from which the flood peak, old flood and lower discharge levels were computed. From the resulting rating curve the flood volume discharges were calculated.

All the flood surveys details and ensueing flood calculations are included in (Appendix 'G'). The surveyed levels were related to a 'TBM' established on the downstream face of the left bank bridge abutment (Site Sketch-History notes)

The total flood volume was 5.17 m^3x10^6 with a mean flood flow of $28.7m^3/sec$. This volume discharge generated from a catchment area of 272 square kilometers returns a unit run-off of $0.0190m^3x10^6/km^2$, and a unit discharge of $1.096m^3/sec/km^2$. This unit discharge agree's favourably with similar run-off factors obtained in the semi-arid regions of Botswana, for similar type catchment and conditions. (F.A.O Report"The Water Resources of Eastern and Northern Botswana and their Development 1972").

The flood marks of a minor flood were observed on the 19/11/80. The flood most likely occured on the 6/11/80, at the same time as the flood observed in the Wadi Kelli Carro. Further flood events took place in 1981, but no details of flood peaks or durations are available.

When the flood survey was carried out older flood marks located were included. The highest flood marks found were old marks returning a maximum peak discharge of $374m^3/sec$, and a unit discharge of $1.38m^3/sec/km^2$.

8.2. Wadi Kelli Carro At Nurr Fanax.

Three major flood peaks were observed at this station, but duration data for only two. The first observed flood was from 8/5 to 10/5/80, and the second from 6/11 to 8/11/80. The largest flood occured at the end of March or beginning of April 1981. Unfortunately the duration data was not obtained for this flood. Very inadequate information from the local inhabitants stated that the flood had risen and fallen seven times, with the water on five to six occasions reaching the junction with the Shebelli river. This information was insufficient to calculate volume discharge. (Appendix 'H').

TABLE 9

FLOOD DETAILS

DATE	G.H.	PEAK Q m^3/sec	TOTAL VOL $m^3 x 10^6$	CATCHMENT Km^2	UNIT 'Q' $m^3/sec/Km^2$	UNIT R/OFF m^3/Km^2
8/05/80	1.72	144.75	2.57	220.0	0.66	0.0116
6/11/80	2.20	283.00	4.41	220.0	1.29	0.0201
MAR/81	2.75	431.50	-	220.0	1.96	-

The unit discharge for the flood of March 1981 at $1.96m^3/sec/km^2$ is quite high, but fairly common when dealing with small barron catchments and high storm intensities.

8.3. Wadi Bur Acaba Near Bur Acaba

This wadi is situated approximately four kilometers from the Bur Acaba 'Rock', and flows south west before joining the lower Shebelli catchments in the Dinsor area.

A number of floods occured at this site in 1980/81. In 1980 the floods were fairly low in the order of $20m^3/sec$ with the exception of the largest flood that occured on the 26/10/80. On the 1/5/80 a small flood of total volume $0.65m^3 x 10^6$ occured. The volume was calculated by using a triangular hydrograph, with a flood peak of $20m^3/sec$.

A flood survey was carried out for the flood of 26/10/80 on the 27/10/80 with a flow of $18.6m^3/sec$ still in progress. The flood peak was calculated to be $313m^3/sec$ utilising the section and surveyed flood and water level slopes, and a rating curve was established. All survey details were related to a benchmark on the upstream right bank bridge abutment, (See History notes Appendix 'I').

The flood volume (26/10 - 28/10) was calculated at $7.19m^3 x 10^6$, with a flood mean discharge of $19.97m^3$/sec. As no figures are available for the catchment area, no unit discharge factors were calculated.

On the 23/3/81 a flood of similar proportions to the flood of 26/10/80 occured at 2000hrs, lasting for two days. The discharge at 1730hrs on 25/3/81 was in the order of 2-4 m^3/sec. No details relating to the peak discharge were collected.

During heavy storms the run-off tends to back up from the bridge and forms a resevoir situation. There is a fair difference between the upstream and downstream water levels. A recorder should be installed at this site in a structure similar to that illustrated in (Fig.13.)

9.0. WATER QUALITY OBSERVATIONS

Although 'Water Quality' investigations were not included in the Project terms of Reference, and no equipment available to enable such observations to be taken, a few 'Spot' observations were managed by borrowing an 'Electrical Conductivity' meter from (MMP) during the initial months of the project.

On a few occasions water samples were collected and then analysed by (MMP) personnel at the Ministry Laboratory in Johar. The 'EC' meter used was a Kent Instrument with two measuring containers with 1.0 and 0.1 factors. The 'EC' observations and sediment sample analysis are included in (Appendix 'J').

Current meter discharge measurements were always taken just prior to the water samples being collected, and the samples were usually collected from the center of the river the maximum mixing point of the cross section. Samples for sediment analysis were collected from the same places as the 'EC' observations, and stored in gallon plastic containers.

There is a very great difference between the 'EC' observations carried out before and after the start of the 'GU' floods, as shown in Table. 10

TABLE 10

'EC' VALUES (Comparisons)

RIVER	STATION	DATE	BEFORE FLOOD	DATE	AFTER FLOOD
Shebelli	Belet Uen	21/2/80	2,453 (25°C)	9/5/80	153.5 (25°C)
Shebelli	Mahaddei Uen	16/2/80	2,745 (25°C)	-	-
Shebelli	Mahaddei Uen	01/3/80	3,218 (25°C)	8/5/80	394.6 (25°C)
Jubba	Lugh Ganana	18/3/80	897 (25°C)	21/5/80	563.0 (25°C)

In the report 'Water control and management of the Shebelli River' it is stated that the electrical conductivity only went above 1,200 m/mhos at Afgoi on thirteen days during a years observations, and then only during the initial water level rise of the beginning of the 'GU' floods. This may be the situation in normal years when flow is maintained through out the year, but becomes much more severe in drought periods. In February 1980 the 'EC' value had risen to 2,313m/mhos by the 13th of March at a water level of 1.08m, with still a further two months to go before the arrival of the flood waters. Under these conditions the 'EC' value probably increased to above 3,000 m/mhos.

In 1980 and in 1981 when the lower Shebelli dried up completely the 'EC' values were in excess of 1,200 m/mhos for probably more than two months in the year.

In future projects,water quality observations and sediment sampling should be included, as it does not increase the costs by very much. The additional work load is negligible, especially as gauging teams are at the gauging sites for long periods on routine field visits.

10.0 STREAMFLOW DATA ANALYSIS

The hydrological objectives of the 'Hydrometry Project' fell into two separate but related aspects. In the long term the need to re-establish the Hydrological Network and create an organisation to continue its maintenance and operation; and secondly in the short term to try and re-rate all the Hydrological streamflow stations along the Jubba and Shebelli rivers, and to collect data which could be used to check the validity of all data used in technical estimates and justification proposals with regard to important projects such as the 'Bardheere Dam Project'.

Data has been more-or-less collected on a semi regular basis since 1951, although frequent gaps in daily observations, transcription errors and wrong calculation methods have caused concern, and promoted caution with its use and application.

This report is the presentation of the data collected during the 'Hydrometry Project' period (1980/81), and not a statistical analysis of the data. However, the 1980/81 data is assessed and compared to the past data and long term trends. With regard to Lugh Ganana(Jubba), and Belet Uen(Shebelli), the discharge data for 1977 to 1979 has been recalculated utilising the latest established rating curves.

10.1.0. JUBBA RIVER

Complete daily stage data for the period 1980/81 was collected at Lugh Ganana, but only partially at Bardheere and Jamamme. However, the missing data has been generated by correlating Bardheere with Lugh Ganana, and Jamamme with the complete records of stage from the 'Jubba Sugar Project' station at Mareery.

Annual flow details have been computed utilising the revised rating curves established over the Project period 1980/81. At Lugh Ganana the rating was established from 35 discharge measurements which covered the full range of all the flood occurances during the project period. This included the highest measurement on record at 1,463 m^3/sec, and the lowest at 2.59 m^3/sec.

JUBBA RIVER

(Streamflow in $m^3 \times 10^6$)

STATION : LUGH GANANA — PERIOD: 1951 / 1981

Year	Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sep 9	Oct 10	Nov 11	Dec 12	TOTAL ($m^3 \times 10^6$)	Max'Q' (m^3/sec)	MIN 'Q' (m^3/sec)
1951	205	95	76	793	1562	573	383	841	565	1559	1226	645	8523	1,030	20.6
1952	172	49	34	159	592	204	260	611	982	1612	785	117	5578 *	860	10.6
1953	53	30	31	82	434	174	640	1168	410	600	853	154	4628	650	8.8
1954	68	30	29	547	517	363	720	1310	1322	1578	347	217	7048	980	9.7
1955	71	59	34	84	233	59	136	506	689	1120	472	125	3588	676	10.3
1956	95	59	34	226	635	256	362	844	886	2105	728	166	6386 *	1,430	10.2
1957	76	48	150	150	996	697	589	680	381	522	677	439	5406	705	14.3
1958	97	101	76	72	319	1734	873	1275	1172	1240	819	619	8396	690	19.4
1959	166	48	41	102	554	529	509	565	1179	1500	1371	265	6829	1,205	8.7
1960	103	428	1152	103	41	456	645	455	581	753	990	597	6314 *	668	9.4
1961	80	60	65	586	603	422	603	1379	1052	1698	2094	1256	9899	1,320	21.0
1962	211	71	61	145	506	120	193	463	609	1361	728	308	4766	598	14.3
1963	49	39	56	734	1342	454	340	391	316	487	490	696	5393	755	13.8
1964	217	93	65	149	203	251	266	678	635	1366	816	375	5114 *	777	15.5
1965	340	91	23	28	81	36	66	132	235	1671	1283	525	4511	985	8.2
1966	136	75	87	195	562	391	337	496	899	691	715	260	4847	390	26.0
1967	79	57	70	212	678	132	447	1020	868	1848	2035	854	8300	1,105	22.4
1968	-	-	-	-	-	-	-	-	-	-	-	-	- *	-	-
1969	-	-	-	-	-	-	-	-	-	-	430	155		-	-
1970	163	137	281	630	504	855	458	659	969	1730	1353	196	7935	1,250	28.9
1971	97	67	74	156	522	422	611	568	638	1596	1052	329	6133	970	27.5
1972	138	118	144	293	822	562	587	686	596	881	1065	362	6254 *	1,065	27.5
1973	144	77	52	(65)	74	41	61	768	(687)	1213	676	20	(3878)	720	-
1974	3	0	0	41	213	474	430	608	987	617	439	56	3868	655	-
1975	12	18	14	74	182	92	558	1130	980	1049	648	88	4845	730	-
1976	42	15	22	59	1114	713	573	498	557	587	943	141	4264 *	1,095	-
1977	123	126	69	744	871	942	679	822	1090	1573	2727	695	10393	2,052	10.3
1978	185	89	585	348	723	303	1041	980	750	1624	836	401	7870	1,045	24.3
1979	164	185	140	393	(595)	790	428	560	317	734	784	728	5818	(510)	21.8
1980	58	25	16	32	289	205	400	309	335	479	245	84	2476 *	265	5.0
1981	21	8	208	2115	1472	326	309	690	1040	1146	498	198	8030	1,533	2.3
MEAN	116	80	127	321	595	434	466	727	749	1205	938	369	6113	921	15.6

Sum of Monthly Means:- 6,127 $m^3 \times 10^6$ NOTE:- Bracketed figures 1973(Lugh/Kaitoi correlation - Selchozpromexport). 1979 - Mean values used.

DATA SOURCE: A). Selchozpromexport 1965 & 1973. B). 'MMP' & Ministry of Agriculture records 1973/79. C). B.P.Gemmell 1980/81. Note that data for period 1977 to 1981 computed from 1980/81 rating curve. NOTE: The asterisk denotes leap year.

TABLE. 11.

At Bardheere the rating curve was established from a total of 22 discharge measurements which only covered 50 % of the gauge height range, and 37 % of the lower sector of the discharge curve. Fortunately, the flood peak levels were observed immediately after the events and maximum discharges calculated from surveys and the 'Slope Area Method'(Mannings formula). The surveys brought to light an error in the flood peak level for the 1977 flood, which has been adjusted from 6.47 meters to 6.72 meters gauge height, and the flood discharge re-calculated to the present rating curve and river section.

At Jamamme the full gauge height range was gauged including the maximum flood peak level of the 24th May 1981. However, this was only the total flow passing the gauging station in the main river channel, and excluding the by-pass flow across the wide flood plain. The total flow for the 1981 flood can only be estimated at between 1,200 and 1,500 m^3/sec. This figure has been estimated from flood information recieved from the 'MMP' and Chinese reports (Appendix 'K'), supplied by personnel who were in the area for the entire period of the flood event. On May 16th 1981, the flood peak in the main channel at Mareery reached a level of 21.97 meters gauge height (950 m^3/sec), as estimated from the design data of the flood protection bunds, and an estimated flow of 400 m^3/sec flowed down the Snake River(Far Shebelli) to the west of the Sugar Project, making a total of 1,350 m^3/sec. for the peak flood in the lower Jubba. The peak discharge at Jamamme was only 532 m^3/sec in the main channel, therefore the flow across the flood plain must have been in the order of 800 to 1,000 m^3/sec.

It must also be noted that the river ceased to flow in both 1980 and 1981 along its lower reaches. The driest period being February/March 1981, when the river dried up as far upstream as the gauging station at Mareery.

10.1.1. ANNUAL VOLUME DISCHARGES

Annual flow data for the annual series 1951/81 is available for Lugh Ganana, with the exception of two years 1968/69(Table 11, & Fig. 35). Unfortunately very limited data is available for

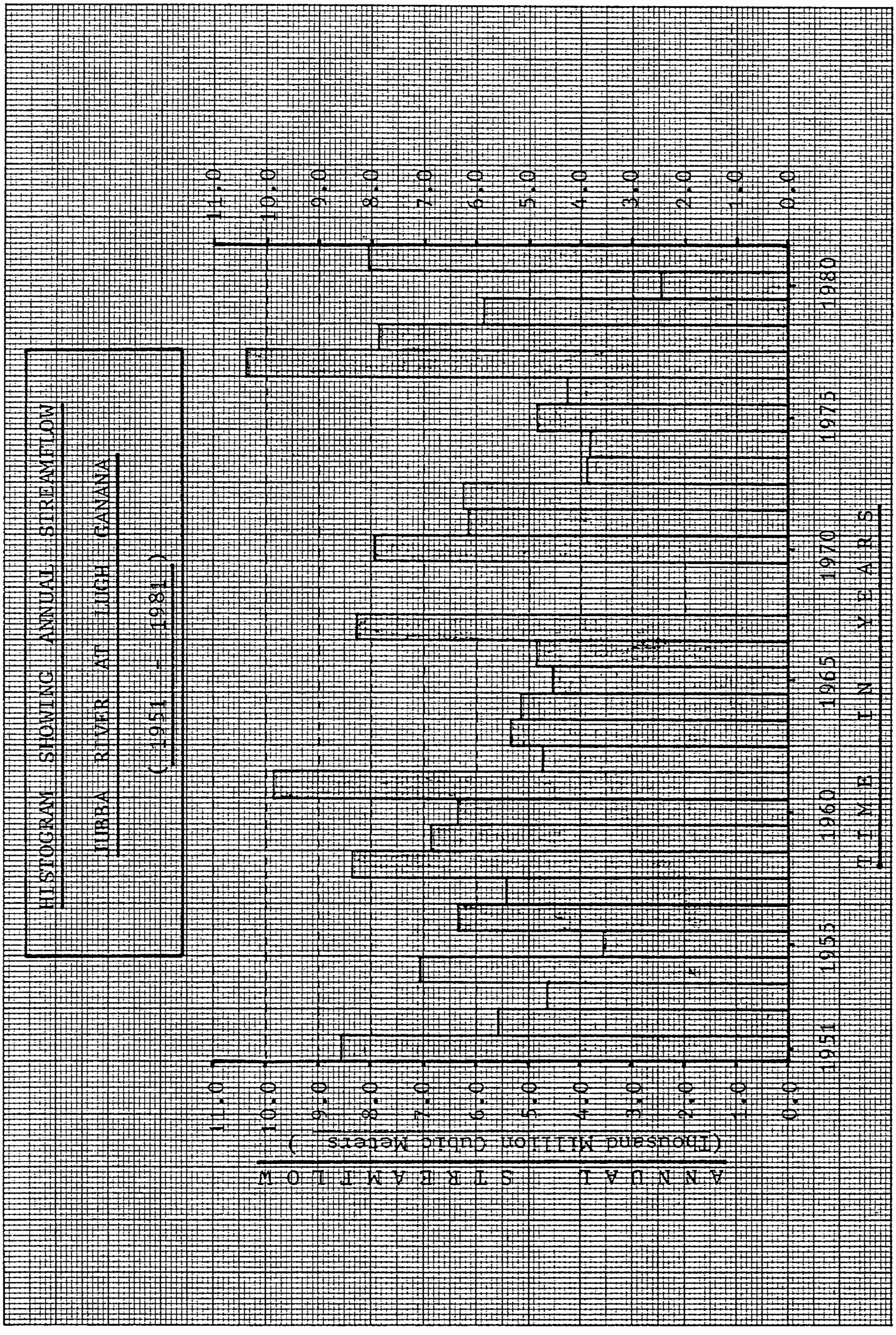

HISTOGRAM SHOWING ANNUAL STREAMFLOW
JUBBA RIVER AT LUGH GANANA
(1951 - 1981)
ANNUAL STREAMFLOW
(Thousand Million Cubic Meters)
TIME IN YEARS
1951
1955
1960
1965
1970
1975
1980
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0

FIG. 35.

the stations at Bardheere and Jammame, therefore comparisons will have to be based on the sparse data available, and any additional information obtained from other reports such as the 1965 Selchozpromexport report, Technital (1977 &1979), and various 'MMP' documents.

The discharges for the three Jubba gauging stations for the period 1980/81 are illustrated in the following Table .12.

TABLE : 12

JUBBA RIVER 1980/81 ANNUAL STREAMFLOW

STATION	1980			1981	
	ANNUAL VOLUMES			ANNUAL VOLUMES	
	$M^3 10^6$	% Diff.		$M^3 10^6$	% Diff
Lugh Ganana	2,476			8,030	
		+ 6.1			+ 13.3
Bardheere	2,626		- 4.0	9,194	
		- 20.0			-
Jamamme	2,087			7,356*	

* Only main channel flow, excluding flood plain flow.

The data for the two years 1980 & 1981 belong to the lowest and sixth highest years on record, from a series of 29 years between 1951 to 1981, for the Jubba at Lugh Ganana (Fig. 35.)

The average discharge increase of 10% between Lugh Ganana and Bardheere for the period 1980/81, agree's favourably with the 13-14% increase claimed by the Selchozpromexport(1965) report. The lower percentage increase of 6.1% for 1980 is acceptable, because of the extremely low river levels experienced that year, which resulted in the river drying up in April 1980. The 13.3% increase in 1981 is similar to the Russian figures, and supports the lateral inflow theory. However, surface run-off contributions from the seasonal tributaries (Wadis), situated between Lugh Ganana and Bardheere, also play a major role in the annual streamflow distribution.

In 1980 the highest flood peak observed at Bardheere was generated from local catchments within Somalia, as it was not recorded upstream at Lugh Ganana. On a number of occasions the consultant, and personnel from other organisations, observed almost continious flow joining the main river during April and May 1981, while on reconnaissance flights over the Jubba river between Lugh Ganana and Dujuuma.

The annual 1981 discharge for Jamamme (Table.12.), is not representative of the total flood in the area, because it does not include the overbank flow across the wide flood plain. The maximum observed channel discharge of 532 m^3/sec, only constitutes approximately one third of the total discharge(flood peak) which was estimated at Mareery. Considering the long duration of the high water levels during the flood period, it can be safely assumed that the flood plain discharge over a period of two weeks or more, most certainly would have increased the annual discharge at Jamamme to more than the total volume, or at least similar to the total volume at Lugh Ganana for the year. This in turn would show a plus factor, rather than an attenuation of flow between Lugh Ganana and Jamamme, as illustrated by the 20% attenuation recorded in 1980.

It is generally claimed in the lower Jubba area that the flood of April/May 1981 was the largest on record. This claim is hard to accept especially after examination of the discharge distribution at Lugh Ganana over 29 years, for the one,two and three month consecutive discharges.(Table.13.).

TABLE.13.

JUBBA RIVER AT LUGH GANANA

Maximum One, Two and Three Month Volumes (M^3x10^6)

ONE MONTH			TWO MONTHS			THREE MONTHS		
Year	M^3x10^6	Rank	Year	M^3x10^6	Rank	Year	M^3x10^6	Rank
1977	2,727	1	1977	4,300	1	1977	5,390	1
1981	2,115	2	1967	3,885	2	1961	5,048	2
1956	2,105	3	1961	3,792	3	1967	4.751	3
1961	2,094	4	1981	3,587	4	1954	4,210	4
1967	2,035	5	1970	3,085	5	1970	4,054	5
1958	1,734	6	1956	2,991	6	1959	4,050	6
1970	1,730	7	1965	2,950	7	1981	3,913	7
1965	1,671	8	1954	2,900	8	1956	3,835	8

The 1977 one, two and three month volume flows on each occasion are the largest on record. The individual flood peak of 2,052 m^3/sec is also the largest flood, some 25% higher than the peak of 1,553 m^3/sec, recorded in 1981.

The corresponding flow details for the station at Bardheere in 1981 shows that there was an attenuation of 12.5%, over the initial one month volume discharge, with an increase of 2.1% over two months and then rapidly increasing to 8.7% over the three month period, as the river flow returns below the bank full level. (Table.14.).

TABLE. 14.
(1981)
Comparison of Annual Discharges of the Jubba River

STATION	ONE MONTH	TWO MONTHS	THREE MONTHS
Lugh Ganana	2,115 m^3x10^6	3,587 m^3x10^6	3,913 m^3x10^6
Bardheere	1,853 "	3,665 "	4,254 "
Percent Diff.	- 12.5	+ 2.1	+ 8.7

Assuming that the flow at Bardheere in 1977 was in the order of 13-14% more than at Lugh Ganana below bankfull level, but less for the first month similar to the 1981 figures, the probable discharges at Bardheere would have been of the following order shown in Table 15.

TABLE. 15.

The Jubba River at Bardheere Probable Volume- 1977

STATION	ONE MONTH	TWO MONTHS	THREE MONTHS
Lugh Ganana	2,727 m^3x10^6	4,300 m^3x10^6	5,620 m^3x10^6
Bardheere	*(2,386) "	*(4,390) "	*(5,676) "

Note: * 1981 Percentage variations used.

These figures show that the flow past Bardheere in 1977 was significantly greater than in 1981. The mean discharge increase over the three month total discharges was 27%, with 28.8%

increase for the first month, and 20% over the second month. Therefore, if the flood levels on the lower Jubba in 1981 were the highest on record, other factors were responsible for the situation, and not the magnitude of the flood past Bardheere. The Anticeedent rainfall prior to the arrival of the peak flood, and the overhead rainfall during the flood in connection with an exceptional contribution of flood water from the local (wadi) catchments between Bardheere and Dujuuma, must have been the main factors responsible for the situation.

On the other hand, the river levels in the lower Jubba could have been affected by the flood control bunds along the river banks, constructed since the flood in 1977. The restriction of flow to the channel could have caused backwater effects which raised the water level higher than normal, thereby causing the flow down the Snake river or 'Far Shebelli', situated to the west of the Jubba Sugar Project cane fields, into Scorpion Lake. (See Flood Reports Appendix 'K' - & 'History of the 'GU' floods in Somalia - B.P.Gemmell 1981).

The Chinese Report (Appendix 'K'), states that the 1981 flood at Lugh Ganana had a flood peak level of 147.45 meters(MSL), which infact is 0.22 meters lower than the peak of 6.25 meters gauge height, or 147.67 meters (MSL). This suggests that the correction factor for the overlap of the gauges at Lugh Ganana is not being applied correctly. Doubt has also been shown with regard to the traverse levels between Jelib and Kaitoi. 'MMP' suggest an error of one meter in connection with the mean sea level datum.

10.1.2. FREQUENCY ANALYSIS (Annual Streamflow - Lugh Ganana)

Frequency analysis of the Annual Streamflow at Lugh Ganana, has been carried out in the past by Selchozpromexport (1965), Lockwood/FAO 1968, Technital Sp.A. (1977 & 1979), and MacDonald & Partners 1978. The most accurate study to-date was carried out by MacDonalds, mainly due to the extended data series available at the time. Fairly large differences were found between 'MMP' and Technital, but similar to the Selchozpromexport(1965 & 1973) results.

The data used for this analysis is based on the original Selchozpromexport data(1965 & 73), and MacDonald & Partners combined with the Ministry of Agriculture data from 1973 to 1979, and finally 1980/81 data collected by Gemmell/FAO including the re-calculated figures for the period 1977 to 1979.

The basic summarised discharge data for Lugh Ganana 1951/81 is tabulated in Table.11, and the data inclusive of the monthly percentage flow distribution for Lugh Ganana, Bardheere and Jamamme appears in Appendix 'E', for the Project period 1980/81.

The annual discharge data is also shown plotted following an Extremal Type 1 (Gumbel) distribution in Fig. 36. From the frequency distribution curve the 100 year flood is estimated at 13,410 M^3x10^6, with the highest observed annual discharge in 1977 of 10,390 M^3x10^6 having a return period of approximately 18 years. The 1,000 year annual discharge would be in the order of 17,600 M^3x10^6. The data from the frequency plot is tabulated in the following Table.16.

TABLE. 16.

Probability of Annual Streamflow at Lugh Ganana

Jubba River - 1951/81

Return Period (Years)	Probability (%)	Discharge (M^3x10^6)
1.11	90	3,680
1.33	75	4,576
2	50 (median)	5,831
2.1	48 (mean)	6,125
4	25	7,407
10	10	9,199
25	4	10,901
50	2	12,890
100	1	13,410

The mean annual discharge calculated from the 1951/73 series was 6,250 M^3x10^6, with a mean flow of 198 m^3/sec. An extension of the data series to 1978 reduced the long term mean annual flow by 3% to 6,066 M^3x10^6, with a mean discharge of of 192 m^3/sec. Finally, with the data series extended to

JUBBA RIVER AT LUGH GANANA

ANNUAL SERIES OF STREAMFLOW (1951 - 1981)

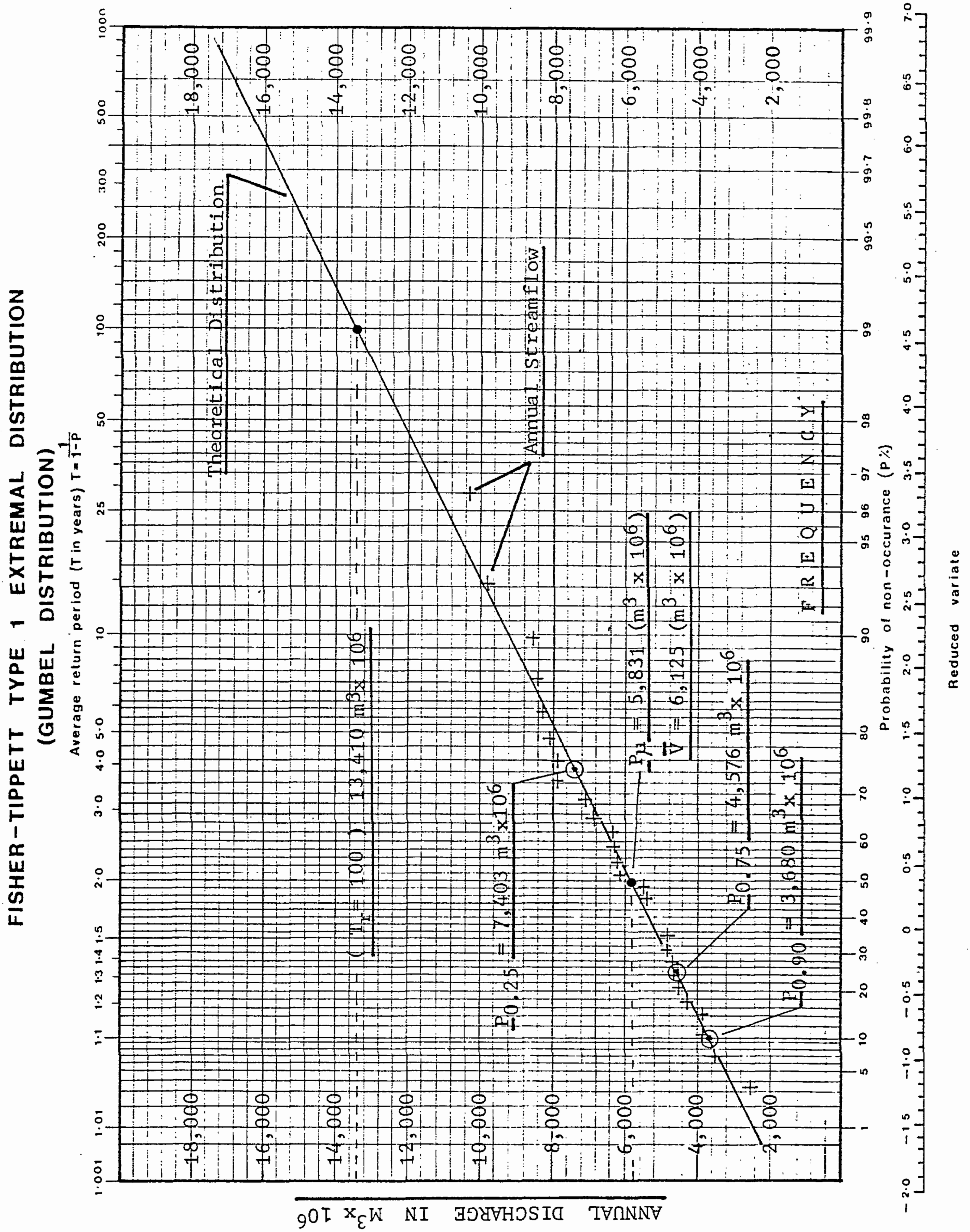


FIG. 36.

FREQUENCY ANALYSIS COMPUTATIONS

PERIOD	ANNUAL 'Q' ($M^3 x 10^6$)	RANK	PROB/TY $1 - \frac{r}{n+1}$	REC/INT T_r (Years)	$(x - \bar{x})$	$(x - \bar{x})^2$	$(x - \bar{x})^3$	LOG X	(Log x - Log $\bar{x}$)	(Log x - Log $\bar{x})^2$	(Log x - Log $\bar{x})^3$
1977	10,390	28	96.55	29.00	4,265	18,190,225	77581310000	4.0166		0.0636	
1961	9,900	27	93.10	14.50	3,775	14,250,625	53796110000	3.9956		0.0535	
1951	8,520	26	89.66	9.67	2,395	5,736,025	13737780000	3.9304		0.0276	
1958	8,400	25	86.21	7.25	2,275	5,175,625	11774547000	3.9243		0.0256	
1967	8,300	24	82.76	5.80	2,175	4,730,625	10289109000	3.9191		0.0239	
1981	8,030	23	79.31	4.83	1,905	3,629,025	6913292606	3.9047		0.0197	
1970	7,940	22	75.86	4.14	1,815	3,294,225	5979018374	3.8998		0.0183	
1978	7,870	21	72.41	3.63	1,745	3,045,025	5313568657	3.8960		0.0173	
1954	7,054	20	68.97	3.22	925	855,625	791453123	3.8482		0.0070	
1959	6,830	19	65.52	2.90	705	497,025	350402626	3.8344		0.0049	
1956	6,390	18	62.07	2.64	265	70,225	18609625	3.8055		0.0017	
1960	6,310	17	58.62	2.42	185	34,225	6331625	3,8000		0.0013	
1972	6,250	16	55.17	2.23	125	15,625	1953125	3,7959		0.0010	
1971	6,130	15	51.72	2.07	5	25	125	3.7875		0.0005	
1952	5,580	14	48.28	1.93	- 545	297,025	- 161878626	3.7466		0.0003	
1957	5,410	13	44.83	1.81	- 715	511,225	- 365525876	3.7332		0.0010	
1963	5,390	12	41.38	1.71	- 735	540,225	- 397065376	3.7316		0.0011	
1964	5,110	11	37.93	1.61	-1,015	1,030,225	-1045678381	3.7084		0.0031	
1966	4,850	10	34.48	1.53	-1,275	1,625,625	-2072671869	3.6857		0.0062	
1975	4,850	9	31.03	1.45	-1,275	1,625,625	-2072671869	3.6857		0.0062	
1962	4,780	8	27.59	1.38	-1,345	1,809,025	-2433138634	3.6794		0.0072	
1953	4,630	7	24.14	1.32	-1,495	2,235,025	-3341362383	3.6656		0.0098	
1965	4,510	6	20.69	1.26	-1,615	2,608,225	-4212283387	3.6542		0.0121	
1976	4,260	5	17.24	1.21	-1,865	3,478,225	-6486889649	3.6294		0.0182	
1973	3,880	4	13.79	1.16	-2,245	5,040,025	11314856000	3.5888		0.0308	
1974	3,870	3	10.34	1.12	-2,255	5,085,025	11466731000	3.5877		0.0312	
1955	3,590	2	6.90	1.07	-2,535	6,426,225	16290480000	3.5551		0.0438	
1980	2,480	1	3.45	1.04	-3,645	13,950,225	48427561000	3.3945		0.1368	
-	171,500	28	-	-	+ 10	105,786,100	84158691830	105.40		0.5737	

Note: $(x-\bar{x})^3$ - The minus signs to the bottom of column. The total is plus.

JUBBA AT LUGH GANANA

(TABLE 16 - A)

ARITHMETIC MEAN : $\frac{171,500}{28} = 6,125\ m^3 10^6$

STANDARD DIVIATION : $\sqrt{\frac{1}{28-1}(105,786,100)} = 1,979.4\ m^3 10^6$

Coefficient Skew: 2.31.

GEOMETRIC MEAN : $\frac{105.4039}{28} = 3.7644 = 5,813\ m^3 10^6$

STANDARD DIVIATION : $\sqrt{\frac{1}{28-1}(0.5737)} = 0.14577$

Coefficient Skew:

include the latest three years data 1979 to 1981, the long term mean is increased by 1% to 6,125 $m^3 10^6$, or 194 m^3/sec.

Re-examination and adjustment of the Ministry of Agriculture records, would mainly increase the January to April low flow values, for the period 1973 to 1976. The adjustments already carried out to the 1977 and 1978 data, has shown an increase in discharge for the four month periods of 35 and 106%, with increases to the annual means of 2.7 and 9.7%, respectively. Therefore the mean annual discharges for the drier years would be more seriously affected than the wetter periods. In general the drier period annual means are under estimated by some 8-10 %, and decreasing to 3-5 % for the wetter years.

The same pattern was found for the January data of 1979, with the adjusted mean monthly discharge being 111% greater than the original calculations. This large variation suggests that the original rating was under estimating the low flows, or the low flow observations were not recorded, and assumed to be below gauge zero levels. A mean increase of 6% would be required to correct the pre-1977 data in relation to the present 1980/81 rating curve.

10.1.3. JUBBA RIVER RUNOFF CHARACTERISTICS

Runoff characteristics for the 29 year series (1951/81) at Lugh Ganana, and miscellaneous data for Bardheere is tabulated in the following table :

TABLE. 17.

Runoff Characteristics of the Jubba river at Lugh Ganana and Bardheere

Parameters	Lugh Ganana	Bardheere
1. Catchment Area (km^2)	179,520	216,732
2. Data series (Years)	(1951/81)	(1980/81)
3. Mean Annual Discharge ($m^3 10^6$)	6,125	5,910
4. Max. Annual Discharge (")	10,393	9,194
5. Min. Annual Discharge (")	2,476	2,626
6. Mean (2 consecutive dry years)	3,873	-
7. Mean (3 " " ")	4,197	-
8. Mean Unit Runoff ($10^6 m^3/km^2$)	0.0341	0.0273
9. Mean Max. Unit Runoff ($10^6 m^3/km^2$)	0.0578	0.0424
10. Mean Min. Unit Runoff (" ")	0.0138	0.0121

With the majority of the river flow being generated in the highlands of Ethiopia, the annual flow rate decreases as the river flows through Somalia. At Lugh Ganana the mean annual flow rate of 1.08 $l/sec/km^2$, is similar to the Selchozpromexport figure of 1.05 $l/sec/km^2$, with the mean maximum and minimum rates of flow at 1.84 and 0.44 $l/sec/km^2$.

At Bardheere the mean flow rate of 0.86 $l/sec/km^2$, for the two year period 1980/81, is 22% less than the Lugh Ganana long term mean of 1.08 $l/sec/km^2$. The individual flow rates for 1980 and 1981 are 0.38 and 1.38 $l/sec/km^2$ respectively. The mean flow rate for 1980/81 is 8.5% less than the 0.94 $l/sec/km^2$ reported by Selchozpromexport (1965).

10.1.4. JUBBA RIVER ANNUAL PEAK DISCHARGES

a) Lugh Ganana

The maximum and minimum flood levels for the Jubba at Lugh Ganana are tabulated in Table.11, with the maximum flood peaks illustrated in histogram form in Fig.37.

The highest flood level was recorded in 1977 at a gauge height of 7.13 meters, or (MSL) 148.55 meters, with a peak flow of 2,052 m^3/sec. The second highest peak was recorded in May 1981 at a gauge height of 6.25 meters, or (MSL) 147.67 meters and a peak flow of 1,553 m^3/sec.

There are a number of different maximum flood levels quoted or attributed to the 1977 flood event. This is mainly due to the confusion over the overlap between the 0-2 & 2-6 meter gauge stands and the method of correcting the levels. There is also confusion with regard to the gauge zero levels of the two sets of gauges.

There is an overlap in the gauge range of 0.22 meters between the 0-2 and 2-6 meter range of gauges. To obtain the 'MSL' level of the gauge reading, the reading is added to the gauge zero level of 'MSL' 141.42 meters. This level is identical to the gauge zero level surveyed in 1972 (See Old Installation data, Vol. 2. - Sect H). The Ministry of Agriculture personnel are using an (MSL) value of 141.45 meters as the gauge zero level, which is 0.03 meters different and immediately injects an error into the conversion equation. Secondly, the adjustment of the levels for the 0.22 meters overlap can add confusion and increase the error. To obtain the (MSL) values of the staff Gauge readings, the staff gauge readings have to be added to the gauge zero value of (MSL) 141.42 meters, but all readings from 0-2 meters have to be adjusted by adding 0.22 meters to counter the overlap, before being added to the gauge zero level to obtain the (MSL) level. This action infact lowers the 0-2 meter gauge by 0.22 meters, and brings the 0-2 meter observations into level sequence with the 2-6 meter gauges with the correct gauge zero of (MSL) 141.42 meters. The 2-6 meter gauge installation was the original structure, with the 0-1 and 1-2 meter ranges installed at latter dates.

It appears from statements like the Chinese report on the floods in the lower Jubba (<u>Appendix 'K'</u>), that the gauge zero level of 141.42 meters (MSL), is being applied to the 0-2 meter range of gauges, and the 0.22 meter adjustment factor is being subtracted from the 2-4 meter observations. This action infact raises the gauge zero level by 0.22 meters and if coupled with the 0.03 meter error in gauge zero level, creates a total error of 0.25 meters. This error could be the difference factor which is reflected in the peak flood level of (MSL) 148.80 meters claimed by 'MMP' for the 1977 flood at Lugh Ganana (Jubba Sugar Project - Kamsuma North & Labaddad South - 'MMP 1978'). The (MSL) value of 148.80 is equivalent to a gauge height of 7.38 meters, which is exactly 0.25 meters higher than the correct flood level of 7.13 meters. However, if the actual gauge zero of the 0-2 meter gauges (MSL) 141.64 meters was used, the error would be a plus factor instead of minus. Assuming the error in peak gauge levels is correct, the flood peak for the flood of 1977, as estimated by MacDonalds & Partners at 2,120 m^3/sec, will be reduced to the B.P.Gemmell (1980/81) estimation of 2,052 m^3/sec.

At Lugh Ganana the river begins to spill over the bank at a gauge height of 5.30 meters. In 1977 the approach road to the bridge on the right bank was washed away, whereas in 1981 at a gauge height of 6.25 meters, only a controlled flow through the culverts.

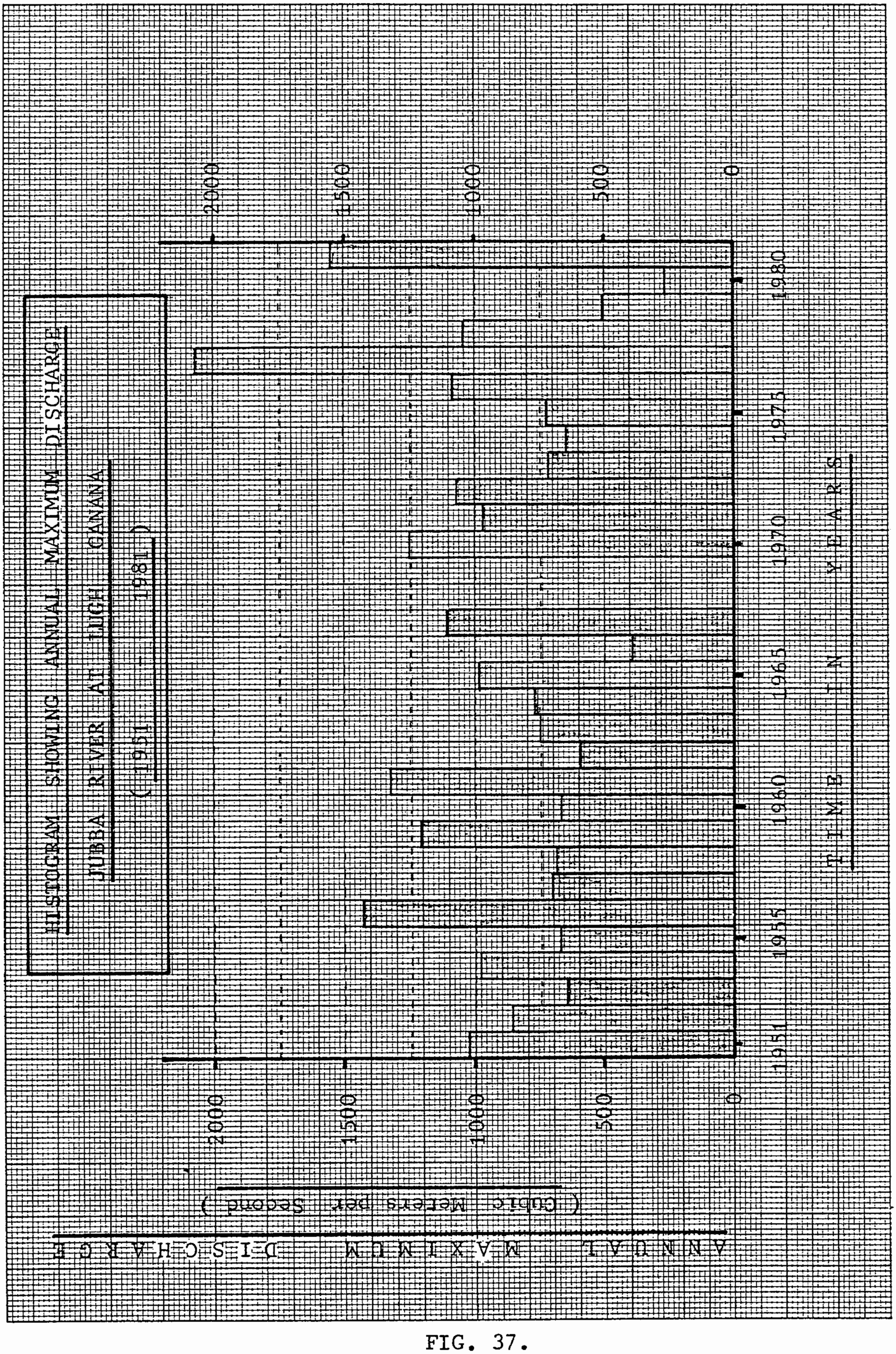

HISTOGRAM SHOWING ANNUAL MAXIMUM DISCHARGE
JUBBA RIVER AT LUGH GANANA
(1951 - 1981)
2000
1500
1000
500
0
1951
1955
1960
1965
1970
1975
1980
TIME IN YEARS
ANNUAL MAXIMUM DISCHARGE
(Cubic Meters per Second)

FIG. 37.

It must be stressed that doubts still exist with regard to the pre-1977 data. The flood level for 1961 is a prime example, where Selchozpromexport claim a maximum flood discharge of 1,430 m^3/sec, and Technital (1977/79) with J.C.Henry(1979) claim a peak discharge of 1,700 m^3/sec. Detailed studies of all the old records in Somalia, not only at the Ministry of Agricuture but also any other Ministry that had been responsible for the hydrological activities in the past, is needed. Private consultant firms should also be requested to make available any data records they may hold, both in local offices in Mogadishu or at their head offices abroad. This report supplies a data base and reference from which to start.

The mean annual flood peak discharge for the data series 1951 to 1981 is 921 m^3/sec. This is slightly higher than the Selchozpromexport mean for the data series 1951/65 (909 m^3/sec), by 1.3 %. The mean minimum annual discharge is 15.6 m^3/sec, with the lowest recorded minimum discharge at 2.3 m^3/sec recorded in March 1981.

b) Bardheere

The data available for Bardheere is very sketchy and full of data gaps, and no records of any substance from mid 1977 until the start of the 'FAO' Hydrometry project in January 1980. Here again is confusion over the gauge levels and corresponding zero levels, brought about because of the very confusing overlap method of staff gauge installation.

Fortunately, consultant staff members (MMP), were in the area during or immediately after the floods of 1977, and marked the maximum flood level inside the recorder house, and is still visable to-date. The gauge height attributed to the flood of 1977 by 'MMP', was 6.47 meters or (MSL) 95.70 meters. In relation to the present 'In level sequence' gauges (MSL) 95.70 meters refers to a gauge height of 6.72 meters gauge height. The 0.25 m difference refers to the difference in gauge zero between the present gauges and those in use at the time of the flood. The details refering to the relatioship of the gauges is explained in

'Volume 2- Sect'B'- Gauge Details '. The old gauge zero had had an (MSL) value of 89.23 meters, while the new range of gauges have a value of (MSL) 88.98 meters.

The original estimated flood peak of 1,550 m^3/sec by 'MMP' in 1978, has been re-calculated to an increased value of 1,641 m^3/sec, an increase of 6 % or 91 m^3/sec. The reassessed discharge shows an attenuation of 20 % between the 1977 flood peaks of Lugh Ganana and Bardheere.

The 1981 flood peak of 1,395 m^3/sec is probably the second highest flood on record, some 15 % or 247 m^3/sec less discharge than the flood of 1977. The attenuation in flood peak discharges for 1981 was 10.2 %, or 159 m^3/sec less discharge than the peak at Lugh Ganana.

The highest flood level in 1980 was generated locally and did not come from the highlands in Ethiopia, and had a gauge height of 3.54 meters with a peak discharge of 593 m^3/sec, double the peak of 268 m^3/sec in October , which was generated from Etiopia. The discharge at Lugh Ganana for this second flood was 270 m^3/sec, which was similar to the peak at Bardheere , and no appreciable attenuation of flow.

Whenever the flood peaks are contained within the river banks, there is usually an increase in discharge, but at this low level the flow stayed constant with only slight signs of attenuation. Whenever there is overbank spillage, water is usually trapped in the low depressions and ox-bow lakes along the river flood plain, resulting with comparatively high rates of attenuation, between the two stations.

c) Jamamme

Only two years data is available for this station, and those are the two years 1980/81 when monitored by the Hydrometry project. The maximum flood level in 1980 was 3.30 meters gauge height which relates to the locally generated flood at Bardheere of 593 m^3/sec. The peak at Jamamme was 259 m^3/sec which shows an attenuation of 334 m^3/sec, or 56 %. The second peak which occurred in October 1980 was generated in Ethiopia and was recorded at all the three Jubba stations showed an attenuation in peak discharge of 21.3 % (Table 18.). The high attenuation figure for the locally generated flood was probably because of the short duration of the peak, which would have dissipated considerably by the time it reached Jamamme.

TABLE. 18.

