OVERSEAS DEVELOPMENT ADMINISTRATION

HYDROMETRY PROJECT-SOMALIA

Mission Report
Stage 2, February – June 1986

SIR M MACDONALD & PARTNERS LIMITED
Consulting Engineers
Demeter House, Cambridge CB1 2RS
United Kingdom

in association with

INSTITUTE OF HYDROLOGY
Wallingford, Oxon OX10 8BB
United Kingdom

September 1986

OVERSEAS DEVELOPMENT ADMINISTRATION

HYDROMETRY PROJECT-SOMALIA

Mission Report
Stage 2, February – June 1986

SIR M MACDONALD & PARTNERS LIMITED
Consulting Engineers
Demeter House, Cambridge CB1 2RS
United Kingdom

in association with

INSTITUTE OF HYDROLOGY
Wallingford, Oxon OX10 8BB
United Kingdom

September 1986

OVERSEAS DEVELOPMENT ADMINISTRATION

HYDROMETRY PROJECT - SOMALIA

MISSION REPORT

STAGE 2, FEBRUARY - JUNE 1986

SIR M. MACDONALD & PARTNERS LIMITED
Consulting Engineers
Demeter House, Cambridge CB1 2RS
United Kingdom

in association with

INSTITUTE OF HYDROLOGY
Wallingford, Oxon OX10 8BB
United Kingdom

JULY 1986

CONTENTS

CONTENTS (cont.)

LIST OF FIGURES

SUMMARY

The February to June 1986 mission of the hydrologist from Sir M. MacDonald & Partners brought to an end Stage 2 of the British Government funded Somalia Hydrometry Project. This report presents the background to the project and describes the work undertaken during the last mission and the position at the end of Stage 2. The principal activities of the mission were the completion of the automatic water level recorder stations, continuation of counterpart training and assistance in the daily running of the Hydrology Section.

The report also assembles under one cover a number of documents describing various aspects of the project and of the Somali hydrometric network. As such, it should also serve as a basic reference work for those engaged on hydrometric work in Somalia in the future. Finally, based on the experience of the mission, some observations are made on the project and the future of hydrometric data collection in Somalia.

SECTION 1 - INTRODUCTION

1.1 Scope of Report

This report has two objectives:

(i) to describe the work undertaken by the MMP hydrologist during his February to June 1986 visit to Somalia and the state of the hydrometric network at his departure, and;

(ii) to assemble under one cover a number of documents containing relevant information on the Somalia Hydrometry Project and the hydrometric network.

It therefore serves both as a mission report and as a reference work for those concerned with the hydrometric network on the Jubba and Shebelli rivers.

As a report chronicling the Hydrometry Project it follows on chronologically from the Final Report - Stage 1 of February 1985 and the Project Review and Proposal for Stage 3 of March 1986. The February to June 1986 mission described in the current report brought to an end Stage 2 of the project.

The following reports complete the documentation of the project:

(i) Progress Report - February, 1984;

(ii) Annual Summaries of Daily River Flow for the Primary Gauging Stations Operated on the Jubba and Shebelli Rivers - February, 1985;

(iii) Water Resources of Wadis of Northern Somalia - January, 1986;

(iv) Annual Summaries of Daily Flow of the Jubba River at Bardheere (1963-1986) - August, 1986;

(v) Annual Summaries of Daily River Flow for the Primary Gauging stations operated on the Jubba and Shebelli Rivers (1984-86) - August, 1986.

(vi) Institute of Hydrology Hydrological Database - Version 3.0 - September 1986.

A bibliography of other recent publications relevant to the Hydrometry Project is included in the references.

1.2 Background

The Hydrometry Project is concerned with the operation of the hydrometric network of river level and flow gauging stations in Somalia. At present these stations are concentrated on the two perennial watercourses of southern Somalia, the Jubba and Shebelli rivers.

Stage 1 of the project was initiated following a request by the Somali Government for assistance to bridge the gap between the end of an FAO funded project in 1980/81 and the proposed establishment of the national Water Centre, part of a UNDP IPF country programme originally scheduled for 1985. A joint proposal (April 1983) by Sir M. MacDonald & Partners (MMP) and the Institute of

Hydrology (IH) was accepted by the Overseas Development Administration (ODA) and the project commenced in November, 1983.