Flood Peaks at Bardheere and Jamamme 1980/81

Year	Bardheere GH. (m)	Bardheere Q (m^3/sec)	Jamamme GH. (m)	Jamamme Q (m^3/sec)	Q Diff (m^3/sec)	% Diff.
1980						
May	3.54	593	3.30	259	334	- 56.3
Oct	1.96	268	2.70	211	57	- 21.3
1981						
May	6.20	1,394	5.55	(1,350)*	(44)	(- 3.3)
Sept	3.85	664	5.35	501	163	- 24.6
Oct	3.62	611	5.53	532	79	- 13.0
					Mean	- 24.0

* Maximum estimated discharge at Mareery plus Snake River (MMP).

The flood details for the maximum flood peak of May 1981 at Jamamme are those estimated by 'MMP' for the station at Mareery plus the discharge down the Snake River (Far Shebelli), because the discharge measured at Jamamme only represented the channel flow at the station, and not the overbank flood plain discharge.

The extraction of water from the river by the Jubba Sugar Scheme, and the Fanoole Project will have marked effects on the amount of water reaching Jamamme, especially during the low flow and maximum irrigation water requirement periods. The mean peak discharge attenuation utilising the 1980/81 data, is approximately 24 %, with the largest variations in the dry season when the river on occasions ceases to flow.

For comparison purposes two tables showing the increases in peak discharges as estimated by Selchozpromexport (1965) between Lugh Ganana, Bardheere and Kaitoi, and the reductions in Peak flow in the reaches between Lugh Ganana, Bardheere and Kaitoi according to the Lockwood/FAO (1968) report, are herewith included:

TABLE. 19.

Increases in Peak Flows Between Lugh Ganana, Bardheere and Kaitoi - 1965

Station	Mean Annual Peak Flow (m^3/s)		1 in 10 year Peak Flow (m^3/s)		1 in 20 year Peak Flow (m^3/s)	
	SP/Export	% Inc	SP/Export	% Inc	SP/Export	% Inc
Lugh Ganana	909	-	1,391	-	1,620	-
Bardheere	965	6	1,505	8	1,760	-
Kaitoi	982	8	1,540	11	1,800	11
Lugh Ganana (1980/81)	921	-	1,505	-	1,752	-

TABLE. 20.

Reductions in Peak Flow in the reaches between Lugh Ganana, Bardheere & Kaitoi as estimated by Lockwood (1968)

	Peak Flows (m^3/sec)					
Station	Oct 1951	% Reduct.	Nov 1956	% Reduct.	Nov 1961	% Reduct.
Lugh Ganana	710	-	810	-	830	-
Bardheere	560	21	650	20	620	13
Kaitoi	600	15	605	25	600	28

Note: For flows contained within the river banks, little or no attenuation would be expected.

Note: The existing evidence on the controversy surrounding the the question of attenuation or incrementation of flood peaks in the Jubba is contradictory.

10.1.5. FREQUENCY ANALYSIS (Peak Flows - Lugh Ganana)

Frequency analysis of the annual peak flows at Lugh Ganana have been carried out by Lockwood/FAO, Selchozpromexport (1965 & 73), MacDonald & Partners 1977, and reassessed in 1978. The original 'MMP' study was based on the flows derived by Selchozpromexport for the period 1951 to 1964. In the reassessment study the method adopted was to generate flows for the missing data between 1965 and 1976, assuming that they were distributed according to a logarithmic - normal probability. The data were generated using random numbers(normally distributed) and applying the mean and standard deviations for the sample period (1951/65 & 1977). Revised statistics for the total period were then recalculated to compare with those for the recorded data.

For this analysis the data from 'MacDonald 1978' report has been extended utilising the recalculated 1977 to 1979 Ministry of Agriculture data, and the additional two years data 1980/81 collected by the Hydrometry project(Gemmell/FAO).

The extended record is shown plotted following an 'Extremal Type .1. (Gumbel) distribution (Fig.38.)

The estimated 100 year flood is shown to be in the order of 2,310 m^3/sec, and the largest flood peak on record, the flood of 1977 (2,052 m^3/sec) is shown to have a return period of about 50 years. This figure differs from the 'MMP' 1978 estimated return period, because of the different peak flood level given to the flood of 1977(See para. 10.1.4)

Technital (1977 & 1979) estimated peak flow frequencies which according to J.C.Henry (Present and Future Irrigated Agriculture in the Shebelli and Jubba Basins - 1979), appeared to be very low at 2,550 m^3/sec for the 1,000 year flood, and 3,100 m^3/sec for the 10,000 year event. However, Technital retained their low frequency 1,000 year flood of 2,550 m^3/sec for their design for a 70 meter high dam, involving flood retention on the Jubba.

TABLE. 21.

Probability of Annual Peak Discharges - Lugh Ganana - 1951/81

Return Period (Years)	Occurance Probability Percent (%)	Discharge m^3/sec
1.05	95	358
1.11	90	450
1.33	75	625
2	50 (median)	861
2.27	44 (mean)	918
4	25	1,163
10	10	1,505
25	4	1,830
50	2	2,070
100	1	2,310

The latest probability plot with the extended data series (1951/81), supports J.C.Henry's statement that the frequency values used by Technital S.pA. were too low. The 1,000 year flood has an estimated discharge of 3,150 m^3/sec, and the 10,000 year discharge estimated at 3,900 m^3/sec. These figures are 7-8 % higher than the Selchozpromexport (1965) and the MacDonalds reassessed values (1979) in the higher range, and 2-3 % in the lower range. The present 1,000 and 10,000 year return discharge values are 25 % greater than the values estimated by Technital.

The mean maximum discharge for the period 1951/65 for Lugh Ganana was 909 m^3/sec, and for the extended period 1951/81 the mean is increased by 1.3 % to 921 m^3/sec. The adjusted data and the extended series does not appear to make a great deal of difference.

The revised 'MMP' peak flows (estimated) are herewith compared to the present findings in Table.22. The 100 year flood has an estimated discharge of 2,310 m^3/sec which is approximately 9 % greater than the 'MMP' estimate. The peak flood of 1977 can be seen to have a return period in the order of 50 years, and 12 years for the 1981 flood.

JUBBA RIVER AT LUGH GANANA

ANNUAL SERIES OF MAXIMUM FLOOD DISCHARGES (1951 - 1981)

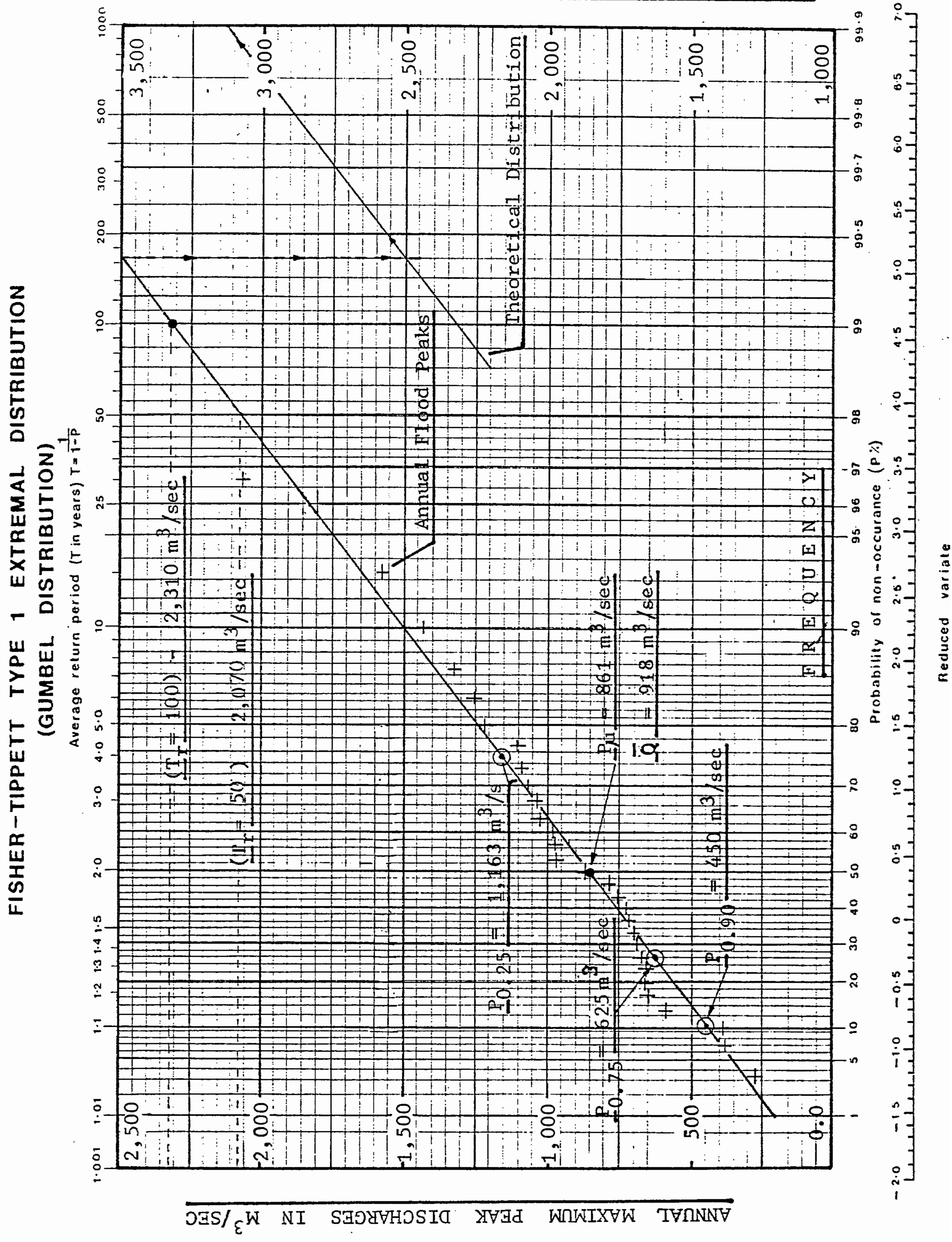


FIG. 38

FREQUENCY ANALYSIS COMPUTATIONS

PERIOD	MAXIMUM PEAK 'Q' (m^3/sec)	RANK	PROB/TY $1 - \frac{r}{n+1}$	REC/INT T_r (Years)	$(x - \bar{x})$	$(x - \bar{x})^2$	$(x - \bar{x})^3$	LOG X	(Log x - Log $\bar{x}$)	(Log x - Log $\bar{x})^2$	(Log x - Log $\bar{x})^3$
1977	2,052	29	96.67	30.00	1,134	1,836,689	1458274100	3.3122		0.1494	
1981	1,570	28	93.33	15.00	652	423,801	277167809	3.1841		0.0670	
1956	1,430	27	90.00	10.00	512	261,121	134217729	3.1553		0.0529	
1961	1,320	26	86.67	7.50	402	160,801	64964808	3.1206		0.0382	
1970	1,250	25	83.33	6.00	332	109,561	36594368	3.0969		0.0295	
1959	1,205	24	80.00	5.00	287	81,796	23639903	3.0810		0.0243	
1967	1,105	23	76.67	4.29	187	34,596	6539203	3.0434		0.0140	
1976	1,095	22	73.33	3.75	177	30,976	5545233	3.0394		0.0130	
1972	1,065	21	70.00	3.33	147	21,316	3176523	3.0273		0.0104	
1978	1,045	20	66.67	3.00	127	15,876	2048383	3.0191		0.0088	
1951	1,030	19	63.33	2.73	112	12,321	1404928	3.0128		0.0077	
1965	985	18	60.00	2.50	67	4,356	300763	2.9934		0.0047	
1954	980	17	56.67	2.31	62	3,721	238328	2.9912		0.0044	
1971	970	16	53.33	2.14	52	2,601	140608	2.9868		0.0038	
1952	860	15	50.00	2.00	- 58	3,481	- 195112	2.9345		0.0001	
1964	780	14	46.67	1.88	- 138	19,321	- 2628072	2.8921		0.0011	
1963	755	13	43.33	1.76	- 163	26,896	- 4330747	2.8779		0.0022	
1975	730	12	40.00	1.67	- 188	35,721	- 6644672	2.8633		0.0038	
1973	720	11	36.67	1.58	- 198	39,601	- 7762392	2.8573		0.0046	
1957	705	10	33.33	1.50	- 213	45,796	- 9663597	2.8482		0.0059	
1958	690	9	30.00	1.43	- 228	52,441	- 11852352	2.8388		0.0075	
1955	676	8	26.67	1.36	- 242	59,049	- 14172488	2.8299		0.0091	
1960	668	7	23.33	1.30	- 250	63,001	- 15625000	2.8248		0.0101	
1974	655	6	20.00	1.25	- 263	69,696	- 18191447	2.8162		0.0119	
1953	650	5	16.67	1.20	- 268	72,361	- 19248832	2.8129		0.0126	
1962	598	4	13.33	1.15	- 320	103,041	- 32768000	2.7767		0.0221	
1966	390	3	10.00	1.11	- 528	279,841	-147197952	2.5911		0.1116	
1969	380	2	6.67	1.07	- 538	290,521	-155720872	2.5798		0.1193	
1980	265	1	3.33	1.03	- 653	427,716	-278445078	2.4232		0.2520	
					JUBBA	AT LUGH	GANANA				
						(TABLE 21	A)				
	26,624	29	-	-	+ 2	4,035.000	1289806073	84,830		1.0019	

ARITHMETIC MEAN : $\frac{26,624}{29}$ = 918 m^3/sec

STANDARD DIVIATION : $SD = \sqrt{\frac{1}{29-1}(4,035,000)} = 379.6\ m^3/sec$

Coefficient Skew: 0.90

GEOMETRIC MEAN : 84.8302 = $\frac{2.9252}{29}$ = 842 m^3/sec

STANDARD DIVIATION : $SD = \sqrt{\frac{1}{29-1}(1.0019)} = 0.18916$

TABLE. 22

'MMP' Probability data (1951/77) & B.P.Gemmell (1980/81)

1978 'MMP'	1981 Gemmell	% Diff.	Return Period (Years)
2,000	2,140	+ 7.0	60
1,800	1,920	+ 6.7	33
1,700	1,820	+ 7.1	24
1,600	1,720	+ 7.5	18
1,400	1,420	+ 1.5	8
1,200	1,245	+ 3.8	5
1.000	1,020	+ 2.0	2.8

10.1.6. JUBBA RIVER MAXIMUM DISCHARGE CHARACTERISTICS

The Unit discharge figures are based on the 1951 /81 data series for Lugh Ganana, and 1977 & 1980/81 for Bardheere. the details are presented in Table.23

TABLE.23

Maximum Discharge Characteristics (Jubba)

Parameters	Lugh Ganana	Bardheere
Catchment Areas (km^2)	179,520	216,732
Data Series (Years)	1951/81	1977 & 1980/81
Mean Annual Max. Discharge (m^3/sec)	921	-
Max Peak Discharge (m^3/sec)	2,052	1,641
Min Peak Discharge (m^3/sec)	265	593
Mean Annual Max Unit Discharge	0.00513	-
Max Unit Discharge(m^3/sec/km^2)	0.01143	0.00757
Min Unit Discharge(" ")	0.00148	0.00274

The three years data available for Bardheere is not sufficient to obtain a representative mean. The mean annual flow calculated by Selchozpromexport was 965 m^3/sec, a 6 % increase over Lugh Ganana.

10.2.0 SHEBELLI RIVER

Water level observations for the Shebelli River stations at Belet Uen and Afgoi were virtually complete for the project period, except for short periods when the observers were on leave. At Belet Uen the gaps in the observers records were covered by the recorder, which functioned fairly reliably.

Unfortunately, at the start of the project in 1980 a number of the stations did not have resident observers, these were Bulo Burti, Mahaddei Uen and Audegle. The absence of observers resulted in the loss of data for the initial flood period at Mahaddei Uen and Audegle and almost ten months at Bulo Burti. Frequent gauging and inspection visits to the stations by the field staff in Mogadishu, ensured at least 'spot check' observations which enabled the straight line recession curves to be drawn for the low water periods. The 'spot observations' also provided the sample observations by which the correlations of water level were established, and enabled the missing data to be synthesised (Vol.3. - Sect 'G').

Water level quality 'bar charts' illustrating the various ways the data was obtained appear as Figures 3 & 4.

At Belet Uen the discharge curve was established with 44 discharge measurements ranging from 2.0 m^3/sec to 360 m^3/sec. Estimates were also carried out at 6.14 and 6.70 meter gauge heights, or 597 and 1,394 m^3/sec respectively. The estimates were carried out with the use of float observations onsite, at the time of the flood. Slope and area surveys after the event, and discharge measurements at the gauging section at the 6.14 meter water level. The road embankment was assumed to be acting as a broad crested weir. The maximum and minimum measurements observed at the site were the highest and lowest ever observed, and due to the unique nature of the floods will probably be the highest ever to be recorded.

The observations at Bulo Burti also covered the whole range of flood occurances, including the peak flood of May 1981. A total of 30 discharge measurements were carried out, with the highest current meter gauging at a level of 7.51 meters and a discharge of 360 m^3/sec. The flood peak was obtained from slope and cross sectional surveys after the event, when the floodmarks were still fresh on the ground. There was a maximum of 448 m^3/sec in the main channel with an additional 82 m^3/sec bypassing the bridge on the left bank, within a well defined section. The minimum flow on March 8th was only a trace. The arrival of the first flood waters was gauged on the same day at 1400 hours at a discharge of 0.36 m^3/sec. These were also the highest and lowest measurements ever observed.

Mahaddei Uen is a 'bottle neck' and control point where the flood levels do not go much higher than approximately 5.30 meters, and usually remaining constant for a long period, as illustrated by the flat topped hydrographs common to the station. The levels at the station depending on the stability of the flood protection bunds situated along the banks of the river upstream of the station. A total of 25 discharge gaugings were used to establish the rating curve, ranging from 1.51 m^3/sec to 167 m^3/sec at the maximum observed water level of 5.20 meters. It must also be noted that the river was completely dry for a period in excess of two weeks.

The flood levels at the downstream stations of Afgoi and Audegle are no longer truly representative of the floods because they are considerably affected or controlled by the water extractions upstream, namely for the Johar 'Offstream Storage Resevoir ' and the S.N.A.I Sugar Scheme. The 'Offstream Resevoir' is designed as a storage resevoir, as it's name implies, but is also being utilised as a flood control regulator, and effectively so. Without the extraction of approximately 45 m^3/sec from the river in May 1981 at Sabun, extensive damage would have occured downstream of Johar in the main agricultural areas of Balaad, Afgoi and Genale.

The station at Balaad was closed soon after the 'Balaad Barrage' came into operation in April 1980, when only a few low level discharge measurements had been obtained, but did indicate that there had been no large change in the low level rating, suggesting very limited siltation. 'Spot Gaugings' were carried out after the closure of the station, and they mainly illustrate the effect of the barrage on the flow (Fig.28).

Establishment of the new rating curve at Afgoi where the flood levels were maintained within the river banks for both the 1980 and 1981 flood periods, 14 discharge measurements were carried out ranging from 1.27 m^3/sec to 100 m^3/sec. It must also be noted that the river ran dry both in 1980 and 1981, but more severe in 1981 when water holes had to be dug in the river beds to obtain water at depths of two meters.

The rating curve at Audegle was also established with 14 discharge measurements ranging from 0.54 to 95 m^3/sec, the full range of both years flood occurances. The flood level in 1980 was higher than 1981, but only because of the malfunction of the Genale 'Barrage' gates which caused overbank flooding as far upstream as Audegle, affecting the energy gradient of the flow and consequently the discharge in the river.(see rating curves).

Annual streamflows for 1980/81 for the five observation stations along the Shebelli have been computed utilising the new rating curves. The details relating to the discharges and percentage flow distributions appear in tabulated form in Appendix 'F'.

Belet Uen data for the period 1977 to 1979, has also been recalculated to reflect the recent ratings. Unfortunately, past data for the other stations lack the continuity of the Belet Uen records, with periods of upto a year or more missing, so no attempts have been made to adjust the data.

It is not known whether the gaps in the data series is due to the lack of field observations, or just misplacement of the data. When time is available during follow-up projects, it should be undertaken to try and trace the missing data, from both the Government Ministries and Independent Consultant companies, with offices both in Somalia and oversea's who have

SHEBELLI RIVER

STATTION : Belet Uen

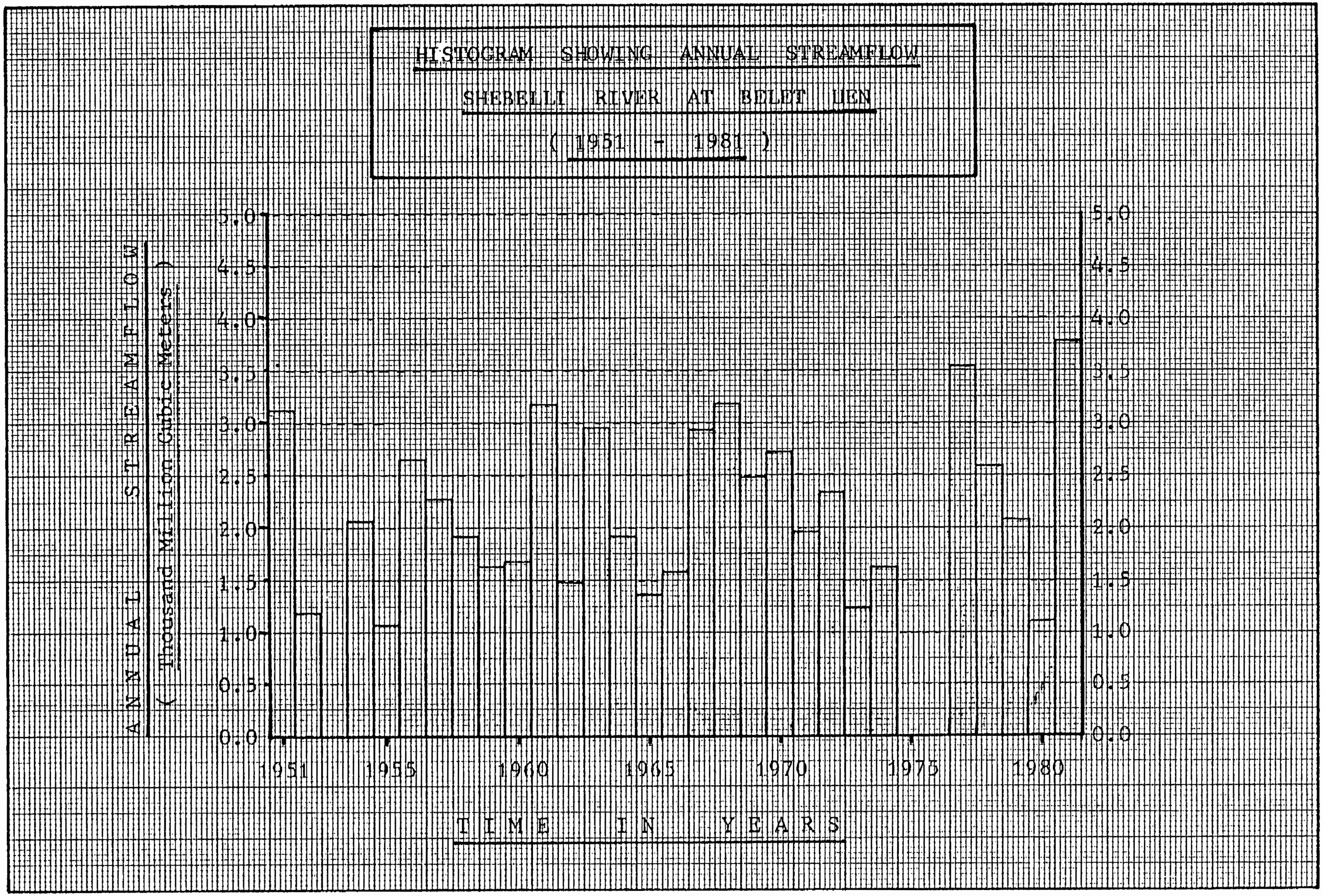
(Streamflow in m^3/sec)

PERIOD: 1951/1981

Year	Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sep 9	Oct 10	Nov 11	Dec 12	Annual Mean	Annual 'Q' (m^3x 10^6)	Max 'Q' (m^3/sec)	MIN 'Q' (m^3/sec)
1951	(16.00)	(13.00)	(37.36)	171.00	229.00	193.00	24.60	62.00	81.30	72.30	191.00	92.70	(98.61)	(3,110)	300	-
1952	8.20	4.97	4.65	5.02	87.50	39.70	7.48	38.80	125.30	84.30	42.10	4.12	37.90 *	1,198	160	-
1953	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1954	8.58	11.20	8.60	88.80	59.00	25.50	6.73	102.30	153.50	209.50	7.73	34.70	65.80	2,075	250	-
1955	7.84	7.45	8.97	9.65	44.00	12.73	7.47	29.80	97.50	135.80	42.50	8.60	34.50	1,088	255	-
1956	7.84	7.45	9.35	33.20	147.00	29.30	25.30	99.00	151.20	145.00	218.00	29.40	83.80 *	2,650	320	-
1957	11.20	8.28	20.10	59.80	200.00	106.30	51.90	124.20	130.00	52.60	56.30	42.20	72.40	2,283	270	-
1958	9.70	18.20	44.80	20.40	63.10	10.80	13.80	117.20	161.20	169.50	81.00	16.70	61.00	1,924	205	-
1959	8.97	8.28	7.48	7.34	73.70	21.98	11.92	76.90	143.00	122.80	112.00	22.40	51.60	1,627	194	-
1960	67.00	25.20	8.97	19.65	65.70	38.60	16.40	41.10	88.00	(127.26)	(89.57)	(44.35)	(52.65)*	1,665	-	-
1961	10.42	10.30	7.83	9.28	52.60	15.00	46.30	122.90	235.00	214.00	215.00	260.00	100.40	3,166	381	-
1962	15.30	7.86	7.10	13.50	59.10	17.40	8.60	31.00	75.70	88.70	157.00	75.20	46.50	1,466	245	-
1963	22.65	19.00	8.23	60.70	301.00	139.00	62.00	108.00	158.00	99.30	54.80	79.50	93.50	2,949	243	-
1964	39.20	14.80	6.72	23.20	32.40	16.20	23.10	122.60	158.60	156.00	97.20	29.50	60.40 *	1,910	225	-
1965	53.40	14.05	5.60	8.12	46.00	10.80	3.73	31.00	70.70	85.00	94.30	(8.97)	43.00	1,356	180	-
1966	1.12	5.38	24.90	35.50	89.20	38.60	38.00	74.00	126.00	101.00	60.50	8.97	50.70	1,599	195	-
1967	1.87	2.07	1.49	47.10	124.63	54.05	31.72	113.43	182.24	220.90	147.88	183.95	92.61	2,921	289	-
1968	25.37	12.80	66.42	95.37	278.36	135.90	87.69	127.99	143.24	117.16	60.23	60.07	100.88 *	3,190	341	-
1969	20.16	24.28	116.70	106.60	131.90	45.85	61.90	128.00	174.00	82.60	40.90	14.00	78.90	2,488	204	-
1970	7.51	20.72	65.70	103.19	162.02	27.80	25.29	124.12	218.06	172.30	95.76	15.59	86.50	2,728	233	-
1971	8.65	5.70	4.50	50.18	90.50	45.58	80.80	103.80	151.98	104.65	74.80	32.20	62.79	1,980	173	-
1972	10.10	22.87	15.00	53.59	173.60	67.13	83.10	117.90	144.40	111.40	71.60	17.90	74.00 *	2,340	232	-
1973	17.90	4.50	3.00	6.70	58.10	24.10	27.70	90.10	127.20	100.40	25.90	4.60	39.40	1,243	159	-
1974	(0)	(2)	(0)	69.70	62.10	70.20	75.30	106.10	131.70	78.50	19.00	5.50	(51.70)	(1,630)	167	-
1975	-	-	-	-	79.00	43.30	64.70	127.00	208.70	126.00	33.70	8.00	-	-	221	-
1976	-	-	-	-	83.00	52.60	38.00	-	-	-	-	-	- *	-	336	-
1977	12.68	12.68	15.30	104.10	193.40	60.80	29.28	135.70	156.20	171.50	262.50	120.80	111.94	3,530	327	7.79
1978	24.32	12.68	84.00	50.13	41.27	29.80	59.02	154.80	192.00	122.00	119.40	29.80	85.36	2,580	261	10.27
1979	20.26	63.65	48.85	75.41	84.00	111.10	60.82	112.90	69.43	81.61	53.34	12.68	66.17	2,084	157	7.21
1980	8.96	4.17	3.51	9.95	96.92	16.90	25.29	87.23	83.19	55.37	18.53	6.11	34.84 *	1,103	172	2.01
1981	2.54	0.26	60.10	335.30	304.00	50.13	24.37	120.30	211.30	228.10	48.85	17.71	119.33	3,761	1,394	0.49
MEAN	16.00	13.00	37.36	59.73	122.07	51.67	39.08	97.59	143.06	127.26	89.57	44.35	70.06	2,209	282	-

DATA SOURCE: A). Irrigation Report by J.C. Henry- 1979. B). Ministry of Agriculture records 1951 - 79. C). B.P.Gemmell 1980 - 81 (Water Hydrometry Project. NOTE: Data for period 1977 - 1981 computed from 1980/81 rating curve. The bracketed figures 1951 & 1960 are mean values due to missing data. Asterisk denotes leap year.

TABLE 24.



HISTOGRAM SHOWING ANNUAL STREAMFLOW
SHEBELLI RIVER AT BELET UEN
(1951 - 1981)
ANNUAL STREAMFLOW
(Thousand Million Cubic Meters)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
1951
1955
1960
1965
1970
1975
1980
TIME IN YEARS

FIG 39.

SHEBELLI RIVER

STATION : Bulo Burti (Streamflow in m^3/sec) PERIOD : 1951/81

YEAR	Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sep 9	Oct 10	Nov 11	Dec 12	Annual Mean	Annual ' Q ' ($m^3 \times 10^6$)
1951	-	-	-	151.74	176.12	162.93	17.54	55.60	76.06	60.07	163.32	87.69	105.67	3,332
1952	10.82	9.20	9.33	9.65	83.58	20.08	10.07	22.76	117.76	81.34	36.68	9.70	35.08 *	1.109
1953	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1954	10.45	10.33	10.45	81.47	44.78	22.00	8.21	68.28	137.45	170.00	75.29	29.10	55.65	1,755
1955	9.70	9.09	9.70	9.65	32.84	11.58	8.96	21.64	94.59	125.37	36.68	9.70	31.63	997
1956	9.70	9.20	10.45	29.34	186.57	22.78	24.63	91.42	137.06	128.36	181.08	22.39	71.08 *	2,248
1957	11.19	9.50	19.03	53.28	151.87	100.77	44.40	114.43	117.37	46.64	51.35	37.31	63.14	1,991
1958	10.07	15.29	39.55	20.08	57.46	10.81	12.31	110.45	141.70	151.49	73.36	13.80	54.70	1,725
1959	9.70	9.92	9.70	9.65	69.40	17.76	11.19	72.76	131.27	114.93	101.54	16.79	47.88	1,510
1960	59.70	19.60	10.45	14.29	60.07	33.20	13.43	30.97	82.24	-	-	-	35.99 *	1.138
1961	10.82	10.74	9.33	10.04	49.25	11.97	32.09	114.93	171.81	163.43	180.30	222.00	82.23	2,593
1962	20.15	7.44	9.33	12.36	54.10	16.99	9.70	25.75	73.36	83.21	150.97	81.34	45.39	1,431
1963	21.64	9.09	3.36	59.85	216.04	140.54	60.07	98.51	142.47	95.90	56.37	82.84	82.22	2,593
1964	32.84	12.00	4.10	20.08	27.61	11.58	32.09	120.52	171.81	172.00	102.32	16.04	60.25 *	1,905
1965	51.49	6.20	2.61	4.25	49.25	5.02	2.24	21.27	79.15	100.37	121.24	(30.22)	39.44	1,244
1966	11.94	2.07	3.73	30.89	94.40	34.75	33.21	67.91	133.98	107.46	102.70	23.13	53.85	1,698
1967	5.60	1.65	1.12	39.77	132.84	68.73	35.45	129.85	196.14	220.52	163.71	185.45	98.40	3,103
1968	28.36	11.60	85.82	96.53	231.34	163.32	95.52	135.45	154.83	131.34	63.71	62.69	105.04 *	3.322
1969	14.30	13.80	126.40	-	-	41.90	75.30	135.80	193.70	103.90	49.50	5.70	76.03	2,398
1970	3.00	11.20	58.30	120.27	169.67	23.62	14.32	126.93	208.49	169.13	104.41	11.48	85.06	2,682
1971	3.85	1.69	2.74	47.11	107.40	59.78	95.95	121.47	163.48	120.11	83.80	30.79	69.84	2,202
1972	4.70	18.08	8.82	63.10	112.10	42.80	38.80	13.10	164.10	181.60	82.90	12.00	62.19 *	1,967
1973	4.10	1.70	1.30	13.00	50.90	20.70	16.70	102.20	15.30	29.20	21.80	17.20	27.60	870
1974	(0)	1.40	-	76.00	57.90	-	-	-	117.20	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	172.40	75.10	132.50	174.30	151.60	136.40	58.40	- *	-
1977	-	-	-	-	215.10	103.80	-	-	-	199.30	242.30	187.20	-	-
1978	62.00	-	-	-	-	-	133.80	210.40	26.16	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	10.94	8.09	2.90	11.12	87.74	19.01	22.41	75.41	80.17	53.23	21.07	9.15	33.44 *	1,057
1981	0.89	0.07	41.91	273.30	384.90	64.53	24.93	107.80	193.20	244.20	51.09	16.36	116.93	3,688
MEAN	17.22	8.32	21.49	51.54	112.10	49.99	36.39	89.58	138.18	128.26	97.88	51.02	67.18	2,119

DATA SOURCE : Selchozpromexport(1965 &73), M.MacDonalds & Partners, Ministry of Agriculture records, and B.P.Gemmell/FAO (1980/81)

* Asterisk denotes a leap year.

TABLE 25.

S H E B E L L I   R I V E R

(Streamflow in m^3 / sec)

STATION : Mahaddei Uen

PERIOD : 1951/81

YEAR	Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sep 9	Oct 10	Nov 11	Dec 12	Annual Mean	Annual ' Q ' ($m^3 \times 10^6$)
1951	-	-	-	121.62	129.10	106.56	22.01	54.85	78.38	45.90	129.73	91.79	(86.66)	2,733
1952	10.82	5.20	5.22	5.02	77.61	22.39	10.07	23.88	88.80	78.73	42.08	4.48	31.19 *	986
1953	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1954	11.19	11.57	11.19	72.59	60.07	26.64	4.10	71.27	128.96	129.48	69.11	33.58	52.48	1,655
1955	5.97	2.89	7.46	8.49	38.43	13.51	2.61	20.15	93.44	126.12	39.77	6.72	30.46	961
1956	5.60	3.60	9.70	18.92	118.66	28.57	24.63	91.04	127.41	118.28	120.46	30.22	58.09 *	1,837
1957	13.43	6.61	15.30	54.05	127.99	102.32	46.64	105.60	120.08	48.88	51.74	39.18	60.99	1,923
1958	9.33	16.53	41.79	22.39	63.43	11.58	14.18	100.75	129.73	129.48	69.11	19.78	52.34	1,651
1959	9.70	7.44	5.60	5.41	73.88	23.55	14.18	69.03	115.83	116.04	103.09	23.12	47.24	1,490
1960	61.94	24.00	11.19	20.85	59.33	37.07	18.28	36.94	79.54	-	-	-	(38.79)*	1,227
1961	11.19	11.98	5.22	8.49	50.00	16.99	41.04	113.81	129.34	128.73	129.73	129.48	64.67	2,039
1962	15.67	3.72	3.73	11.58	49.25	15.44	8.58	26.49	67.95	80.60	125.87	69.40	39.86	1,257
1963	6.34	3.72	2.99	50.58	127.99	93.05	51.49	97.01	130.50	92.91	47.10	80.60	65.36	2,061
1964	36.94	17.60	7.46	24.71	35.45	22.39	30.22	89.18	124.63	131.27	88.80	26.49	52.93 *	1,674
1965	54.85	16.94	7.46	5.79	47.01	14.67	4.85	20.52	64.09	81.72	108.11	46.27	39.36	1,241
1966	11.94	4.13	27.61	35.14	85.07	44.79	40.30	61.57	108.49	96.27	77.99	18.28	50.97	1,607
1967	4.10	0.83	0.37	37.45	100.75	75.29	29.48	95.52	135.52	131.34	130.50	123.51	72.06	2,273
1968	38.43	19.20	71.27	78.76	138.80	120.46	82.84	104.85	128.57	116.00	69.88	70.15	86.60 *	2,738
1969	28.45	23.88	99.80	64.48	112.68	62.43	53.00	108.87	134.07	99.77	52.45	17.68	71.46	2,254
1970	9.67	22.76	42.94	103.20	137.12	43.32	20.13	96.30	139.93	138.87	101.92	27.27	73.62	2,322
1971	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-	-	-	-	-	- *	-
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	(0)	-	-	-	-	73.20	77.20	103.90	153.90	89.40	23.30	46.10	-	-
1975	45.50	-	-	-	60.10	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	126.00	-	87.80	112.60	136.50	97.60	80.00	-	- *	-
1977	12.10	11.90	13.20	79.20	139.10	84.20	69.20	103.30	118.10	135.50	144.60	130.40	86.73	2,735
1978	-	21.00	-	68.80	92.90	-	33.80	17.00	42.70	106.00	89.30	39.30	-	-
1979	56.90	69.90	75.80	45.20	65.30	105.00	62.60	102.00	-	-	-	-	-	-
1980	9.23	4.48	2.93	6.08	85.80	22.80	19.90	96.80	86.70	55.70	22.10	6.60	33.18 *	1,103
1981	1.71	0.01	34.10	152.10	160.70	79.30	34.30	97.50	152.10	156.70	70.30	26.10	80.41	2,545
MEAN	19.60	13.50	22.90	45.82	90.90	51.83	34.76	76.95	112.40	105.38	82.87	48.08	58.75	1,853

DATA SOURCE : Selchozpromexport(1965 & 73), M. MacDonalds & Partners, Ministry of Agriculture records, and B.P.Gemmell/FAO (1980/81).

* Asterisks denotes a leap year.

TABLE 26.

SHEBELLI RIVER

STATION : AFGOI (Streamflow in m^3/sec) PERIOD : 1951/81

YEAR	Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sep 9	Oct 10	Nov 11	Dec 12	Annual Mean	Annual 'Q' ($m^3 \times 10^6$)
1951	(14.80)	(8.50)	(12.90)	91.12	92.91	81.08	17.91	49.25	75.59	42.54	93.05	75.00	(54.55)	1,720
1952	5.22	1.20	1.12	1.16	70.15	20.08	3.73	17.91	84.56	70.90	37.45	1.49	26.25 *	830
1953	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1954	4.85	4.96	5.22	73.36	53.73	21.24	1.12	55.22	93.05	89.93	60.23	28.73	40.97	1,296
1955	1.87	0.83	2.24	2.70	38.81	8.11	1.12	16.42	80.31	92.91	34.75	2.61	23.56	745
1956	1.49	1.20	4.10	6.18	88.43	23.17	19.03	81.34	93.05	88.81	89.58	25.75	43.51 *	1,376
1957	6.72	1.65	1.12	47.10	91.79	87.64	42.16	84.33	92.66	44.40	48.65	32.46	48.39	1,530
1958	3.36	11.16	47.39	11.58	56.72	5.02	7.84	82.09	93.05	92.91	61.00	13.43	40.46	1,279
1959	3.36	2.07	1.12	1.16	61.57	16.60	7.84	65.30	87.64	91.42	81.08	16.79	36.33	1,149
1960	57.09	18.00	4.85	14.29	55.97	33.98	11.94	32.46	75.29	-	-	-	- *	-
1961	5.22	5.37	1.87	3.47	32.09	15.06	35.82	89.55	93.05	92.91	96.14	92.91	47.97	1,517
1962	10.07	1.24	1.12	7.34	46.27	12.36	4.10	21.64	65.25	74.63	92.66	64.18	33.41	1,057
1963	2.99	0.83	1.12	39.77	92.16	76.45	47.76	81.34	94.21	83.96	45.95	77.99	53.71	1,698
1964	38.06	14.80	3.36	15.08	32.84	16.60	23.13	33.58	91.89	91.04	80.31	66.42	42.26 *	1,336
1965	46.64	14.46	2.61	2.70	45.52	9.27	1.49	2.24	55.98	63.43	84.56	48.88	31.48	995
1966	8.21	0.83	22.76	23.94	68.66	36.29	32.09	48.88	80.31	74.25	63.32	13.81	39.45	1,248
1967	1.49	1.24	(0)	26.64	77.61	69.88	27.61	81.34	96.14	92.91	91.51	89.93	54.69	1,729
1968	29.48	9.20	52.99	56.76	91.79	86.49	70.90	83.96	91.51	88.81	62.16	64.18	65.69 *	2,077
1969	24.60	18.60	72.90	94.90	89.04	63.00	46.40	83.50	95.10	85.08	52.07	16.60	61.82	1,955
1970	4.75	15.04	31.50	87.20	96.90	49.90	18.80	79.40	97.80	97.00	86.20	25.90	57.53	1,819
1971	10.31	2.33	(0)	23.39	74.89	52.35	70.88	87.70	97.81	88.18	69.00	45.11	51.81	1,638
1972	9.65	5.12	19.58	17.64	92.60	74.70	60.60	97.70	102.10	96.10	82.10	30.40	57.40 *	1,815
1973	(0)	(0)	(0)	(0)	-	36.40	-	-	-	83.80	45.70	16.70	-	-
1974	(0)	(0)	(0)	(0)	59.60	57.60	82.00	82.00	90.70	73.50	29.10	(17.90)	(41.03)	1,294
1975	-	-	-	-	59.40	46.80	37.40	92.50	96.70	85.20	29.50	5.10	-	-
1976	-	-	-	-	86.20	90.90	62.10	90.40	98.40	73.40	63.70	40.10	- *	-
1977	12.30	11.60	7.73	54.10	101.20	66.20	55.40	-	93.90	94.80	98.70	-	-	-
1978	56.20	9.80	(13.40)	53.50	74.60	44.10	37.00	93.30	42.20	112.10	94.20	44.00	56.20	1,777
1979	22.80	58.90	29.22	81.11	70.91	110.00	52.90	64.80	65.05	54.40	37.10	9.95	54.80	1,733
1980	2.50	1.10	0.07	1.40	62.20	18.40	9.00	55.00	61.20	40.90	15.00	0.01	22.20 *	702
1981	(0)	(0)	16.60	84.30	96.20	60.30	33.70	58.40	97.40	95.10	67.80	20.50	52.50	1,656
MEAN	13.83	7.93	13.00	33.30	71.00	43.60	31.80	64.70	85.40	81.30	65.10	35.90	45.60	1,438

DATA SOURCE : Selchozpromexport (1965 & 73), M. MacDonalds & Partners, Ministry of Agriculture records, and B.P.Gemmell/FAO (1980/81).

* Asterisk denotes leap year.

TABLE 27.

SHEBELLI RIVER MEAN MONTHLY AND ANNUAL DISCHARGE COMPARISONS

STATION	PERIOD	JAN 1	FEB 2	MAR 3	APR 4	MAY 5	JUN 6	JUL 7	AUG 8	SEP 9	OCT 10	NOV 11	DEC 12	ANNUAL MEAN m^3/sec	ANNUAL VOLUME m^3x10^6
Belet Uen	1951/79	17.3	13.5	24.5	46.2	117.3	50.3	39.5	96.0	145.3	126.9	94.3	48.5	68.3	2,154
	1951/81	16.0	13.0	37.4	59.7	122.1	51.7	39.1	97.6	143.1	127.3	89.6	44.4	70.1	2,209
	% Diff.	+ 7.5	- 3.7	+52.6	+29.2	+ 4.1	+ 2.8	- 1.0	+ 1.7	- 1.5	+ 0.3	- 5.0	- 8.5	+ 2.6	+ 2.6
Bulo Burti	1951/79	18.2	8.7	21.4	43.3	105.4	50.7	37.5	89.4	138.3	126.4	103.5	54.5	66.4	2,094
	1951/81	17.2	8.3	21.5	51.5	116.3	50.0	36.4	89.6	138.2	128.3	97.9	51.0	67.2	2,119
	% Diff.	- 5.5	- 4.6	+ 0.5	+18.9	+10.3	- 1.4	- 2.9	+ 0.2	- 0.1	+ 1.5	- 5.4	- 6.4	+ 1.2	+ 1.2
Mahaddei Uen	1951/79	21.3	11.3	23.3	41.6	89.0	49.4	34.2	77.6	114.9	105.3	86.0	51.7	58.8	1,854
	1951/81	20.0	10.4	22.9	44.9	91.9	49.5	33.6	78.4	115.3	105.4	82.5	48.5	58.6	1,848
	% Diff.	- 6.1	- 8.0	- 1.7	+ 7.9	+ 3.3	+ 0.2	- 1.8	+ 1.0	+ 0.4	+ 0.1	- 4.1	- 6.2	- 0.3	- 0.3
Afgoi	1951/79	14.8	8.5	12.9	30.7	70.4	41.4	31.8	65.3	86.7	83.3	68.0	39.1	46.1	1,454
	1951/81	13.8	7.9	13.0	33.3	71.0	43.6	31.8	64.7	85.4	81.3	65.1	35.9	45.6	1,438
	% Diff.	- 6.8	- 7.1	+ 0.8	+ 8.5	+ 0.9	+ 5.3	0.0	- 0.9	- 1.5	- 2.4	- 4.3	- 8.2	- 1.1	- 1.1
Audegle	1980	1.0	0.5	Trace	0.5	67.3	28.3	11.3	65.9	69.1	58.6	24.6	0.2	27.3	863
	1981	0.0	0.0	15.4	80.6	95.7	66.0	44.9	67.9	94.1	93.7	65.2	25.3	54.1	1,705
	MEAN	0.5	0.3	7.7	40.6	81.5	47.1	28.1	68.5	81.6	76.1	44.9	12.8	40.8	1,287

NOTE : Audegle data only for two years 1980 & 1981. The mean probably not representative of the long term.

TABLE 28.

been involved with hydrological investigations in the past. Also , data prior to 1951 apparently exists at some Italian universities which should also be collected and lodged in the Somali archives, once and for all.

10.2.1. ANNUAL VOLUME DISCHARGES

Annual discharge data for the Shebelli River for the period 1951/81, has been tabulated and appears in this report in Tables 24-27, and the annual volumes for Belet Uen are also presented in 'Histogram' form in Fig.39.

The details for the long term data 1951/79 for Audegle were not available to the consultant, but the monthly and annual data for the 1980/81 period is presented in Table.28.

The frequency data analysis has been limited to the data at Belet Uen where the records(long term) are available and complete. It is also the point at which the water potential to Somalia on the Shebelli is monitored. The only additional inflow to the Shebelli system in Somalia occurs between Belet Uen and Bulo Burti. 'MMP' estimated the local contribution under normal conditions to be in the order of 10% of the total annual discharge. There is a constant decrease in discharge the further the river flows into Somalia, which is also illustrated by the narrowing of the river channel as the river approaches the coast. The flow from Ethiopia usually terminates in the swamp areas in the vicinity and south of Avai. Only under extremely rare occasions of extreme flooding has the flow continued south to join the Jubba river south of Jelib in the Kamsuma area. It has on many occasions been assumed that the Shebelli waters have reached the Jubba having breached the main road from Jelib to Mogadishu. Infact, only local storms and run-off from the Bohol Madagoi causes flooding in the Bulo Darou and Farta Tuculle areas which is responsible for the cutting of the main road, which did happen in 1981. With the control of the lower shebelli flows by overbank spillage upstream of Mahaddei Uen , the extraction of 50 m^3/sec at Sabuun and increased agricultural activity, the through flow to the Jubba may be a thing of the past, especially as it did not occur during the exceptional flooding which occured in 1981.

The mean annual and monthly discharges for the data series 1951/79 and 1951/81 are presented in Table 28, with the percentage differencies included. A comparison of the various annual means for the increasing data series are included in the following Table 29.

TABLE .29.

Increasing 'Series' Mean Annual Discharges (m^3/sec)

STATION	KM	1951/72	1951/78	1951/81
Belet Uen	0	68.6	68.3	70.1
Bulo Burti	161	64.7	66.4	67.2
Mahaddei Uen	349	55.0	58.8	58.6
Balaad	477	44.5	46.9	-
Afgoi	547	44.5	46.1	45.6
Audegle	597	-	-	40.8*

* Note: Audegle(mean for 1980/81).
Data sources: 1951/72 (Tractional), 1972 to 1979 (MMP & MOA) 1980/81 (B.P.Gemmell).

As a corollary to the extension and updating of the data series, it is found that the extremely high flow in May 1981 has produced an increase of 2.64% in the long term mean at Belet Uen, and 1.2% at Bulo Burti. However, at Mahaddei Uen and Afgoi in the middle Shebelli where the discharges have been maintained within the river banks, a decrease in annual mean discharge is apparent.

The stations at Belet Uen and Bulo Burti are directly related to the natural fluctuations of the flood flows, while at Mahaddei Uen and Afgoi the flows are mainly dependant on other factors such as the flood protection or control bunds, situated upstream of Mahaddei Uen. The level at which they are overtopped or breached and the timing of the breaching in relation to the arrival of the flood peaks, is of great importance. Since the

Johar 'Offstream Storage Resevoir' came on stream, the peak extraction of 50 m^3/sec from the river system, will affect the energy gradient and probably increase the flow substantially at Mahaddei Uen without increasing the water level. The losses to the resevoir will also be reflected in the attenuation of discharge observed at Afgoi and Audegle.

This point is illustrated by the Annual mean streamflow data for Belet Uen and Bulo Burti for 1981. These were the highest on record, while at Mahaddei Uen they were the fourth and at Afgoi the tenth highest. Downstream of Bulo Burti the flood distribution pattern is more important than a high flood of short duration. A long duration flood of bankful level will produce a larger annual discharge, than a high peaked flood which looses a large proportion of its flow to overbank losses.

The mean annual discharges for the 1951/81 data series shows an increasing attenuation of discharge from Belet Uen to Bulo Burti of 4.1%, and from Bulo Burti to Mahaddei Uen some 12.6 %. This is increased to almost double at 22.4% for the Mahaddei Uen to Afgoi stretch.

The long term mean has shown that the discharge attenuation does not occur every year. On five occasions there has been an increase in discharge between Belet Uen and Bulo Burti, ranging between 4.14% in 1968 to 11.21% in 1970, probably years of high rainfall over the local catcment areas between Belet Uen and Bulo Burti.

The data for 1980 and 1981 relate to the second lowest and the highest Annual Streamflow discharges on record, the details appearing in Table 30.

TABLE 30.

Shebelli River 1980/81 Annual Streamflow

Station	m^3x 10^6 (1980)	% Diff.	m^3x 10^6(1981)	% Diff.
Belet Uen	1,103		3,761	
Bulo Burti	1,057	- 4.17	3,688	- 1.94
Mahaddei Uen	1,049	- 0.76	2,545	- 30.99
Afgoi	702	- 33.08	1,656	- 34.93
Audegle	863	(+ 22.93)	1,705	+ (2.60)

The figures in Table 30. show the large difference in flow attenuation between Bulo Burti and Mahaddei Uen in a dry year (1980), and a wet year (1981). With no overbank spillage there was was hardly any attenuation (0.8%) in 1980, while during the very wet year and high level flood periods the attenuation in 1981 was recorded at 31%. A large percentage of the attenuation was the result of the extreme overbank flooding in April/May, which occured between Jalalaqsi and Dudunle on the right bank, then flowed in a southerly direction for over a hundred and twenty kilometers, along the old river channel path. Additional flow also bypassed the gauging station at Mahaddei Uen on the left bank, then joining up with the 'Togga' Harway to flow towards the low depressions near the sand dunes in the vicinity of the 'Johar Offstream Resevoir'.(History Of the 'GU' Floods).

The attenuation between Mahaddei Uen and Afgoi remained much the same for both years, as the river levels were kept at the same levels after the 'Barrage' at Sabuun, with a maximum flow of between 100 and 110 m^3/sec. The large attenuation between Mahaddei Uen and Afgoi reflects the present extraction for the 'Offstream Storage Resevoir', the 'SNAI' Sugar Scheme, with a large proportion over this stretch of the river going to recharge the groundwater aquifer extending towards the coast.

The 1980/81 data for Audegle shows an increase in the Annual Streamflow between Afgoi and Audegle. This appears to be inacurate and must be checked again, although previous data Table 29, showed no attenuation in discharge between Balaad and Afgoi (1951/72 data series).

The downstream site at Audegle has a very unsatisfactory gauging section, and is also affected by energy gradient changes probably caused by the 'Barrage' downstream at Genale, as shown by the changes in discharge for similar gauge heights from time to time at Audegle. A close check should be carried out of the water levels and discharges, preferably with the use of a Water Level Recorder. Abandonment of this station and calibration of the Barrage at Genale, may be a better alternative, as the site would be more accessible during the rainy season.

The lowest discharge periods on the Shebelli are between January and April, followed by the start of the 'GU' floods which usually start between mid march to mid april. The lowest mean annual discharge does not identify the most severe drought periods, as illustrated by the 1981 data which was the highest Annual discharge on record, but also laid claim to being one of the worst drought periods on record. The six lowest mean annual discharges at Belet Uen are listed in Table 31.

TABLE 31.

No	Year	Mean Annual 'Q' (m^3x 10^6)
1	1955	1,088
2	1980	1,103
3	1952	1,198
4	1973	1,243
5	1965	1,356
6	1962	1,446

In contrast to the minimum mean annual discharges, the lowest one, two and three month discharge figures for Belet Uen and Afgoi are identified in the following Tables 32 & 33.

TABLE 32.

Shebelli River at Belet Uen

Lowest One, Two and Three Month Discharge Totals

Rank	One Month Year	(m^3x10^6)	Two Months Year	(m^3x10^6)	Three Months Year	(m^3x10^6)
1	1974	0.00	1974	0.00	1974	0.00
2	1981	0.26	1981	2.80	1967	5.43
3	1966	1.12	1967	3.36	1980	16.64
4	1967	1.49	1966	6.50	1952	17.82
5	1973	3.00	1973	7.50	1971	18.85
6	1980	3.51	1980	7.68	1955	24.26
7	1971	4.50	1952	9.62	1956	24.64
8	1952	4.65	1971	10.20	1959	24.73

At Belet Uen 1974 appears to be the lowest year over all the three time intervals, followed by 1981 for the two month interval and 1967 for the three month interval.

TABLE 33.

Shebelli River at Afgoi

Minimum One, Two and Three Month Discharge Totals

Rank	One Month Year	One Month (m^3x 10^6)	Two Months Year	Two Months (m^3x 10^6)	Three Months Year	Three Months (m^3x 10^6)
1	1974	0.00	1974	0.00	1974	0.00
2	1981	0.00	1981	0.00	1973	0.00 (?)
3	1973	0.00	1973	0.00	1967	2.73
4	1967	0.00	1980	1.17	1952	3.48
5	1971	0.00	1967	1.24	1980	3.67
6	1980	0.07	1963	1.95	1959	4.35
7	1955	0.83	1959	2.28	1955	4.94
8	1963	0.83	1971	2.33	1963	4.94

A similar pattern emerges at Afgoi as found at Belet Uen. The lowest discharges for all three time intervals are claimed for 1974, with nil discharges for all periods. There is some doubt as to whether the nil ratings for data prior to 1980, were infact dry periods or just very low flows which were considered unimportant by the observers.

As shown in Table 32, the lowest mean annual discharge at Belet Uen was observed in 1955 and followed by 1980. Whereas, the driest consecutive One, Two and Three month periods were observed in 1974, and followed by 1981 and 1973 repectively.

The dry periods attributed to 1973 and 1974 have been accepted at face value, but doubts do exist as to whether the data is truly representative of the situation at Afgoi in 1973. The mean flow for January in 1973 was 17.0 m^3/sec at Belet Uen, and falling to 3.0 m^3/sec in March, which are much higher than other periods which did not produce nil flows at Afgoi. The data has been used for this report, but should be re-examined in the future, especially for the period 1972 to 1976.

SHEBELI RIVER AT BELET UEN

ANNUAL SERIES OF STREAMFLOW (1951 - 1981)

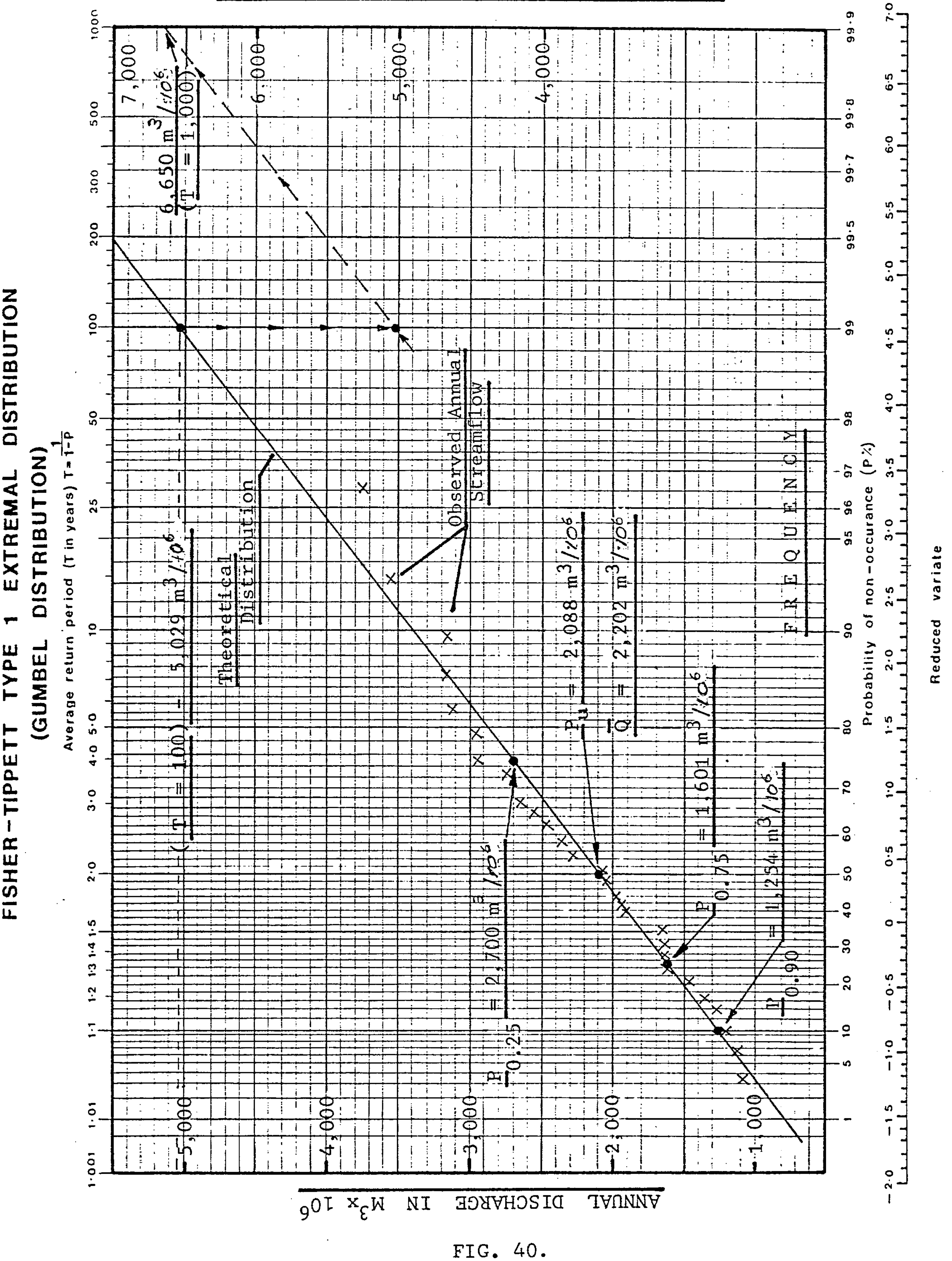


FIG. 40.

FREQUENCY ANALYSIS COMPUTATIONS

PERIOD	ANNUAL ' Q ' ($M^3 x 10^6$)	RANK	PROB/TY $1 - \frac{r}{n+1}$	REC/INT T_r (Years)	$(x - \bar{x})$	$(x - \bar{x})^2$	$(x - \bar{x})^3$	LOG X	(Log x - Log $\bar{x}$)	$(\text{Log } x - \text{Log } \bar{x})^2$	(Log x - Log $\bar{x}$)
1981	3,761	28	96.55	29.00	1559	2,430,481	3789119889	3.5753		0.067200	
1977	3,530	27	93.10	14.50	1328	1,763,584	2342039551	3.5478		0.053710	
1968	3,190	26	89.66	9.87	988	976,144	964430268	3.5038		0.035270	
1961	3,166	25	86.21	7.25	964	929,296	895841349	3.5005		0.034040	
1951	3,110	24	82.76	5.80	908	824,464	748613315	3.4928		0.031260	
1963	2,949	23	79.31	4.83	747	558,009	416832725	3.4697		0.023620	
1967	2,921	22	75.86	4.14	719	516,961	371694958	3.4655		0.022350	
1970	2,728	21	72.41	3.63	526	276,676	145531576	3.4358		0.014350	
1956	2,650	20	69.97	3.22	448	200,704	89915392	3.4232		0.011490	
1978	2,580	19	65.52	2.90	378	142,884	54010152	3.4116		0.009140	
1969	2,488	18	62.07	2.64	286	81,796	23393656	3.3959		0.006380	
1972	2,340	17	58.62	2.42	138	19,044	2628072	3.3692		0.002830	
1957	2,283	16	55.17	2.23	81	6,561	531441	3.3585		0.001810	
1979	2,084	15	51.72	2.07	- 118	13,924	- 1643032	3.3189		0.000008	
1954	2,075	14	48.28	1.93	- 127	16,129	- 2048383	3.3170		0.000001	
1971	1,980	13	44.83	1.81	- 222	49,284	- 10941048	3.2967		0.000373	
1958	1,924	12	41.38	1.71	- 278	77,284	- 21484952	3.2842		0.001011	
1964	1,910	11	37.93	1.61	- 292	85,265	- 24897088	3.2810		0.001225	
1960	1,665	10	34.48	1.53	- 537	288,369	-154854154	3.2214		0.008949	
1974	1,630	9	31.03	1.45	- 572	327,184	-187149247	3.2122		0.010774	
1959	1,627	8	27.59	1.38	- 575	330,625	-190109375	3.2114		0.010941	
1966	1,599	7	24.14	1.32	- 603	363,609	-219256227	3.2038		0.012589	
1962	1,466	6	20.69	1.26	- 736	541,696	-398688257	3.1661		0.022470	
1965	1,356	5	17.24	1.21	- 846	715,716	-605495737	3.1323		0.033746	
1973	1,243	4	13.79	1.16	- 959	919,681	-881974084	3.0945		0.049062	
1952	1,198	3	10.34	1.12	- 1004	1,008,016	1012048063	3.0785		0.056406	
1980	1,103	2	6.90	1.07	- 1099	1,207,801	1327373295	3.0426		0.074748	
1955	1,088	1	3.45	1.04	- 1114	1,240,996	1382469542	3.0366		0.078064	
28	61,644	-	-	-	- 12	15,912,182	9844582368	92,8468		0.673800	

Note: Annual Streamflow Shebelli at Belet Uen.

(TABLE 33- A)

ARITHMETIC MEAN : $\frac{61,644}{28} = 2,202 \times 10^6 \, m^3/sec$

STANDARD DIVIATION : $SD = \sqrt{\frac{1}{28-1} (15,912,182)} = 768 \times 10^6 \, m^3/sec$

COEFFICIENT SKEW : 0.87

GEOMETRIC MEAN : $\frac{92.8468}{28} = 3.3160 = 2,070 \times 10^6 \, m^3/sec$

STANDARD DIVIATION : $SD = \sqrt{\frac{1}{28-1} (0.67380)} = 0.17116$

COEFFICIENT SKEW :

10.2.2. FREQUENCY ANALYSIS (Annual Streamflow - Belet Uen)

A frequency analysis has been carried out with regard to the Annual Streamflow data at Belet Uen, as the data was available, although no indication was found of any previous attempt being made. The lack of any information to such an analysis does not mean it was never done.

The data used for this analysis has been obtained from the Ministry of Agriculture records in Mogadishu, 'MMP' report on the control and management of the Shebelli river, and the data collected during the Hydrometry Project 1980/81. The data for 1977 to 1979 has been recalculated from the recently established rating curves. The summarised discharge data for Belet Uen 1951/81 is presented in Table 24, and illustrated in Fig 39. The percentage flow distributions and discharge details for all the Shebelli stations for the period 1980/81 appears in Appendix 'F'.

The mean annual discharge data for Belet Uen is shown plotted following an Extremal Type I (Gumbel) distribution in FIG.40. From the frequency distribution curve the 100 year flood is estimated at 5,029 m^3x10^6 with the highest observed annual discharge of 3,761 m^3x10^6 having a return period in the order of 16.0 years. The 1,000 year annual discharge would be in the order of 6,640 m^3x10^6.

The data from the frequency plot is tabulated and presented in the following Table 34.

TABLE 34

Probability of Annual Streamflow at Belet Uen - 1951/81

Return Period (Years)	Occurance Probability Percent (%)	Discharge (m^3x10^6)
1.11	90.0	1,254
1.33	75.0	1,601
2	50.0 (Median)	2,088
2.27	44.0 (Mean)	2,202
4	25.0	2,700
10	10.0	3,395
25	4.0	4,055
50	2.0	4,542
100	1.0	5,029

The mean annual discharge calculated for the 1951/72 data series was 2,163 m^3x10^6, or 68.6 m^3/sec. This was reduced to 2,154 m^3x10^6 or 68.3 m^3/sec with the extension of the data series by six years to cover the period 1951/78. The recent increase in the data series to 1981, and the recalculation of the data from 1977 to 1979 has increased the mean annual flow by 2.6% to 2,209 m^3x10^6 or 70.1 m^3/sec.

The recalculation of the historic data which was almost complete and available at the time (1977/79), showed an increase (mean) of approximately 5%. The increases were mainly in the upper sector of the water levels and the decreases during the lower levels. The period from 1972 to 1976 have the most gaps in the observations at Belet Uen, and upto 1979 at the other Shebelli stations.

10.2.3. SHEBELLI RIVER RUNOFF CHARACTERISTICS (Belet Uen & Bulo Burti)

Runoff characteristics for the 1951/81 data series at Belet Uen and Bulo Burti are tabulated and presented in the following Table. 35.

TABLE 35.

Runoff Characteristics of the Shebelli River Stations
(Belet Uen & Bulo Burti)

Parameters	Belet Uen	Bulo Burti
1. Catchment Area (Km^2)	217,000	225,000
2. Data Series (years)	1951/81	1951/81
3. Mean Annual Discharge (m^3x10^6)	2,209	2,119
4. Max. Annual Discharge (" ")	3,761	3,688
5. Min. Annual Discharge (" ")	1,088	870
6. Mean 2 consec Dry years(m^3x10^6)	1,437	1,324
7. Mean 3 " " "(m^3x10^6)	1,622	1,458
8. Mean Unit Runoff(m^3x10^6/km^2).	0.0102	0.0094
9. Maximum Unit Runoff (m^3x10^6/km^2).	0.0173	0.0164
10. Minimum Unit Runoff (" ").	0.0050	0.0039

The Shebelli is similar to the Jubba having the majority of its contributing catchment in the high plateau area of Ethiopia, with the flow rates decreasing as the river proceeds through Somalia, and on occasions drying up completely in the lower reaches of the river, as happened both in 1980 and 1981.

The mean flow rate for the Shebelli at Belet Uen has been calculated at 0.32 litres/sec/km^2, with an observed maximum and minimum rate of 0.55 and 0.16 litres/sec/km^2.

The flow rates at Bulo Burti including the extra 3.7% contributing catchment, are slightly lower than for Belet Uen. The mean flow rate is 0.30 litres/sec/km^2, with maximum and minimum rates of 0.52 and 0.12 litres/sec/km^2.

These flow rates are considerably lower than the rates found for the Jubba river, inspite of the catchments being of comparable size and situated in the same areas, and mountain conditions. The flow rates for the Jubba are approximately three and a half times greater than those for the Shebelli. The probable relative factors for this difference are as follows:-

1. The Shebelli northern catchment embraces a lower rainfall belt.
2. Overbank spillage and swamp retention upstream of Belet Uen in the Callafo and 'Faf' depression area.
3. The flow from the northern Farfan river does not always reach the main shebelli river course.
4. A larger extraction of water for agriculture along the upper Shebelli.

The upper Jubba catchments are much steeper than for the Shebelli, with limited agricultural potential due to the lack of arable land, and its isolation and distance from areas of dense population.

By the time the flow reaches Mahaddei Uen, the maximum flow rate had decreased by 35% from 0.52 to 0.34 litres/sec/km^2. The mean annual flow rate also decreased, by 23% from 0.30 to 0.23 litres/sec/km^2. However, the minimum rate remained constant at 0.12 litres/sec/km^2.

10.2.4. SHEBELLI RIVER ANNUAL PEAK DISCHARGES

Under normal conditions the flood peaks are contained within the river banks with help from the flood control bunds along the river banks at various low depression areas. In times of excessive flooding these banks or bunds are overtopped or breached naturally, and or intentionally causing large areas of low lying land to be inundated. The loss of this water from the river system is one of the main reasons for the large attenuation which occurs between Bulo Burti and Mahaddei Uen.

a). Belet Uen

At Belet Uen the annual maximum flood peaks over the period 1951/81, have varied between 150 and 380 m^3/sec, with the exception of the 'GU' flood of 1981 when the peak was estimated at 1,395 m^3/sec. This estimate may prove to be too high, but due to the complicated circumstances of the flood and lack of data, it is the best available and a guide to the extreme magnitude of the event. The details relating to the flood and the methods of flow estimation can be found in the report 'History of the 'GU' floods - 1981).

The peak flood was estimated in three sections. Discharge gauging at the main station river channel, slope area surveys of the breaches on the left and right banks with onsite float measurements, and finally the estimation of flow through the town and over the three kilometers of the approach road, utilising the road embankment as a broadcrested weir. The magnitude of this flood suggests that the event as a statisical parameter, may not belong to the same sample or family, as the other floods with a maximum flow of 400 m^3/sec.

Under normal circumstances the river begins to overflow its banks above five meters gauge height, with the flood relief canal coming into operation at about four meters with a maximum discharge of between 18 to 25 m^3/sec.

The mean annual peak discharge for the period 1951/81 including the extreme peak in 1981 is calculated at 282 m^3/sec.

and excluding the extreme event of 1981, some 14% lower at 243 m^3/sec. The maximum peak details appear in Table 24, where it shows that for the data series 1951/81 (29 years), the annual maximum flood peaks have only exceeded 300 m^3/sec on six occasions. The highest peak prior to the 1981 event was 381 m^3/sec in 1961, some 73% less than the 1,395 m^3/sec in 1981.

The minimum mean annual flood peak for the data series is 157 m^3/sec, which was recorded in 1979 and closely followed with discharges of 159 and 160 m^3/sec, in 1973 and 1952.

b) Bulo Burti

The annual maximum peak discharges fluctuate between 100 and 300 m^3/sec, with the discharge for 1981 reaching an all time high of 560 m^3/sec at a gauge height of 9.19 meters, some 66% higher than the previous maximum peak. This station is also located at a bottle neck control point, where the entire flood flows must flow past the station at the road bridge. This situation tends to delay and reduce the flood peak levels, but extends the high flow period. This point was illustrated during the extreme event of 1981 when the flood peak 'lag time' was increased from two to four days, to two weeks. The flood peak was recorded at Belet Uen on 3/5/81, and reached Bulo Burti on 17/5/81. The proposed dam sites of El Geibo and Geiglei, also play a major part with regard to holding up the flood waters. The attenuation of flood peak discharges between Belet Uen and Bulo Burti, for the period 1980/81 are shown in Table 36.

TABLE 36.

Flood Peak Attenuation on the Shebelli River

Period	Belet Uen		Bulo Burti			Mahaddei Uen		
	GH	(m^3x10^6)	GH	(m^3x10^6)	Diff	GH	(m^3x10^6)	Diff
1980								
May	2.83	172.1	4.65	170.9	- 0.70 %	5.19	158.4	- 7.31%
Apr	1.46	71.7	2.95	68.9	- 3.91 %	-	-	-
Sep	2.06	122.2	3.91	124.6	+ 1.96 %	4.35	112.9	- 9.39%
1981								
May	6.70	1,394.0	9.19	530.0	-62.10 %	5.29	164.0	-69.10%
Oct	4.81	312.7	6.66	298.7	- 4.48 %	5.20	167.0	-46.80%

During low flow periods the discharge between Belet Uen and Bulo Burti can vary between +2 and -2%, and the attenuation increases to 10% at Mahaddei Uen. When flood discharges at Belet Uen are above 200 m^3/sec the attenuation at Bulo Burti increases to approximately 5%, and between 40 to 50% at Mahaddei Uen. As the overbank spillage increases as experienced in April and May 1981, the attenuation at Bulo Burti increased to 62%, and to 69% between Bulo Burti and Mahaddei Uen.

c) Mahaddei Uen

The flood peaks at Mahaddei Uen do not appear to go much above 170 m^3/sec. Inspection of the Mahaddei Uen hydrographs show flat topped graphs that do not exceed 5.30 meters gauge height. ('MMP' Report - Water Control and Management of the Shebelli River - 1969). The station is situated at a bottle neck control, and the flood levels are determined by the stability of the flood control bunds rather than the peak level at Bulo Burti. This statement is supported by the fact that the flood peak in 1980 at Bulo Burti was 4.65 meters, which produced a peak level of 5.19 meters at Mahaddei Uen, while the maximum peak in 1981 of 9.19 meters at Bulo Burti produced a maximum flood level at Mahaddei Uen of 5.25 meters. The discharge had increased at Bulo Burti for the two levels from 171 m^3/sec to 530m^3/sec, while the discharge at Mahaddei Uen remained almost the same for the two floods, at approximately 160 m^3/sec. The flood peaks did not differ very much but the duration did. In 1981 the water level at Mahaddei Uen remained above 5.0 meters (147.0 m^3/sec) , for more than 70 days for the 'GU' flood, and only one day in 1980.

With the initiation of the Johar ' Offstream Storage Resevoir' in 1980, the overbank flood spillage is expected to be a thing of the past. The maximum extraction of 50 m^3/sec for the 'Offstream Resevoir', and 10-20 m^3/sec for the 'SNAI' Sugar Scheme' at Johar can reduce the 170 m^3/sec flood peaks at Mahaddei Uen to 110 m^3/sec, the channel capacity downstream of Johar, thereby retaining the flood waters within the river banks.

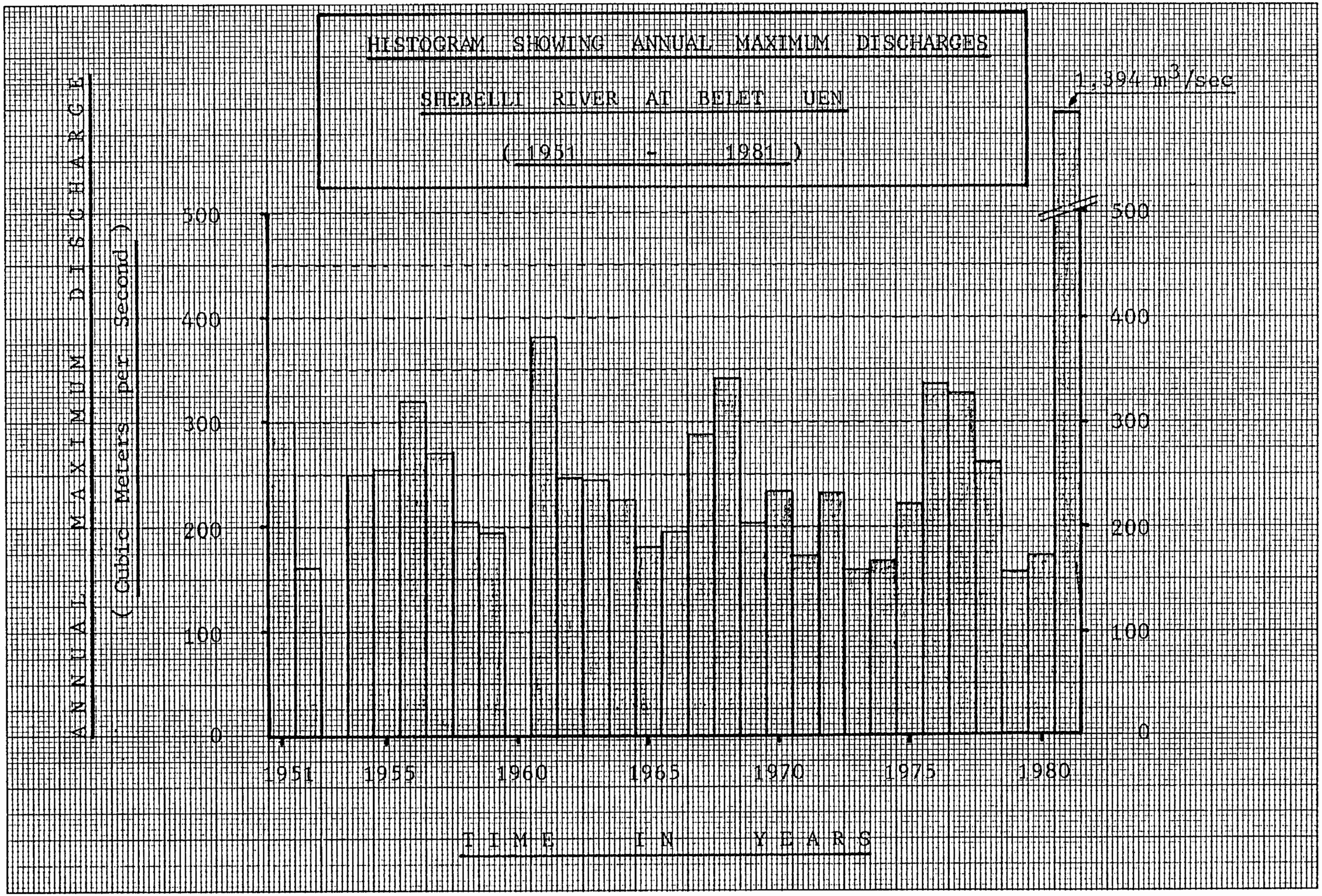

HISTOGRAM SHOWING ANNUAL MAXIMUM DISCHARGES
SHEBELLI RIVER AT BELET UEN
(1951 - 1981)
1,394 m3/sec
ANNUAL MAXIMUM DISCHARGE
(Cubic Meters per Second)
500
400
300
200
100
0
1951
1955
1960
1965
1970
1975
1980
TIME IN YEARS

FIG. 41.

SHEBELLI RIVER AT BELET UEN

ANNUAL SERIES OF MAXIMUM FLOOD DISCHARGES (1951 - 1980)

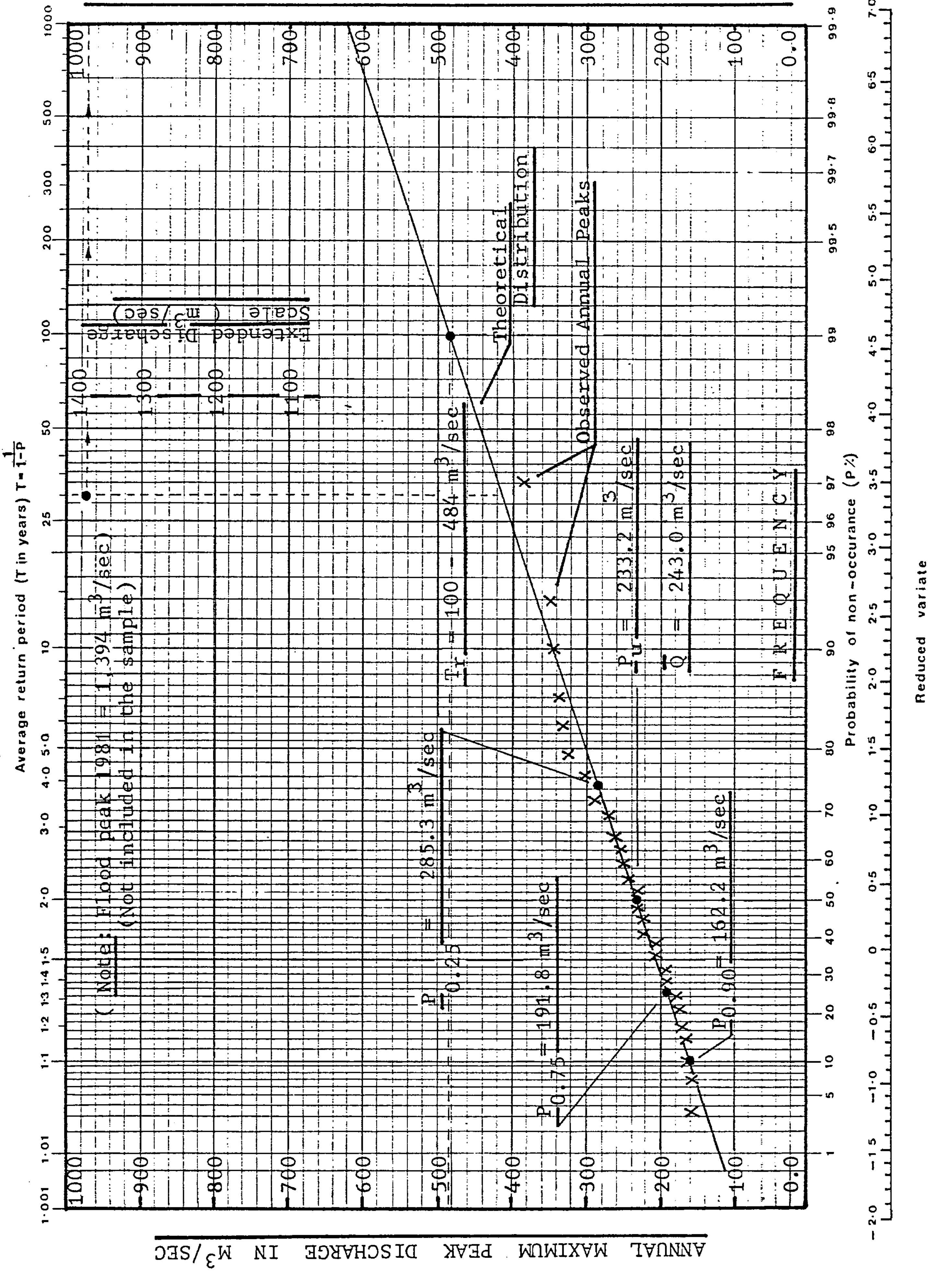


FIG .42.

10.2.5. FREQUENCY ANALYSIS (Peak Discharges - Belet Uen)

Information relating to previous frequency analysis of the Shebelli river was not available at the Ministry of Agriculture in Mogadishu, so no comparisons can be made. The data series used for this analysis is tabulated in Table 24., and illustrated in histogram form in Fig.41.

The data series 1951/80 has been used in the analysis with the exclusion of the exceptional flood peak of May 1981. This event was excluded as it appears not to be of the same family, or sample group as the other lower discharge peaks. The magnitude of the flood peak itself suggests that the event was an extreme occurance. Local information recalls such an event having taken place in the past, but whether in living memory, or in legend form, has not really been established.

The frequency curve for the data series 1951/80 has been plotted and illustrates the probabilities of the normal sample of discharges ranging between 150 and 400 m^3/sec. The 1981 flood peak of 1,395 m^3/sec has also been included on the graph, and appears to relate to a return period in excess of 10,000 years.

The extended record is shown plotted following an Extremal Type 1 (Gumbel) distribution in Fig.42, and tabulated in Table 38. The tabulated data includes both the Gumbel distribution calculations, and the Logarithmic data calculations, incase checks or comparisons are required in the future.

TABLE 37.

Probability of Annual Peak Discharges at Belet Uen

Return Period (Years)	Occurance Probability (Percent %)	Discharge (m^3/sec)
1.05	95	146
1.11	90	162
1.33	75	192
2	50 (Median)	233
2.20	55 (Mean)	243
4	25	285
10	10	345
25	4	401
50	2	442
100	1	484

FREQUENCY ANALYSIS COMPUTATIONS

PERIOD	MAXIMUM PEAKS (m^3/sec)	RANK 2	PROB/TY $1 - \frac{r}{n+1}$	REC/INT T_r (Years)	$(x - \overline{x})$	$(x - \overline{x})^2$	$(x - \overline{x})^3$	LOG X	(Log x - Log $\overline{x}$)	(Log x - Log $\overline{x})^2$	(Log x - Log $\overline{x}$)
1961	381	28	96.6	29.00	138	19,044	2,628,072	2.5809	0.2004	0.04020	0.008050
1963	343	27	93.0	14.50	100	10,000	1,000,000	2.5353	0.1548	0.02400	0.003710
1968	341	26	90.0	9.67	98	9,604	941,192	2.5328	0.1523	0.02320	0.003530
1976	336	25	86.2	7.25	93	8,649	804,357	2.5263	0.1458	0.02130	0.003100
1977	327	24	82.8	5.80	84	7,056	592,704	2.5145	0.1340	0.01800	0.002410
1956	320	23	79.3	4.83	77	5,929	456,533	2.5051	0.1246	0.01550	0.001930
1951	300	22	75.9	4.14	57	3,249	185,193	2.4771	0.0966	0.00930	0.000900
1967	289	21	72.4	3.63	46	2,116	97,336	2.4609	0.0804	0.00650	0.000520
1957	270	20	69.0	3.22	27	729	19,683	2.4314	0.0509	0.00260	0.000130
1978	261	19	65.5	2.90	18	324	5,832	2.4166	0.0361	0.00130	0.000050
1955	255	18	62.1	2.64	12	144	1,728	2.4065	0.0260	0.00070	0.000020
1954	250	17	58.6	2.42	7	49	343	2.3979	0.0174	0.00030	0.000005
1962	245	16	55.2	2.23	2	4	8	2.3892	0.0087	0.00008	0.000000
1970	233	15	51.7	2.07	- 10	100	- 1,000	2.3674	- 0.0131	0.00017	- 0.000002
1972	232	14	48.3	1.93	- 11	121	- 1,331	2.3655	- 0.0150	0.00023	- 0.000006
1964	225	13	44.8	1.81	- 18	324	- 5,832	2.3522	- 0.0283	0.00080	- 0.000023
1975	221	12	41.4	1.71	- 22	484	- 10,648	2.3444	- 0.0361	0.00130	- 0.000047
1958	205	11	37.9	1.61	- 38	1,444	- 54,872	2.3118	- 0.0687	0.00472	- 0.000324
1969	204	10	34.5	1.53	- 39	1,521	- 59,319	2.3096	- 0.0709	0.00503	- 0.000356
1966	195	9	31.0	1.45	- 48	2,304	- 110,592	2.2900	- 0.0905	0.00819	- 0.000741
1959	194	8	27.6	1.38	- 49	2,401	- 117,649	2.2878	- 0.0927	0.00859	- 0.000797
1965	180	7	24.1	1.32	- 63	3,696	- 250,047	2.2553	- 0.1252	0.01568	- 0.001963
1971	173	6	20.7	1.26	- 70	4,900	- 343,000	2.2380	- 0.1425	0.02031	- 0.002894
1980	172	5	17.2	1.21	- 71	5,041	- 357,911	2.2355	- 0.1450	0.02103	- 0.003049
1974	167	4	13.8	1.16	- 76	5,776	- 438,976	2.2227	- 0.1578	0.02490	- 0.003929
1952	160	3	10.3	1.12	- 83	6,889	- 571,787	2.2041	- 0.1764	0.03112	- 0.005489
1973	159	2	6.9	1.07	- 84	7,056	- 592,704	2.2014	- 0.1791	0.03208	- 0.005745
1979	157	1	3.5	1.04	- 86	7,396	- 636,056	2.1959	- 0.1846	0.03408	- 0.006291
28	6,795				- 9	116,350	3,181,257	66.654	- 0.3000	0.37121	+ 0.017054

(TABLE. 38)

ARITHMETIC MEAN : $\frac{6,795}{28} = \underline{243\ m^3/sec.}$

STANDARD DIVIATION : $SD = \sqrt{\frac{1}{28 - 1}(116350)} = \underline{65.64\ m^3/sec}$

GEOMETRIC MEAN : $\frac{66.654}{28} = 2.3805 = \underline{240\ m^3/sec.}$

STANDARD DIVIATION : $SD = \sqrt{\frac{1}{28 - 1}(0.37121)} = \underline{0.11725}$

FREQUENCY ANALYSIS COMPUTATIONS

PERIOD	MAXIMUM PEAKS m^3/sec	RANK	PROB/TY $1 - \frac{r}{n+1}$	REC/INT T_r (Years)	$(x - \bar{x})$	$(x - \bar{x})^2$	$(x - \bar{x})^3$	LOG X	(Log x - Log $\bar{x}$)	(Log x - Log $\bar{x})^2$	(Log x - Log $\bar{x})^3$
1981	1,394	29	96.67	30.00	1,112	1,236,544	375036928	3.1443	0.7477	0.559060	0.4180056
1961	381	28	93.33	15.00	99	9,801	970299	2.5809	0.1843	0.033970	0.0062600
1963	343	27	90.00	10.00	61	3,721	226981	2.5353	0.1387	0.019240	0.0026683
1968	341	26	86.67	7.50	59	3,481	205379	2.5328	0.1362	0.018550	0.0025266
1976	336	25	83.33	6.00	54	2,916	157464	2.5263	0.1297	0.016820	0.0021818
1977	327	24	80.00	5.00	45	2,025	91125	2.5145	0.1179	0.013900	0.0016389
1956	320	23	76.67	4.30	38	1,444	54872	2.5051	0.1085	0.011770	0.0012773
1951	300	22	73.33	3.73	18	324	5832	2.4771	0.0805	0.006480	0.0005217
1967	289	21	70.00	3.33	7	49	343	2.4609	0.0643	0.004130	0.0002659
1957	270	20	66.67	3.00	- 12	144	- 1728	2.4314	0.0348	0.001210	0.0000421
1978	261	19	63.33	2.73	- 21	441	- 9261	2.4166	0.0200	0.000400	0.0000080
1955	255	18	60.00	2.50	- 27	729	- 19683	2.4065	0.0099	0.000098	0.0000010
1954	250	17	56.67	2.31	- 32	1,024	- 32768	2.3979	0.0013	0.000002	0.0000000
1962	245	16	53.33	2.14	- 37	1,369	- 50653	2.3892	-0.0074	0.000055	-0.0000004
1970	233	15	50.00	2.00	- 49	2,401	- 117649	2.3674	-0.0292	0.000853	-0.0000249
1972	232	14	46.67	1.88	- 50	2,500	- 125000	2.3655	-0.0311	0.000967	-0.0000301
1964	225	13	43.33	1.76	- 57	3,249	- 185193	2.3522	-0.0444	0.001971	-0.0000875
1975	221	12	40.00	1.67	- 61	3,721	- 226981	2.3444	-0.0522	0.002725	-0.0001422
1958	205	11	36.67	1.58	- 77	5,929	- 456533	2.3118	-0.0848	0.007191	-0.0006098
1969	204	10	33.33	1.50	- 78	6,084	- 474552	2.3096	-0.0870	0.007569	-0.0006585
1966	195	9	30.00	1.43	- 87	7,569	- 658503	2.2900	-0.1066	0.011364	-0.0012114
1959	194	8	26.67	1.36	- 88	7,744	- 681472	2.2878	-0.1088	0.011837	-0.0012879
1965	180	7	23.33	1.30	- 102	10,404	-1061208	2.2553	-0.1413	0.019966	-0.0028212
1971	173	6	20.00	1.25	- 109	11,881	-1295029	2.2380	-0.1586	0.025154	-0.0039894
1980	172	5	16.67	1.20	- 110	12,100	-1331000	2.2355	-0.1611	0.025953	-0.0041811
1974	167	4	13.33	1.15	- 115	13,225	-1520088	2.2227	-0.1739	0.030241	-0.0052589
1952	166	3	10.00	1.11	- 122	14,884	-1815848	2.2041	-0.1925	0.037056	-0.0071333
1973	159	2	6.67	1.07	- 123	15,129	-1860867	2.2014	-0.1952	0.038103	-0.0074379
1979	157	1	3.33	1.03	- 125	15,625	-1860867	2.1959	-0.2007	0.040280	-0.0080843
29	8,189	-	-	-	+ 11	1,396,457	1363072082	69.501	-0.0010	0.946920	0.4783558

Note: Frequency calculations . Belet Uen data series including peak of 1981. Not plotted as the data relates to a different family or sample group. See data series excluding the 1981 event, Table 38. (Table 38- A)

ARITHMETIC MEAN : $\frac{8,189}{29} = 282.4\ m^3/sec$

STANDARD DIVIATION : SD $\sqrt{\frac{1}{29-1}(1,396,457)} = 223.3\ m^3/sec$

Coefficient Skew: 4.7

GEOMETRIC MEAN : $\frac{69.501}{29} = 2.3966 = 249.2\ m^3/sec$

STANDARD DIVIATION : SD $\sqrt{\frac{1}{29-1}(0.94692)} = 0.18390$

Coefficient Skew:

The mean discharge for the data series 1951/80 is 243 m^3/sec, with a standard diviation of 66 m^3/sec and a coefficient skew of 0.45. These figures are considerably increased to a mean of 282 m^3/sec and standard diviation of 223 m^3/sec when the 1981 estimated flood peak of 1,395 m^3/sec is included in the sample.

Both the highest and lowest discharges on record at Belet Uen were recorded in the same year (1981). From January to March 15th, the lower Shebelli ran dry, extending as far upstream as Bulo Burti where only trace flow remained. The water level at Belet Uen fell below the zero gauge level to - 0.12 meters, and a minimum discharge of 0.43 m^3/sec.

This severe drought period was then followed by an extended and early 'GU' flood, which produced the unique flood on the upper and middle shebelli, which has been estimated to have a return period in excess of one in ten thousand years.

10.2.6. SHEBELLI RIVER MAXIMUM DISCHARGE CHARACTERISTICS

The discharge characteristics are based on the data series 1951/81 for Belet Uen, and 1980/81 for Bulo Burti and Mahaddei Uen, which also includes the extreme flood data of April/May 1981.

TABLE 39

Maximum Discharge Characteristics - Shebelli

Parameters	Belet Uen	Bulo Burti	Mahaddei Uen
1. Catchment Areaa (km^2)	211,800	231,000	255,000
2. Data Series (Years)	1951/81	1980/81	1980/81
3. Mean Ann. Max 'Q'(m^3/sec)	282	351	162
4. Max Peak 'Q' (m^3/sec)	1,395	530	167
5. Min Peak 'Q' (" ")	157	171	157
6. Mean Unit 'Q'(m^3/sec/km^2)	0.00133	0.00152	0.00064
7. Max Unit 'Q' (" ")	0.00658	0.00229	0.00065
8. Min Unit 'Q' (" ")	0.00074	0.00074	0.00062

* Mean not representative of the long term - indicates higher value than for Belet Uen.

The mean maximum discharges for both Belet Uen and Bulo Burti are higher than the normal long term means for the data series 1951/80, as the exceptional flood discharges for the flood in 1981 are included and tend to weight the results to a higher bias.

Under normal conditions the maximum flood peaks at the the border and entry point to Somalia are in the order of 300 to 400 m^3/sec, with extensive overbank losses in the Callafo area. Assuming an increase in peak discharges due to the de-forestration of the catchment slopes in Ethiopia, which is happening, and coupled with river training by canalisation and flood bank protection, the flood levels experienced in 1981 may be repeated more frequently, requiring immediate action with regard to planning protection measures for the town.

However, the arrival of the flood peaks, or more accurately major flood peaks at Belet Uen do not occur as flash floods, but take days to build up. This was clearly illustrated by the events leading upto the flooding of Belet Uen in 1981. News of the approaching flood reached Belet Uen weeks before the flood arrived, through the 'Bush Telegraph' system, more accurate and reliable than the present counterpart system. The consultant observed the floods progress on the 14th April 1981 , when the flood front had reached a point 20 kilometers north of Belet Uen, the road juntion of the Chinese constructed northern road. The water level at this time at Belet Uen was 5.30 meters. The flood, or valley flood as called by the locals, reached the town some six or seven days later, and only reached its peak of 6.70 meters on the 3rd. May 1981.

Under these conditions ample flood warning was given, and emergency evacuation plans had been drawn up, as informed by the Governor of the area. The planning is the simple stage, the application of the plans is where the problems begin especially with trying to convince people to leave their homes.

On site and aerial observation of the flood would suggest that protection works for the town, to cope with floods of this magnitude would be extremely costly and very difficult to implement. Apart from constructing a flood protection bund which would encircle the town, with flood control gates to allow the water through the main river channel during the low flow periods and stop the flow during emergency occasions, a secondary inner bund would have to be maintained along the river banks within the outer perimeter wall.

In this way the flood would bypass the town on both banks. This in its self will not be enough, as the approach roads to the town would also have to sustain the flood to enable both human provisions and animal fodder to be brought to the town. The magnitude of the flood is very clearly shown by the photographic record of the event which forms Volume 2. of the report 'History of the 'GU' floods - 1981.

One of the main factors against a protection bund around the town is the danger element should the bund get breached at the height of such a flood. The structures would have to be maintained to a very high degree of efficiency to ensure no such disaster would occur.

The present record in Somalia with regard to maintenance, and especially as experienced with the existing flood protection bunds along the Shebelli, would suggest that residency of the town during such an event would be a high risk proposition.

After considering all aspects of the situation, construction costs , maintenance costs and efficiency , and the low occurance probability of the event occuring very often, a good reliable early warning system, a service usually supplied by an efficient National Hydrological Service should surfice. This would ensure sufficient warning as to any impending disaster, giving the towns people ample time to evacuate the town in an orderly and organised manner, leaving nature to have its way for one or two weeks over a period of many years, and at an extremely lower cost than trying to control such a unique event, and most probably with limited success.

11.0. PROJECT PERSONNEL

At the start of the project staff were assigned to the 'Project Team' by the Ministry of Agriculture, as requested in the project document. The type and grade of staff stipulated in the project document, were as follows:-

1). Two Senior Hydrometric Field Assistants.
2). One Junior Office Assistant.
3). One Driver Mechanic.
4). Gauge Readers and Survey Chainmen as required.

Staff initially assigned to the project in January 1980 were as follows:-

1). Two Technical Assistants
2). One Office Junior Assistant.
3). One Typist.
4). One Driver.
5). One Boat/Survey Chainman.

It soon became apparent that the personnel assigned to the project, also constituted the whole of the Ministry Hydrological Section. This situation automatically led to the project being responsible for the complete activities of the Hydrological Section, and all the additional work loads relevant to such a department.

At the Consultants request, an additional 'trainee' field assistant was added to the original team because the number of allocated personnel was deemed to be insufficient to cope with all the duties required. A gauge reader who had attached himself to the field team, showing both willingness and ability, was selected and assigned to the Project.

Unfortunately, no Senior Engineer or Hydrologist was directly attached to the project, who could have been responsible for the overall control of the section, and then gone on to head the proposed 'Water Centre Project' and all other relevant, and affiliated hydrological investigations in Somalia.

The standard of the Technical Assistants was not very high, but after intensive (high pressure) In-Service training, they improved immensely with regard to the basic mechanical or practical field aspects of the job, but still found the technical computational and analysis sector, somewhat difficult to understand.

The boatman/chainman was with the team for the first phase of the project, but thereafter did not take part in the work for the remainder of the project duration. The office assistant was only periodically available, and the Typist could not work in English,therefore of no benefit to the Project.

On the whole, the team consisted of the three technical assistants and a driver. During the whole exceptional flood period between April and June 1981, all the field activities were carried out by the Consultant with one field assistant and driver. The other Technical Assistants were on a course in Kenya.

The staff allocated to the Project were not sufficient, nor suitably qualified to obtain all the data required and maintain the installations, let alone run and maintain the Hydrological Section in its entirety. If the Hydrological activities are to be operated in an efficient and acceptable manner, the staff numbers will have to be increased, and the educational level of the members upgraded. (See 'Flow Chart' - FIG. 43)

12.0.0. TRAINING

Throughout the Project 'In-Service Training' was maintained, with the major emphasis on field operational procedures, methods and requirments. Basic data computations and analysis which were within the Staff educational abilities, were carried out when the Teams returned from their field duties, and all data entered into the station operational files.

Three of the Technical Assistants attended a working "Operational Hydrometry" course (3 month duration) in Kenya, under the direction of the World Meterological Organisation

Representative, attached to the "Hydromet Project for Lakes Victoria, Kyoga and Mobuto Sese Seko". This was organised as an Inter/Agency co-operation exercise between the 'FAO' & 'WMO', which worked extremely well.

12.1. INSERVICE TRAINING

a) Field Operations.

From the onset of the Project it was very clear that the 'Inservice Training Programme' was paramount, if any reliable results were to be expected from the local staff members.

Prior to the arrival of the Project equipment in Somalia, a tour of all Hydrological and other stores were conducted which produced a number of derelict 'Leupold and Stevens' water level recorders, 'OTT' current meters and accessories such as spare charts, intrument ink and a few spare parts. All these instruments were gathered together, then systematically stripped, repaired, serviced and then rebuilt where possible. From the debris six 'Leupold and Stevens' water level recorders and two 'OTT' Current meters were made operational. This operation was extremely useful in teaching the trainees the mechanical workings of the instruments, and prepared them for emergency field maintenance and onsite repairs.

While the river levels were very low between February and April 1980, basic stream gauging methods and procedures were demonstrated and practised. Also basic Survey Techniques were taught, when cross sections and other relevant surveys were carried out at all the station sites, while establishing station installation data sheets.

At all the stations gauges were installed, replaced and reset. Recorder Houses and stilling wells were cleaned and desilted and recorder inlet pipes cleaned and flushed. Then the re-commisioned recording instruments replaced in the structures and made operational. Gauge observers were checked, briefed where available, and instructed to mark the recorder charts at each daily observation.

After the arrival of the new project equipment, suspended bridge gauging was introduced utilising an 'OTT' single drum winch and 25 kilogram sinker. Over the period of observations all methods from the 0.6 depth to the'vertical velocity' method were practised, and utilized to establish the rating curves.

Slope Surveys were carried out to establish 'roughness factors' for slope area peak discharge calculations at gauging stations, Flash flood 'Spot observation' gauging sites, and some of the major seasonal water courses which contribute to the flow of the Shebelli River in Somalia.

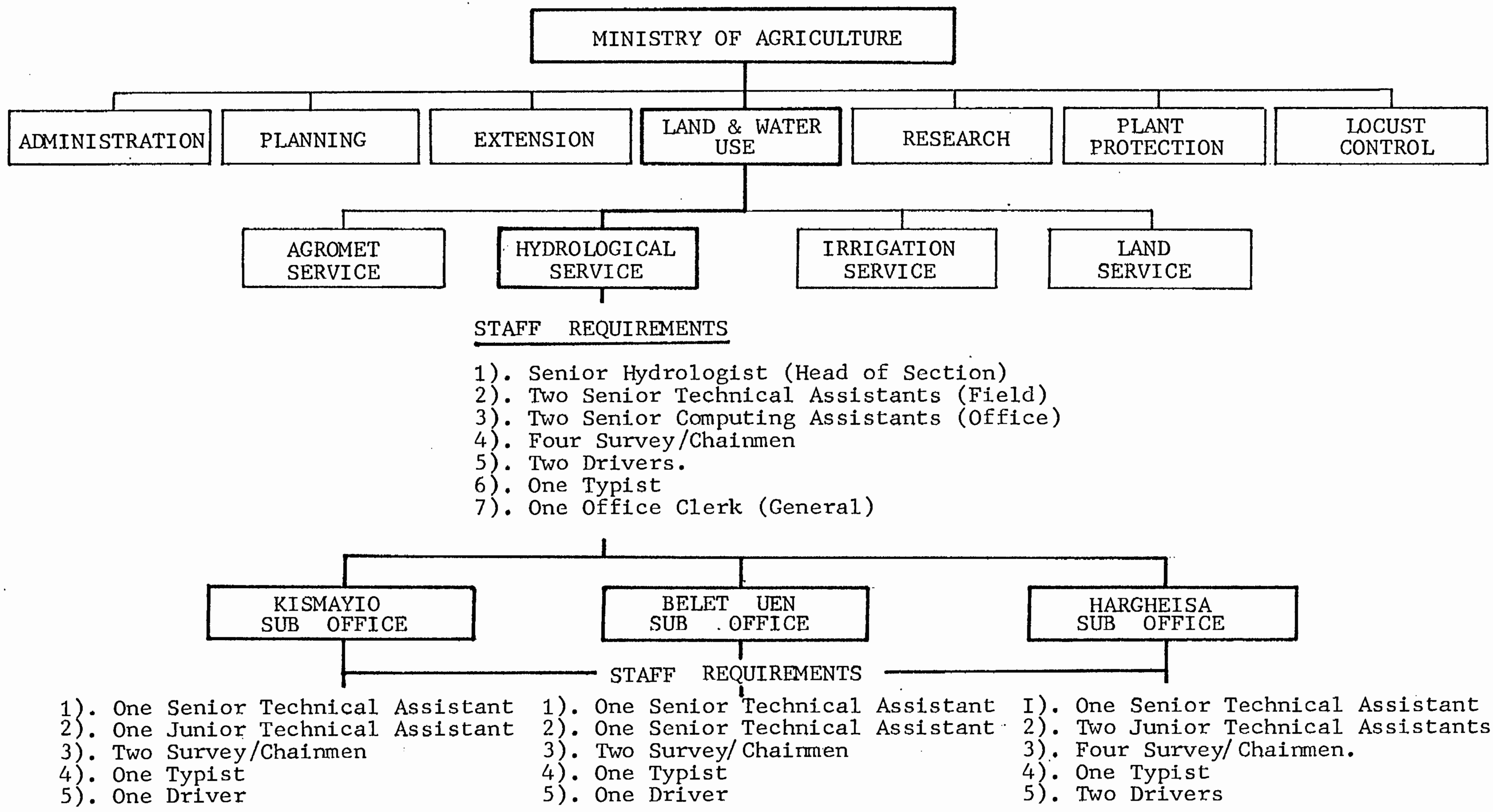
Throughout this field operational training, the trainees showed the ability to be able to cope with the mechanical operations of the work, but required constant monitoring to maintain discipline, which is essential for the collection of reliable data. Also, more interest and understanding was shown with regard to the mechanical operations, rather than the overall reasons and requirments for the said skills.

b) OFFICE PROCEEDURES

In addition to the field practical operations, all efforts were made to teach the trainee's the basic computation and analysis requirments. However, due to the sub-standard educational levels, and the inability to grasp some of the proceedures, only limited time was contributed to this sector as the overall objectives of the project would have been in jeapardy.

Inspite of the problems encountered the following data computations and analysis was practised by the trainee's:-

1. Computation of Basic Surveys (Rise & fall method).
2. Computations of discharge measurements.
3. Computation of Instrument discharge rating tables.
4. Checking and correction of observers daily records.
5. The analysis of Recorder charts(Leupold & Stevens, & SIAP).
6. Computation of daily discharge from daily observations and Recorder charts.
7. Rating curves and tables



OFFICE AND STAFF REQUIREMENTS FOR HYDROLOGY OPERATIONS IN SOMALIA

FIG .43.

8. Computation of mean daily, monthly and annual discharges
9. Plotting and calculation of Slope Area Surveys
10. Establishment of a filing system into which all data and History of field operations are entered. The trainee's were instructed to ensure that this record was maintained without any breaks in continuity.

Additional data processing and analysis, was envisaged as part of the training programme to be administered in Kenya.

13.0. FELLOWSHIPS (OVERSEAS)

The one year fellowship (11,000 Dollars), was originally supposed to be for a Senior Engineer or Hydrologist who would have been attached to the Hydrological Section and the Hydrometry Project, and would ultimately have been responsible for the direction and operational activities of the National Water Center.

Unfortunately, no senior staff member was attached to the Hydrological Section or the Project. However, a number of candidates from totally unrelated faculties were suggested, but rejected by the consultant, on the grounds that they would not further the requirements of the Hydrological department. It was decided that the fellowship would only be used for the benefit of Hydrology, and the staff in the current Hydrological Section.

This would ensure that the staff who were responsible for the collection and basic analysis of the hydrological data, would not be 'side stepped' and neglected because of the usual 'brotherisation' practice. In the long run it would give the people at the 'grass roots' level some hope of a career, and thereby maintain some degree of staff continuity.

A previous candidate who had been on a Hydrological Training Course in Italy, returned to Somalia in August 1980, but was not assigned to the Hydrological Section. He was assigned an administration (engineering) post in the northern area of the country, away from the two main sources of water in Somalia, namely the Juba and Shebelli rivers.

On the Consultants insistance, it was finally agreed with the Government that the fellowship funds would be used to send three of the Field Assistants on short term "Operational Hydrometry" courses.

It was difficult initially to find any courses suited to the beginner Hydrometrists, normally associated with under developed countries. During the early seventies an ideal training course was held on an annual basis in Zambia, under the guidance of "UNESCO". Sadly it has since been discontinued, mainly due to the lack of participation of the countries that it was designed to serve.

Inquiries made in the United Kingdom of Great Britain produced results from the National Water Council (Overseas Manpower Development Group), who agreed to formulate a syllabus to suit the needs and standards of the Somali trainee's. Unfortunately, the final man/month costs were considerable and beyond the small allocated training allowance in the Project budget.

The final reduced costs were quoted at £14,850 for the three months, exclusive of value added tax at 15%, making a grand total £17,078 sterling. This total was still three times the training allowance in the Project document.

The proposed course would have been ideal for the Somali trainee's and Somalia. The correspondence and proposed syllabus has been included in (Appendix 'L'). The financial requirments have been included in this report to illustrate how far out of touch the organisation is, with regard to the training costs for third world students in the developed world.

Finally, with the aid of the ' World Meteorological Organisation' the Somali trainee's were accepted to train with the "Hydromet Project of Lakes Victoria, Kyoga and Mobutu Sese Seko" in Kenya (Appendix 'L'). Without the help of the 'W.M.O' the fellowship training would not have taken place. The final co-operation between the 'FAO' and the 'WMO' under an Inter Agency agreement ensured the success of the endeaver.

The proposed training schedule was as follows:-

1) Two weeks orientation and theoretical training in Nairobi, under the guidance of the 'WMO' representative and advisor to the Project.

2) Two months attached to the Project field office in Kisumu, under going field operational and data analysis duties.

3) The final two weeks back in Nairobi for discussions ,and final theoretical training, and debriefing.

After detailed discussions with the trainee's on their return to Somalia, it appears that the field training had not been of a very high standard. The trainee's had been left too much too their own devices without trained guidance. However, on the whole it was felt that the trainee's had benefited from the experience with regard to their general approach to the work they were doing, and made them aware that there was much more to 'Hydrology', than just gauging rivers. Also, they returned with an apparent desire to remain in the field of hydrology, and improved understanding of the importance of the work, and its paramount importance to their country.

However, all the advantages gained from this training exercise, the rehabilitation of the Hydrological Section and data collection programme, will be lost if the status of the Hydrological studies is allowed to return to a low level priority, similar to that which existed prior to the start of the 'Hydrometry Project' in January 1980. The major 'pitfall' which will dishearten the staff and lead to such a situation occuring, would be the discontinuation of the United Nations financial assistance and technical guidance.

14.0. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

14.1. INTRODUCTION

The following conclusions and recommendations have been obtained from data gathered and collected from 'onsite' field operations and investigations, carried out by the FAO consultant and Government team over the project duration between January 1980, and December 1981. During this period the Consultant spent a total of 13½ months in the country, phased into four visits.

14.2. CONCLUSIONS

14.2.1. Data Series 1972 - 1979

Throughout this period there are major water level data gaps which cause concern. Some of the missing data is the direct result of no onsite observations, but a fair amount is only missing due to misplacement for one reason or another, and mainly due to transfer of documents from one ministry to the other during re-allocation of authority. A large proportion of the missing data would probably come to light if a thorough search of all Ministries and field offices were carried out. Additional gaps would be filled if all Consultant Companies who have been involved in hydrological activities in Somalia, were requested to forward copies of the data they held at their offices in Somalia and abroad. A concentrated effort should be made to collect all such data, before a full scale attempt at adjusting the data is attempted.

14.2.2. Ratings

a. Jubba at Lugh Ganana

The present curve confirms that the Lockwood/FAO rating was inaccurate, and should be ignored. Also that the (1965) Selchozpromexport rating was under estimating the discharge over the lower stages, and slightly over estimating in the middle to high range, but similar at about 1500 m^3/sec.

Unexplained discharge corrections in the 1973 Selchozpromexport report, probably took into account the 0.22 meter overlap in the gauges and adjusted accordingly. Unless background data with regard to gauge zero levels and dates of gauge changes are available, data adjustment cannot be carried out in full confidence. Present curve applicable to the past decade.

b. Bardheere

At Bardheere, after an adjusment of 0.25 meters to allow for the difference in the old and present gauge zero levels, the Selchozpromexport and present curves are very similar in the lower sector below 3.0 meters (550 m^3/sec), but would have over estimated the discharges above the 3.0 meter gauge level by about 20%. The present curve should be used to recalculate all the past data as far back as possible.

c. Jamamme

Although this station was rated over its probable maximum range, it only represents the discharge in the main channel , and not the total flood inclusive of overbank flooding. It will be representative of most annual peak flows but not 1981, or other extreme events. This curve can be used to compute all water level data for the past decade, where available, for flows within the river banks.

d. Shebelli at Belet Uen.

There does not appear to be any significant difference between the new curve and the old ones. If any difference, it is biased to slightly more flow than the old curves, suggesting a possible present scour cycle. This curve can be applied to all data collected to date. The extension of the curve which includes the overbank discharges only applies to the flood of April/May 1981, as does the relief canal rating.

The overbank discharges will vary according to the circumstances at the time the events occur, with regard to flood bund breaching and flood peak magnitude.

e. Shebelli at Bulu Burti

With an adjustment of minus 0.05 meters for the gauge heights observed from the 'MB' point on the bridge, prior to the installation of the downstream gauges, the present rating shows a fairly large increase in discharge over the old curves, approximately 50% at the very low levels. The increase falls to 10% at the 50 m^3/sec level, then remains constant over the high range of the rating at 10%. With the new curve showing an increase in discharge over the whole range, it suggests that the river is in the process of scouring rather than silting up.

The new rating could safely be applied to all stage data observed since 1977, though inaccuracies must be expected at the lower end of the curve because of the shifting bed conditions at the gauge site.

f. Shebelli at Mahaddei Uen

A marked decrease in discharge over the lower range of the curve, between the present and 1965/68 ratings, then changing to an increase above the 70 m^3/sec level suggests that the 'Sabuun Barrage' probably affects both the low and high ratings in opposite ways. The backwater effects from the Barrage causes an increase in water level, but an attenuation in discharge over the lower range. While during the high flows the extraction of 50 m^3/sec from the river system, tends to prevent overbank flooding downstream of Mahaddei Uen, thereby retaining the higher energy gradient and increasing the flow through the control point at Mahaddei Uen gauging station. All future gauging programmes will have to be tied into the operational programme at the Sabuun Barrage.

The rating curves established over the 1980/81 period can only apply to the data (stage levels) since the Barrage came into operation. The 1965/68 curves will have to be used for all data collected prior to the installation of the Barrage. The probable maximum flow through the control at Mahaddei Uen will probably never exceed 170 m^3/sec.

g. Shebelli at Balaad.

The low level discharge measurements carried out prior to the completion of the Balaad Barrage indicate that there was no change in rating at the baseflow discharges. This would also suggest that siltation was minimal, or the river was in a scouring stage of the cycle. Deposition will now be accelerated due to the Barrage. This station was closed in April 1980 due to the backwater effects from the Barrage, but should be re-opened at the Barrage if the Barrage is calibrated, and if not, slightly downstream.

h. Shebelli at Afgoi

There is considerable difference between the 1965 and the present 1980/81 ratings, although a closer relationship to the 1968 curve. The 1980/81 curve returns less water along low and medium sectors of the rating, but an increase at the higher levels above 70 m^3/sec discharges.

The old curves show an attenuation in discharge increase against water level rise above the 4.0 meter gauge height, but the 1980/81 measurements indicate a normal progressive rise in discharge to stage increase. The 1980/81 stage data has been calculated according to the new ratings, but before any adjustments are attempted to the past data , additional discharge observations should be obtained to clarify the situation along the upper 25% of the ratings.

i. Shebelli at Audegle.

The situation at Audegle was found to be very similar to Afgoi, with the 1980/81 curves showing less water below the 4.0 meter gauge level (60 m^3/sec), with a closer relationship to the 1968 rating than the 1965 curve. In the higher sector of the rating a definite changing relationship occurs as shown by the rating in 1980, which at a gauge height of 5.0 m returns a discharge of 70 m^3/sec, and in 1981 a discharge of 87 m^3/sec, a variation increase of almost 25%.

The reasons for these variations probably relate to two factors :

a. In 1980 the peak flood levels on the Shebelli were very low, and consequently the Barrage gates at Genale had to be lowered to raise the upstream water levels to bankful level, so that the local farmers could irrigate their fields by gravity flow from overbank spillage, which caused flooding in the Audegle area. The lower gauged results are relected in the 1980 rating curve plot.

b. Whereas in 1981, water had to be removed from the river system to avoid overbank flooding along the lower Shebelli. Approximately 45 m^3/sec was diverted from the system at Sabuun, which maintained the water level at bankful level. The free flow conditions at this level naturally resulted in higher peak discharges, as illustrated by the 1981 rating curve plot.

The two upstream stations of the Shebelli at Belet Uen and Bulo Burti closely relate to the long term ratings, with slight increases in discharge which suggests that the river may be on the scour cycle of its channel. The three downstream sites show decreases at low level flows , with probable siltation due to the reduced velocities caused by the artificial restrictions, and in general the river reacts like a large irrigation canal, rather than a free flowing river.

The three lower Shebelli stations will have to be gauged more often each season to establish the relative curves, whereas periodic checks will surfice for the two upstream sites.

14.3. RECOMMENDATIONS

14.3.1 Personnel

a. The present staff members constituting the National Hydrological Section is totally inadequate, and must be upgraded both in technical ability, and numerical numbers.

b. A full time hydrologist must head the section, to ensure that the technical requirements and standards are met and maintained. Also, to be responsible for the overall direction of the sections future within the Ministry of Agriculture, and its progress towards a national 'Water Center'.

c. Regional Hydrological Offices should be established at key centres, such as Jelib and Lugh Ganana on the Jubba, and Johar and Belet Uen on the Shebelli. Offices should also be established in the northern area to prepare for investigations into the water potential from the seasonal wadis which are homogeneous to the area.

14.3.2. Operational Proceedures.

a. The Hydrological Field teams must be in control of their operations while on duty at the various gauging sites, as they are the only ones who know what is required to be done, and when it is required to be done, and not the administration or military personnal at such sites. Valuable information has been lost when military personnel at check points situated at bridge sites, have refused permission for the hydrological teams to carry out their duties, such as stream gauging from the bridges and survey connections to Benchmarks situated on the bridges.

b. Field teams must also be equipped with field imprest accounts, which are unrelated to the Ministry of Agriculture field office control. The Hydrometrists work unrelated and very extended hours, which is required when dealing with the natural elements, and they require funds to pay labourers, for repairs to equipment onsite, hire of pumps or water tankers to desilt recorder wells, and on many occasions payment for extraction of vehicles from the quagmires which constitute some of the main feeder roads in the country.

At present, field teams have to rely on personnel relationships at the sites for funds, and if not possible they return to Mogadishu to have minor repairs carried out, at great expense and loss of time, usually resulting in postponement of the work and consequent loss of data. This situation sets the stage for built in excuses relating to inefficient and unreliable work outputs.

c. The Data Analysis and Computing section should be a seperate team, who compute and analyse all the data from the field collected by the 'Field Operations' team. After quality checks the data is plotted and tabulated ready for storage, either in the filing system or on computer tape. Then requests are made back to the Field Teams as to what data is required from their next Field trip. If this system can be maintained there will be no data analysis backlog, which unfortunately is very common. Data is only useful if it is put to use when required.

d. All efforts should be directed towards establishing a Data Center equipped with computers. However, in the mean time the installation of a small computer costing about £1,500 (there are many on the market these days) in the Ministry of Agriculture, will ensure the safe retention of hydrological records, and immediate access to data when required.

The installation of such a Computer does not mean that the old classical file system is obsolete, as basic field data must always be retained incase re-assesment is required in the future.

14.4. NETWORK

14.4.1 SHEBELLI

The present National Hydrological Network with regard to the Shebelli river is good, with major attention being focused on the three upstream stations of Belet Uen, Bulo Burti and Mahaddei Uen. It is at these sites that the water potential for Somalia, and for the irrigated areas of somalia are monitored.

14.5.2 JUBBA

In addition to the present three gauging stations which form the National Network on the Jubba, the closed station at Kaitoi should be reopened and included in the Network and monitored on a permanent basis. It is only at this point that the total input to the lower Jubba can be observed, before the water spills over the flood plain. The Jamamme station at times of high flood events is not representative of the total flow , so illustrating the need for another station such as Kaitoi. The flood of 1981 illustrated the point further, as there was no observation point at which the total peak flood input to the lower Jubba, could be measured in its entirety.

14.4.3. SEASONAL 'WADIS'

a. The 'Spot' gauging sites on the Wadi Kelli Carro, Wadi Kelli Gurat and Wadi Bur Acaba should also be included in the National Network. Staff gauges should be installed as they were in the past, to avoid unnecessary survey work whenever floods take place to obtain the levels. If the gauges were installed the data would be collected and not ignored as it is at present.

b. During the end of mission conference, when the United Nations Multi-Agency Mission on Drought visited Somalia in October 1981, it was mentioned by a number of speakers, and especially by the Project Manager of the Northern Rangelands Project, that no hydrological investigations were being carried out on the 'Flash flood' wadis in the northern regions. This is an important factor with regard to water availability in the area, and must be investigated. However, unless the Hydrological section is upgraded it will not be able to cope with the extra work load.

15.0. EQUIPMENT

a. The hydrological activities are continuing in a hand to mouth situation with regard to equipment availability, under the present conditions. It is imperative that spare sets of equipment supported by an assortment of spare parts are always available in stock, to ensure that the recording and gauging eouipment is always serviceable. There is a very high casualty rate with regard to equipment, mainly due to the loss of gauging equipment in the floods, and damage to the equipment from bouncing in the back of LandRovers over rough roads. The Water level Recorders have suffered at the hands of vandals, and maintenance equipment and tools are sadly lacking within the ministry and associated workshops.

b. To ensure serviceability of all equipment at all times, it is recommended that an Instrument Mechanic be assigned to the hydrological section as a member of the operational teams. He would have to be equiped with the necessary tools and workshop space, and be prepared to travel in the field to carry out on-site maintenance and repairs, also assist with equipment and structure installations. Such services are not available at present, resulting in a fairly high percentage loss of data.

An ex-military truck mounted type workshop would be one way to solve the problems. At the base it could act as the base workshop, and when required be moved to field installation sites.

c. Apart from stage and discharge measurements, equipment for Silt Sampling and Water Quality tests should also be included, in order to improve the standard of data collection. These additional measurements would not increase the work load at all as they do not require seperate field trips, but form part of the standard discharge observations.

16.0. TRANSPORTATION

a. The hydrological field vehicles should be fitted with tool and equipment storage compartments, where equipment could be packed securely, and so avoid the high rate of damage that is sustained at present due to the rough roads that have to be negotiated.

b. If vehicles were fitted out for hydrological activities they would more likely be available when required, instead of being used for other unrelated activities.

17.0. TRAINING

The training aspect is extremely important, and must be more disciplined and technically advanced than the course the the students attended in Kenya. If funds are available the proposed course submitted by the National Water Council in the United Kingdom would be ideal. The costs for such a course have been outlined in this report, and should be a guide line when training funds are allocated in the future.

18.0. EPILOGUE

Hydrometeorology in Somalia as in the majority of the third world countries, appears to be the 'Cinderella' faculty within the overall Water Resources Programmes, inspite of water being the 'root' requirement for all agricultural and urban activities.

Hydrometeorology unfortunately is not a 'Tombstone' endeavor to which the finger of publicity can point, and thereafter be on view to the public as a constant reminder of the constructors achievements, and the donors generosity.

The end result to a long and hard fought battle against the natural elements, in remote and often dangerous situations and conditions, ends up on the dusty shelves of some ministry store or library, in the form of a little read report. The Hydrometeorological investigative type projects are often spoken about, and categorised as being essential and of paramount importance, but at the end of the day financial committment and probable donors are conspicious by their absence.

The derelict condition of the hydrological network in Somalia, as found in January 1980, is but one example which supports these statements. It is rather sad and disheartening to realise that the keen interest in hydrology, which was with much effort re-kindled during the Hydrometry Project, and the example set during the unique flood events of April/May 1981, will be allowed to revert to the disinterested situation of the past.

Without long term committments from such organisations as the FAO, both with financial and technological guidance and support, the original short term benifits, in the long term will be doomed to failure.

APPENDICES

A P P E N D I C E S

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APPENDIX ' A '

A C K N O W L E D G E M E N T S

APPENDIX ' A '

ACKNOWLEDGEMENTS :

The writer wishes to thank and express his warm appreciation for the co-operation and assistance offered to him , by the Officials of the Government of Somalia. Also the Resident Representative of the United Nations Development Programme and his staff, the 'WFP' Mission and the FAO Representative and supporting staff.

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Mr. Ibrahim Musa Ali	-	Director, Water Resources and Land Use Department.

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Ahmed Ali Dejane

Haidar Abukhar

Last but not least, the drivers and survey chainmen, who all contributed long and tedious hours under trying, difficult and on many occasions dangerous conditions, which enabled the enormous amount of data to be collected in such a limited time, and with minimal resources.

APPENDIX ' B '

B I B L I O G R A P H Y

APPENDIX ' B '

R E F E R E N C E S

1965	- SELCHOZPROMEXPORT :	The Jubba River Scheme.
1967	- HUNTING TECHNICAL : SERVICES (MMP)	Project for the Water Control and Management of the Shebelli River.
1970	- A.KHATIB & L.KADRY :	Regional Water Resources & Soil Survey (Duty Trip Report)
1977	- HUNTING TECHNICAL : SERVICES (FAO)	Inter Riverine Agricultural Study (Final Report).
1977	- J.DOORENBOS AND : M.SMITH (FAO)	Water Use in Agriculture in Somalia (Country Brief).
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1978	- J.JOHNSON (FAO) :	A Conceptual Review of Somalia's Groundwater Resources.
1978	- M.MACDONALD AND : PARTNERS LTD.	Genale - Bulo Marreta Project(Vol.4 Water Resources Report).
1978	- M.MACDONALD AND : PARTNERS LTD.	Jubba Sugar Project (Draft Note - Flood Protection of Project).
1978	- HUNTING TECHNICAL : SERVICES (MMP).	Mogambo Irrigation Project Somalia (Supplementary Feasibility Study).
1979	- J.C.HENRY (FAO) :	Present and Future Irrigated Agriculture in the Shebelli and Jubba basins.
1980	- HUNTING TECHNICAL : SERVICES (MMP)	Proposed Irrigation Scheme at Lugh for the Refujee's in the Halba area.
1981	- M.MACDONALD AND : PARTNERS.	Johar Offstream Storage Resevoir (Operation and Maintenance Manual).
1981	- B.P.GEMMELL (FAO) :	History of the 'GU' floods in Somalia (March to June 1981).
1981	- M.MACDONALD AND : PARTNERS (HTS)	Flood Damage Assessment Study (Main Report).
1981	- UN GENERAL ASSEMBLY:	Assistance to the drought stricken area's in Somalia.

APPENDIX ' C '

JUBBA RIVER

R A T I N G   T A B L E S

(1980/81 CURVES)

1. Lugh Ganana
2. Bardheere
3. Jamamme

RATING TABLE

River: JUBBA **Location:** LUGH GANANA **Period:** 1980 / 81

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
141.42	0.00										
141.52	0.10										
141.62	0.20										
141.72	0.30										
141.82	0.40										
141.92	0.50	0.260	0.300	0.330	0.368	0.404	0.440	0.476	0.512	0.548	0.584
142.02	0.60	0.620	0.690	0.760	0.830	0.900	0.970	1.030	1.100	1.170	1.240
142.12	0.70	1.310	1.430	1.550	1.670	1.790	1.910	2.020	2.140	2.260	2.380
142.22	0.80	2.500	2.690	2.880	3.070	3.260	3.460	3.650	3.840	4.030	4.220
142.32	0.90	4.411	4.700	4.990	5.290	5.580	5.870	6.160	6.450	6.750	7.040
142.42	1.00	7.330	7.757	8.184	8.611	9.038	9.465	9.892	10.32	10.75	11.17
142.52	1.10	11.60	12.21	12.81	13.42	14.02	14.63	15.23	15.84	16.44	17.05
142.62	1.20	17.65	18.48	19.31	20.14	20.97	21.81	22.64	23.47	24.30	25.13
142.72	1.30	25.96	26.72	27.47	28.23	28.99	29.75	30.50	31.26	32.02	32.77
142.82	1.40	33.53	34.30	35.08	35.85	36.63	37.40	38.17	38.95	39.72	40.50
142.92	1.50	41.27	42.16	43.04	43.93	44.81	45.70	46.58	47.47	48.35	49.24
143.02	1.60	50.12	51.12	52.13	53.13	54.14	55.14	56.14	57.15	58.15	59.16
143.12	1.70	60.16	61.29	62.42	63.55	64.68	65.81	66.93	68.06	69.19	70.32
143.22	1.80	71.45	72.71	73.98	75.24	76.50	77.77	79.03	80.29	81.55	82.82
143.32	1.90	84.08	85.58	87.09	88.59	90.10	91.60	93.10	94.61	96.11	97.62
143.42	2.00	99.12	100.6	102.0	103.5	104.9	106.4	107.8	109.3	110.7	112.2
143.52	2.10	113.6	115.3	117.0	118.7	120.4	122.2	123.9	125.6	127.3	129.0
143.62	2.20	130.7	132.6	134.4	136.3	138.2	140.1	141.9	143.8	145.7	147.5
143.72	2.30	149.4	151.5	153.5	155.6	157.6	159.7	161.7	163.8	165.8	167.9
143.82	2.40	169.9	172.1	174.3	176.6	178.8	181.0	183.2	185.4	187.7	189.9
143.92	2.50	192.1	194.5	196.9	199.3	201.7	204.1	206.5	208.9	211.3	213.7
144.02	2.60	216.1	218.5	220.8	223.3	225.7	228.1	230.5	232.5	234.8	237.2
144.12	2.70	239.5	241.5	243.5	245.5	247.5	249.5	251.5	253.5	255.5	257.5
144.22	2.80	259.5	261.6	263.6	265.7	267.7	269.8	271.8	273.9	275.9	278.0
144.32	2.90	280.5	282.7	284.9	287.0	289.2	291.4	293.6	295.8	297.9	300.1
144.42	3.00	302.3	304.6	306.8	309.1	311.4	313.7	315.9	318.2	320.5	322.7
144.52	3.10	325.0	327.4	329.7	332.1	334.5	336.9	339.2	341.6	344.0	346.3
144.62	3.20	348.7	351.2	353.6	356.1	358.5	361.0	363.5	365.9	368.4	370.8
144.72	3.30	373.3	375.8	378.4	380.9	383.5	386.0	388.5	391.1	393.6	396.2
144.82	3.40	398.7	401.3	404.0	406.6	409.3	411.9	414.5	417.2	419.8	422.5
144.92	3.50	425.1	427.8	430.6	433.3	436.1	438.8	441.5	444.3	447.0	449.8
145.02	3.60	452.5	455.3	458.1	461.0	463.8	466.6	469.4	472.2	475.1	477.9
145.12	3.70	480.7	483.6	486.6	489.5	492.4	495.4	498.3	501.2	504.1	507.1
145.22	3.80	510.0	513.0	516.0	519.0	522.0	525.1	528.1	531.1	534.1	537.1
145.32	3.90	540.1	543.2	546.3	549.4	552.5	555.7	558.8	561.9	565.0	568.1

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
145.42	4.00	571.2	574.4	577.6	580.8	584.0	587.3	590.5	593.7	596.9	600.1
145.52	4.10	603.3	606.6	609.9	613.2	616.5	619.8	623.1	626.4	629.7	633.0
145.62	4.20	636.3	639.7	643.1	646.5	649.9	653.3	656.7	660.1	663.5	666.9
145.72	4.30	670.3	673.8	677.3	680.8	684.3	687.8	691.3	694.8	698.3	701.8
145.82	4.40	705.3	708.9	712.5	716.1	719.7	723.3	726.8	730.4	734.0	737.6
145.92	4.50	741.2	744.9	748.6	752.3	756.0	759.7	763.4	767.1	770.8	774.5
146.02	4.60	778.2	782.0	785.8	789.6	793.4	797.2	800.9	804.7	808.5	812.3
146.12	4.70	816.1	820.0	823.9	827.8	831.7	835.6	839.4	843.3	847.2	851.1
146.22	4.80	855.0	859.0	863.0	867,0	871.0	875.0	879.0	883.0	887.0	891.0
146.32	4.90	894.9	899.0	903.1	907.2	911.3	915.4	919.4	923.5	927.6	931.7
146.42	5.00	935.8	940.0	944.2	948,4	952,6	956.8	960.9	965.1	969.3	973.5
146.52	5.10	977.7	982.0	986.4	990.7	995.0	999.4	1,004	1,008	1,012	1,017
146.62	5.20	1,021	1,025	1,030	1,034	1,039	1,043	1,047	1,052	1,056	1,061
146.72	5.30	1,065	1.069	1,074	1.078	1,083	1,087	1,091	1,096	1,100	1,105
146.82	5.40	1,109	1,114	1,118	1,123	1,127	1,132	1,137	1,141	1,146	1,150
146.92	5.50	1,155	1,160	1,164	1,169	1,174	1,179	1,183	1,188	1,193	1,197
147.02	5.60	1,202	1,207	1,212	1,216	1,221	1,226	1,231	1,236	1,240	1,245
147.12	5.70	1,250	1,255	1,260	1,265	1,270	1,275	1,279	1,284	1,289	1,294
147.22	5.80	1,299	1.304	1,309	1,314	1,319	1,324	1,329	1,334	1,339	1,344
147.32	5.90	1,349	1,354	1,359	1,364	1,370	1,375	1,380	1,385	1,391	1,396
147.42	6.00	1,401	1,406	1,411	1,417	1,422	1,427	1,432	1,437	1,443	1,448
147.52	6.10	1,453	1,458	1,464	1,469	1,474	1,480	1,485	1,490	1,495	1,501
147.62	6.20	1,506	1,511	1,517	1,522	1,528	1,533	1,538	1,544	1,549	1,555
147.72	6.30	1,560	1,566	1,571	1,577	1,582	1,588	1,594	1,599	1,605	1,610
147.82	6.40	1,616	1,622	1,627	1,633	1,638	1,644	1,650	1,655	1,661	1,666
147.92	6.50	1,672	1,678	1,683	1,689	1,695	1,701	1,706	1,712	1,718	1,723
148.02	6.60	1,729	1,735	1.741	1,747	1,753	1,759	1,764	1,770	1,776	1,782
148.12	6.70	1,788	1,794	1,800	1,806	1,812	1,818	1,823	1,829	1,835	1,841
148.22	6.80	1,847	1,853	1,859	1,865	1,871	1,878	1,884	1,890	1,896	1,902
148.32	6.90	1,908	1,914	1,920	1,927	1,933	1,939	1,945	1,951	1,958	1,964
148.42	7.00	1,970	1,976	1,983	1,989	1,995	2,002	2,008	2,014	2,020	2,027
148.52	7.10	2,033	2,039	2,046	2,052	2,058	2,064	2,071	2,077	2,083	2,090
148.62	7.20	2,096	2,103	2,109	2,116	2,122	2,129	2,135	2,142	2,148	2,155
148.72	7.30	2,161	2,168	2,174	2,181	2,187	2,194	2,201	2,207	2,214	2,220
148.82	7.40	2,227	2,234	2,240	2,247	2,254	2,261	2,267	2,274	2,281	2,287
148.92	7.50	2,294	2,301	2,308	2,315	2,322	2,329	2,335	2,342	2,349	2,356
149.02	7.60	2,363	2,370	2,377	2,384	2,391	2,398	2,404	2.411	2,418	2,425
149.12	7.70	2,432	2,439	2,446	2,453	2,460	2.467	2,474	2,481	2,488	2,495
149.22	7.80	2.502	2.509	2.516	2,524	2,531	2,538	2,545	2,552	2,560	2,567
149.32	7.90	2,574									

River: JUBBA Location: BARDHEERE Period: JANUARY 1980 TO DECEMBER 1981

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
88.48	- 0.50	0.12	0.13	0.15	0.17	0.19	0.21	0.24	0.27	0.29	0.33
88.58	- 0.40	0.36	0.40	0.44	0.49	0.53	0.60	0.66	0.73	0.80	0.87
88.68	- 0.30	0.94	1.03	1.12	1.21	1.32	1.43	1.55	1.68	1.82	1.97
88.78	- 0.20	2.13	2.30	2.48	2.67	2.87	3.09	3.32	3.56	3.82	4.09
88.88	- 0.10	4.38	4.69	5.01	5.36	5.72	6.10	6.51	6.94	7.39	7.86
88.98	0.00	8.36	8.89	9.44	10.0	10.6	11.2	12.0	12.7	13.4	14.2
89.08	0.10	14.9	15.9	16.8	17.2	17.6	18.1	18.6	19.1	19.5	20.0
89.18	0.20	20.5	21.0	21.6	22.1	22.6	23.2	23.7	24.3	24.7	25.4
89.28	0.30	26.0	26.6	27.2	27.8	28.5	29.1	29.7	30.4	31.0	31.7
89.38	0.40	32.4	33.1	33.8	34.5	35.2	36.0	36.7	37.4	38.2	39.0
89.48	0.50	39.8	40.5	41.3	42.2	43.0	43.8	44.6	45.5	46.4	47.2
89.58	0.60	48.1	49.0	49.9	50.8	51.8	52.7	53.7	54.6	55.6	56.6
89.68	0.70	57.6	58.6	59.7	60.7	61.7	62.7	63.8	64.9	66.0	67.1
89.78	0.80	68.2	69.3	70.6	71.6	72.8	74.0	75.1	76.3	77.5	78.9
89.88	0.90	80.0	81.3	82.5	83.8	85.1	86.4	87.7	89.1	90.4	91.8
89.98	1.00	93.1	94.5	95.9	97.3	98.8	100.2	101.7	103.1	104.6	106.1
90.08	1.10	107.6	109.1	110.7	112.3	113.8	115.4	117.0	118.6	120.2	121.8
90.18	1.20	123.5	125.2	126.9	128.6	130.3	132.0	133.7	135.5	137.3	139.1
90.28	1.30	140.9	142.7	144.5	146.4	148.2	150.1	152.0	153.9	155.9	157.8
90.38	1.40	159.8	161.8	163.8	165.9	167.8	169.8	171.8	173.9	175.9	178.2
90.48	1.50	180.3	182.4	184.8	186.8	189.0	191.2	193.4	195.7	197.7	200.1
90.58	1.60	202.0	203.6	205.2	206.8	208.4	210.0	211.6	213.2	214.8	216.4
90.68	1.70	218.0	219.9	221.8	223.7	225.6	227.5	229.4	231.3	233.2	235.1
90.78	1.80	237.0	238.9	240.8	242.7	244.6	246.5	248.4	250.3	252.2	254.1
90.88	1.90	257.0	259.0	261.0	263.0	265.0	267.0	268.0	269.0	271.0	273.0
90.98	2.00	277.0	279.0	281.0	283.0	285.0	287.0	289.0	291.0	293.0	295.0
91.08	2.10	297.0	299.1	301.2	303.2	305.4	307.5	309.6	311.7	313.8	315.9
91.18	2.20	318.0	319.9	321.8	323.7	325.6	327.5	329.4	331.3	333.2	335.1
91.28	2.30	337.0	339.1	341.2	343.3	345.4	347.5	349.6	351.7	353.8	355.9
91.38	2.40	358.0	360.3	362.7	365.0	367.3	369.7	372.0	374.3	376.6	379.0
91.48	2.50	381.3	383.1	384.9	386.8	388.6	390.6	392.1	394.3	396.5	398.2
91.58	2.60	400.0	401.9	403.8	405.6	407.5	409.4	411.3	413.3	415.3	417.3
91.68	2.70	419.0	420.9	422.8	424.8	426.7	428.7	430.7	432.6	434.5	436.4
91.78	2.80	438.5	440.5	442.5	444.4	446.4	448.3	450.3	452.3	454.3	456.3
91.88	2.90	458.3	460.3	462.3	464.3	466.3	468.3	470.3	472.3	474.3	476.3
91.98	3.00	478.4	480.8	482.9	484.9	487.0	488.6	490.7	492.7	494.8	496.8
92.08	3.10	498.9	501.0	503.1	505.1	507.2	509.3	511.4	513.5	515.6	517.7
92.18	3.20	519.8	521.9	524.0	526.1	528.2	530.3	532.4	534.6	536.7	538.8
92,28	3.30	541.0	543.1	545.2	547.4	549.6	551.7	553.9	556.0	558.2	560.4
92.38	3.40	562.6	564.8	567.0	569.1	571.3	573.5	575.8	577.9	580.1	582.3

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
92.48	3.50	584.5	586.7	588.9	591.1	593.3	595.5	597.8	600.0	602.2	604.2
92.58	3.60	606.7	609.0	611.3	613.5	615.8	618.0	620.3	622.5	624.8	627.1
92.68	3.70	629.3	631.5	633.7	636.0	638.2	640.7	643.0	645.3	647.6	649.9
92.78	3.80	652.2	654.5	656.8	659.2	661.5	663.8	666.1	668.5	670.8	673.1
92.88	3.90	675.5	677.8	680.1	682.5	684.9	687.3	689.7	692.0	694.4	696.6
92.98	4.00	699.1	701.5	703.9	706.3	708.6	711.0	713.4	715.8	718.2	720.6
93.08	4.10	723.0	725.4	727.8	730.3	732.7	735.1	737.6	740.0	742.4	744.8
93.18	4.20	747.3	749.8	752.3	754.7	757.1	759.6	762.0	764.5	767.0	769.5
93.28	4.30	771.9	774.4	776.9	779.3	781.8	784.3	786.8	789.3	791.8	794.3
93.38	4.40	796.8	799.3	801.8	804.4	806.9	809.4	811.9	814.5	817.0	819.5
93.48	4.50	822.1	824.5	827.0	829.7	832.2	834.8	837.4	840.0	842.0	847.0
93.58	4.60	847.6	850.2	852.8	855.4	857.9	860.3	863.1	865.7	868.3	870.9
93.68	4.70	873.5	876.1	878.4	881.4	884.0	886.6	889.2	891.8	894.4	897.8
93.78	4.80	899.7	902.4	905.1	907.7	910.3	913.0	915.6	918.3	921.0	923.7
93.88	4.90	926.3	929.0	931.7	934.3	936.9	939.7	942.4	945.0	947.7	951.1
93.98	5.00	953.1	955.8	958.5	961.2	964.0	966.7	969.4	972.1	974.8	977.6
94.08	5.10	980.5	983.0	985.7	988.8	991.2	994.0	996.8	999.5	1,003	1,005
94.18	5.20	1,008	1,011	1,013	1,016	1,018	1,022	1,025	1,027	1,030	1,033
94.28	5.30	1,036	1,040	1,044	1,047	1,051	1,055	1,059	1,063	1,067	1,071
94.38	5.40	1.075	1,079	1,083	1,086	1.090	1,094	1,098	1,102	1.105	1,109
94.48	5.50	1,113	1,117	1,121	1,125	1,129	1,133	1,137	1,141	1,145	1,149
94.58	5.60	1,153	1,157	1,161	1,165	1.169	1,173	1,177	1.181	1,185	1,189
94.68	5.70	1,193	1,197	1,201	1.205	1.209	1,213	1,217	1,221	1.226	1.230
94.78	5.80	1,234	1,238	1,242	1,246	1,251	1,255	1,259	1,263	1.267	1,271
94.88	5.90	1.276	1,280	1,284	1,288	1,293	1,297	1,301	1,305	1,310	1,314
94.98	6.00	1,318	1,322	1,327	1,331	1,336	1,340	1,344	1,349	1,353	1,357
95.08	6.10	1,361	1,365	1,370	1,375	1,379	1,383	1,388	1,392	1 397	1,401
95.18	6.20	1 406	1,410	1,415	1,419	1,423	1,428	1,432	1,437	1,441	1,446
95.28	6.30	1,450	1,454	1,459	1,464	1,469	1,473	1,478	1,482	1,487	1,491
95.38	6.40	1,496	1,500	1,505	1,510	1,515	1,519	1,523	1,528	1,533	1,538
95.48	6.50	1,543	1,548	1,552	1,557	1,561	1,566	1,570	1,575	1,580	1,585
95.58	6.60	1,590	1,595	1,600	1,604	1,609	1,614	1,619	1,623	1,628	1,633
95.68	6.70	1,638	1,643	1,648	1,653	1,657	1,662	1,667	1,672	1,677	1,682
95.78	6.80	1,687	1,692	1,697	1,702	1,707	1,712	1,717	1,722	1,727	1,732
95.88	6.90	1,737	1,741	1,746	1,752	1,757	1,762	1,767	1.772	1,777	1,782
95.98	7.00	1,787									

NOTE : Discharge figures tabulated at actual MSL and GH levels.

River: JUBBA **Location:** JAMAMME **Period:** 1980/81 (No. 1.)

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
87.23	- 2.00										
87.33	- 1.90	0.256	0.316	0.376	0.436	0.497	0.557	0.617	0.677	0.738	0.798
87.43	- 1.80	0.858	0.946	1.034	1.120	1.210	1.300	1.390	1.470	1.560	1.650
87.53	- 1.70	1,739	1.850	1.970	2.080	2.190	2.310	2.420	2.530	2.650	2.760
87.63	- 1.60	2.872	3.010	3.150	3.280	3.420	3.550	3.690	3.830	3.960	4.100
87.73	- 1.50	4.237	4.400	4.550	4.710	4.870	5.030	5.190	5.350	5.510	5.660
87.83	- 1.40	5.822	6.000	6.180	6.360	6.540	6.720	6.900	7.080	7.260	7.440
87.93	- 1.30	7.616	7.820	8.020	8.220	8.420	8.620	8.820	9.020	9.220	9.420
88.03	- 1.20	9.611	9.830	10.05	10.27	10.49	10.70	10.92	11.14	11.36	11.59
88.13	- 1.10	11.80	12.04	12.28	12.52	12.76	12.99	13.23	13.47	13.71	13.95
88.23	- 1.00	14.18	14.44	14.69	14.95	15.20	15.46	15.71	15.97	16.22	16.48
88.33	- 0.90	16.74	17.01	17.29	17.56	17.84	18.11	18.38	18.66	18.93	19.21
88.43	- 0.80	19.48	19.77	20.06	20.36	20.65	20.94	21.23	21.52	21.82	22.11
88.53	- 0.70	22.40	22.71	23.02	23.33	23.64	23.95	24.25	24.56	24.87	25.18
88.63	- 0.60	25.49	25.82	26.14	26.47	26.79	27.12	27.45	27.77	28.10	28.42
88.73	- 0.50	28.75	29.09	92.43	29.78	30.12	30.46	30.80	31.14	31.49	31.83
88.83	- 0.40	32.17	32.53	32.89	33.24	33.60	33.96	34.32	34.68	35.03	35.39
88.93	- 0.30	35.75	36.13	36.50	36.88	37.25	37.63	38.00	38.38	38.75	39.13
89.03	- 0.20	39.50	39.89	40.28	40.67	41.06	41.45	41.84	42.23	42.62	43.01
89.13	- 0.10	43.40	43.81	44.21	44.61	45.02	45.43	45.84	46.24	46.65	47.05
89.23	0.00	47.46	47.88	48.30	48.72	49.14	49.57	49.99	50.41	50.83	51.25
89.33	0.10	51.67	52.11	52.54	52.98	53.41	53.85	54.29	54.72	55.16	55.59
89.43	0.20	56.03	56.48	56.93	57.39	57.84	58.29	58.74	59.19	59.65	60.10
89.53	0.30	60.55	61.02	61.48	61.95	62.41	62.88	63.35	63.81	64.28	64.74
89.63	0.40	65.21	65.69	66.17	66.65	67.13	67.62	68.10	68.58	69.06	69.54
89.73	0.50	70.02	70.52	71.01	71.51	72.00	72.50	72.99	73.49	73.98	74.48
89.83	0.60	74.97	75.48	75.99	76.50	77.01	77.52	78.03	78.54	79.05	79.56
89.93	0.70	80.07	80.59	81.12	81.64	82.17	82.69	83.21	83.74	84.26	84.79
90.03	0.80	85.31	85.85	86.39	86.92	87.46	88.00	88.54	89.08	89.61	90.15
90.13	0.90	90.69	91.24	91.79	92.35	92.90	93.45	94.00	94.55	95.11	95.66
90.23	1.00	96.21	96.78	97.35	97.92	98.49	99.06	99.62	100.2	100.8	101.3
90.33	1.10	101.9	102.5	103.1	103.6	104.2	104.8	105.4	105.0	106.5	107.1
90.43	1.20	107.7	108.3	108.9	109.5	110.1	110.7	111.2	111.8	112.4	113.0
90.53	1.30	113.6	114.2	114.8	115.4	116.0	116.7	117.3	117.9	118.5	119.1
90.63	1.40	119.7	120.3	120.9	121.6	122.2	122.8	123.4	124.0	124.7	125.3
90.73	1.50	125.9	126.5	127.2	127.8	128.4	129.1	129.7	130.3	130.9	131.6
90.83	1.60	132.2	132.9	133.5	134.2	134.8	135.5	136.1	136.8	137.4	138.1
90.93	1.70	138.2	139.4	140.0	140.7	141.3	142.0	142.7	143.3	144.0	144.6
91.03	1.80	145.3	146.0	146.6	147.3	148.0	148.7	149.3	150.0	150.7	151.3
91.13	1.90	152.0	152.7	153.4	154.0	154.7	155.4	156.1	156.8	157.4	158.1

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
91.23	2.00	158.8	159.5	160.2	160.9	161.6	162.3	163.0	163.7	164.4	165.1
91.33	2.10	165.8	166.5	167.1	167.9	168.6	169.4	170.1	170.8	171.5	172.2
91.43	2.20	172.9	173.6	174.4	175.1	175.8	176.6	177.3	178.0	178.7	179.5
91.53	2.30	180.2	180.9	181.7	182.4	183.1	183.9	184.6	185.3	186.0	186.8
91.63	2.40	187.5	188.3	189.0	189.8	190.5	191.3	192.1	192.8	193.6	194.3
91.73	2.50	195.1	195.9	196.6	197.4	198.1	198.9	199.6	200.4	201.1	201.9
91.83	2.60	202.6	203.4	204.2	205.0	205.8	206.6	207.4	208.2	209.0	209.8
91.93	2.70	210.6	211.4	212.1	212.9	213.6	214.4	215.2	215.9	216.7	217.4
92.03	2.80	218.2	219.0	219.8	220.6	221.4	222.2	223.0	223.8	224.6	225.4
92.13	2.90	226.2	227.0	227.8	228.6	229.4	230.3	231.1	231.9	232.7	233.5
92.23	3.00	234.3	235.1	225.0	236.8	237.6	238.5	239.3	240.1	240.9	241.8
92.33	3.10	242.6	243.4	244.3	245.1	245.9	246.8	247.6	248.4	249.2	250.1
92.43	3.20	250.9	251.8	252.6	253.5	254.3	255.2	256.0	256.9	257.7	258.6
92.53	3.30	259.4	260.3	261.1	262.0	262.8	263.7	264.6	265.4	266.3	267.1
92.63	3.40	268.0	268.9	269.7	270.6	271.5	272.4	273.2	274.1	275.0	275.8
92.73	3.50	276.7	277.6	278.5	279.3	280.2	281.1	282.0	282.9	283.7	284.6
92.83	3.60	285.5	286.4	287.3	288.2	289.1	290.0	290.9	291.8	292.7	293.6
92.93	3.70	294.5	295.4	296.3	297.2	298.1	299.0	299.9	300.8	301.7	302.6
93.03	3.80	303.5	304.4	305.3	306.3	307.2	308.1	309.0	309.9	310.9	311.8
93.13	3.90	312.7	313.6	314.6	315.5	316.4	317.4	318.3	319.2	320.1	321.1
93.23	4.00	322.0	322.9	323.9	324.8	325.8	326.7	327.6	328.6	329.5	330.5
93.33	4.10	331.4	332.4	333.3	334.3	335.2	336.2	337.1	338.1	339.0	340.0
93.43	4.20	340.9	341.9	342.8	343.8	344.8	345.8	346.7	347.7	348.7	349.6
93.53	4.30	350.6	351.6	352.5	353.5	354.5	355.5	356.4	357.4	358.4	359.3
93.63	4.40	360.3	361.3	362.3	363.3	364.3	365.3	366.2	367.2	368.2	369.2
93.73	4.50	370.2	371.6	373.0	374.5	375.9	377.3	378.7	380.1	381.6	383.0
93.83	4.60	384.5	385.9	387.4	388.8	390.3	391.7	393.1	394.6	396.0	397.5
93.93	4.70	399.0	400.5	402.0	403.4	404.9	406.4	407.9	409.4	410.8	412.3
94.03	4.80	413.8	415.3	416.8	418.4	419.9	421.4	422.9	424.4	426.0	427.5
94.13	4.90	429.0	430.6	432.1	433.7	435.2	436.7	438.3	439.9	441.4	443.0
94.23	5.00	444.5	446.1	447.7	449.2	450.8	452.3	454.0	455.6	457.1	458.7
94.33	5.10	460.3	461.9	463.5	465.1	466.7	468.3	470.0	471.6	473.2	474.8
94.43	5.20	476.4	478.1	479.7	481.4	483.0	484.6	486.3	488.0	489.6	491.3
94.53	5.30	492.9	494.6	496.3	497.9	499.6	501.2	503.0	504.7	506.3	508.0
94.63	5.40	509.7	511.4	513.1	514.9	516.6	518.2	520.0	521.7	523.5	525.2
94.73	5.50	526.9	528.6	530.4	532.1	533.9	535.6	537.3	539.1	540.8	542.6
94.83	5.60	544.3	546.1	547.9	549.7	551.5	553.2	555.0	556.8	558.6	560.4
94.93	5.70	562.2	564.0	565.8	567.6	569.4	571.2	573.1	574.9	576.7	578.5
95.03	5.80	580.3	582.2	584.0	585.9	587.7	589.6	591.5	593.3	595.2	597.0
95.13	5.90	598.9	600.8	602.6	604.5	606.3	608.2	610.1	611.9	613.8	615.6

APPENDIX 'D'

SHEBELLI RIVER

R A T I N G   T A B L E S

(1980/81 CURVES)

1. Belet Uen
2. Bulo Burti
3. Mahaddei Uen
4. Afgoi
5 Audegle

River: SHEBELLI Location: BELET UEN Period: 1980/1981 (No. 1.)

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
175.81	- 0.30										
175.91	- 0.20						0.260	0.320	0.380	0.430	0.490
176.01	- 0.10	0.550	0.660	0.780	0.890	1.010	1.120	1.260	1.410	1.550	1.700
176.11	0.00	1.840	2.010	2.190	2.360	2.540	2.710	2.910	3.110	3.310	3.510
176.21	0.10	3.710	3.940	4.170	4.390	4.620	4.850	5.100	5.350	5.610	5.860
176.31	0.20	6.110	6.390	6.660	6.940	7.210	7.490	7.790	8.090	8.380	8.680
176.41	0.30	8.980	9.300	9.620	9.950	10.27	10.59	10.91	11.23	11.56	11.88
176.51	0.40	12.31	12.68	13.04	13.41	13.77	14.14	14.53	14.92	15.30	15.69
176.61	0.50	16.08	16.49	16.90	17.30	17.71	18.12	18.53	18.94	19.34	19.75
176.71	0.60	20.26	20.72	21.17	21.63	22.09	22.55	23.00	23.46	23.92	24.37
176.81	0.70	24.83	25.29	25.74	26.20	26.66	27.12	27.57	28.03	28.49	28.94
176.91	0.80	29.80	30.33	30.87	31.40	31.94	32.47	33.00	33.54	34.07	34.61
177.01	0.90	35.14	35.67	36.21	36.74	37.28	37.81	38.34	38.88	39.41	39.95
177.11	1.00	40.85	41.46	42.06	42.67	43.28	43.89	44.49	45.10	45.71	46.31
177.21	1.10	46.92	47.56	48.20	48.85	49.49	50.13	50.77	51.41	52.06	52.70
177.31	1.20	53.34	54.02	54.69	55.37	56.04	56.72	57.40	58.07	58.75	59.02
177.41	1.30	60.10	60.82	61.52	62.23	62.94	63.65	64.36	65.07	65.78	66.79
177.51	1.40	67.20	67.94	68.69	69.43	70.17	70.92	71.66	72.40	73.14	73.89
177.61	1.50	74.63	75.41	76.18	76.96	77.73	78.51	79.28	80.06	80.83	81.61
177.71	1.60	82.38	83.19	84.00	84.80	85.61	86.42	87.23	88.04	88.84	89.65
177.81	1.70	90.46	91.27	92.08	92.88	93.69	94.50	95.31	96.12	96.92	97.73
177.91	1.80	98.85	99.73	100.6	101.5	102.4	103.2	104.1	105.0	105.9	106.7
178.01	1.90	107.6	108.5	109.4	110.2	111.1	112.0	112.9	113.7	114.6	115.5
178.11	2.00	116.6	117.5	118.5	119.4	120.3	121.3	122.2	123.1	124.0	125.0
178.21	2.10	125.9	126.9	127.8	128.8	129.7	130.7	131.7	132.6	133.6	134.5
178.31	2.20	135.5	135.7	135.8	136.0	136.1	136.3	136.5	136.6	136.8	136.9
178.41	2.30	137.1	137.8	138.4	139.1	139.7	140.4	141.0	141.7	142.3	143.0
178.51	2.40	143.6	144.3	144.9	145.6	146.2	146.9	147.6	148.2	148.9	149.5
178.61	2.50	150.2	150.9	151.5	152.2	152.9	153.5	154.2	154.8	155.5	156.2
178.71	2.60	156.8	157.5	158.1	158.8	159.5	160.1	160.8	161.5	162.1	162.8
178.81	2.70	163.5	164.1	164.8	165.5	166.1	166.8	167.5	168.1	168.8	169.5
178.91	2.80	170.2	170.8	171.5	172.1	172.8	173.5	174.1	174.8	175.5	176.1
179.01	2.90	177.0	177.7	178.3	179.0	179.7	180.3	181.0	181.7	182.3	183.0
179.11	3.00	183.8	184.5	185.2	185.8	186.5	187.2	187.9	188.6	189.2	189.9
179.21	3.10	190.6	191.3	192.0	192.7	193.4	194.1	194.7	195.4	196.1	196.8
179.31	3.20	197.5	198.2	198.9	199.6	200.3	201.0	201.6	202.3	203.0	203.7
179.41	3.30	204.4	205.1	205.8	206.5	207.2	207.9	208.5	209.2	210.0	210.6
179.51	3.40	211.3	212.0	2 2.7	213.4	214.1	214.8	215.4	216.1	216.8	217.5

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
179.61	3.50	218.3	218.9	219.6	220.3	221.0	221.8	222.5	223.2	223.9	224.6
179.71	3.60	225.3	226.0	226.7	227.4	228.1	228.9	229.6	230.3	231.0	231.7
179.81	3.70	232.4	233.1	233.8	234.5	235.2	236.0	236.7	237.4	238.1	238.8
179.91	3.80	239.5	240.2	240.9	241.6	242,3	243.1	243.8	244.5	245.2	245.9
180.01	3.90	246.6	247.3	248.0	248.8	249.5	250.2	250.9	251.6	252.4	253.1
180.11	4.00	253.8	254.5	255.2	256.0	256.7	257.4	258.1	258.8	259.6	260.3
180.21	4.10	261.0	261.7	262.4	263.2	263.9	264.6	265.3	266.0	266.8	267.5
180.31	4.20	268.2	268.9	269.6	270.4	271.1	271.8	272.5	273.2	274.0	274.7
180.41	4.30	275.4	276.1	276.8	277.6	278.3	279.0	279,7	280.4	281.2	281.9
180.51	4.40	282.7	283.3	284.1	284.8	285.5	286.2	286.9	287.6	288.4	289.1
180.61	4.50	290.0	290.7	291.5	292.5	293.0	293.7	294.4	295.2	295.9	296.7
180.71	4.60	297.4	298.1	298.9	299.6	300.3	301.1	301.8	302.5	303.2	304.0
180.81	4.70	304.7	305.4	306.2	306.9	307.6	308.4	309.1	309.8	310.5	311.3
180.91	4.80	312.1	312.7	313.5	314.2	314.9	315.7	316.4	317.1	317.8	318.6
181.01	4.90	319.5	320.2	321.0	321.7	322.4	323.2	323.9	324.6	325.3	326.1
181.11	5.00	327.0	327.8	328.5	329.3	330.0	330.8	331.5	332.3	333.0	333.8
181.21	5.10	334.5	335.3	336.0	336.8	337.5	338.3	339.0	339.8	340.5	341.3
181.31	5.20	342.0	342.8	343.5	344.3	345.0	345.8	346.5	347.3	348.0	348.8
181.41	5.30	349.5	350.3	351.0	351.8	352.5	353.3	354.0	354.8	355.5	356.3
181.51	5.40	357.1	357.8	358.5	359.3	360.0	360.8	361.5	362.3	363.0	363.8
181.61	5.50	364.6	365.3	366.0	366.8	367.5	368.3	369.0	369.8	370.5	371.3
181.71	5.60	372.3	373.1	373.8	374.6	375.3	376.1	376,9	377.6	378.4	379.1
181.81	5.70	379.9	380.7	381.4	382.2	382.9	383.7	384.5	385.2	386.0	386.7
181.91	5.80	387.5	388.3	389.0	389.8	390.5	391.3	392.1	392.8	393.7	399.8
182.01	5.90	406.0	413.2	420.4	427.5	434.7	441.9	449.1	456.3	463.4	470.6
182.11	6.00	477.8	486.1	494.4	507.7	511.0	519.3	527.6	535.9	544.2	552.5
182.21	6.10	560.8	570.4	579.9	589.5	599.1	608.7	618.3	627.9	637.4	647.0
182.31	6.20	656.6	667.6	678.6	689.7	700.7	711.7	722.7	733.7	744.8	755.8
182.41	6.30	766.8	779.5	792.1	804.8	817.4	830.0	842.8	855.4	868.1	880.7
182.51	6.40	893.4	907.9	922.4	936.9	951.4	966.0	980.5	995.0	1,009	1,024
182.61	6.50	1,038	1,055	1,072	1,088	1,105	1,122	1,138	1,155	1,171	1,188
182.71	6.60	1,204	1,224	1,243	1,261	1,280	1,299	1,318	1,337	1,356	1,375
182.81	6.70	1,394	1,416	1,437	1,459	1,481	1,502	1,524	1,545	1,567	1m588
182.91	6.80	1,610									

River: SHEBELLI **Location:** BULO BURTI **Period:** 1980/1981 (No. 1.)

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
133.39	0.00										
133.49	0.10										
133.59	0.20										
133.69	0.30			0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.006
133.79	0.40	0.007	0.008	0.009	0.010	0.010	0.020	0.020	0.020	0.030	0.030
133.89	0.50	0.040	0.040	0.050	0.060	0.060	0.070	0.080	0.090	0.110	0.120
133.99	0.60	0.130	0.150	0.170	0.190	0.210	0.230	0.270	0.300	0.330	0.370
134.09	0.70	0.400	0.450	0.500	0.550	0.600	0.660	0.730	0.810	0.890	0.970
134 19	0.80	1.040	1.160	1.270	1.390	1.500	1.620	1.780	1.940	2.110	2.270
134.29	0.90	2.440	2.670	2.900	3.130	3.360	3.600	3.910	4.240	4.560	4.880
134.39	1.00	5.200	5.640	6.080	6.520	6.960	7.390	7.910	8.090	8.270	8.450
134.49	1.10	8.640	8.810	8.980	9.150	9.320	9.490	9.670	9.850	10.02	10.20
134.59	1.20	10.38	10.57	10.75	10.94	11.12	11.31	11.50	11.70	11.89	12.09
134.69	1.30	12.28	12.48	12.68	12.89	13.09	13.29	13.50	13.71	13.93	14.14
134.79	1.40	14.35	14.57	14.79	15.01	15.23	15.45	15.68	15.91	16.13	16.36
134.89	1.50	16.59	16.83	17.07	17.30	17.54	17.78	18.03	18.27	18.52	18.76
134.99	1.60	19.01	19.26	19.52	19.77	20.03	20.28	20.54	20.80	21.07	21.33
135.09	1.70	21.59	21.86	22.13	22.41	22.68	22.95	23.23	23.51	23.79	24.07
135.19	1.80	24.35	24,64	24.93	25.22	25.51	25.80	26.10	26.39	26.69	26.98
135.29	1.90	27.28	27.59	27.90	28.20	28.51	28.82	29.13	29.45	29.76	30.08
135.39	2.00	30.39	30.71	31.04	31.36	31.69	32.01	32.34	32.68	33.01	33.35
135.49	2.10	33.68	34.02	34.26	34.71	35.05	35.39	35.74	36.09	36.44	36.79
135.59	2.20	37.14	37.50	37.86	38.22	28,58	38.94	39.31	39.68	40.04	40.41
135.69	2.30	40.78	41.16	41.54	41.91	42.29	42.67	43.06	43.45	43.83	44.22
135.79	2.40	44.61	45.00	45.40	45.79	46.19	46.58	46.99	47.39	47.80	48.20
135,89	2.50	48.61	49.02	49.43	49.85	50.26	50.67	51.09	51.52	51.94	52.37
135.99	2.60	52.79	53.23	53.66	54.10	54.53	54.95	55.41	55.84	56.28	56.71
136.09	2.70	57.15	57.60	58.06	58.51	58.97	59.40	59.87	60.33	60.78	61.34
136.19	2.80	61.69	62.16	62.64	63.11	63.58	64.03	64.53	65.00	65.47	65.95
136.29	2.90	66.42	66.91	67.40	67.89	68.38	68.85	69.37	69.86	70.35	70.84
136.39	3.00	71.33	71.84	72.35	72.86	73.37	73.86	74.39	74.90	75.41	75.92
136.49	3.10	76.43	76.96	77.49	78.01	78.54	79.04	79.60	80.13	80.65	81.18
136.59	3.20	81.71	82.26	82.80	83.35	83.89	84.42	84.99	85.53	86.08	86.62
136.69	3.30	87.17	87.74	88.30	88.87	89.43	89.97	90.56	91.13	91.69	92.26
136.79	3.40	92.82	93.40	93.99	94.57	95.16	95.72	96.32	96.91	97.49	98.08
136.89	3.50	98.66	99.24	99.83	100.4	101.0	101.7	102.2	102.8	103.3	103.9
136.99	3.60	104.5	105.1	105.8	106.4	107.1	107.8	108.3	109.0	109.6	110.3
137.09	3.70	110.9	111.5	112.2	112.8	113.5	114.1	114.7	115.4	116.0	116.7
137.19	3.80	117.3	118.0	118.6	119.3	119.9	120.6	121.3	121.9	122.6	123.3
137.29	3.90	123.9	124.6	125.3	125.9	126.6	127.3	128.0	128.7	129.2	130.0

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
137.39	4.00	130.7	131.4	132.1	132.8	133.5	134.1	134.8	135.5	136.2	136.9
137.49	4.10	137.6	138.3	139.0	139.8	140.5	141.2	141.9	142.6	143.4	144.1
137.59	4.20	144.8	145.5	146.2	147.0	147.7	148.4	149.1	149.7	150.2	150.8
137.69	4.30	151.4	151.9	152.5	153.1	153.6	154.1	154.7	155.3	155.8	150.4
137.79	4.40	156.9	157.5	158.0	158.6	159.1	159.7	160.2	160.8	161.4	161.9
137.89	4.50	162.5	163.1	163.6	164.2	166.8	165.3	165.9	166.4	167.0	167.6
137.99	4.60	168.1	168.7	169.2	169.8	170.4	170.9	171.5	172.1	172.6	173.2
138.09	4.70	173.8	174.4	175.0	175.6	176.1	176.7	177.3	177.9	178.5	179.1
138.19	4.80	179.6	180.2	180.8	181.3	181.9	182.5	183.1	183.6	184.2	184.8
138.29	4.90	185.4	186.0	186.6	187.2	187.8	188.4	189.0	189.6	190.2	190.8
138.39	5.00	191.4	192.0	192.6	193.2	193.8	194.3	194.9	195.5	196.1	196.7
138.49	5.10	197.3	197.9	198.5	199.1	199.7	200.3	201.0	201.6	202.2	202.8
138.59	5.20	203.4	204.0	204.6	205.2	205.8	206.4	207.1	207.7	208.2	208.9
138.69	5.30	209.5	210.1	210.7	211,4	212.0	212.6	213.2	213.8	214.5	215.1
138.79	5.40	215.7	216.3	216.9	217.6	218.2	218.8	219.4	220.0	220.7	221.3
138.89	5.50	221.9	222.3	223.2	223.8	224.4	225.0	225.7	226.3	226.9	227.6
138.99	5.60	228.2	228.8	229.5	230.1	230.8	231.4	232.0	232.7	233.3	234.0
139.09	5.70	234.6	235.2	235.9	236.5	237.2	237.8	238.4	239.1	239.7	240.4
139.19	5.80	241.0	241.7	242.3	243.0	243.6	244.2	244.9	245.6	246.2	246.9
139.29	5.90	247.5	248.2	248.8	249.5	250.1	250.7	251.4	252.1	252.7	253.4
139.39	6.00	254.0	254.7	255.3	256,0	256.6	257.3	258.0	258.6	259.3	260.0
139.49	6.10	266.6	261.3	261.9	262.6	263.3	264.0	264.6	265.3	266.0	266.6
139.59	6.20	267.3	268.0	268.6	269.3	270.0	270.7	271.3	272.0	272.7	273.3
139.69	6.30	274.0	274.7	275.4	276.0	276.7	277.4	278.1	278.8	279.4	280.1
139.79	6.40	280.8	281.5	282.2	282.9	283.6	284.2	284.9	285.6	286.3	287.0
139.89	6.50	287.7	288.4	289.1	289.8	290.5	291.1	291.8	292.5	293.2	293.9
139.99	6.60	294.6	295.3	296.0	296.7	297.4	298.1	298.7	299.4	300.1	300.8
140.09	6.70	301.5	302.2	302.9	303.6	304.3	305.0	305.8	306.5	307.2	307.9
140.19	6.80	308.6	309.3	310.0	310.7	311.4	312.1	312.8	313.5	314.2	314.9
140.29	6.90	315.6	316.3	317.0	317.8	318.5	319.2	319.9	320.6	321.4	322.1
140.39	7.00	322.8	323.5	324.2	325.0	325.7	326.4	327.1	327.8	328.6	329.3
140.49	7.10	330.0	330.7	331.4	332.2	332.9	333.6	334.3	335.0	335.8	336.5
140.59	7.20	337.2	337.9	338.7	339.4	340.1	340.9	341.6	342.3	343.0	343.8
140.69	7.30	344.5	345.2	346.0	346.7	347.5	348.2	348.9	349.7	350.4	351.2
140.79	7.40	351.9	352.6	353.4	354.1	354.9	355.6	356.3	357.1	357.8	358.6
140.89	7.50	359.3	360.1	360.8	361.6	362.3	363.0	363.8	364.6	365.3	366.1
140.99	7.60										

CONTINUED ON SHEET "2"

RATING TABLE

River: SHEBELLI **Location:** BULO BURTI **Period:** 1980/1981 (No.2.)

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
		CONTINUED:									
140,89	7.50	359.3	360,1	360.8	361.6	362,3	363,0	363.8	364.6	365.3	366.1
	7.60	366.8	367.6	368.3	369.1	369.8	370.5	371.3	372.1	372.8	373.6
	7.70	374.3	375.1	375.8	376.6	377.3	378.1	378.9	379.6	380.4	381.1
	7.80	381.9	382.7	383.4	384.2	284.9	385.7	386.5	387.2	388.0	388.7
	7.90	389.5	390.3	391.0	391.8	392.6	93.4	394.1	394.9	395.7	396.4
141.39	8.00	397.2	398.2	399.2	400.2	401.2	402.0	403.2	404.2	405.2	406.2
	8.10	407.2	408.3	409.3	410.4	411.4	412.5	413.5	414.6	415.6	416.7
	8.20	417.7	418.8	419,8	420.9	422.0	423.0	424.0	425.2	426.3	427.3
	8.30	428.4	429.5	430.6	431.6	432.7	433.8	434.9	436.0	437.0	438.1
	8.40	439.2	440.3	441.4	442.5	443.6	444.7	445.7	446.8	447.9	449.0
141.89	8.50	450.1	451.2	452.3	458.4	454.5	455.7	456.8	457.9	459.0	460.1
	8.60	461.2	412.3	463.5	464.6	465.7	466.8	468.0	469.1	470.2	471.4
	8.70	472.5	473.6	474.8	475.9	477.0	478.1	479.3	480.4	481.5	482.7
	8,80	483.8	485.0	486.1	487.3	488.4	489.6	490.7	491.9	493.0	494.2
	8.90	495.3	496.5	497.6	498.8	500.0	501.1	502.3	503.5	504.7	505.8
142.39	9.00	507.0	508.2	509.4	510.5	511.7	512.9	514.1	515.3	516.4	577.6
	9.10	518.8	520.0	521.2	522.5	523.7	524.7	526.1	527.3	528.6	529.8
	9.20	531.0	532.2	522.4	534.5	535.7	536.7	538.1	529.3	540.4	541.6
	9.30	542.8	544.0	545.2	546.5	547.7	550.1	550.1	551.3	552.6	553.8
	9.40	555.0	556.2	557.5	558.7	560.0	561.1	562.4	563.6	564.8	566.1
142.89	9.50	567.3	568.6	569.8	571.0	572.3	573.5	574.8	576.1	577.8	578.6

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09

River: SHEBELLI Location: MAHADDEI UEN Period: 1980/1981 (No. 1.)

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
104.57	0.00	-	-	-	0.000	0.010	0.020	0.030	0.040	0.050	0.070	108.57	4.00	96.09	96.55	97.01	97.47	97.93	98.41	98.86	99.32	99.78	100.2
104.67	0.10	-.080	0.100	0.120	0.140	0.160	0.180	0.200	0.220	0.260	0.290	108.67	4.10	100.7	101.2	101.7	102.1	102.6	103.1	103.6	104.1	104.5	105.0
104.77	0.20	0.310	0.340	0.370	0.410	0.440	0.470	0.510	0.550	0.580	0.620	108.77	4.20	105.5	106.0	106.5	107.0	107.5	108.0	108.4	108.9	109.4	109.9
104.87	0.30	0.660	0.710	0.750	0.800	0.840	0.890	0.940	1.000	1.050	1.110	108.87	4.30	110.4	110.9	111.4	111.9	112.4	112.9	113.4	113.9	114.4	114.9
104.97	0.40	1.160	1.220	1.280	1.330	1.390	1.450	1.510	1.580	1.640	1.710	108.97	4.40	115.4	115.9	116.4	116.9	117.4	117.9	118.5	119.0	119.5	120.0
105.07	0.50	1.770	1.840	1.910	1.980	2.060	2.130	2.200	2.280	2.360	2.440	109.07	4.50	120.5	121.0	121.5	122.1	122.6	123.1	123.6	124.1	124.7	125.2
105.17	0.60	2.520	2.600	2.680	2.760	2.850	2.930	3.020	3.110	3.200	3.290	109.17	4.60	125.7	126.2	126.8	127.3	127.8	128.3	128.9	129.4	129.9	130.5
105.27	0.70	3.380	3.480	3.570	3.670	3.760	3.860	3.970	4.070	4.170	4.270	109.27	4.70	131.0	131.5	132.1	132.6	133.2	133.7	134.2	134.8	135.3	135.9
105.37	0.80	4.370	4.480	4.590	4.700	4.810	4.910	5.040	5.150	5.260	5.370	109.37	4.80	136.4	137.0	137.5	138.1	138.6	139.1	139.7	140.3	140.8	141.4
105.47	0.90	5.480	5.600	5.730	5.850	5.970	6.080	6.220	6.340	6.460	6.590	109.47	4.90	141.9	142.5	143.0	143.6	144.1	144.7	145.3	145.8	146.4	146.9
105.57	1.00	6.710	6.850	6.980	7.120	7.350	7.370	7.520	7.660	7.790	7.930	109.57	5.00	147.5	148.1	148.6	149.2	149.8	150.3	150.9	151.5	152.1	152.6
105.67	1.10	8.060	8.210	8.350	8.500	8.640	8.780	8.940	9.080	9.230	9.370	109.67	5.10	153.2	153.8	154.4	154.9	155.5	156.1	156.7	157.3	157.8	158.4
105.77	1.20	9.520	9.680	9.840	9.990	10.15	10.30	10.47	10.63	10.78	10.94	109.77	5.20	159.0	159.6	160.2	160.7	161.3	162.0	162.5	163.1	163.6	164.2
105.87	1.30	11.10	11.27	11.44	11.61	11.78	11.94	12.12	12.29	12.46	12.63	109.87	5.30	164.9	165.5	166.1	166.7	167.3	167.9	168.6	169.2	169.8	170.4
105.97	1.40	12.80	12.98	13.16	13.35	13.53	13.69	13.89	14.07	14.26	14.44	109.97	5.40	171.0	171.6	172.2	172.8	173.4	174.0	174.7	175.3	175.9	176.5
106.07	1.50	14.62	14.81	15.00	15.20	15.39	15.57	15.77	15.96	16.16	16.35												
106.17	1.60	16.54	16.75	16.95	17.16	17.36	17.55	17.77	17.98	18.18	18.39			SECONDARY CURVE (BARRAGE AFFECTED)									
106.27	1.70	18.59	18.81	19.02	19.24	19.45	19.65	19.88	20.10	20.31	20.53	104.77	0.20	0.090	0.100	0.110	0.130	0.140	0.150	0.170	0.190	0.200	0.220
106.37	1.80	20.74	20.97	21.19	21.42	21.65	21.88	22.10	22.23	22.56	22.78	104.87	0.30	0.240	0.260	0.280	0.310	0.330	0.350	0.380	0.400	0.430	0.450
106.47	1.90	23.01	23.25	23.49	23.72	23.96	24.20	24.44	24.68	24.91	25.15	104.97	0.40	0.480	0.510	0.540	0.580	0.610	0.640	0.680	0.710	0.750	0.780
106.57	2.00	25.39	25.64	25.89	26.14	26.39	26.63	26.89	27.14	27.39	27.64	105.07	0.50	0.820	0.860	0.900	0.950	0.990	1.030	1.080	1.130	1.180	1.230
106.67	2.10	27.89	28.15	28.41	28.67	28.93	29.17	29.45	29.71	29.97	30.23	105.17	0.60	1.280	1.330	1.390	1.440	1.500	1.550	1.610	1.670	1.730	1.790
106.77	2.20	30.49	30.76	31.03	31.31	31.58	31.84	32.12	32.39	32.67	32.94	105.27	0.70	1.850	1.920	1.980	2.050	2.110	2.180	2.250	2.330	2.400	2.480
106.87	2.30	33.21	33.49	33.78	34.06	34.34	34.61	34.91	35.19	35.47	35.76	105.37	0.80	2.550	2.630	2.710	2.790	2.870	2.950	3.040	3.130	3.210	3.300
106.97	2.40	36.04	36.33	36.63	36.92	37.21	37.51	37.80	38.09	38.38	38.68	105.47	0.90	3.390	3.480	3.580	3.670	3.770	3.860	3.960	4.060	4.170	4.270
107.07	2.50	38.97	39.28	39.58	39.89	40.19	40.48	40.80	41.11	41.41	41.72	105.57	1.00	4.370	4.480	4.590	4.700	4.810	4.920	5.040	5.150	5.270	5.380
107.17	2.60	42.02	42.34	42.65	42.97	43.28	43.60	43.92	44.23	44.55	44.86	105.67	1.10	5.500	5.620	5.750	5.870	6.000	6.120	6.250	6.380	6.520	6.650
107.27	2.70	45.18	45.51	45.83	46.16	46.49	46.82	47.14	47.47	47.80	48.12	105.77	1.20	6.780	6.920	7.060	7.200	7.340	7.480	7.630	7.780	7.920	8.070
107.37	2.80	48.45	48.80	49.14	49.49	49.84	50.19	50.53	50.88	51.23	51.57	105.87	1.30	8.220	8.380	8.540	8.690	8.850	9.010	9.170	9.340	9.500	9.670
107.47	2.90	51.92	52.26	52.60	52.94	53.28	53.62	53.95	54.29	54.63	54.97	105.97	1.40	9.830	10.00	10.18	10.35	10.53	10.70	10.88	11.06	11.25	11.4
107.57	3.00	55.31	55.67	56.03	56.39	56.75	57.09	57.46	57.82	58.18	58.54	106.07	1.50	11.61	11.80	11.99	12.19	12.38	12.57	12.77	12.97	13.16	13.3
107.67	3.10	58.90	59.27	59.64	60.01	60.38	60.74	61.13	61.50	61.87	62.24	106.17	1.60	13.56	13.77	13.98	14.19	14.40	14.61	14.83	15.05	15.26	15.4
107.77	3.20	62.61	63.00	63.38	63.76	64.14	64.50	64.91	65.29	65.67	66.05	106.27	1.70	15.70	15.93	16.15	16.38	16.60	16.83	17.07	17.31	17.54	17.7
107.87	3.30	66.42	66.81	67.20	67.59	67.98	68.36	68.76	69.15	69.54	69.93	106.37	1.80	18.02	18.27	18.51	18.76	19.00	19.25	19.50	19.76	20.01	20.2
107.97	3.40	70.33	70.73	71.14	71.54	71.95	72.33	72.75	73.16	73.56	73.97	106.47	1.90	20.52	20.79	21.05	21.32	21.58	21.85	22.13	22.40	22.68	22.9
108.07	3.50	74.36	74.77	75.19	75.60	76.01	76.41	76.84	77.25	77.66	78.08	106.57	2.00	23.23	23.51	23.80	24.08	24.37	24.65	24.94	25.24	25.53	25.8
108.17	3.60	78.49	78.91	79.34	79.76	80.19	80.61	81.03	81.46	81.88	82.31	106.67	2.10	26.12	26.43	26.73	27.04	27.34	27.65	27.96	28.28	28.59	28.9
108.27	3.70	82.73	83.17	83.60	84.04	84.47	84.89	85.34	85.78	86.21	86.65	106.77	2.20	29.22	29.55	29.87	30.20	30.52	30.85	31.19	31.52	31.86	32.1
108.37	3.80	87.08	87.53	87.97	88.42	88.86	89.31	89.75	90.20	90.64	91.09	106.87	2.30	32.53	32.88	33.22	33.57	33.91	34.26	34.62	34.97	35.33	35.6
108.47	3.90	91.53	91.99	92.44	92.90	93.35	93.80	94.27	94.72	95.18	95.63	106.97	2.40	36.04									

River: SHEBELLI **Location:** AFGOI **Period:** 1980/81 (No.1)

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
77.42	0.00										
77.52	0.10										
77.62	0.20										
77.72	0.30										
77.82	0.40										
77.92	0.50					0.000	0.001	0.002	0.003	0.004	0.005
78.02	0.60	0.006	0.007	0.008	0.009	0.010	0.011	0.012	0.014	0.016	0.018
78.12	0.70	0.020	0.020	0.030	0.030	0.040	0.040	0.046	0.054	0.068	0.071
78.22	0.80	0.081	0.095	0.110	1.125	0.145	0.162	0.200	0.230	0.360	0.290
78.32	0.90	0.327	0.384	0.440	0.497	0.553	0.610	0.678	0.746	0.814	0.882
78.42	1.00	0.950	1.032	1.115	1.197	1.280	1.340	1.444	1.527	1.609	1.692
78.52	1.10	1.774	1.869	1.964	2.060	2.155	2.250	2.353	2.455	2.558	2.660
78.62	1.20	2.763	2.870	2.978	3.085	3.193	3.300	3.419	3.538	3.658	3.777
78.72	1.30	3.896	4.019	4.142	4.264	4.387	4.510	4.640	4.770	4.899	5.029
78.82	1.40	5.159	5.295	5.431	5.567	5.704	5.840	5.976	6.110	6.249	6.385
78 92	1.50	6.542	6.688	6.833	6.979	7.124	7.270	7.420	7.580	7.730	7.880
79.02	1.60	8.035	8.195	8.355	8.514	8.674	8.820	8.994	9.154	9.313	9.473
79.12	1.70	9.633	9.793	9.953	10.11	10.27	10.47	10.63	10.79	10.95	11.11
79.22	1.80	11.33	11.51	11.70	11.88	12.06	12.21	12.43	12.61	12.80	12.98
79.32	1.90	13.12	13.35	13.53	13.72	13.90	14.05	14.27	14.45	14.63	14.82
79.42	2.00	15.00	15.20	15.39	15.59	15.78	15.98	16.18	16.38	16.57	16.77
79.52	2.10	16.97	17.18	17.38	17.59	17.79	17.99	18.20	18.41	18.61	18.82
79.62	2.20	19.02	19.23	19.45	19.66	19.88	20.08	20.30	20.52	20.73	20.95
79.72	2.30	21.16	21.38	21.60	21.82	22.04	22.25	22.49	22.71	22.93	23.15
79.82	2.40	23.37	23.60	23.83	24.05	24.28	24.50	24.74	24.97	25.19	25.42
79.92	2.50	25.65	25.88	26.12	26.35	26.59	26.82	27.06	27.30	27.53	27.77
80.02	2.60	28.01	28.25	28.49	28.72	28.96	29.22	29.46	29.70	29.93	30.17
80.12	2.70	30.44	30.69	30.94	31.19	31.44	31.69	31.95	32.20	32.45	32.70
80.22	2.80	32.95	33.21	33.46	33.72	33.98	34.22	34.49	34.75	35.01	35.26
80.32	2.90	35.52	35.78	36.05	36.31	36.58	36.83	36.84	37.10	37.37	37.63
80.42	3.00	38.16	38.43	38.70	38.96	39.23	39.50	39.77	40.04	40.32	40.59
80.52	3.10	40.86	41.14	41.41	41.69	41.97	42.25	45.52	42.80	43.08	43.35
80.62	3.20	43.63	43.91	44.20	44.48	44.76	45.05	45.33	45.61	45.89	46.18
80.72	3.30	46.46	46.75	47.04	47.37	47.62	47.91	48.19	48.48	48.77	49.06
80.82	3.40	49.35	49.65	49.94	50.24	50.53	50.83	51.12	51.42	51.71	52.01
80.92	3.50	52.30	52.60	52.90	53.20	53.50	53.80	54.10	54.40	54.70	55.00
81.02	3.60	55.32	55.63	55.93	56.24	56.55	56.86	57.16	57.47	57.78	58.08
81.12	3.70	58.39	58.70	59.02	59.33	59.64	59.96	60.27	60.58	60.89	61.21
81.22	3.80	61.52	61.84	62.16	62.47	62.79	63.11	63.43	63.75	64.06	64.38
81.32	3.90	84.70	65.03	65.35	65.68	66.00	66.33	66.65	66.98	67.30	67.63

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
81.42	4.00	67.95	68.28	68.61	68.94	69.27	69.59	69.92	70.25	70.58	70.91
81.52	4.10	71.24	71.58	71.91	72.25	72.58	72.92	73.25	73.59	72.92	74.26
81.62	4.20	74.59	74.93	75.27	75.60	75.94	76.27	76.61	76.94	77.28	77.61
81.72	4.30	78.00	78.35	78.69	79.04	79.38	79.73	80.08	80.42	80.77	81.11
81.82	4.40	81.46	81.81	82.16	82.51	82.86	83.22	83.57	83.92	84.27	84.62
81.92	4.50	84.97	85.33	85.68	86.04	86.39	86.74	87.11	87.46	87.82	88.17
82.02	4.60	88.53	88.89	89.25	89.61	89.97	90.34	90.74	91.06	91.42	91.78
82.12	4.70	92.14	92.51	92.87	93.24	93.61	93.98	94.34	94.71	95.08	95.44
82.22	4.80	95.81	96.21	96.61	97.01	97.41	97.81	98.21	98.61	99.01	99.41
82.32	4.90	99.52	99.90	100.3	100.7	101.0	101.4	101.8	102.2	102.5	102.9
82.42	5.00	103.3	103.7	104.0	104.4	104.8	105.2	105.6	106.0	106.3	106.7
82.52	5.10	107.1									

River: SHEBELLI **Location:** AUDEGLE **Period:** 1980/1981 (No.1.)

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
70.55	0.50			(LOW	CURVE	1980)					
70.65	0.60										
70.75	0.70										
70.85	0.80										
70.95	0.90										
71.05	1.00	0.000	0.002	0.004	0.006	0.007	0.009	0.010	0.020	0.030	0.040
71.15	1.10	0.050	0.070	0.090	0.110	0.130	0.160	0.180	0.200	0.220	0.240
71.25	1.20	0.260	0.310	0.360	0.410	0.460	0.510	0.560	0.600	0.630	0.670
71.35	1.30	0.700	0.760	0.820	0.880	0.940	1.000	1.060	1.120	1.180	1.240
71.45	1.40	1.300	1.390	1.480	1.570	1.660	1.750	1.840	1.930	2.020	2.110
71.55	1.50	2.200	2.380	2.560	2.740	2.920	3.100	3.280	3.460	3.640	3.820
71.65	1.60	4.000	4.220	4.440	4.660	4.880	5.100	5.240	5.380	5.520	5.660
71.75	1.70	5.800	5.850	6.000	6.150	6.300	6.450	6.600	6.750	6.900	7.050
71.85	1.80	7.200	7.310	7.430	7.540	7.650	7.770	7.880	7.990	8.100	8.220
71.95	1.90	8.330	8.450	8.580	8.700	8.820	8.950	9.070	9.290	9.310	9.440
72.05	2.00	9.560	9.690	9.830	9.960	10.10	10.23	10.36	10.50	10.63	10.77
72.15	2.10	10.90	11.05	11.19	11.34	11.48	11.63	11.78	11.92	12.07	12.21
72.25	2.20	12.36	12.52	12.67	12.83	12.99	13.15	13.30	13.46	13.62	13.77
72.35	2.30	13.93	14.10	14.27	14.44	14.61	14.78	14.94	15.11	15.28	15.45
72.45	2.40	15.62	15.80	15.98	16.17	16.35	16.53	16.71	16.89	17.08	17.26
72.55	2.50	17.44	17.63	17.83	18.02	18.22	18.41	18.60	18.80	18.99	19.19
72.65	2.60	19.38	19.59	19.80	20.00	20.21	20.42	20.63	20.84	21.04	21.25
72.75	2.70	21.46	21.68	21.90	22.12	22.34	22.57	22.79	23.01	23.23	23.45
72.85	2.80	23.67	23.91	24.14	24.38	24.61	24.85	25.08	25.32	25.55	25.79
72.95	2.90	26.02	26.27	26.52	26.76	27.01	27.26	27.51	27.76	28.00	28.25
73.05	3.00	28.50	28.76	29.03	29.29	29.56	29.82	30.08	30.35	30.61	30.88
73.15	3.10	31.14	31.42	31.70	31.97	32.25	32.53	32.81	33.09	33.36	33.64
73.25	3.20	33.92	34.21	34.51	34.80	35.09	35.39	35.68	35.97	36.26	36.56
73.35	3.30	36.85	37.16	37.47	37.77	38.08	38.39	38.70	39.01	30.31	39.62
73.45	3.40	39.93	40.26	40.58	40.91	41.23	41.56	41.88	42.21	42.53	42.86
73.55	3.50	43.18	43.52	43.86	44.20	44.54	44.88	45.22	45.56	45.90	46.24
73.65	3.60	46.58	46.84	47.09	47.35	47.60	47.86	48.11	48.37	48.62	48.88
73.75	3.70	49.13	49.61	50.08	50.56	51.03	51.51	51.98	52.46	52.93	53.41
73.85	3.80	53.88	54.09	54.30	54.52	54.73	54.94	55.15	55.36	55.38	55.79
73.95	3.90	56.00	56.24	56.48	56.72	56.96	57.20	57.44	57.68	57.92	58.16
74.05	4.00	58.40	58.59	58.78	58.97	59.16	59.35	59.54	59,73	59.92	60.11
74.15	4.10	60.30	60.49	60.68	60.87	61.06	61.25	61.44	61.63	61.82	62.01
74.25	4.20	62.20	62.24	62.38	62.53	62.66	62.80	62.94	63.08	63.22	63.36
74.35	4.30	63.60	63.73	63.86	63.99	64.12	64.25	64.38	64.51	64.64	64.77
74.45	4.40	64.90	65.00	65.09	65.19	65.28	65.38	65.47	65.57	65.66	65.76

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
74.55	4.50	65.85	65.94	66.03	66.13	66.22	66.31	66.40	66.49	66.59	66.68
74.65	4.60	66.77	66.86	66.95	67.05	67.14	67.23	67.32	67.41	67.51	67.60
74.75	4.70	67.68	67.78	67.87	67.97	68.06	68.15	68.24	68.33	68.43	68.52
74.85	4.80	68.59	68.68	68.77	68.87	68.96	69.05	69.14	69.23	69.33	69.42
74.95	4.90	69.48	69.57	69.66	69.75	69.84	69.93	70.01	70.10	70.19	70.28
75.05	5.00	70.37	70.46	70.55	70.64	70.73	70.82	70.90	70.99	71.08	71.17
75.15	5.10	71.26	71.35	71.43	71.52	71.61	71.70	71.78	71.87	71.96	72.04
75.25	5.20	72.13	72.22	72.30	72.39	72.48	72.57	72.65	72.74	72.83	72.91
75.35	5.30	73.00	73.09	73.17	73.26	73.35	73.44	73.52	73.61	73.70	73.78
75.45	5.40	73.87	73.96	74.04	74.13	74.21	74.30	74.39	74.47	74.56	74.64
75.55	5.50	74.73	74.82	74.90	74.99	75.07	75.16	75.24	75.33	75.41	75.50
75.65	5.60	75.58	75.67	75.75	75.84	75.92	76.01	76.09	76.18	76.26	76.35
75.75	5.70	76.43	76.51	76.60	76.68	76.77	76.85	76.93	77.02	77.10	77.19
75.85	5.80	77.27	77.35	77.44	77.52	77.61	77.69	77.77	77.86	77.94	78.03
75.95	5.90	78.11	78.19	78.28	78.36	78.44	78.53	78.61	78.69	78.77	78.86
76.05	6.00	78.94	FLOOD CURVE 'A' (1980)								

River: SHEBELLI Location: AUDEGLE Period: 1981/1982 (No.2.)

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
70.55	0.50			(LOW	CURVE	1981	)				
70.65	0.60										
70.75	0.70	0.000	0.010	0.020	0.030	0.050	0.070	0.090	0.110	0.130	0.140
70.85	0.80	0.150	0.160	0.170	0.180	0.190	0.200	0.220	0.240	0.260	0.290
70.95	0.90	0.420	0.440	0.470	0.490	0.510	0.540	0.560	0.580	0.600	0.630
71.05	1.00	0.650	0.680	0.710	0.740	0.770	0.810	0.840	0.870	0.900	0.930
71.15	1.10	0.960	1.000	1.040	1.080	1.120	1.270	1.210	1.270	1.290	1.330
71.25	1.20	1.370	1.420	1.480	1.530	1.580	1.640	1.690	1.740	1.790	1.850
71.35	1.30	1.900	1.970	2.030	2.100	2.170	2.240	2.300	2.370	2.440	2.500
71.45	1.40	2.570	2.650	2.740	2.820	2.910	2.990	3.070	3.160	3.240	3.330
71.55	1.50	3.410	3.510	3.620	3.720	3.830	3.930	4.030	4.140	4.240	4.350
71.65	1.60	4.450	4.580	4.700	4.830	4.950	5.080	5.200	5.330	5.450	5.580
71.75	1.70	5.700	5.850	6.000	6.150	6.300	6.450	6.600	6.730	6.900	7.050
71.85	1.80	7.200	7.310	7.430	7.540	7.650	7.770	7.880	7.990	8.100	8.220
71.95	1.90	8.330	8.450	8.580	8.700	8.820	8.950	9.070	9.190	9.310	9.440
72.05	2.00	9.560	9.690	9.830	9.960	10.10	10.23	10.36	10.50	10.63	10.77
72.15	2.10	10.90	11.05	11.19	11.34	11.48	11.63	11.78	11.92	12.07	12.21
72.25	2.20	12.36	12.52	12.67	12.83	12.99	13.15	13.30	13.46	13.62	13.77
72.35	2.30	13.93	14.10	14.27	14.44	14.61	14.78	14.94	15.11	15.28	15.45
72.45	2.40	15.62	15.80	15.98	16.17	16.35	16.53	16.71	16.89	17.08	17.26
72.55	2.50	17.44	17.63	17.83	18.02	18.22	18.41	18.60	18.80	18.99	19.19
72.65	2.60	19.38	19.59	19.80	20.00	20.21	20.42	20.63	20.84	21.04	21.25
72.75	2.70	21.46	21.68	21.90	22.12	22.34	22.57	22.79	23.01	23.23	23.45
72.85	2.80	23.67	23.91	24.24	24.38	24.61	24.85	25.08	25.32	25.55	25.79
72.95	2.90	26.02	26.27	26.52	26.76	27.01	27.26	27.51	27.76	28.00	28.25
73.05	3.00	28.50	28.76	29.03	29.29	29.56	29.82	30.08	30.35	30.61	30.88
73.15	3.10	31.14	31.42	31.70	31.97	32.25	32.53	32.81	33.09	33.36	33.64
73.25	3.20	33.92	34.21	34.51	34.80	35.09	35.39	35.68	35.97	36.26	36.56
73.35	3.30	36.85	37.16	37.47	37.77	38.08	38.39	38.70	39.01	39.31	39.62
73.45	3.40	39.93	40.26	40.58	40.91	41.23	41.56	41.88	42.21	42.53	42.86
73.55	3.50	43.18	43.52	43.86	44.20	44.54	44.88	45.22	45.56	45.90	46.24
73.65	3.60	46.58	46.84	47.09	47.35	47.60	47.86	48.11	48.37	48.62	48.88
73.75	3.70	49.13	49.61	50.08	50.56	51.03	51.51	51.98	52.46	52.93	53.41
73.85	3.80	53.88	54.19	54.50	54.82	55.13	55.44	55.75	56.06	56.38	56.69
73.95	3.90	57.00	57.30	57.60	57.90	58.20	58.50	58.80	59.10	59.40	59.70
74.05	4.00	60.00	60.37	60.74	61.11	61.48	61.85	62.22	62.59	62.96	63.33
74.15	4.10	63.70	64.03	64.36	64.69	65.02	65.35	65.68	66.01	66.34	66.67
74.25	4.20	67.00	67.30	67.60	67.90	68.20	68.50	68.80	69.10	69.40	69.70
74.35	4.30	70.00	70.30	70.30	70.90	71.20	71.50	71.80	72.10	72.40	72.70
74.45	4.40	73.00	73.26	73.26	73.78	74.04	74.30	74.56	74.82	75.08	75.34

M.S.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
74,55	4.50	75.60	75.82	76.03	76.25	76.47	76.69	76.90	77.12	77.34	77.55
74.65	4.60	77.77	77.99	78.20	78.42	78.64	78.86	79.07	79.29	79.51	79.72
74.75	4.70	79.94	80.16	80.38	80.60	80.82	81.04	81.25	81.47	81.69	81.91
74.85	4.80	82.13	82.35	82.57	82.79	83.01	83.23	83.44	83.66	83.88	84.10
74.95	4.90	84.32	84.54	84.76	84.98	85.20	85.43	85.65	85.87	86.09	86.31
75.05	5.00	86.53	86.75	86.97	87.20	87.42	87.64	87.86	88.08	88.31	88.53
75.15	5.10	88.75	88.97	89.20	89.42	89.65	89.87	90.09	90.32	90.54	90.77
75.25	5.20	90.99	91.22	91.44	91.67	91.89	92.12	92.34	92.57	92.79	93.02
75.35	5.30	93.24	92.47	93.69	93.92	94.14	94.37	94.59	94.82	95.04	95.27
75.45	5.40	95.49	95.72	95.94	96.17	96.40	96.62	96.85	97.08	97.31	97.53
				(FLOOD	CURVE	'B')					

APPENDIX ' E '

JUBBA RIVER

STAGE AND DISCHARGE DATA SHEETS

1. Lugh Ganana - 1977/81
2. Bardheere - 1980/81
3. Jamamme - 1980/81

STAGE AND DISCHARGE DATA SHEET

River: JUBBA **Year:** 1977

Station	Quantity	Units	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
LUGH GANANA	MEAN MONTHLY (GH)	Meters	1.56	1.62	1.30	2.93	3.10	3.26	2.77	3.02	3.38	4.05	5.27	2.80
	MEAN MONTHLY (Q)	M^3/Sec	46.58	52.13	25.96	287.00	325.00	363.50	253.50	306.80	393.60	587.30	1052.00	259.50
1977	MEAN DAILY VOLUME	M^3x 10^6	4.03	4.50	2.24	24.80	28.08	31.41	21.90	26.51	34.01	50.74	90.89	22.42
(1980/81 RATING	MONTHLY VOLUME	M^3x 10^6	124.93	126.00	69.44	744.00	870.48	942.30	678.90	821.81	1020.30	1572.94	2726.70	695.02
CURVE)	MONTHLY VOLUME	Percent(%)	1.63	1.64	0.91	9.70	11.35	12.29	8.85	10.72	13.30	20.51	35.56	9.06
	ANNUAL MEANS :	MONTHLY(VOL): 866.07 M^3x 10^6				DAILY(VOL): 28.47 M^3x 10^6			DAILY(Q): 329.51 M^3/Sec		ANNUAL DISCHARGE: 10,393 M^3x10^6			
LUGH GANANA	MEAN MONTHLY (GH)	Meters	1.78	1.44	2.61	2.22	2.85	2.12	3.36	3.27	2.94	4.11	3.09	2.31
	MEAN MONTHLY (Q)	M^3/Sec	69.19	36.63	218.50	134.40	269.80	117.00	388.50	365.90	289.20	606.60	322.70	151.50
1978	MEAN DAILY VOLUME	M^3x 10^6	5.98	3.16	18.88	11.61	23.31	10.11	33.57	31.61	24.99	52.41	27.88	13.09
	MONTHLY VOLUME	M^3x 10^6	185.32	88.48	585.28	348.30	722.61	303.30	1040.67	979.91	749.70	1624.71	836.40	405.79
	MONTHLY VOLUME	Percent(%)	2.35	1.12	7.44	4.43	9.18	3.85	13.22	12.45	9.53	20.64	10.63	5.16
	ANNUAL MEANS :	MONTHLY(VOL): 655.92 M^3x 10^6				DAILY(VOL): 21.56 M^3x 10^6			DAILY(Q): 249.59 M^3/Sec		ANNUAL DISCHARGE: 7,871 M^3x10^6			
LUGH GANANA	MEAN MONTHLY (GH)	Meters	1.71	1.83	1.62	2.31	(2.63)	3.01	2.35	2.57	2.15	2.87	3.00	2.86
	MEAN MONTHLY (Q)	M^3/Sec	61.29	75.24	52.13	151.50	223.30	304.60	159.70	208.90	122.20	273.90	302.30	271.80
1979	MEAN DAILY VOLUME	M^3x 10^6	5.30	6.50	4.50	13.09	19.29	26.32	13.80	18.05	10.56	23.66	26.12	23.48
	MONTHLY VOLUME	M^3x 10^6	164.30	182.00	139.50	392.70	598.00	789.60	427.80	559.55	316.80	733.46	783.60	727.88
	MONTHLY VOLUME	Percent(%)	2.83	3.13	2.40	6.75	10.28	13.58	7.38	9.62	5.45	12.61	13.48	12.52
	ANNUAL MEANS :	MONTHLY(VOL): 484.60 M^3x 10^6				DAILY(VOL): 15.93 M^3x 10^6			DAILY(Q): 184.4 M^3/Sec		ANNUAL DISCHARGE: 5,815 M^3x10^6			
	MEAN MONTHLY (GH)	Meters												
	MEAN MONTHLY (Q)	M^3/Sec												
	MEAN DAILY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	Percent(%)												
	ANNUAL MEANS :	MONTHLY(VOL): M^3x 10^6				DAILY(VOL): M^3x 10^6			DAILY(Q): M^3/Sec		ANNUAL DISCHARGE: M^3x10^6			
	MEAN MONTHLY (GH)	Meters												
	MEAN MONTHLY (Q)	M^3/Sec												
	MEAN DAILY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	Percent(%)												
	ANNUAL MEANS:	MONTHLY(VOL): M^3x 10^6				DAILY(VOL): M^3x 10^6			DAILY(Q): M^3/Sec		ANNUAL DISCHARGE: M^3x10^6			

STAGE AND DISCHARGE DATA SHEET

River: J U B B A **Year:** 1980

Station	Quantity	Units	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
LUGH GANANA	MEAN MONTHLY (GH)	Meters	1.25	1.06	0.96	1.11	2.06	1.86	2.30	2.11	2.19	2.44	1.97	1.37
	MEAN MONTHLY (Q)	M^3/Sec	21.81	9.89	6.16	12.21	107.80	79.03	149.40	115.50	129.00	178.80	94.61	31.26
	MEAN DAILY VOLUME	$M^3 x 10^6$	1.88	0.85	0.53	1.06	9.31	6.83	12.91	9.96	11.15	15.45	8.17	2.70
	MONTHLY VOLUME	$M^3 x 10^6$	58.28	24.65	16.43	31.80	288.61	204.90	400.21	308.76	334.50	478.95	245.10	83.70
	MONTHLY VOLUME	Percent(%)	2.35	1.00	0.66	1.28	11.66	8.28	16.16	12.47	13.51	19.34	9.90	3.38
	ANNUAL MEANS :	MONTHLY(VOL): 206.32 $M^3 x 10^6$				DAILY(VOL): 6.76 $M^3 x 10^6$			DAILY(Q): 78.24 M^3/Sec		ANNUAL DISCHARGE: 2,476 $M^3 x 10^6$			
BARDHEERE	MEAN MONTHLY (GH)	Meters	0.06	- 0.10	- 0.15	0.05	1.22	0.90	1.40	1.18	1.28	1.52	1.14	0.48
	MEAN MONTHLY (Q)	M^3/Sec	12.00	4.38	3.09	11.20	126.90	80.00	159.80	120.20	137.30	184.80	113.80	38.20
	MEAN DAILY VOLUME	$M^3 x 10^6$	1.04	0.38	0.27	0.97	10.96	6.91	13.81	10.39	11.86	15.97	9.83	3.30
	MONTHLY VOLUME	$M^3 x 10^6$	32.24	11.02	8.37	29.10	339.76	207.30	428.11	322.09	355.80	495.07	294.90	102.30
	MONTHLY VOLUME	Percent(%)	1.23	0.42	0.32	1.11	12.94	7.89	16.30	12.27	13.55	18.85	11.23	3.90
	ANNUAL MEANS :	MONTHLY(VOL): 218.84 $M^3 x 10^6$				DAILY(VOL): 7.18 $M^3 x 10^6$			DAILY(Q): 83.10 M^3/Sec		ANNUAL DISCHARGE: 2,626 $M^3 x 10^6$			
JAMAMME	MEAN MONTHLY (GH)	Meters	- 0.64	- 1.13	-	-	0.74	0.50	1.31	1.02	1.01	1.65	1.35	- 0.17
	MEAN MONTHLY (Q)	M^3/Sec	24.25	11.14	3.45	0.66	82.17	70.02	114.20	97.35	96.78	135.50	116.70	40.67
	MEAN DAILY VOLUME	$M^3 x 10^6$	2.10	0.96	0.30	0.06	7.10	6.05	9.87	8.41	8.36	11.71	10.08	3.51
	MONTHLY VOLUME	$M^3 x 10^6$	65.10	27.84	0.03	0.93	220.10	181.50	305.97	260.71	250.80	363.01	302.40	108.81
	MONTHLY VOLUME	Percent(%)	3.12	1.33	Trace	0.04	10.55	8.70	14.66	12.49	12.02	17.39	14.49	5.21
	ANNUAL MEANS :	MONTHLY(VOL): 173.93 $M^3 x 10^6$				DAILY(VOL): 5.70 $M^3 x 10^6$			DAILY(Q): 65.97 M^3/Sec		ANNUAL DISCHARGE: 2 087 $M^3 x 10^6$			
	MEAN MONTHLY (GH)	Meters												
	MEAN MONTHLY (Q)	M^3/Sec												
	MEAN DAILY VOLUME	$M^3 x 10^6$												
	MONTHLY VOLUME	$M^3 x 10^6$												
	MONTHLY VOLUME	Percent(%)												
	ANNUAL MEANS :	MONTHLY(VOL): $M^3 x 10^6$				DAILY(VOL): $M^3 x 10^6$			DAILY(Q): M^3/Sec		ANNUAL DISCHARGE: $M^3 x 10^6$			
	MEAN MONTHLY (GH)	Meters												
	MEAN MONTHLY (Q)	M^3/Sec												
	MEAN DAILY VOLUME	$M^3 x 10^6$												
	MONTHLY VOLUME	$M^3 x 10^6$												
	MONTHLY VOLUME	Percent(%)												
	ANNUAL MEANS:	MONTHLY(VOL): $M^3 x 10^6$				DAILY(VOL): $M^3 x 10^6$			DAILY(Q): M^3/Sec		ANNUAL DISCHARGE: $M^3 x 10^6$			

STAGE AND DISCHARGE DATA SHEET

River: J U B B A **Year:** 1981

Station	Quantity	Units	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
LUGH GANANA	MEAN MONTHLY (GH)	Meters	1.01	0.85	1.85	4.70	3.93	2.17	2.11	2.79	3.41	3.51	2.50	1.82
	MEAN MONTHLY (Q)	M^3/Sec	7.76	3.46	77.77	816.10	549.40	125.60	115.30	257.50	401.30	427.80	192.10	73.98
	MEAN DAILY VOLUME	M^3x 10^6	0.67	0.30	6.72	70.51	47.47	10.85	9.96	22.25	34.67	36.96	16.60	6.39
	MONTHLY VOLUME	M^3x 10^6	20.77	8.40	208.32	2115.30	1471.57	325.50	308.76	689.75	1040.10	1145.76	498.00	198.09
	MONTHLY VOLUME	Percent(%)	0.26	0.10	2.59	26.34	18.33	4.05	3.84	8.59	12.95	14.27	6.20	2.47
	ANNUAL MEANS :	MONTHLY(VOL): 669.19 M^3x 10^6			DAILY(VOL): 22.00 M^3x 10^6			DAILY(Q): 254.63 M^3/Sec			ANNUAL DISCHARGE: 8,030 M^3x10^6			
BARDHEERE	MEAN MONTHLY (GH)	Meters	0.15	- 0.10	1.71	4.00	3.97	1.63	1.36	2.15	2.84	2.96	1.67	0.66
	MEAN MONTHLY (Q)	M^3/Sec	18.10	4.38	219.90	699.10	692.00	206.80	152.00	307.50	446.40	470.3	213.20	53.70
	MEAN DAILY VOLUME	M^3x 10^6	1.56	0.38	19.00	60.40	59.79	17.87	13.13	26.57	38.57	40.63	18.42	4.64
	MONTHLY VOLUME	M^3x 10^6	48.36	10.64	589.00	1812.00	1853.49	536.10	407.03	823.67	1157.10	1259.53	552.60	143.84
	MONTHLY VOLUME	Percent(%)	0.53	0.12	6.41	19.71	20.16	5.83	4.43	8.96	12.59	13.70	6.01	1.56
	ANNUAL MEANS :	MONTHLY(VOL): 766.11 M^3x 10^6			DAILY(VOL): 25.19 M^3x 10^6			DAILY(Q): 291.55 M^3/Sec			ANNUAL DISCHARGE: 9,194 M^3x10^6			
JAMAMME	MEAN MONTHLY (GH)	Meters	- 1.22	- 1.62	-	5.35	5.39	2.86	1.53	2.90	4.14	5.07	3.30	1.07
Note: These figures only apply to the main channel flow.	MEAN MONTHLY (Q)	M^3/Sec	9.22	1.42	41.76	501.26	508.00	223.00	127.80	226.00	335.20	455.60	259.40	100.20
	MEAN DAILY VOLUME	M^3x 10^6	0.80	0.12	3.61	43.31	43.89	19.27	11.04	19.53	28.96	39.36	22.41	8.66
	MONTHLY VOLUME	M^3x 10^6	24.80	3.36	111.91	1299.30	1360.59	578.10	342.24	605.43	868.80	1220.16	672.30	268.46
	MONTHLY VOLUME	Percent(%)	0.34	0.05	1.52	17.66	18.50	7.86	4.65	8.23	11.81	16.59	9.14	3.65
	ANNUAL MEANS :	MONTHLY(VOL): 612.95 M^3x 10^6			DAILY(VOL): 20.15 M^3x 10^6			DAILY(Q): 233.22 M^3/Sec			ANNUAL DISCHARGE: 7.356 M^3x10^6			
	MEAN MONTHLY (GH)	Meters												
	MEAN MONTHLY (Q)	M^3/Sec												
	MEAN DAILY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	Percent(%)												
	ANNUAL MEANS :	MONTHLY(VOL): M^3x 10^6			DAILY(VOL): M^3x 10^6			DAILY(Q): M^3/Sec			ANNUAL DISCHARGE: M^3x10^6			
	MEAN MONTHLY (GH)	Meters												
	MEAN MONTHLY (Q)	M^3/Sec												
	MEAN DAILY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	Percent(%)												
	ANNUAL MEANS:	MONTHLY(VOL): M^3x 10^6			DAILY(VOL): M^3x 10^6			DAILY(Q): M^3/Sec			ANNUAL DISCHARGE: M^3x10^6			

APPENDIX 'F'

SHEBELLI RIVER

STAGE AND DISCHARGE DATA SHEETS

1.	Belet Uen	-	1977/81
2.	Bulo Burti	-	1980/81
3.	Mahaddei Uen	-	1980/81
4.	Afgoi	-	1980/81
5.	Audegle	-	1980/81

STAGE AND DISCHARGE DATA SHEET

River: SHEBELLI

Year: 1977 / 1979

Station	Quantity	Units	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
BELET UEN 1977 (1980/81 RATING CURVE)	MEAN MONTHLY (GH)	Meters	0.41	0.41	0.48	1.86	3.14	1.31	1.56	2.21	2.59	2.82	4.19	2.13
	MEAN MONTHLY (Q)	M^3/Sec	12.68	12.68	15.30	104.10	193.40	60.82	79.28	135.70	156.20	171.50	267.50	128.80
	MEAN DAILY VOLUME	M^3x 10^6	1.10	1.10	1.32	8.99	16.71	5.25	6.85	11.72	13.50	14.82	23.11	11.13
	MONTHLY VOLUME	M^3x 10^6	34.10	30.80	40.92	269.70	518.01	157.50	212.35	363.32	405.00	459.42	693.30	345.03
	MONTHLY VOLUME	Percent(%)	0.97	0.86	1.16	7.64	14.67	4.46	6.02	10.29	11.47	13.01	19.64	9.77
	ANNUAL MEANS :	MONTHLY(VOL): 294.12 M^3x 10^6			DAILY(VOL): 9.67 M^3x 10^6			DAILY(Q): 111.94 M^3/Sec			ANNUAL DISCHARGE: 3,530 M^3x10^6			
BELET UEN 1978	MEAN MONTHLY (GH)	Meters	0.69	0.41	1.62	1.15	1.71	0.80	1.29	2.57	3.12	2.90	2.03	0.80
	MEAN MONTHLY (Q)	M^3/Sec	24.37	12.68	84.00	50.13	91.27	29.80	59.02	154.80	192.00	177.00	119.40	29.80
	MEAN DAILY VOLUME	M^3x 10^6	2.11	1.10	7.26	4.33	7.89	2.57	5.10	13.37	16.59	15.29	10.32	2.57
	MONTHLY VOLUME	M^3x 10^6	65.41	30.80	225.06	129.90	244.59	77.10	158.10	414.47	497.70	473.99	309.60	79.67
	MONTHLY VOLUME	Percent(%)	2.42	1.14	8.32	4.80	9.04	2.85	5.84	15.32	18.39	17.52	11.44	2.94
	ANNUAL MEANS :	MONTHLY(VOL): 225.50 M^3x 10^6			DAILY(VOL): 7.41 M^3x 10^6			DAILY(Q): 85.81 M^3/Sec			ANNUAL DISCHARGE: 2,706 M^3x10^6			
BELET UEN 1979	MEAN MONTHLY (GH)	Meters	0.60	1.35	1.13	1.51	1.62	1.94	1.31	1.96	1.43	1.59	1.20	0.41
	MEAN MONTHLY (Q)	M^3/Sec	20.26	63.65	48.85	75.41	84.00	111.10	60.82	112.90	69.43	81.61	53.34	12.68
	MEAN DAILY VOLUME	M^3x 10^6	1.75	5.50	4.22	6.52	7.26	9.60	5.25	9.75	6.00	7.05	4.61	1.10
	MONTHLY VOLUME	M^3x 10^6	54.25	154.00	130.82	195.60	225.06	288.00	162.75	302.25	180.00	218.55	138.30	34.10
	MONTHLY VOLUME	Percent(%)	2.60	7.39	6.28	9.39	10.80	13.82	7.81	14.50	8.64	10.49	6.64	1.64
	ANNUAL MEANS :	MONTHLY(VOL): 173.67 M^3x 10^6			DAILY(VOL): 5.71 M^3x 10^6			DAILY(Q): 66.08 M^3/Sec			ANNUAL DISCHARGE: 2,084 M^3x10^6			
	MEAN MONTHLY (GH)	Meters												
	MEAN MONTHLY (Q)	M^3/Sec												
	MEAN DAILY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	Percent(%)												
	ANNUAL MEANS :	MONTHLY(VOL): M^3x 10^6			DAILY(VOL): M^3x 10^6			DAILY(Q): M^3/Sec			ANNUAL DISCHARGE: M^3x10^6			
	MEAN MONTHLY (GH)	Meters												
	MEAN MONTHLY (Q)	M^3/Sec												
	MEAN DAILY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	M^3x 10^6												
	MONTHLY VOLUME	Percent(%)												
	ANNUAL MEANS:	MONTHLY(VOL): M^3x 10^6			DAILY(VOL): M^3x 10^6			DAILY(Q): M^3/Sec			ANNUAL DISCHARGE: M^3x10^6			

STAGE AND DISCHARGE DATA SHEET

River: SHEBELLI **Year:** 1980

Station	Quantity	Units	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
BELET UEN	MEAN MONTHLY (GH)	Meters	0.30	0.12	0.09	0.33	1.78	0.52	0.71	1.66	1.61	1.23	0.56	0.20
	MEAN MONTHLY (Q)	M^3/Sec	8.98	4.17	3.51	9.95	96.92	16.90	25.29	87.23	83.19	55.37	18.53	6.11
	MEAN DAILY VOLUME	M^3x 10^6	0.78	0.36	0.30	0.86	8.37	1.46	2.19	7.54	7.19	4.78	1.60	0.53
	MONTHLY VOLUME	M^3x 10^6	24.18	10.44	9.30	25.79	259.47	43.80	67.89	233.74	215.70	148.18	48.00	16.43
	MONTHLY VOLUME	Percent(%)	2.19	0.95	0.84	2.34	23.53	3.97	6.16	21.19	19.56	13.44	4.35	1.49
	ANNUAL MEANS :	MONTHLY(VOL):	91.91	M^3x 10^6	DAILY(VOL):	3.01	M^3x 10^6	DAILY(Q):	34.84	M^3/Sec	ANNUAL DISCHARGE:		1.103	M^3x10
BULO BURTI	MEAN MONTHLY (GH)	Meters	1.23	1.07	0.92	1.24	3.31	1.60	1.73	3.08	3.17	2.61	1.68	1.13
	MEAN MONTHLY (Q)	M^3/Sec	10.94	8.09	2.90	11.12	87.74	19.01	22.41	75.41	80.17	53.23	21.07	9.15
	MEAN DAILY VOLUME	M^3x 10^6	0.95	0.70	0.25	0.96	7.58	1.64	1.94	6.52	6.93	4.60	1.82	0.79
	MONTHLY VOLUME	M^3x 10^6	29.45	20.30	7.75	28.80	234.98	49.20	60.14	202.12	207.90	142.60	54.60	24.49
	MONTHLY VOLUME	Percent(%)	2.77	1.91	0.73	2.71	22.12	4.63	5.66	19.03	19.57	13.42	5.14	2.31
	ANNUAL MEANS :	MONTHLY(VOL):	88.53	M^3x 10^6	DAILY(VOL):	2.90	M^3x 10^6	DAILY(Q):	33.56	M^3/Sec	ANNUAL DISCHARGE:		1,062	M^3x10
MAHADDEI UEN	MEAN MONTHLY (GH)	Meters	1.18	0.81	0.65	0.95	3.77	1.89	1.76	3.56	3.79	3.01	1.86	0.99
	MEAN MONTHLY (Q)	M^3/Sec	9.23	4.48	2.93	6.08	85.78	22.78	19.88	76.84	86.65	55.67	22.10	6.59
	MEAN DAILY VOLUME	M^3x 10^6	0.80	0.39	0.25	0.53	7.41	1.97	1.72	6.64	7.49	4.81	1.91	0.57
	MONTHLY VOLUME	M^3x 10^6	24.80	11.31	7.85	15.90	229.71	59.10	53.32	205.81	224.60	149.11	57.28	17.65
	MONTHLY VOLUME	Percent(%)	2.35	1.07	0.74	1.49	21.75	5.59	5.05	19.48	21.26	14.12	5.42	1.67
	ANNUAL MEANS :	MONTHLY(VOL):	88.04	M^3x 10^6	DAILY(VOL):	2.89	M^3x 10^6	DAILY(Q):	33.45	M^3/Sec	ANNUAL DISCHARGE:		1,056	M^3x10
AFGOI	MEAN MONTHLY (GH)	Meters	1.17	1.02	0.79	-	3.82	2.17	1.66	3.59	3.79	3.10	2.00	-
	MEAN MONTHLY (Q)	M^3/Sec	2.46	1.12	0.07	1.35	62.16	18.41	8.99	55.00	61.21	40.86	15.00	0.01
	MEAN DAILY VOLUME	M^3x 10^6	0.21	0.10	Trace	0.12	5.37	1.59	0.78	4.75	5.29	3.53	1.30	Trace
	MONTHLY VOLUME	M^3x 10^6	6.51	2.90	0.19	3.60	166.47	47.70	24.18	147.25	158.70	109.43	39.00	0.03
	MONTHLY VOLUME	Percent(%)	0.92	0.41	0.03	0.51	23.58	6.76	3.43	20.86	22.48	15.50	5.52	0.01
	ANNUAL MEANS :	MONTHLY(VOL):	58.83	M^3x 10^6	DAILY(VOL):	1.93	M^3x 10^6	DAILY(Q):	22.34	M^3/Sec	ANNUAL DISCHARGE:		706	M^3x10
AUDEGLE	MEAN MONTHLY (GH)	Meters	1.36	1.25	-	-	4.66	2.99	2.13	4.51	4.86	4.01	2.84	-
	MEAN MONTHLY (Q)	M^3/Sec	1.00	0.54	0.01	0.50	67.32	28.25	11.34	65.94	69.14	58.59	24.61	0.20
	MEAN DAILY VOLUME	M^3x 10^6	0.09	0.05	Trace	0.04	5.82	2.44	0.98	5.70	5.97	5.06	2.13	0.02
	MONTHLY VOLUME	M^3x 10^6	2.79	1.45	0.03	1.20	180.42	73.20	30.38	176.70	179.10	156.86	63.90	0.62
	MONTHLY VOLUME	Percent(%)	0.32	0.17	0.01	0.14	20.81	8.45	3.51	20.39	20.61	18.10	7.37	0.07
	ANNUAL MEANS:	MONTHLY(VOL):	72.22	M^3x 10^6	DAILY(VOL):	2.37	M^3x 10^6	DAILY(Q):	27.43	M^3/Sec	ANNUAL DISCHARGE:		867	M^3x10

STAGE AND DISCHARGE DATA SHEET

River: SHEBELLI **Year:** 1981

Station	Quantity	Units	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
BELET UEN	MEAN MONTHLY (GH)	Meters	0.04	- 0.05	1.30	5.11	4.69	1.15	0.69	2.04	3.40	3.64	1.13	0.54
* Figures include By-pass canal discharge.	MEAN MONTHLY (Q)	M^3/Sec	2.54	0.26	60.10	335.30	304.00	50.13	24.37	120.30	211.30	228.10	48.85	17.71
	MEAN DAILY VOLUME	M^3x 10^6	0.22	0.02	5.19	28.97	26.27	4.33	2.11	10.39	18.26	19.71	4.22	1.53
	MONTHLY VOLUME	M^3x 10^6	6.82	0.56	160.89	909.10*	814.37	129.90	65.41	322.09	554.54*	624.14*	126.60	47.43
	MONTHLY VOLUME	Percent(%)	0.18	0.01	4.28	24.17	21.65	3.45	1.74	8.56	14.74	16.59	3.37	1.26
	ANNUAL MEANS :	MONTHLY(VOL):	313.49	M^3x 10^6	DAILY(VOL):	10.31	M^3x 10^6	DAILY(Q):	119.33	M^3/Sec	ANNUAL DISCHARGE:		3,761 *	M^3x10^6
BULO BURTI	MEAN MONTHLY (GH)	Meters	0.78	0.55	2.33	6.29	7.84	2.86	1.82	3.65	5.03	5.85	2.56	1.49
	MEAN MONTHLY (Q)	M^3/Sec	0.89	0.07	41.91	273.30	384.90	64.53	24.93	107.80	193.20	244.20	51.09	16.36
	MEAN DAILY VOLUME	M^3x 10^6	0.08	0.01	3.62	23.61	33.26	5.58	2.15	9.31	16.69	21.10	4.41	1.41
	MONTHLY VOLUME	M^3x 10^6	2.48	0.28	112.22	708.30	1031.06	167.40	66.65	288.61	500.70	654.10	132.30	43.71
	MONTHLY VOLUME	Percent(%)	0.07	0.01	3.03	19.10	27.81	4.51	1.80	7.78	13.50	17.64	3.57	1.18
	ANNUAL MEANS :	MONTHLY(VOL):	308.98	M^3x 10^6	DAILY(VOL):	10.16	M^3x 10^6	DAILY(Q):	117.59	M^3/Sec	ANNUAL DISCHARGE:		3,708	M^3x10^6
MAHADDEI UEN	MEAN MONTHLY (GH)	Meters	0.49	0.05	-	5.08	5.23	3.62	2.34	4.03	5.08	5.16	3.40	2.03
	MEAN MONTHLY (Q)	M^3/Sec	1.71	0.01	34.09	152.10	160.70	79.34	34.34	97.47	152.10	156.70	70.33	26.14
	MEAN DAILY VOLUME	M^3x 10^6	0.15	Trace	2.95	13.14	13.88	6.85	2.97	8.42	13.14	13.54	6.08	2.26
	MONTHLY VOLUME	M^3x 10^6	4.65	0.02	91.45	394.20	430.28	205.50	92.07	261.02	394.24	419.74	182.40	70.06
	MONTHLY VOLUME	Percent(%)	0.18	0.01	3.59	15.49	16.90	8.07	3.62	10.25	15.49	16.49	7.16	2.75
	ANNUAL MEANS :	MONTHLY(VOL):	212.12	M^3x 10^6	DAILY(VOL):	6.97	M^3x 10^6	DAILY(Q):	80.67	M^3/Sec	ANNUAL DISCHARGE:		2,545	M^3x10^6
AFGOI	MEAN MONTHLY (GH)	Meters	0.00	0.00	-	4.48	4.81	3.76	2.83	3.70	4.84	4.78	3.84	2.27
	MEAN MONTHLY (Q)	M^3/Sec	0.00	0.00	16.62	84.27	96.21	60.27	33.72	58.39	97.41	95.08	67.79	20.52
	MEAN DAILY VOLUME	M^3x 10^6	0.00	0.00	1.44	7.28	8.31	5.21	2.91	5.05	8.42	8.22	5.86	1.77
	MONTHLY VOLUME	M^3x 10^6	0.00	0.00	44.64	218.40	257.61	156.30	90.21	156.55	252.60	254.82	175.80	54.87
	MONTHLY VOLUME	Percent(%)	0.00	0.00	2.69	13.14	15.50	9.41	5.43	9.42	15.20	15.34	10.58	3.30
	ANNUAL MEANS :	MONTHLY(VOL):	138.46	M^3x 10^6	DAILY(VOL):	4.55	M^3x 10^6	DAILY(Q):	52.66	M^3/Sec	ANNUAL DISCHARGE:		1,662	M^3x10^6
AUDEGLE	MEAN MONTHLY (GH)	Meters	0.00	0.00	-	5.14	5.41	4.52	3.55	4.73	5.34	5.32	4.43	2.87
	MEAN MONTHLY (Q)	M^3/Sec	0.00	0.00	15.56	80.63	95.72	66.03	44.88	67.87	94.14	93.69	65.19	25.32
	MEAN DAILY VOLUME	M^3x 10^6	0.00	0.00	1.34	6.97	8.27	5.70	3.88	5.86	8.13	8.09	5.63	2.19
	MONTHLY VOLUME	M^3x 10^6	0.00	0.00	41.54	209.00	256.37	171.00	120.28	181.66	243.90	250.79	168.90	67.89
	MONTHLY VOLUME	Percent(%)	0.00	0.00	2.43	12.21	14.98	9.99	7.03	10.62	14.25	14.65	9.87	3.97
	ANNUAL MEANS:	MONTHLY(VOL):	142.61	M^3x 10^6	DAILY(VOL):	4.69	M^3x 10^6	DAILY(Q):	54.28	M^3/Sec	ANNUAL DISCHARGE:		1,711	M^3x10^6

APPENDIX ' G '

WADI KELLI GURAT AT HALGAN

(Seasonal Wadi Observation site)

1. History Notes
2. Flood Survey Sheet
3. Discharge Measurement Sheet
4. Rating Curve
5. Rating Table
6. Flood Hydrograph
7. Discharge Calculation Sheet

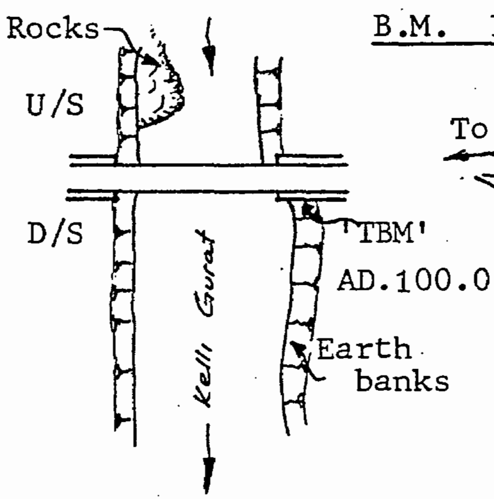
SHEET NO: .1.

RIVER FLOW GAUGING STATION

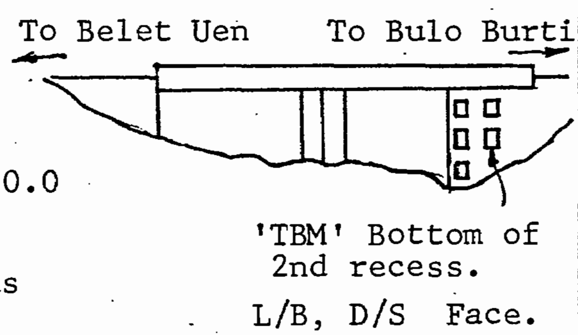
HISTORY NOTES

RIVER : WADI KELLI GURAT   AT : HALGAN (QUARANTUNO)   STN. NO: SPOT

DATE	TIME	R E M A R K S	SIGN
8.05.80	1845	B.P.Gemmell The wadi was flowing in full spate and still on the rising leg. Still raining heavily at the time of inspection. Rained all the way to Belet Uen with sheet runoff across the road from time to time.	
10.05.80	1600	B.P.Gemmell Wadi still flowing approximately 200 litres/second. Continious recession from flood peak of 8.05.80.	
14.05.80	1200	Hydro Team No flow in wadi at time of passing the site.	
17.09.80	1230	B.P.Gemmell Carried out Slope Area survey of floodmarks. Flood debris found at full bank level appears fairly recent as it had not discoloured from the strong sun light. Locals state that floods can and do last for upto a week. The flood of 8.05.80 lasted for three days . High flows last for about 24 Hours. Slope Area Survey related to 'TBM' bottom lip of recess on d/s face of left bank bridge abutment. See following sketch.	



B.M. Location



RIVER FLOW GAUGING STATION

HISTORY NOTES

RIVER : WADI KELLI GURAT AT : HALGAN (QUARANTUNO) STN. NO: SPOT

DATE	TIME	REMARKS	SIGN
19.11.80	1200	B.P.Gemmell A small flood had taken place with an estimated flood peak of 4.0 m^3/sec. Probably took place at the same time as the flood at Wadi Keli Carro on November 6th.	
7.04.81	2000	B.P.Gemmell Wadi dry at the time of inspection.	
12.04.81	2030	B.P.Gemmell Wadi dry at time of passing inspite of rain at time.	B.P.(

SURVEY SHEET

SITE : WADI KELLI GURAT LOCATION : HALGAN (QUARANTUNO)

DATE : 17.09.80 TIME : 1230 Hrs. WATER LEVEL : Dry

REMARKS : Survey related to 'BM' on bridge as per sketch. Flood of 8.05.80.

B.S	I.S	F.S	RISE	FALL	R.L.	DIST	ANG	REMARKS
1.33					100.00			BM. Lower lip of recess
	0.21		1.12		101.12	95.0		Start of section R/B
	0.70			0.49	100.63	93.0		Old FM.
	1.57			0.87	99.76	91.0		Low FM.
	1.81			0.24	99.52	89.0		Small flood.
	1.80		0.01		99.53	85.0		Wadi Bed
	2.30			0.50	99.03	80.0		" "
	2.11		0.19		99.22	75.0		" "
	2.24			0.13	99.09	63.0		" "
	2.43			0.19	98.90	56.0		" "
	2.45			0.02	98.88	51.0		" "
	2.72			0.27	98.61	36.0		" "
	2.72		0.00	0.00	98.61	33.0		" "
	2.76			0.04	98.57	26.0		" "
	2.63		0.13		98.70	19.0		" "
	2.56		0.07		98.77	16.0		" "
	1.29		1.27		100.04	10.0		Bank
	0.43		0.86		100.90	7.0		
	0.12		0.31		101.21	0.0		End section L/B
	2.04			1.92	99.29	155.0		Low FM. D/S
	1.62		0.42		99.71	"		High FM. D/S
		1.33	0.29		100.00			BM. AD.100.00 (Bridge)
1.33		1.33	4.67	4.67	0.00			Survey correct.

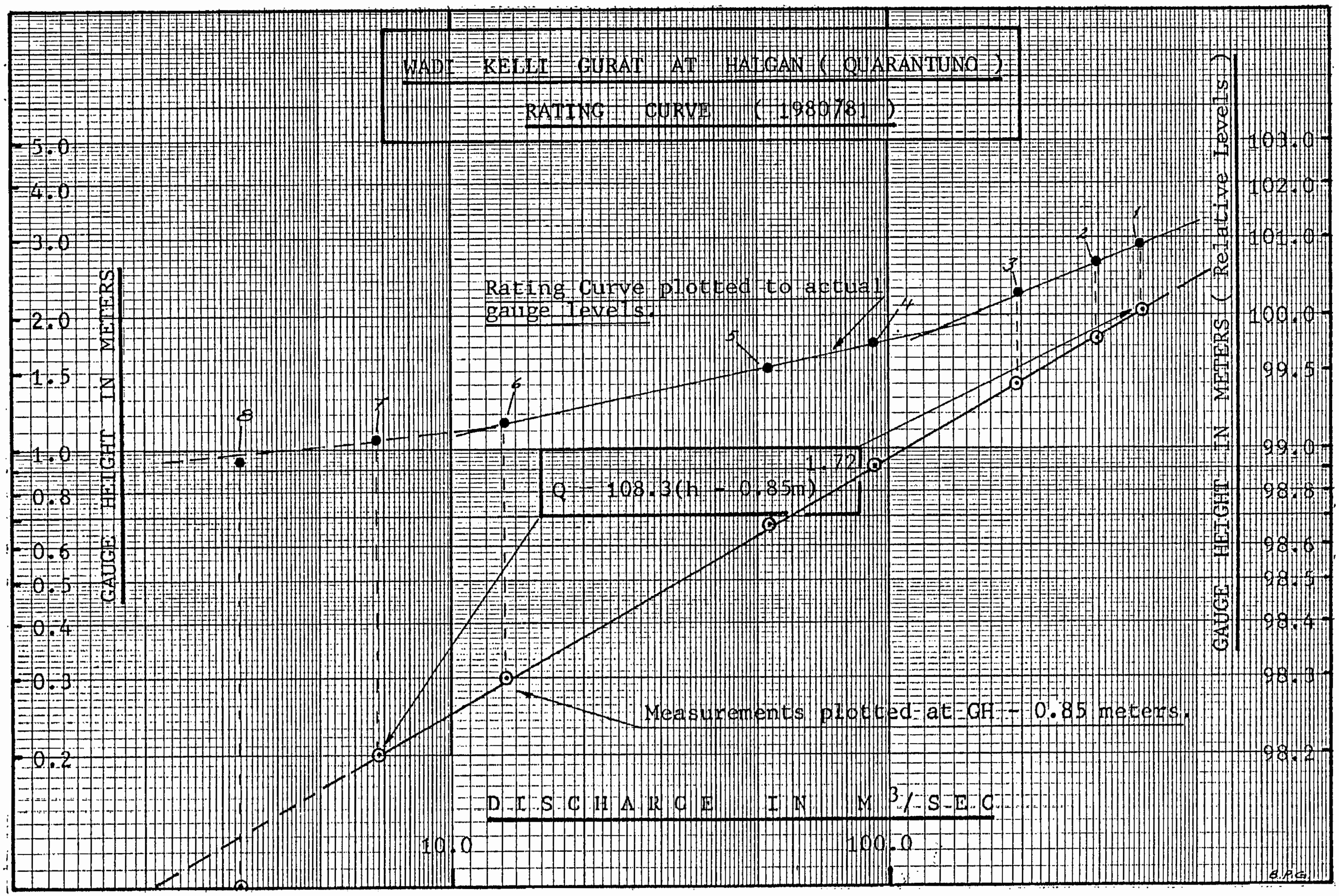
NOTE: Main flood lasted for one week. Latest flood for three days. High flow for 24 Hrs. (Local information).

Surveyed by: B.Gemmell.

DISCHARGE MEASUREMENTS

STREAM : WADI KELLI GURAT AT : HALGAN (QUARANTUNO) STATION NO : SPOT

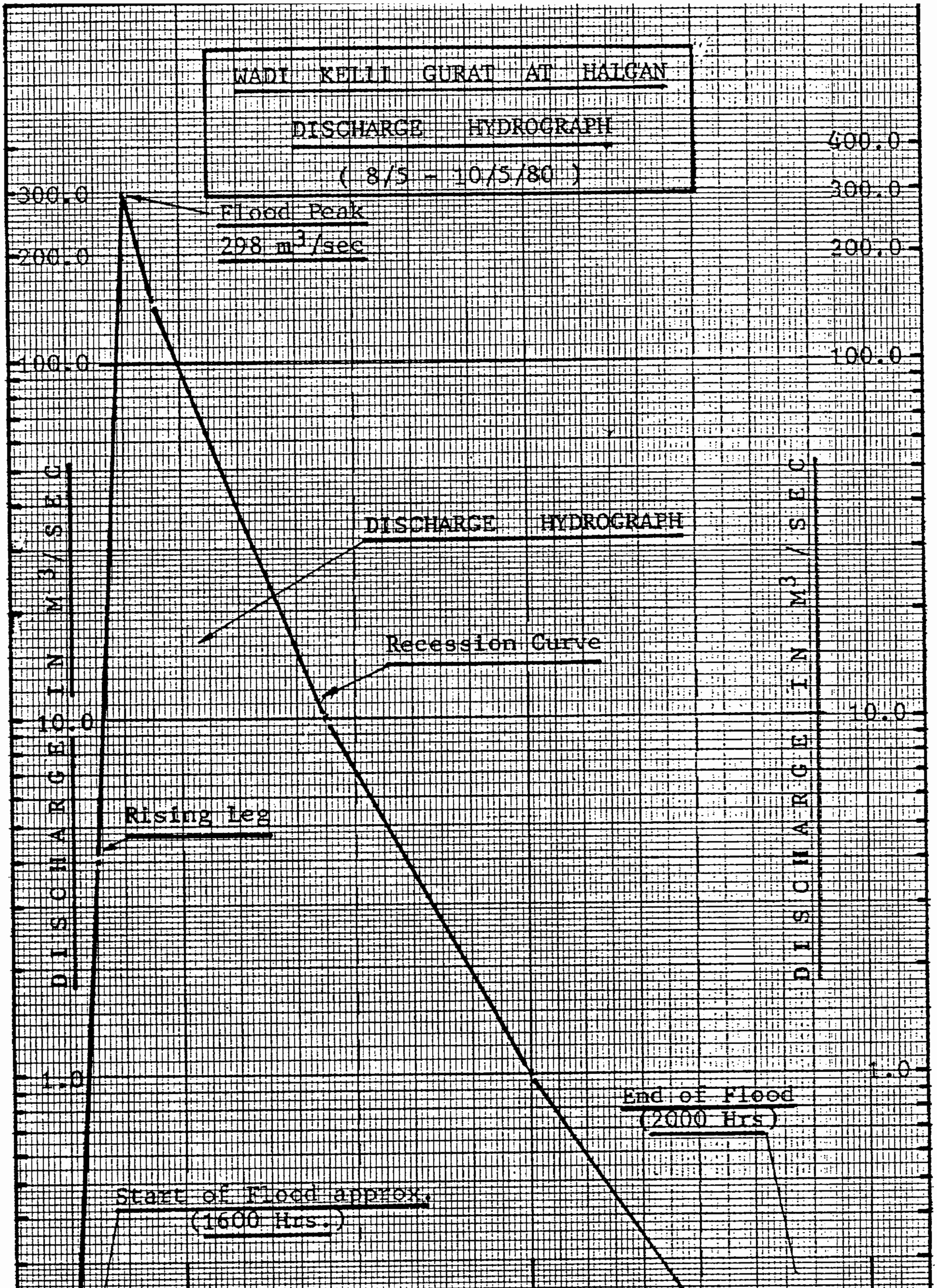
NO	DATE	OBSERVER	GH m	WIDTH m	AREA m²	Vm m/sec	Q m³/sec	METH	R.L.	REMARKS
1	17.09.80	B.P.Gemmell	2.90	88.00	157.60	2.37	373.47	S/A	100.90	Calculated from surveyed cross section
2	"	"	2.63	85.00	134.20	2.22	298.00	"	100.63	Calculated from the same cross section.
3	"	"	2.25	83.00	103.80	1.92	199.50	"	100.25	Flood of 8.05.80. (Peak)
4	"	"	1.76	80.00	65.00	1.43	92.63	"	99.76	Calculated from surveyed cross section
5	"	"	1.52	74.00	44.80	1.19	53.45	"	99.52	" " " "
6	"	"	1.15	55.00	18.80	0.70	13.20	"	99.15	" " " "
7	"	"	0.95	44.00	9.60	0.35	3.33	"	98.95	" " " "
8	"	B.P.Gemmell	1.05	47.0	13.0	0.52	6.80	S/A	99.05	" " " "


WADI KELLI GURAT AT HALGAN (QUARANTUNO)
RATING CURVE (1980/81)
GAUGE HEIGHT IN METERS
5.0
4.0
3.0
2.0
1.5
1.0
0.8
0.6
0.5
0.4
0.3
0.2
Rating Curve plotted to actual gauge levels.
1
2
3
4
5
6
7
8
$Q = 108.3(h - 0.85m)^{1.72}$
Measurements plotted at GH - 0.85 meters.
DISCHARGE IN M³/SEC
10.0
100.0
GAUGE HEIGHT IN METERS (Relative Levels)
103.0
102.0
101.0
100.0
99.5
99.0
98.8
98.6
98.5
98.4
98.3
98.2
B.P.G.

RATING TABLE (1980/81)

WADI KELLI GURAT AT HALGAN (QUARANTUNO)

M.S.L	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
98.50	0.50										
98.60	0.60										
98.70	0.70										
98.80	0.80										
98.90	0.90						2.06	2.48	2.89	3.31	3.72
99.00	1.00	4.14	4.67	5.20	5.74	6.27	6.80	7.44	8.07	8.71	9.34
99.10	1.10	9.98	10.71	11.45	12.18	12.92	13.65	14.48	15.31	16.14	16.97
99.20	1.20	17.80	18.72	19.64	20.56	21.48	22.40	23.41	24.40	25.42	26.40
99.30	1.30	27.43	28.52	29.61	30.69	31.78	32.87	34.04	35.21	36.39	37.56
99.40	1.40	38.73	39.98	41.23	42.48	43.73	44.98	46.31	47.64	48.96	50.29
99.50	1.50	51.62	53.02	54.43	55.83	57.24	58.64	60.12	61.60	63.07	64.55
99.60	1.60	66.03	67.58	69.13	70.68	72.23	73.78	75.40	77.02	78.65	80.27
99.70	1.70	81.89	83.58	85.27	86.97	88.66	90.35	92.11	93.87	95.63	97.39
99.80	1.80	99.15	101.0	102.8	104.6	106.5	108.3	110.2	112.1	114.0	115.9
99.90	1.90	117.8	119.7	121.7	123.7	125.6	127.6	129.6	131.7	133.7	135.7
100.00	2.00	137.7	139.8	141.9	144.0	146.1	148.2	150.4	152.5	154.7	156.8
100.10	2.10	159.0	161.2	163.4	165.6	167.8	170.1	172.3	174.6	176.9	179.2
100.20	2.20	181.5	183.8	186.2	188.5	190.8	193.2	195.6	198.0	200.4	202.8
100.30	2.30	205.2	207.7	210.1	212.6	215.1	217.5	220.0	222.6	225.1	227.6
100.40	2.40	230.1	232.7	235.3	237.9	240.5	243.1	245.7	248.3	251.0	253.6
100.50	2.50	256.3	259.0	261.7	264.4	267.1	268.8	272.5	275.3	278.1	280.8
100.60	2.60	283.6	286.4	289.2	292.0	294.8	297.6	300.5	303.4	306.3	309.1
100.70	2.70	312.0	314.9	317.9	320.8	323.7	326.7	329.6	332.6	335.6	338.6
100.80	2.80	341.6	344.6	347.7	350.7	353.7	356.8	359.9	363.0	366.1	369.2
100.90	2.90	372.3	375.4	378.6	381.7	384.9	388.0	391.2	394.4	397.6	400.8
101.00	3.00	404.0	407.3	410.6	413.8	417.1	420.3	423.6	427.0	430.3	433.6
101.10	3.10	436.9									
101.20	3.20										
101.30	3.30										
101.40	3.40										
101.50	3.50										
101.60	3.60										
101.70	3.70										
101.80	3.80										
101.90	3.90										
102.00	4.00										
102.10	4.10										
102.20	4.20										
102.30	4.30										
102.40	4.40										


WADI KELLI GURAT AT HALGAN
DISCHARGE HYDROGRAPH
(8/5 - 10/5/80)
Flood Peak
298 m3/sec
DISCHARGE HYDROGRAPH
Recession Curve
Rising leg
End of Flood
(2000 Hrs)
Start of Flood approx.
(1600 Hrs.)
DISCHARGE IN M3/SEC
300.0
200.0
100.0
10.0
1.0
400.0
(8/5)
(9/5)
(10/5)
TIME IN DAYS
2400
1200
2400
1200
2400

DISCHARGE COMPUTATION SHEET

WADI : KELLI GURAT LOCATION : HALGAN (QUARANTUNO)

PERIOD : 8/5 to 10/5 SHEET NO : 1 YEAR : 1980

NOTES : Flood duration from site observation.

DATE	TIME	G.H	Q	Q m	TIME	VOL $M^3 x 10^3$	R E M A R K S
8/5	1600		0.00				Mean Flood Q =
	1800		5.00	2.50	7,200	18,000	28.7 m^3/sec
	2000		298.00	151.50	7,200	1,090,800	
	2200		150.00	224.00	7,200	1,612,800	
	2400		90.00	120.00	7,200	864,000	
						3,585,600	m^3
9/5	0400		36.00	63.00	14,400	907 200	
	0800		14.00	25.00	14,400	360,000	
	1200		7.00	10.50	14,400	151,200	
	1600		3.60	5.30	14,400	76,320	
	2000		1.85	2.75	14,400	39,600	
	2400		1.00	1.43	14,400	20,592	
						1,554,912	m^3
10/5	0600		0.46	0.73	21,600	15,768	
	1200		0.33	0.40	21,600	8,640	
	1800		0.00	0.17	21,600	3,672	
						28,080	m^3
				Flood	Total Q=	5,168,592	m^3
Note:							

Flood duration from site observations and local information. Levels related to 'BM' illustrated in History Notes.

Surveyed: B.Gemmell

APPENDIX ' H '

WADI KELLI CARRO AT NURR FANAX

(Seasonal Wadi Observation Site)

1. History Notes
2. Flood Survey Sheet
3. Discharge Measurement Sheet
4. Rating Curve
5. Rating Table
6. Flood Hydrographs
7. Discharge Calculation Sheet

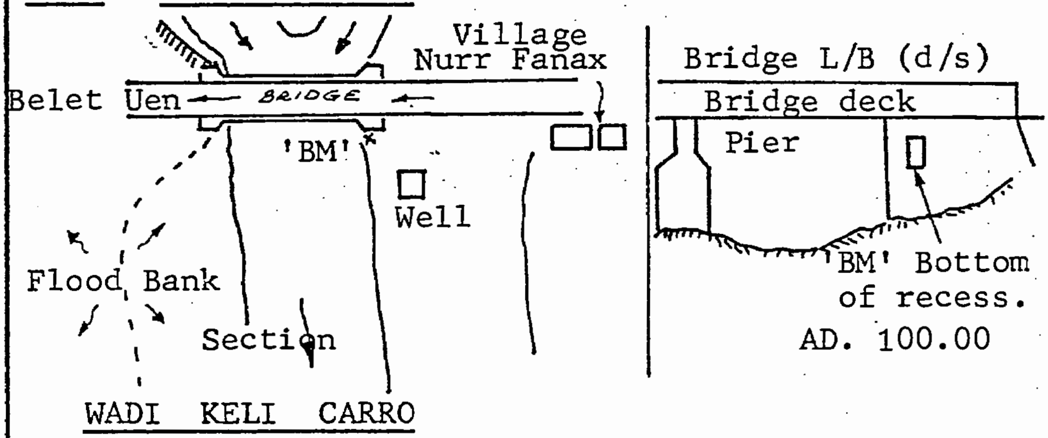
SHEET NO: 1.

RIVER FLOW GAUGING STATION

HISTORY NOTES

RIVER : KELI CARRO AT : NURR FANAX STN. NO: SPOT

DATE	TIME	REMARKS	SIGN
8.05.80	1900	B.P.Gemmell Wadi was in full spate, probably near the peak level. Raining heavily at the time, storm having started about 1700 hours. Rain all the way to Belet Uen.	
10.05.80	1330	B.P.Gemmell Wadi still with trickle flow, more like intermittent flow.	B.P.G.
17.09.80	1330	B.P.Gemmell 'Slope Area Survey' of flood marks carried out. Local information states flood marks from event of 8.05.80. Rainfall records should be checked, if at all available, to check if any further flood events could have taken place. (See Survey sheet) Flood marks related to 'TBM' Bottom of hole in d/s face of bridge abutment, as indicated in following sketches. Note: B.M. Location	B.P.G.



DATE	TIME	REMARKS	SIGN
18.11.80	1400	B.P.Gemmell Local information states flood about 6.11.80. Flood started in evening, peaked at about mid-night and reduced flow to approximately 3.0 m^3/sec by noon next day. Old observer than said that flood started	

Cont:...

RIVER FLOW GAUGING STATION

HISTORY NOTES

RIVER : KELI CARRO AT : NURR FANAX STN. NO: SPOT

DATE	TIME	REMARKS	SIGN
18.11.80	1400	Continued : at 1600 hrs on the 6th. November. Rest of information similar. Took survey of peak floodmarks for calculation of flood peak discharge. (see survey sheet). Flood peak was R.L. 99.70 meters.	
7.04.81	2100	B.P.Gemmell Very small flood just started, but did not increase much more later.	
15.04.81	1500	B.P.Gemmell On return journey questioned locals. Large flood approximately 24 days ago, almost topped the bridge. Flood much higher than previous floods. Locals state that peak rose about 7 times, and flood waters on six occasions reached the Shebbeli river. Estimated level of flood about 0.75 meters above previous flood level. The well downstream of the bridge was covered by the flood water.	B.P.G.

SURVEY SHEET

NO: 1.

SITE : WADI KELI CARRO LOCATION : NURR FANAX

DATE : 17.9.80 TIME : 1200 Hrs. WATER LEVEL : Dry

REMARKS : Local information states floodmarks from 8.05.80.

B.S	I.S	F.S	RISE	FALL	R.L.	DIST	ANG	REMARKS
0.38					100.00	74.0	0°	BM-L/B Abutment d/s.
	0.90			0.52	99.48	0.0		Start section L/B.
	1.54			0.64	98.84	9.0		Instrument
	1.83			0.29	98.55	13.0		Bank edge
	2.72			0.89	97.66	17.0		Wadi bed - sand/Gravel
	2.40		0.32		97.98	34.0		" "
	2.08		0.32		98.30	53.0		" "
	1.97		0.11		98.41	71.0		" "
	1.76		0.21		98.62	98.0		" "
	1.52		0.24		98.86	109.0		Sand
	1.16		0.36		99.22	137.0		Floodmark section L/B
	0.82		0.34		99.56	159.0	0°	End section L/B
	1.08			0.26	99.30	131.0	22°	FM U/S R/B
	1.98			0.90	98.40	170.0	60°	FM D/S R/B
		0.38	1.60		100.0			BM. AD. 100.00
0.38		0.38	3.50	3.50	0.0			Survey correct.
Slope of flood =			0.00657.		($S^{\frac{1}{2}}$ = 0.058)			
R =	1.78	($R^{\frac{2}{3}}$ =	1.43)					
A =	157.6 m^2							
'n'=	0.035	(estimated)						
Peak	Q = 374 m^3/sec.							
								Surveyed: B.P.Gemmell

SURVEY SHEET

NO: 2.

SITE : WADI KELI CARROW LOCATION : NURR FANAX

DATE : 18.11.80 TIME : 1500 Hrs. WATER LEVEL : DRY

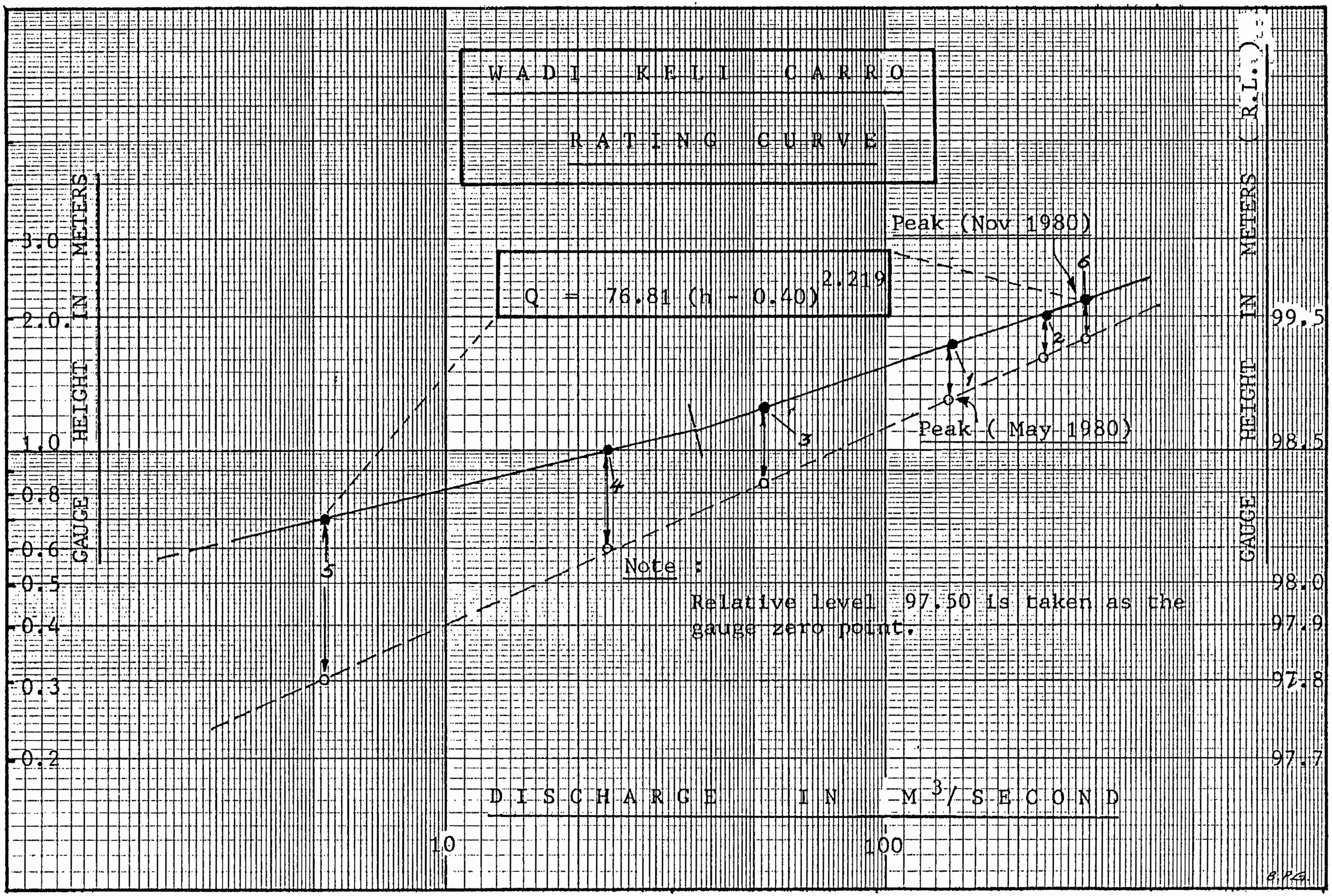
REMARKS : Flood of 6.11.80.

B.S	I.S	F.S	RISE	FALL	R.L.	DIST	ANG	R E M A R K S
1.36					100.00			BM. AD 100.0 (Bridge)
	1.66			0.30	99.70	0.0		FM. L/B.
	1.97			0.31	99.39	38.0		Flood bank
	1.61		0.36		99.75	48.0		Instrument
	1.76			0.15	99.60	53.0		Top of bank
	3.01			1.25	98.35	60.0		Start of river bed
	3.34			0.33	98.02	81.0		Lowest point in bed
	2.67		0.67		98.69	97.0		Sand
	2.44		0.23		98.92	126.0		"
	1.97		0.47		99.39	169.0		"
	1.50		0.47		99.86	203.0		FM. R/B
	1.27		0.23		100.09	148.0	20°	FM U/S.
	1.77			0.50	99.59	190.0	18°	FM D/S
	1.98			0.21	99.38	172.0	25°	FM D/S
		1.67	0.31		99.69			TBM (CP)
1.31								" " (Well)
		0.99	0.32		100.01			BM. AD. 100.00
2.67		2.66	3.06	3.05	0.01			0.01 (error) O.K.

DISCHARGE MEASUREMENTS

STREAM : KELI CARRO AT : NURR FANAX STATION NO : SPOT

NO	DATE	OBSERVER	GH m	WIDTH m	AREA m	Vm m/sec	Q m / sec	METH	R.L.	REMARKS
1	17.09.80	B.Gemmell	1.72	133.0	95.0	1.52	144.74	S/A	99.22	Peak flood 8.05.80
2	"	"	2.00	155.0	133.7	1.75	233.44	"	99.50	Calculated from cross section
3	"	"	1.25	93.0	45.0	1.18	52.94	"	98.75	" " " "
4	"	"	1.00	67.0	24.0	0.96	23.14	"	98.50	" " " "
5	"	"	0.70	32.0	9.5	0.56	5.31	"	98.20	" " " "
6	"	"	2.20	203.0	150.0	1.89	283.00	S/A	99.70	Flood of November 1980
7	"	"	2.75	245.0	212.5	1.56	431.50	"	100.25	Flood of March/April 1981

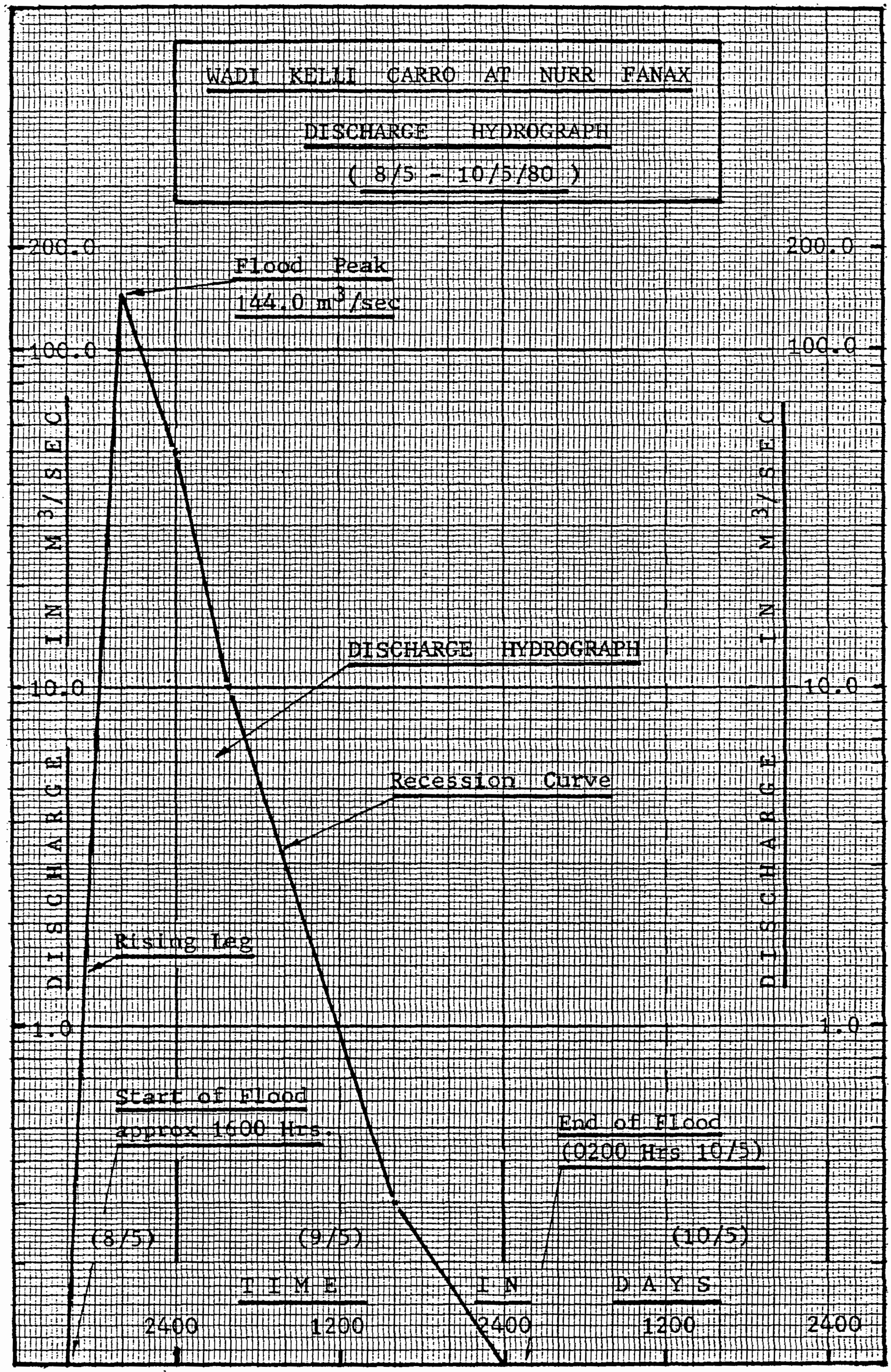


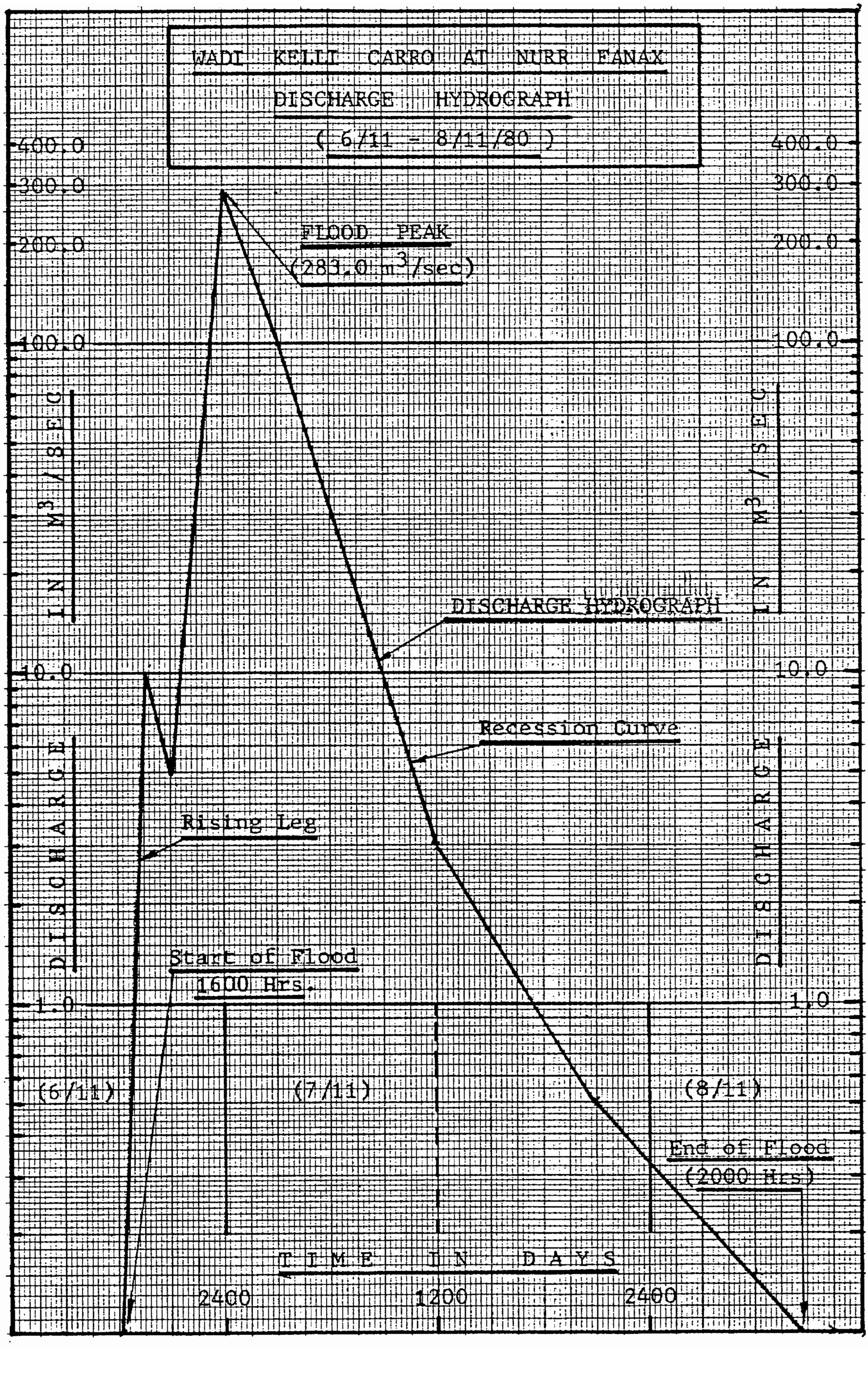
WADI KELI CARRO
RATING CURVE
$Q = 76.81\,(h - 0.40)^{2.219}$
Peak (Nov 1980)
Peak (May 1980)
1
2
3
4
5
6
Note :
Relative Level 97.50 is taken as the gauge zero point.
GAUGE HEIGHT IN METERS
3.0
2.0
1.0
0.8
0.6
0.5
0.4
0.3
0.2
GAUGE HEIGHT IN METERS (R.L.)
99.5
98.5
98.0
97.9
97.8
97.7
DISCHARGE IN M3/SECOND
10
100
B.P.G.

RATING TABLE (1980/81)

WADI KELLI CARRO AT NURR FANAX VILLAGE

R.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
97.50	0.00										
97.60	0.10										
97.70	0.20										
97.80	0.30										
97.90	0.40										
98.00	0.50	0.46	0.60	0.73	0.87	1.00	1.14	1.34	1.55	1.75	1.96
98.10	0.60	2.16	2.44	2.71	2.99	3.26	3.54	3.89	4.25	4.60	4.96
98.20	0.70	5.31	5.74	6.18	6.61	7.05	7.48	8.00	8.51	9.03	9.54
98.30	0.80	10.06	10.66	11.26	11.86	12.46	13.06	13.75	14.44	15.12	15.81
98.40	0.90	16.50	17.28	18.05	18.83	19.60	20.38	21.25	22.12	22.98	23.85
98.50	1.00	24.72	25.68	26.64	27.61	28.57	29.53	30.59	31.64	32.70	33.75
98.60	1.10	34.81	35.96	37.11	38.27	39.42	40.57	41.82	43.07	44.31	45.56
98.70	1.20	46.81	48.61	49.51	50.85	52.20	53.55	55.00	56.45	57.90	59.35
98.80	1.30	60.80	62.35	63.90	65.45	67.00	68.55	70.20	71.85	73.51	75.16
98.90	1.40	76.81	78.57	80.32	82.08	83.83	85.59	87.45	89.31	91.18	93.04
99.00	1.50	94.90	96.86	98.82	100.8	102.7	104.7	106.8	108.9	110.9	113.0
99.10	1.60	115.1	117.3	119.5	121.6	123.8	126.0	128.3	130.6	132.9	135.2
99.20	1.70	137.5	139.9	142.3	144.7	147.1	149.5	152.0	154.5	157.1	159.6
99.30	1.80	162.1	164.7	167.3	170.0	172.6	175.2	177.9	180.7	183.4	186.2
99.40	1.90	188.9	191.7	194.6	197.4	200.3	203.1	205.9	208.7	211.4	214.2
99.50	2.00	218.0	220.3	223.4	226.8	230.1	233.4	236.6	239.9	242.9	246.1
99.60	2.10	249.3	252.6	255.9	259.3	262.6	265.9	269.3	272.8	276.2	279.6
99.70	2.20	283.1	286.6	290.2	293.7	297.3	300.8	304.5	308.1	311.8	315.4
99.80	2.30	319.1	322.9	326.7	330.5	334.3	338.1	342.0	345.9	349.8	353.7
99.90	2.40	357.6	361.6	365.7	369.7	373.8	377.8	381.9	386.1	390.2	394.4
100.00	2.50	398.5	402.8	407.1	411.3	415.6	419.9	424.3	428.7	433.0	437.4
100.10	2.60	441.8	446.3	450.8	455.4	459.9	464.4	469.0	473.7	478.3	483.0
100.20	2.70	487.6	492.4	497.2	501.9	506.7	511.5	516.4	521.3	526.0	531.0
100.30	2.80	535.9	540.9	545.9	551.0	556.0	561.0	566.1	571.3	576.4	581.6
100.40	2.90	586.7	592.0	597.3	602.5	607.8	613.1	618.5	623.9	629.3	634.7
100.50	3.00	640.1	645.6	651.2	656.7	662.2	667.7	673.4	679.0	684.7	690.4
100.60	3.10	696.0	701.8	707.6	713.4	719.1	724.9				
100.70	3.20										
100.80	3.30										
100.90	3.10										
101.00	3.50										
101.10	3.60										
101.20	3.70										
101.30	3.80										
101.40	3.90										


WADI KELLI CARRO AT NURR FANAX
DISCHARGE HYDROGRAPH
(8/5 - 10/5/80)
200.0
100.0
10.0
1.0
Flood Peak
144.0 m³/sec
DISCHARGE HYDROGRAPH
Recession Curve
Rising Leg
Start of Flood
approx 1600 Hrs.
End of Flood
(0200 Hrs 10/5)
DISCHARGE IN M3/SEC
(8/5)
(9/5)
(10/5)
TIME IN DAYS
2400
1200
2400
1200
2400



WADI KELLI CARRO AT NURR FANAX
DISCHARGE HYDROGRAPH
(6/11 - 8/11/80)
400.0
300.0
200.0
100.0
10.0
1.0
FLOOD PEAK
(283.0 m3/sec)
DISCHARGE HYDROGRAPH
Recession Curve
Rising Leg
Start of Flood
1600 Hrs.
End of Flood
(2000 Hrs)
(6/11)
(7/11)
(8/11)
DISCHARGE IN M3 / SEC
TIME IN DAYS
2400
1200
2400

DISCHARGE COMPUTATION SHEET

WADI : KELI CARRO LOCATION : NURR FANAX

PERIOD : 8/5 to 10/5(1980) SHEET NO : 1 YEAR : 1980

NOTES : Calculation of flood discharge related to local information.

DATE	TIME	G.H	Q	Q m	TIME	VOL $M^3 x 10^3$	REMARKS
8/5	1600		0.00				Mean Flood Q =
	1800		4.00	2.00	7,200	14,400	19.8 m^3/sec.
	2000		144.75	74.38	7,200	535,536	
	2400		50.00	97.38	14,400	1,402,200	
						1,952,136	m^3
9/5	0400		10.00	30.00	14,400	432,000	
	1200		1.00	5.50	28,800	158,400	
	1600		0.30	0.75	14,400	10,800	
	2400		0.10	0.20	28,800	5,760	
						607,960	m^3
10/5	0400		0.00	0.05	14,400	720	m^3
				Total	Flood Q=	2,560,816	m^3

NOTE:

The flood duration figure is very suspect, and should only be used with caution, and as an indication to flood magnitudes. The Translators tend to put leading question to which the locals follow and agree too, without thought for accuracy.

B.P.Gemmell.

DISCHARGE COMPUTATION SHEET

WADI : KELLI CARRO LOCATION : NURR FANAX ((SPOT SITE)

PERIOD : 6/11 - 8/11 SHEET NO : ' 1 ' YEAR : 1980

NOTES : Flood duration obtained from local information only.

DATE	TIME	G.H	Q	Q m	TIME	VOL $M^3 x 10^3$	REMARKS
6/11	1600		0.00				
	1800		0.10	0.05	7,200	360	MEAN FLOOD Q =
	1930		10.00	5.05	5,400	27,270	23.5 m^3/sec.
	2100		5.00	7.50	5,400	40,500	
	2230		35.00	20.00	5,400	108,000	FLOOD VOLUME
	2400		283.00	159.00	5,400	859,000	4,411,198 m^3
					28,800	1,035,730	m^3
7/11	0300		110.00	197.00	10,800	2,127,600	
	0600		34.00	72.00	10,800	777,600	
	1200		3.00	18.50	21,600	399,600	
	2100		0.50	1.75	32,400	56,700	
	2400		0.32	0.41	10,800	4,428	
					86,400	3,365,928	m^3
8/11	0300		0.22	0.27	10,800	2,916	
	1200		0.10	0.16	32,400	5,184	
	2000		0.00	0.05	28,800	1,440	
					72,000	9,540	m^3
			TOTAL	FLOOD	Q =	4,411.198	m^3

APPENDIX ' I '

WADI BUR ACABA

(Seasonal Wadi Observation Site)

1. History Notes
2. Survey Details
3. Discharge Measurement Sheet
4. Rating Curve
5. Rating Table
6. Flood Hydrograph
7. Discharge Calculation Sheet.

RIVER FLOW GAUGING STATION

HISTORY NOTES

RIVER : WADI BUR ACABA   AT : NEAR BUR ACABA   STN. NO: SPOT

DATE	TIME	REMARKS	SIGN
1.05.80	1530	B.P.Gemmell While enroute to Lugh Ganana, noticed that a flood had taken place in this usually dry wadi. The flood peak had been in the order of 20 m^3/sec, and local information(soldier at bridge check point) stated that water had flowed for about two days.	
27.10.80	1000	B.P.Gemmell A small flood had taken place on 25/10/80. The peak was lower than the flow in the river at time of the visit to-day. (Local information). Flow throughout the day at low level. The large flood peak had arrived at 10 pm. on the 26/10/80. The water had been backed up on the U/S side of the bridge causing a resevoir state to occur. The flow had considerably reduced by 0500 Hrs on the 27/10/80. At 1000 Hrs. the water level depth from the wooden lip on the upstream face, was 6.21 meters. The flood level depth was 3.08 meters. The slope(flood levels) and present water levels were surveyed (see survey sheet). NOTE : The depth measurements made from the top of the wooden lip along the catwalk along the upstream face of the bridge 'MB' = RL. 100.14 meters.	B.P.G.
29.10.80	2000	B.P.Gemmell On return journey from Lugh Ganana, took soundings from upstream face of bridge. Flow in the wadi had stopped at about 1700 hrs. to-day. Related to BM.	
21.03.81	1200	B.P.Gemmell Rain had taken place over the catchment - slight trickle in the wadi at time, from local run-off rather than long distance flooding.	
25.03.81	1730	B.P.Gemmell Large flood had started on 23/3 at 2000 hrs. Flow on 25/3 at time of visit, approximately 2-4 m^3/sec.	B.P.G.

SURVEY SHEET

SITE : WADI BUR ACABA LOCATION : NEAR BUR ACABA

DATE : 27/10/80 TIME : 1000 Hrs. WATER LEVEL : R.L. 93.85 m

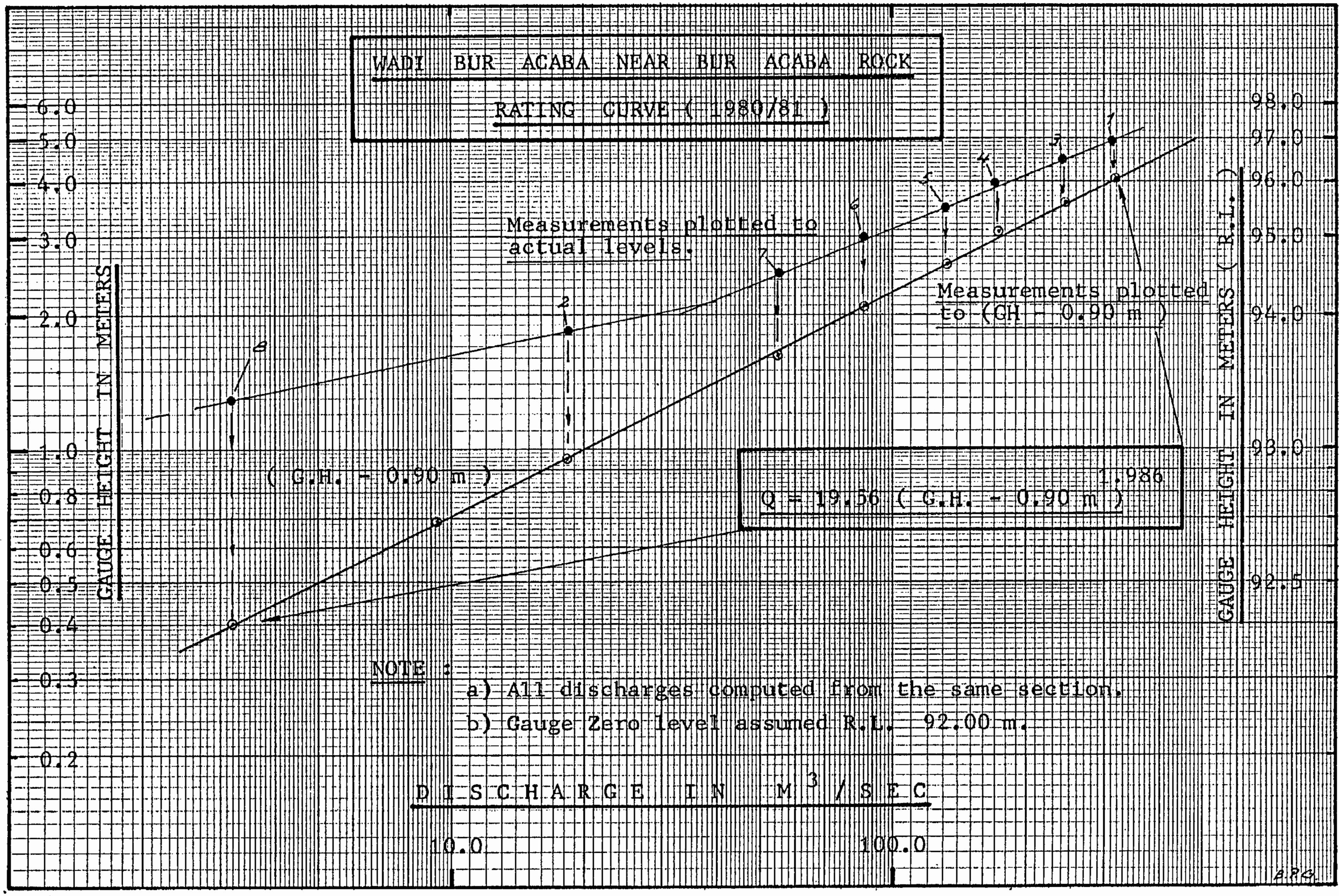
REMARKS : Slopes of flood water and cross sectional soundings.

B.S	I.S	F.S	RISE	FALL	R.L.	DIST	ANG	REMARKS
				SOUNDINGS U/S FACE				
	4.10				96.04	0.0		Depth to GL/L.B.(Abut)
	4.18				95.96	4.0		
	4.47				95.67	7.0		
	5.16				94.98	10.0		
	5.93				94.21	13.0		
	6.45				93.69	16.0		
	6.97				93.17	19.0		
	7.10				93.04	22.0		
	7.07				93.07	25.0		
	7.00				93.14	28.0		
	7.07				93.07	31.0		
	7.10				93.04	34.0		
	7.19				92.95	37.0		WELB
	7.32				92.82	40.0		
	7.54				92.60	43.3		
	7.12				93.02	46.3		WERB
	6.06				94.08	48.0		
	5.47				94.67	50.0		Abutment R/B.
	0.00				100.14			BM - Wooden lip U/S.
				SLOPE SURVEY (27/10/80)				
1.39					100.00			BM- metal strip(100.0)
	1.25		0.14		100.14			Wooden lip U/S face.
		4.48		3.23	96.91			C.P.(WL 30m from R/B)
0.41								
	0.38		0.03		96.94			FM D/S of bridge
	0.28		0.10		97.04			FM Directly D/S Bridge
	0.30			0.02	97.02	122.0		FM U/S of Bridge
	3.47			3.17	93.85			W.L. at Bridge
	0.11		3.36		97.21	216.0		FM. U/S L/B
	3.42			3.31	93.90	214.0		W.L. U/S(1000 Hrs) 29/10
								(Surveyed: B.P.Gemmell)

DISCHARGE MEASUREMENTS

STREAM : WADI BUR ACABA .... AT : BUR ACABA .... STATION NO : ..SPOT....

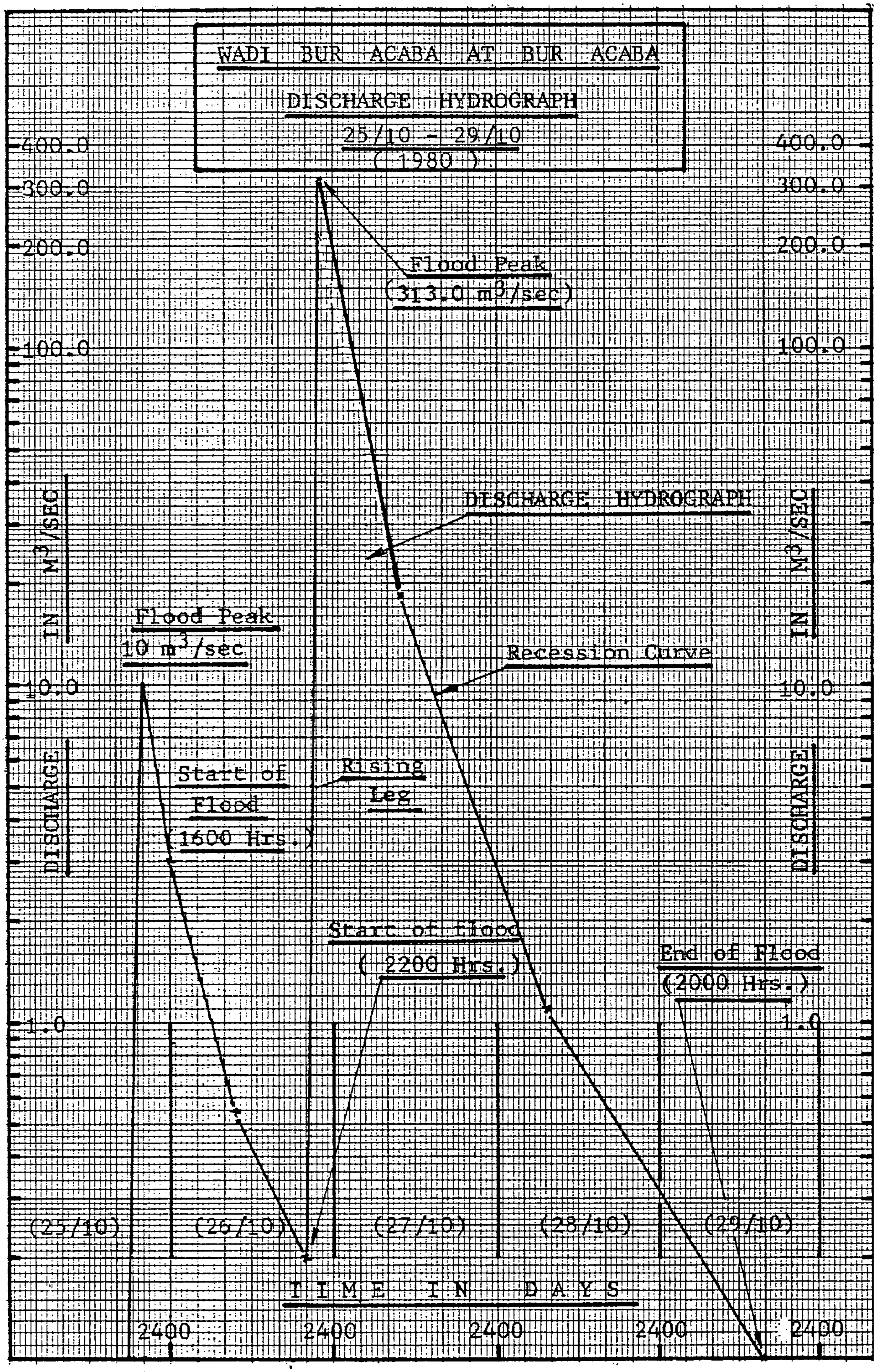
NO	DATE	OBSERVER	GH m	WIDTH m	AREA m	Vm m/sec	Q m / sec	METH	R.L.	REMARKS
1	27.10.80	B .Gemmell	4.94	50.0	161.0	1.94	313.1	S/A	96.94	Peak Flood at 2200 hrs. 26/10/80
2	"	"	1.85	32.5	25.6	0.73	18.6	"	93.85	Discharge at 1000 hrs. on 27/10/80
3	"	"	4.50	50.0	136.0	1.79	242.9	"	96.50	Calculated from survey details.
4	"	"	4.00	50.0	111.0	1.54	170.8	"	96.0	" "
5	"	"	3.50	43.0	89.0	1.48	131.8	"	95.50	" "
6	"	"	3.00	39.5	68.2	1.28	87.1	"	95.00	" "
7	"	"	2.50	37.5	50.4	1.10	55.2	"	94.50	" "
8	"	"	1.30	29.0	9.0	0.35	3.2	S/A	93.30	" "


WADI BUR ACABA NEAR BUR ACABA ROCK
RATING CURVE (1980/81)
Measurements plotted to actual levels.
Measurements plotted to (GH - 0.90 m)
(G.H. - 0.90 m)
Q = 19.56 (G.H. - 0.90 m) 1.986
GAUGE HEIGHT IN METERS
GAUGE HEIGHT IN METERS (R.L.)
6.0
5.0
4.0
3.0
2.0
1.0
0.8
0.6
0.5
0.4
0.3
0.2
98.0
97.0
96.0
95.0
94.0
93.0
92.5
1
2
3
4
5
6
7
8
NOTE :
a) All discharges computed from the same section.
b) Gauge Zero level assumed R.L. 92.00 m.
D I S C H A R G E I N M 3 / S E C
10.0
100.0
B.R.G.

RATING TABLE (1980/81)

WADI BUR ACABA NEAR BUR ACABA ROCK

R.L.	G.H.	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
91.00	1.00	0.20	0.25	0.30	0.35	0.40	0.45	0.52	0.59	0.66	0.73
10	10	0.80	0.89	0.98	1.07	1.16	1.25	1.36	1.47	1.57	1.68
20	20	1.79	1.92	2.05	2.17	2.30	2.43	2.58	2.73	2.87	3.02
30	30	3.17	3.34	3.51	3.67	3.84	4.01	4.20	4.38	4.57	4.75
40	40	4.94	5.15	5.35	5.56	5.75	5.97	6.19	6.42	6.64	6.87
91.50	1.50	7.09	7.33	7.58	7.82	8.07	8.31	8.57	8.84	9.10	9.37
60	60	9.63	9.91	10.20	10.48	10.77	11.05	11.35	11.65	11.96	12.26
70	70	12.56	12.88	13.20	13.52	13.84	14.16	14.50	14.84	15.19	15.53
80	80	15.87	16.23	16.59	16.95	17.31	17.67	18.05	18.43	18.80	19.18
90	90	19.56	19.96	20.36	20.75	21.15	21.55	21.97	22.39	22.80	23.22
92.00	2.00	23.64	24.08	24.51	24.95	25.38	25.82	26.27	26.73	27.18	27.64
10	10	28.09	28.57	29.04	29.52	29.99	30.47	30.96	31.46	31.95	32.45
20	20	32.94	33.45	33.96	34.48	34.99	35.50	36.03	36.56	37.10	37.63
30	30	38.16	38.71	39.26	39.81	40.38	40.91	41.48	42.05	42.62	43.19
40	40	43.76	44.35	44.94	45.53	46.12	46.71	47.32	47.93	48.53	49.14
92.50	2.50	49.75	50.38	51.00	51.63	52.25	52.88	53.53	54.17	54.82	55.46
60	60	50.11	56.78	57.44	58.11	58.77	59.44	60.12	60.81	61.49	62.18
70	70	62.86	63.86	64.26	64.97	65.67	66.37	67.09	67.81	68.54	69.26
80	80	69.98	70.72	71.46	72.20	72.94	73.68	74.44	75.20	75.96	76.72
90	90	77.48	78.27	79.06	79.85	80.64	81.38	82.21	83.00	83.79	84.58
93.00	3.00	85.37	86.19	87.00	87.82	88.64	89.45	90.29	91.12	91.96	92.79
10	10	93.63	94.48	95.34	96.19	97.05	97.90	98.75	99.61	100.5	101.3
20	20	102.3	103.2	104.1	105.0	105.9	106.7	107.7	108.6	109.5	110.4
30	30	111.3	112.2	113.2	114.1	115.1	116.0	116.9	117.9	118.8	119.8
40	40	120.7	121.7	122.7	123.6	124.6	125.5	126.6	127.6	128.5	129.5
93.50	3.50	130.5	131.5	132.5	133.5	134.5	135 5	136.5	137.5	138.6	139.6
60	60	140.6	141.7	142.7	143.8	144.8	145.8	147.0	148.0	149.1	150.1
70	70	151.2	152.3	153.4	154.5	155.6	156.6	157.7	158.8	159.9	161.0
80	80	162.1	163.2	164.4	165.5	166.6	167.7	168.9	170.0	171.1	172.3
90	90	173.4	174.6	175.7	176.9	178.0	179.1	180.4	181.5	182.7	183.8
94.00	4.00	185.0	186.2	187.4	188.6	189.8	191.0	192.2	193.4	194.7	195.9
10	10	197.1	198.3	199.6	200.8	202.1	203.0	204.5	205.8	207.0	208.3
20	20	209.5	210.8	212.1	213.3	214.6	215.8	217.2	218.5	219.7	221.0
30	30	222.3	223.6	224.9	226.2	227.5	228.8	230.2	231.5	232.8	234.1
40	40	235.4	236.8	238.1	239.5	240.8	242.2	243.6	244.9	246.3	247.6
94.50	4.50	249.0	250.4	251.8	253.1	254.5	255.9	257.3	258.7	260.1	261.5
60	60	262.9	264.3	265.8	267.2	268.6	270.0	271.5	272.9	274.3	275.8
70	70	277.2	278.7	280.1	281.6	283.1	284.5	286.0	287.5	289.0	290.4
80	80	291.9	293.4	294.9	296.4	297.9	299.4	300.9	302.4	303.9	305.4
90	90	306.9	308.4	310.0	311.5	313.1	314.6	316.2	317.7	319.3	320.8


WADI BUR ACABA AT BUR ACABA
DISCHARGE HYDROGRAPH
25/10 - 29/10
(1980)
400.0
300.0
200.0
100.0
10.0
1.0
Flood Peak
(313.0 m3/sec)
DISCHARGE HYDROGRAPH
Flood Peak
10 m3/sec
Recession Curve
Start of
Flood
(1600 Hrs.)
Rising
Leg
Start of flood
(2200 Hrs.)
End of Flood
(2000 Hrs.)
DISCHARGE IN M3/SEC
(25/10)
(26/10)
(27/10)
(28/10)
(29/10)
TIME IN DAYS
2400
2400
2400
2400
2400

DISCHARGE COMPUTATION SHEET

WADI : BUR ACABA .... LOCATION : NEAR BUR ACABA (SPOT SITE)

PERIOD : 25/10 to 29/10 .... SHEET NO : 1 .... YEAR : 1980

NOTES : Flood duration from local information and site observations.

DATE	TIME	G.H	Q	Q m	TIME	VOL $M^3 \times 10^3$	REMARKS
25/10	1600		0.00				FLOOD MEAN Q =
	1800		0.30	0.15	7,200	1,080	19.97 m^3/sec.
	2200		10.00	5.15	14,400	74,160	
	2400		3.00	6.50	7,200	46,800	PEAK FLOOD Q=
				Daily	Volume =	122,040	313.10 m^3/sec
26/10	1000		0.55	1.78	36,000	64,080	
	2000		0.20	0.38	"	13,680	
	2100		20.00	10.10	3,600	36,360	FLOOD VOLUME
	2200		313.10	166.55	3,600	599,580	7,189,884 m^3
	2400		200.00	256.55	7,200	1,847,160	
				Daily	Volume =	2,560,860	
27/10	1000		18.60	109.30	36,000	3,934,800	
	1600		8.00	13.30	21,600	287,280	
	2400		3.80	5.90	28,800	169,920	
				Daily	Volume =	4,392,000	
27/10	0700		1.10	2.45	25,200	61,740	
	1200		0.80	0.95	18,000	17,100	
	2400		0.32	0.56	43,200	24,192	
				Daily	Volume =	103,032	
29/10	0800		0.18	0.25	28,800	7,200	
	1600		0.10	0.14	28,800	4,032	
	2000		0.00	0.05	14,400	720	
				Daily	Volume =	11,952	

APPENDIX ' J '

JUBBA AND SHEBELLI RIVERS

(MISCELLANEOUS WATER SAMPLE DATA)

1. Spot ' EC ' Observations

2. Sediment Analysis Sheets

MISCELLANEOUS ELECTRICAL CONDUCTIVITY SPOT OBSERVATIONS - 1980

RIVER	STATION	DATE	TIME	G.H (meters)	Q (m^3/ sec)	TEMP (celcius)	'E.C' (mmhos/cm)	'E.C' (25°C)	REMARKS
SHEBELLI	Belet Uen	27/02/80	1445	0.16	4.55	36.5	2,984	2,453	Baseflow
	" "	9/05/80	1400	1.78	105.40	31.8	175	154	"
	Bulo Burti	29/02/80	1800	1.00	4.33	33.5	3,460	2,944	Baseflow
	Mahaddei Uen	16/02/80	1400	0.74	3.95	33.0	3,200	2,745	"
	" "	1/03/80	1200	0.79	4.32	33.0	3,750	3,218	Flood recession
	" "	8/05/80	1520	3.73	82.40	30.0	435	395	Rising stage
	Balaad	21/02/80	1030	0.36	2.30	33.5	3,450	2,936	Baseflow
	Afgoi	13/02/80	1700	1.08	1.05	30.0	2,550	2,312	"
	Audegle	13/02/80	1530	1.26	0.56	31.0	2,250	2,003	"
JUBBA	Lugh Ganana	18/03/80	1600	0.74	5.81	36.0	1,100	897	Baseflow
	" "	21/05/80	1000	2.36	168.00	29.1	610	563	Falling stage
	Bardheere	23/03/80	1100	- 0.11	4.31	31.0	2,250	1,973	Baseflow
	Jamamme	24/03/80	1600	Dry	Trace	36.5	1,230	994	Intermittent

JOWHAR OFFSTREAM STORAGE PROJECT	SERIAL No: BG/4
SEDIMENT CONCENTRATION DETERMINATION	RECORDED BY :
DATE : 28/05/80	I.B.Bell

Analysis carried out between 16/06/80 and 17/06/80.

SAMPLE No :	(1)	1	2	3	4	5
LOCATION : (Shebelli River)		Bulo Burti 29/02/80	Bulo Burti 29/02/80			
SPECIFIC GRAVITY :		1.0031	1.0013			
VOLUME (ml)		464	458			
SEDIMENT AND FILTER PAPER (Weight/grams)	(1)	5.02	3.71			
	(2)	5.00	3.70			
	(3)					
	(4)					
	(5)					
	(6)					
	(7)					
	FINAL	5.00	3.70			
FILTER PAPER (WT/gms)		0.90	0.90			
SEDIMENT WEIGHT (gms)		4.10	2.80			
SEDIMENT CONCENTRATION	mg/litre	8,840	6,110			
	Kg/ m^3	88.40	61.10			

REMARKS :

1). Bulk sample when shaken was black with a green tinge an offensive smell. Biological oxidation products(anaerobic) were obviously present. Sediment was oven dried at 105°C for one 12 hour period. Sediment after drying was pale reddish brown/light grey colour.

2). Considerable proportion of the sediment was in the sand/course silt grain size. Most sediment had settled out within 30 minutes of being shaken up, and a significant proportion settled within seconds.

3). Considerable difficulties obtaining uniform mixing owing to high sand fraction in the sediment. Samples analysed were probably at each end of the typical range of sediment concentrations found.

JOWHAR OFFSTREAM STORAGE PROJECT	SERIAL No : BG/1
SEDIMENT CONCENTRATION DETERMINATION	RECORDED BY:
DATE : 12/05/80	I.B.Bell

Analysis carried out between 12/06/80 and 17/06/80.

SAMPLE No : (1)		1	2	3	4	5
LOCATION : (Shebelli River)		Belet Uen 12/05/80	Belet Uen 12/05/80			
SPECIFIC GRAVITY :		1.0069	1.0096			
VOLUME : (ml)		457 ml	458 ml			
SEDIMENT AND FILTER PAPER (Weight/grams)	(1)	7.59	9.57			
	(2)	7.49	9.45			
	(3)	7.49	9.42			
	(4)					
	(5)					
	(6)					
	(7)					
	FINAL	7.49	9.42			
FILTER PAPER (WT/gms)		0.90	0.90			
SEDIMENT WEIGHT (gms)		6.59	8.52			
SEDIMENT CONCENTRATION	mg/litre	14,420	18,600			
	kg/ m^3	144.20	186.00			

REMARKS :

1). Sample had high organic content, and was in an anaerobic oxidation condition when tested.

2). Unable to ensure uniform mixing of sample before taking partial samples for analysis (No suitable containers), partial samples were assumed representative of the bulk sample recieved.

3). High proportion of sediment was in the grain size (sand), and settled within 1-2 minutes after being shaken up. Significant amount settled within seconds.

4). Separated sediment was oven dried at 105°C to constant weight. (Two 12 hour periods of drying). Colour of dried sediment was greyish brown, compared with the original settled sediment, which was black.

JOWHAR OFFSTREAM STORAGE PROJECT

SEDIMENT CONCENTRATION DETERMINATION

DATE : 25/05/80

SERIAL No: BG/3

RECORDED BY :

I.B.Bell

Analysis carried out between 14/06/80 and 17/06/80.

SAMPLE No: (1)		1	2	3	4	5
LOCATION : (Shebelli River)		Bardheere 25/05/80	Bardheere 25/05/80			
SPECIFIC GRAVITY :		0.9985	0.9982			
VOLUME : (ml)		448	433			
SEDIMENT AND FILTER PAPER (Weight/grams)	(1)	1.40	1.35			
	(2)	1.40	1.34			
	(3)					
	(4)					
	(5)					
	(6)					
	(7)					
	FINAL	1.40	1.34			
FILTER PAPER (WT/gms)		0.90	0.90			
SEDIMENT WEIGHT (gms)		0.50	0.44			
SEDIMENT CONCENTRATION	mg/litre	1,120	1,020			
	KG/ m^3	11.2	10.2			

REMARKS :

1). Sediment was light red-brown colour, with no visable settlement after 45 minutes of being shaken up. Sediment was almost completely in the fine silt/ clay grain sizes.

2). Sediment was oven dried at 105^{o}C one 12 hour period. Weighings one and two above were taken 15 minutes aoart. Constant weight almost certainlly achieved.

JOWHAR OFFSTREAM STORAGE PROJECT	SERIAL No : BG/2
SEDIMENT CONCENTRATION DETERMINATION	RECORDED BY :
DATE : 21/05/80	I.B.Bell

Analysis carried out between 12/06/80 and 17/06/80.

SAMPLE No : (1)		1	2	3	4	5
LOCATION : (Jubba River)		Lugh Ganana 21/05/80	Lugh Ganana 21/05/80			
SPECIFIC GRAVITY :		1.0063	1.0065			
VOLUME : (ml)		456	459			
SEDIMENT AND FILTER PAPER (Weight/grams)	(1)	1.35	1.30			
	(2)	1.34	1.31			
	(3)	1.33	1.28			
	(4)					
	(5)					
	(6)					
	(7)					
	FINAL	1.33	1.28			
FILTER PAPER (WT/gms)		0.90	0.90			
SEDIMENT WEIGHT (gms)		0.43	0.38			
SEDIMENT CONCENTRATION	mg/litre	940	830			
	kg/ m^3	9.4	8.3			

REMARKS :

1). Sediment was was almost completely in fine silt/ clay grain sizes and light red-brown in colour. No visable settlement what-so-ever after 30 minutes from being shaken up.

2). Samples analysed were oven dried at 105°C, over two 12 hour periods.

APPENDIX ' K '

JUBBA RIVER

MISCELLANEOUS REPORTS ON 1981 ' GU ' FLOODS ON THE LOWER JUBBA

1. Flood Assessment of the Jelib and Fanoole Area's (May 24th 1981)

2. Flood Report & Stage Graphs of the lower Jubba ' GU ' Floods (April/May) 1981 - 'MMP'.

3. Chinese Report - Lower Jubba Floods April / June 1981

NOTES ON VISIT TO CELIB & FANOLE 24TH MAY, 1981.

Purpose of the visit was :-

a) To assess the damage to the Kamsuma - Gelib road.

b) To visit Fanole to determine what information they have relating to the present flood, and to obtain details of their final layout.

Personnel on the visit were : -

W.Sim -(MMP)
J.Calverley-(MMP)
M.Yussuf -(WDA)

a) After a meeting with the Regional Governer and the District Commissioner to discuss the general situation we were kindly lent the D'C's landrover to examine the damage on the Kamsuma Gelib road.

The road has failed approximately 20 kms south from Gelib over a length of 2½ km. Contained within this length are four major breaks with water flowing strongly through them. At these locations culverts will require to be installed. Over the failed length, large parts of road have subsided where sand has been sucked out from under the road formation on the downstream side causing failure of the road pavement.

The best method of remedial work would consist of removing the tarmac from the road and storing it. Thereafter, remove the sandy material and replace with coral, and then use tarmac material as pitching on both sides of the road including areas where road has not yet failed.

The D.C. hoped that JSP might be in a position to help with this work. It was explained how little equipment was available at JSP due to lack of spares.

The present plan is to let the water subside before constructing a temporary road parallel to the existing road, and thereafter putting remedial work in hand.

The D.C. handed over a letter of Authorisation for JSP. to uplift the boat at present stored at the Agricultural Research Station at Alessandra.

b) The General Manager of the Fanole project was then visited, and he in turn applied for a visit to be made to the headworks to obtain any engineering information which we required. At the headworks we were met by Mr.Zhung, Chief Engineer.

After a brief visit to the Construction works a meeting was held to discuss various aspects of the flood.

Mr. Zhung made available the readings at Maleenda for April & May 1981. and confirmed that any other information we required would be made available. He stated that this latest flood was higher than either of the 1961 or 1977 floods. The break which occurred in the Fanole bund on the West side of the River Juba was an actual failure and not an intentional release of water to prevent flooding of the Fanole project.

Mr. Zhung explained that when the barrage is complete in approximately two years time, the bunds upstream will be capable of taking 800 cumecs (this was as per the Russians design). Thereafter flooding would take place to the West of the small villages of Mananca and would then take the same route as per the present flood. At the village of Mananca the bunds tie into the original ground level at 32.5. The bases of the design was the completion of the Bardheera Dam by 1984.

Mr. Zhung indicated that Fanole would have 2000 km spare capacity when the barrage was completed. The main canal leading from the barrage has a capacity of 33.6 cumecs. The Chief Engineer confirmed that they have no survey information on the West side of the Little Juba.

<u>Technical Data Obtained.</u>

Water Levels Of Barrage

<u>UPSTREAM</u> : -	Max	32.35	<u>DOWNSTREAM</u>: -	Max	32.12
	Normal	31.50		Normal	26.60
	Min	31.30		Min	25.30

FLOOD REPORT ON LOWER JUBBA (M.M.P)

NOTES ON FLOODING OF KAMSUMA NORTH CANE AREAS.

MAY 1981.

APRIL 81.

Throughout the whole of April river levels were high, corresponding to flood of 500 - 700 cumecs. Contingency plans were drawn up for the evacuation of the camp in the event of serious flooding within the Project area. Towards the end of the month the river continued to rise and reached the nominal 750 cumec level (21.10 at Mareri) on April 29th.

MAY 81.

River levels remained high for virtually the whole month with a peak level of 21.97 (equivalent to approx 950 m^{3}/s) recorded at Mareri on 16th May. This is 87 cm higher than the nominal 750 cumec design level of the kamsuma flood bend, and breaching was only prevented by extensive sandbagging and topping - up of the bund at potential weak spots. Whilst no breaching of the river bund occurred during the period of peak flooding floodwater did, however, enter the Kamsuma North area from Scorpion Lake. This water spilled over the river bank upstream of Maleenda and entered the system of depressions known as the 'Snake' which in turn flows into Scorpion Lake. The total inflow to Scorpion Lake is estimated at some 350 x $106m^{3}$, over a period of 14 day's. There appears to be no route by which water entering Scorpion Lake can excape other than out through the Kamsuma area, and this is what eventually took place, with the resultant flooding of some 1800 hectors of Sugar Cane.

A day by day account of the flooding is detailed below:

4th MAY.

Authorities at Luuq reported a flood with peak flow 1400 cumecs

6th MAY.

Farmers growing Maize in the Snake area reported that the flood water had reached their fields. An inspection from the air showed that this was only water from the Factory effluent lagoon being pumped along LSD3 disposal drain.

13th MAY.

Whilst the JSP plane was returning to site from Mogadishu it was noticed that the river had burst its banks upstream of the Fanole headworks and that a large volume of water was spilling out from the river on the West side.

14th MAY.

Farmers in the Snake area again reported that flood water was moving down the Snake. A flight that evening showed a large volume of water working its way down the Snake towards Scorpion Lake. By that time the water had reached a point about 1 km downstream of LSD3 outfall.

15th MAY.

Another flight was made in the morning to check on the movement of the water in the Snake. From the observed rate of advance it was estimated that flood water would reach Scorpion Lake the following day. The water level in the Snake near the LSD3 outfall could be seen to be close to the drain bed level (water level subsequently estimated to be approx. 20.00). The Scorpion Lake area was inspected in order to assess the work required to keep flood water out of Cane field KN16. The KND1 disposal area bund would have to be closed and a temporary bund built around the partially completed KND1 pump station.

16th MAY.

Attempts were made to close the KND1 disposal area bund However this later proved to be a futile attempt since the water level rose rapidly in Scorpion Lake and the temporary bunds were breached later that day, partly flooding field KN16.

17th MAY.

Water continued to rise rapidly in Scorpion Lake. Water level 8 a.m. approx 15.50. Rate of rise at one time observed as 15cm in 3 hours. The water passing down the Snake was observed at LSD3 outfall and could be seen to still be flowing as full as on 15th May. Subsequent estimates of flow gave a figure of 350 cumecs, which corresponded to the order of magnitude of the observed rate of rise of water in Scorpion Lake.

It was clear that the water level in Scorpion Lake would continue to rise and that floodwater would then cut the marine plan road near KND1 drain. A plan was envolved in an attempt to confine water to the West side of the main canal - by using the main canal embankment as a secondary bund to be closed at its southern end by a temporary bund between the main canal and the south extension bund. The South extension bund was also to be cut to allow flood water to return to the River.

18th MAY.

Water from Scorpion Lake now crossed the Marine Plain Road and flowed through Cane areas to the West of Main Canal. Temporary works were carried out as outlined above in order to try and confine water to West Bank of main canal. Scorpion Lake water level 16.50 (morning).

19th MAY.

Water ponded up against main canal embankment between KN4 and KN5, breaching the West bank in a number of places. An attempt was made to minimise damage to the canal bank by regulating water levels in the main canal but this was later abandoned and KN5 gates were left fully open. By the evening some breaching of the East bank had taken place and flood water was flowing into cane area's to the East of the main canal.

20th MAY.

Water reached the South extention bund and flowed through the existing cut in the bund as well as causing breaching in several other places. Water continued to flow to the East side of the main canal.

An estimate of the inflow to Scorpion Lake was made after observing flows from a boat on the trace line at LSD3 outfall. Mean flow velocity was taken as 0.15 m/s with cross section normal to flow = 2400 m2. This gave an estimated inflow = 350 m^3/s. Observations at the trace line suggested that the peak flow would not have been much greater than this, possibly 400 m^3/s.

21st MAY.

Flow through West of Kamsuma area now reached a steady state as water flowed out of South extension bund. Scorpion Lake water level reached maximum of 17.10.

23rd MAY.

Water level falling in the Snake, estimated inflow to Scorpion Lake now 200 m^3/s.

24th MAY.

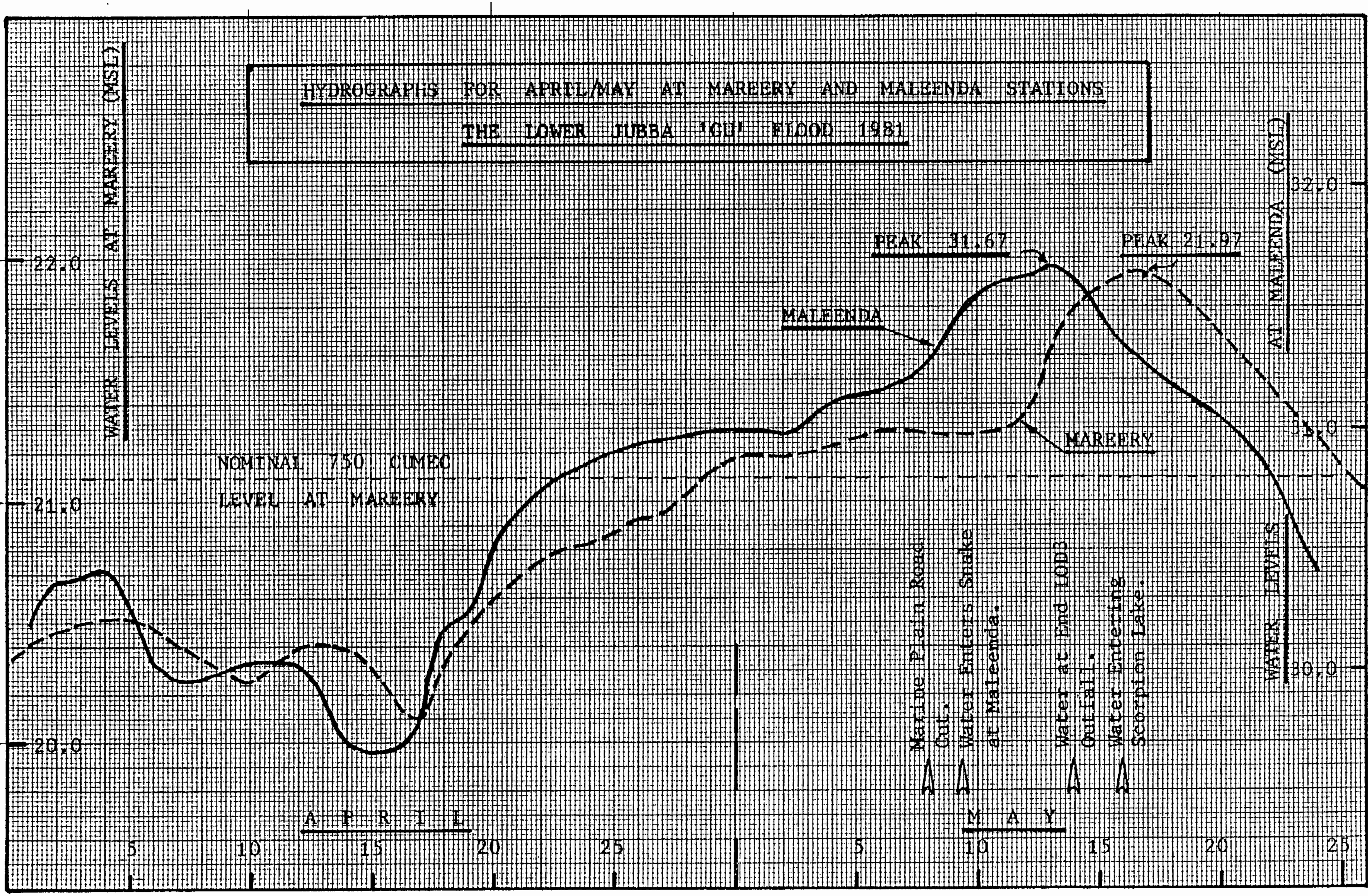
Data was collected from Fanole project relating to present flood - gauge readings etc, also information on design of Fanole headwalls. The latter suggest that the design of the Fanole barrage allows for maximum discharge of only 800m^3/s (assumes early completion of bardhere) and that for flows greater than this spillage will occur into the depressions to the West of the River (ie the Snake).

25th MAY.

Scorpion Lake water level now 16.80 water still flowing through Kamsuma area.

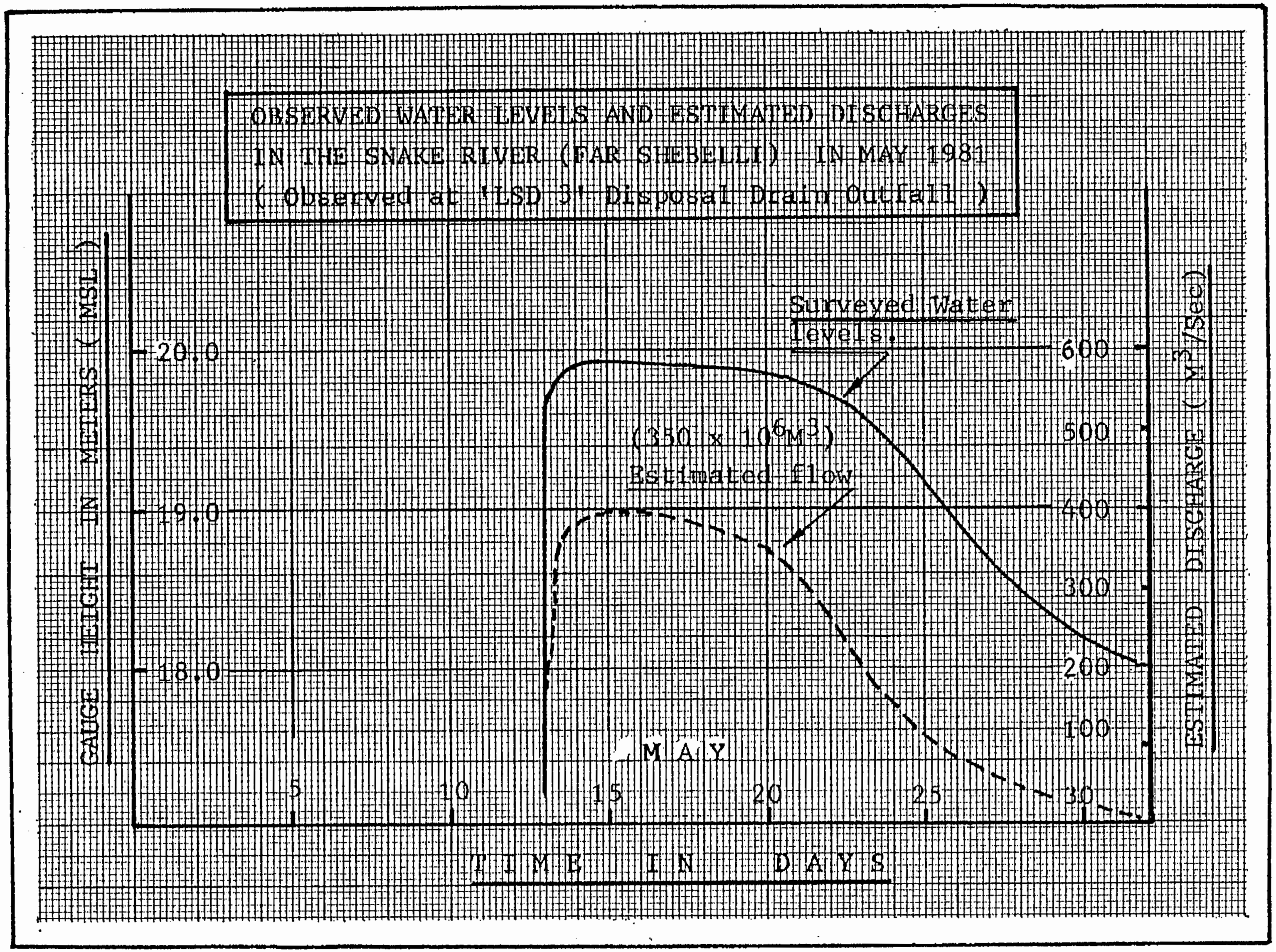
26th MAY.

Water level in Snake still falling. Estimated flow now 90 m^3/s. Scorpion Lake water level now approx.



A4 210 x 297 mm

MADE IN GERMANY


OBSERVED WATER LEVELS AND ESTIMATED DISCHARGES
IN THE SNAKE RIVER (FAR SHEBELLI) IN MAY 1981
(Observed at 'LSD 3' Disposal Drain Outfall)
GAUGE HEIGHT IN METERS (MSL)
20.0
19.0
18.0
Surveyed Water levels.
(350 x 10^6 M^3)
Estimated flow
600
500
400
300
200
100
ESTIMATED DISCHARGE (M^3/Sec)
MAY
5
10
15
20
25
30
TIME IN DAYS

CHINESE REPORT JUBBA FLOODS

APRIL/JUNE 1981

Fanole Project, Jilib
June 14th 1981

TO: Dr Hassan Mohamud,
The general manager of Fanole Project,
Jelib,
Somalia.

There had been a continuous storm in the area of the upper reaches of the Juba river from mid March 1981. As a result, the water level of the river kept rising. On April 30 in Lugh Ganane, flood peak occurred that was seldom seen in the local history. The then water level there was*147.45 meters, 0.29 meter higher than the 50-year frequency flood in November 19,1961. On May 15, there was a flood peak stage in Fanole, which reached 31.67 meters, approaching the historically high water in 1961. The water level in the section of Jilib on May 16 was gauged 23.25 meters, about 0.75 meter exceeded that of 1961. Due to this case, the river overflowed its banks,causing a stretch of water. Many villages and farmland were flooded at that time. What's more, the highway from Jilib to Kismayu was destroyed with more than 200 meters in serious case and two kilometers immersed in the water of above one meter, The traffic was broken so seriously that we had no way to carry the sand, stone and the materials arrived on the Kismayu Port back to the worksite from Kismayu.

Because of rapid rising of water of the river, the headworks area of Fanole Project was surrounded by flood in three sides. The groud surface of the spillway dam, powerhouse power-station, concrete mixing plant, store-houses and mechanical and electrical equipment for drainage were one to two meters below the flood level. The river-sided dike of completed 26-meter main canal was not high enough and resulted in two breaches measuring 100 meters long, not only because it was originally intended just for the prevention of 20-year frequency flood and not for 50-year frequency flood as it came this time, but also because some sections were damaged both by humen and animals. So flood flowed through breaches down the canal and caused as long as 10 kilometers of canal slope destroyed. The flow surface of the river is greatly narrowed since an embankment around Island Touata was built by the Juba Sugar Refinery. The flood was therefore dammed up and 0.75 meter higher than peak level in the local history in 1961. The ground surface of Jilib center of the Project, living quarters, 4th KM machinery service site, store-houses, concrete prefabricating site and diesel power station were all 1.5 to 2.3 meters below the flood level. It is fortunate that all of them have now been in safety, thanks to the fact that before the flood the both sides of China and Somalia took an emergency step to get all the personnel mobilised and concentrate all the available machinery on the prevention of flood.

Owing to the quick rising (reaching 7.2 meters) but slow reducing, the flood lasted one month. This severely threatened the progress of the project. Concrete and earth work had to be in state of half-ceasing from work. Despite of all the efforts made by both sides, the construction progress was still affected a great deal. We therefore anticipated that from the time of reconstruction of the project to the half of this year, the earth work fulfilled is accumulated as 3.48 cubic meters, concrete 28130 cubic meters, crushed stone 30500 cubic meters, sand 18570 cubic meters. For power station, the pouring of concrete of turbine floor of No.2 unit and No. 1 unit pier have been finished. The top closure of three-gate dam body and 26 kilometers of the main canal have also been suceeded. In case of no influence of special natural disasters, we may be able to fulfil the plan for the whole year.

1982 is still the year of high tide of construction of the Project as well as the key year. It is hoped that both sides will strive for the earlier completion of the project.

We therefore formulated " Proposals of Working Plan of the Project for 1982 ", and " Proposals of Local Expenses Plan of Fanole Project for 1982 ", just for your reference when working out a formal plan.

The Chinese Expert Team
Fanole Water Conservancy Project.

* N.B.

Note that the present water levels at Lugh Ganana between 0.0 to 2.0 meters are corrected by adding 0.22 meters to counteract the overlap in the gauges. This effectively lowers the zero of the gauges by 0.22 meters. The Chinese appear to be correcting the 2.0 to 6.0 meter gauge readings by subtracting 0.22 meters. This causes a discrepancy of 0.22 meters between the gauge levels. The correct flood level at Lugh Ganana for 1981 was 'MSL' 147.67 meters or Gauge Height 6.25 meters, and not as claimed by the Chinese at 147.42 meters ('MSL'), which relates to a gauge level of 6.03 meters. (0.22 meters lower than the observed level).

Note by :

B.A.P.Gemmell
(UN Consultant Hydrologist)

Note : The Chinese report typed as per original document.

APPENDIX ' L '

' T R A I N I N G '

CORRESPONDENCE ON FELLOWSHIP TRAINING

1. 'WMO' Letter accepting trainee's for Hydrometry training in Kenya.
2. Consultants letter to FAO Country Projects Officer (For Information)
3. Correspondence with National Water Council in England (Formulation of suitable programme)
4. Proposed Training Syllabus.

ORGANISATION MÉTÉOROLOGIQUE MONDIALE — WORLD METEOROLOGICAL ORGANIZATION

Téléphone : 34 64 00
Télégrammes : METEOMOND GENÈVE

SECRÉTARIAT
GENÈVE - Suisse

Telex : 23 260
Case postale N° 5
CH - 1211 Genève 20

In reply refer to / Dans la réponse, mentionner
N° 26130/RAF/001

Please address all replies to the Secretary-General
Veuillez adresser votre réponse au Secrétaire général

Annexes :

GENÈVE, 21 July 1980

Dear Mr. Gemmell,

I wish to refer to the discussions you had with various officers of the WMO Secretariat regarding the possibility of training three Somalian fellows in streamgauging under the FAO project ICP/SOM/8906. As I understand, the period of the training is three months for each candidate, one in 1980 and the other two in 1981.

The matter has been brought to the attention of the extra-ordinary meeting of the Technical Committee of the Hydrometeorological Survey project of Lakes Victoria, Kyoga and Mobutu Sese Seko which was held in Cairo in July. The Committee agreed to this proposal in principle.

The training could be given by the Lake Victoria project staff; the project Director and the WMO Expert have been requested by the Technical Committee to make arrangements for the implementation of these fellowships upon request from WMO.

WMO is ready to complete the necessary administrative formalities for the fellowships as soon as an inter-agency letter of agreement is concluded between FAO and WMO thereon. You are therefore kindly requested to investigate the matter with FAO and inform us of the outcome at your earliest convenience.

Yours sincerely,

(D.H. Nijhoff)
Chief, Division for Africa
Technical Co-operation Department

Mr. B.A.P. Gemmell
FAO Consultant Hydrologist
812 Kenton Lane
Harrow Weald
HARROW
Middlesex
U.K.

B.A.P.Gemmell,
812 Kenton Lane,
Harrow Weald,
Harrow, HA3 6AG
Middlesex,
ENGLAND.

Ref: TCP/SOM/8906/TRAINING.

Mr. D.C.Eva,
Senior Country Project Officer,
AGOA. Division,
FAO (United Nations),
Via Delle Terme di Caracalla,
Rome,
ITALY.

Date: 30th July

Dear Mr Eva,

Ref.: SHORT TERM FELLOWSHIPS (HYDROLOGY)

On my homeward bound trip from Somalia at the end of June, and after calling at the FAO in Rome, I also stopped over in Geneva to make enquiries at the WMO Office in connection with the proposed short term fellowships in Hydrometry. I must have discussed the matter with every person in the Organisation and finally departed feeling very depressed indeed, as to the possibility of achieving anything positive.

It now appears that something positive has taken place and I am attaching hereto a copy of the letter I have just recieved from Mr. Nijhoff, Chief of the Technical Co-operation Department(WMO). It states that the Technical Committee of the Lake Victoria Project, has in principle, accepted the proposals of training three candidates from Somalia for a period of three months each at thier Project Headquarters, probably in Kenya.

I think the costs under these circumstances will only be minimal, and could be met by the Project budget, if so required. There are also possibilities that the costs will be met by the Lake Victoria Project, under the TCADC (Technical co-operation among developing countries). With only the travel expenses to be met from project funds. The clarification of the finance commitment should be dealt with as soon as possible.

Also enclosed herewith are the WMO Fellowship forms for dispatch to Somalia via Mr. M.H.Hirad the Senior Program Assistant. The candidates should complete the forms and return them as soon as possible, inorder to avoid any undue delays. The three candidates would be as follows:

a. Mr Mohamed Abdullahi - Sept.- Nov.
b. Mr Abdullahi Serat - Dec. - Feb.
c. Mr Ahmed Ali - Mar. - May.

Mr Hirad (SPA - UNDP Office) should contact the Director of Land & Water Department, Mr Ibrahim Musa Ali, to ensure that the forms are correctly completed without any omissions which would cause long delays. The candidates would proceed to the course as per the above list.

Should these proposals happen to fall through and be rejected for one reason or another, the candidates names would still be included on the Volantary Co-operation Program (VCP) list, and then circulated to the member countries who would be in a position to offer assistance of this nature.

Futhermore, I have made additional inquiries in the United Kingdom. But, on the whole there is nothing availible at the level we require for the Somali candidates. All the availible courses appear to be geared to the post graduate student. I believe that most of the Training Institutions are not fully aware of the basic level of training which is required in the under developed countries. Training at the 'grassroot' level is probably very much more valuable than many of the Post Graduate holiday trips which are usually handed out.

I have also been informed that the 'UNESCO' training course usually held in Zambia, has now been discontinued due to the lack of participation by the countries for which the course was specially designed. I believe that this has only happened because of the negative attitudes of various Governments, and International Experts, with regard to training people without University qualifications. This attitude still prevails inspite of the fact that a very large percent--age of the investigative work in these countries, is actually carried out by non qualified personnel.

The National Water Council situated at Newbury in Berkshire do organise numerous courses of one to two week duration, in the 'Water' field, and have agreed to put together a package deal at the level we require. They will be forwarding the details in the near future, but the estimated cost of approximately £2,500 per man month, excluding travel costs, is considerably beyond the means of my Project budget. The availability of such a course may be valuable for the future, if programmed costs for training are reviewed. All attempts to try and raise the funds to meet these costs met with a lot of sympathy, but no offers of help.

I hope that the Lake Victoria proposals work out, and I think that it will be more suitable to the standard of the proposed candidates, also more relevant to the conditions found in Somalia.

I would be grateful if you would please keep me posted with the progress of these proposals.

Yours sincerely,

Brian A.P.Gemmell

c.c. - H.Underhill (Hydrologist)

OVERSEAS MANPOWER DEVELOPMENT GROUP
NATIONAL WATER COUNCIL

Overseas Manager
R.P.J. Turrell, BSc, MSc, CEng, MICE, MIPHE, MIWES

Training Division
James House
27/35 London Road
Newbury
Berkshire, RG13 1JL
England.

Telephone
Newbury (0635) 3077
Telex:
848925 NATWAT G

Our Ref: AMR/AJA
Your Ref: TCP/SOM/8906/TRAINING

17 November 1980

Mr B A P Gemmell
812 Kenton Lane
Harrow Weald
Harrow
Middlesex
HA3 6AG

Dear Mr Gemmell

TRAINING OF OVERSEAS STUDENTS - SOMALIA

I am writing to advise you that we have now obtained the agreement for two training attachments for your students and are still negotiating for the placement of the third.

In order to produce a costed proposal, I would be grateful if you would advise me of the anticipated duration and timing of these attachments in order that the costs may be accurately quoted.

At the present time, the cost would appear to be of the order of £1500 per month, exclusive of accommodation.

I enclose additionally a copy of the conditions which have been laid down by one of the water authorities for the practical attachment and look forward to receiving your comments.

Yours sincerely

A M Richards
For R P J Turrell
OVERSEAS MANAGER

Enc

OVERSEAS MANPOWER DEVELOPMENT GROUP

NATIONAL WATER COUNCIL

Overseas Manager
R.P.J. Turrell, BSc, MSc, CEng,
MICE, MIPHE, MIWES

Training Division
James House
27/35 London Road
Newbury
Berkshire, RG13 1JL
England.

Telephone
Newbury (0635) 30777
Telex:
848925 NATWAT G

Our Ref: PRS/AJA
Your Ref: TCP/SOM/8906/TRAINING

21 January 1981

Mr B A P Gemmell
UNDP
P O Box 24
Mogodiscio
SOMALIA

Dear Mr Gemmell

TRAINING OF TECHNICAL ASSISTANTS (HYDROLOGY) - SOMALIA

We are now pleased to advise that training attachments have been arranged as follows for your water staff to study the practical aspects of river gauging and interpretation of data:-

Mr Serat Abdullahi - North West Water Authority

Mr Ali Ahmed - Wessex Water Authority

Mr Abdullahi Mohamed - Severn-Trent Water Authority

At this stage, having been advised of the charges to be made, we are able to offer the attached package which gives a considerable saving on our earlier estimates.

I hope the proposals are acceptable and look forward to an early confirmation to enable final arrangements to be made. It is our practice to request an advance payment of 50% of the fees - £7425 (Seven thousand, four hundred and twenty five pounds sterling) in the form of a Sterling Draft payable to the National Water Council, 1 Queen Anne's Gate, London SW1H 9BT prior to the arrival in the U.K. of your trainees.

I hope the proposals are acceptable and look forward to an early confirmation to enable final arrangements to be made.

Yours sincerely

Peter R Sowrey
For R P J Turrell
OVERSEAS MANAGER

Encs: Programme and Costs
Course Syllabi

cc: B A P Gemmell, home address

COSTS AND PROGRAMME DETAILS

HYDROLOGY TRAINING PROGRAMME - SOMALIA

PROGRAMME

WEEK	COURSE	
1	J.201	An Introduction to Hydrology
2	J.202	Water Level Recorder Maintenance
3	J.203	River Flow Measurement
4-11		Planned Practical Experience
12		Visits to Manufacturers/De-briefing

* * *

COSTS	£ Sterling
Course Fees	
3 National Water Council courses @ £400 per week	1200.00
Planned Practical Experience	
8 weeks with a Water Authority @ £175 per week	1400.00
Accommodation	
(3 nights between courses, 7 nights during secondments and visits) = approximately 70 nights at £25/night, inclusive of meals	1750.00
Travel in U.K.	
Approximately £50 per month	150.00
	4500.00
10% Contingency Fee	450.00
TOTAL	£4950.00
Giving a combined total for 3 trainees of	£14850.00

NOTE: This figure is exclusive of U.K. Value Added Tax (VAT) currently 15% which is payable on all services provided within the U.K.

Course title: J201 AN INTRODUCTION TO HYDROLOGY

Aim:
To develop the trainees' understanding of basic hydrological principles and techniques with particular reference to:-
the hydrological cycle; the methods available for hydrological measurement; the purpose and problems of hydrological measurement.

Selection:
Those employees whose duties require an application of hydrological knowledge and who have a limited understanding of the fundamental principles of hydrology.

Duration:
One week.

Outline syllabus:
Precipitation:-
types of precipitation: measurement of rain and snow; spatial analysis and network design; extreme events resulting in floods and droughts.
Evaporation:-
elementary physics of evaporation; potential evaporation; transpiration; the soil - plant-atmosphere system; measurement of evaporation.
Soil moisture:-
elementary soil physics; soil water storage; soil water measurement.
Streamflow:-
relationship with climatic and catchment variables; hydrograph; streamflow measurement; extreme events; resource assessment.
Groundwater:-
occurrence of groundwater; nature of aquifers; groundwater movement; quality of groundwater; groundwater resources.

February 1979

Course title: J202 WATER LEVEL RECORDER MAINTENANCE

Aim:
To equip the trainee with the ability to:-
- set up paper chart and punch paper tape recorders;
- carry out on-site maintenance;
- strip down to manufacturer's specification;
- carry out routine service;
- carry out simple mechanical and electrical repairs;
- reassemble to manufacturer's specification;
- change charts and/or tapes.

Selection:
Those employees specifically concerned with the use, care and maintenance of water level recorders, or generally concerned with the collection of hydrological data who require detailed knowledge of water level recorders.

Duration:
One week.

Outline syllabus:
Selection of gauging station.
Introduction to stilling well design.
Setting up water level recorder.
Use of hand tools including safety.
On site maintenance of recorders.
Stripping down recorders.
Routine servicing.
Overhaul and repair.
Reassembly.
Changing charts and/or tapes.

February 1979

Course title: J203 RIVER FLOW MEASUREMENT

Aim:
To give training in the techniques involved in river flow measurement, with particular reference to:-
acquisition of river flow data;
processing of data, stage/discharge;
relationships;
maintenance of gauging stations.

Selection:
The course is aimed mainly at those employees whose duties involve the collection or processing of river flow data. It should also be useful for staff involved in the planning and design of river gauging stations.

Duration:
One week.

Outline syllabus:
Principles of flow measurement.
Stream gauging using pre-calibrated structures.
Current metering techniques.
Velocity/area gauging stations.
Dilution gauging.
Processing of flow data, stage/discharge relationships.
Sources and magnitude of errors.
Maintenance of gauging stations.
Recent developments in flow measuring techniques.

Note:
Trainees should where possible come equipped with waders and waterproof clothing for use during the practical sessions.

February 1979