The main objective of the project is to provide assistance to the Hydrology Section of the Department of Land and Water Resources of the Ministry of Agriculture (MOA). The aim of this assistance is to ensure:

(i) Continuity of hydrological records. These records are used both in the design of all major surface water related projects in Somalia and also in the day-to-day management of the two river systems.

(ii) That all historic records are checked and processed to the same standard.

(iii) That counterpart staff are trained in the techniques of hydrological fieldwork and data processing.

It became clear towards the end of Stage 1 that further assistance would be required if these objectives were to be attained and the continuity of the hydrological data to be preserved. Stage 2 was therefore proposed to follow Stage 1 and run along much the same lines as its predecessor.

Delays in signing the contracts, however, caused a break in project activities between the end of Stage 1 in December, 1984 and the start of Stage 2 in April, 1985. Unfortunately, it is only during this period preceding the 'gu' floods that water levels are low enough to permit access to river beds for fieldwork. Missing this low flow period seriously perturbed the planned programme of fieldwork which, as a result, was barely completed by the end of Stage 2 in June, 1986. The obligatory reorganisation of the work programme also had some detrimental repercussions on the office work component of Stage 2.

1.3 Form of Report

The main text (Sections 2 and 3) summarises the achievements of the February to June, 1986 mission and the current state of the hydrometric network. Frequent references are made to the appendices which contain much detailed information on individual gauging stations, data processing and specific project activities. Some observations on the project based on the experience of the mission are presented in Section 3.

During the mission, the word processing facility of the Hydrology Section's microcomputer was used to prepare detailed activitiy reports on all field trips and specific hydrological exercises undertaken. This helped consolidate the training of the counterpart staff and kept the Director of Land and Water Resources informed of the activities of the Hydrology Section. These reports are reproduced in Appendix I.

Appendix II assembles the various guides and manuals prepared to assist the Hydrology Section in the everyday operation of the hydrometric network and the computer system.

A detailed inventory of the equipment procured for the project is included in Appendix III.

Appendix IV presents certain notes and reports relating to previous visits of other MMP and IH hydrologists. In particular, Appendix IV.1 includes the histories of each of the hydrometric stations and a tabulated log of staff gauge zeros.

SECTION 2 - THE FEBRUARY TO JUNE 1986 MISSION

2.1 Mission Objectives

The February to June 1986 mission formed the final input to Stage 2. The work undertaken during the mission followed up and expanded upon the work done during previous visits by MMP and IH hydrologists. This previous work is described in the Project Report and Proposal for Stage 3 and the documents reproduced in Appendix IV of this report.

Within the framework of the general project objectives described in Section 1.2 above, the aims of the mission were:

(i) To complete the installation of the automatic water level recorder stations.

(ii) To assist the day-to-day running of the Hydrology Section and to continue training the staff in both field and office practice.

(iii) To further the input and checking of historic data on the Section's computerised hydrological database.

These objectives were essentially achieved. The data checking programme should be continued after the end of the mission by the Hydrology Section staff who have been trained in the necessary techniques.

2.2 Automatic Water Level Stations

At the beginning of the project it was recommended that automatic water level stations be installed at five key stations to improve the continuity and reliability of data. The stations selected were Beled Weyn and Kurten Warey on the Shebelli river, and Lugh, Bardheere and Kamsuma on the Jubba (see Figure 2.1; Location Map).

Following a study of commercially available equipment, a system comprising a float and counterweight driving an optical shaft encoder linked to a solid-state data recorder was selected.

The installation of these stations was the principal field activity of Stage 2 of the project. It involved the constuction of open ended stilling pipes attached to bridge structures. The instruments are housed in a recorder box fitted on top of the stilling pipe and accessible from the ridge deck. A sketch of a typical installation is given in Figure 2.2.

Because of the delay in starting Stage 2, the initial installation work had to be undertaken during the 1985 gu season when river levels were at their annual maximum. The addition of the lower parts of the stilling wells could only be completed during the low flow period in early 1986 and this was seen as a priority task of the mission.

(i) Lugh Ganana, Bardheere and Kamsuma

At Lugh, Bardheere and Kamsuma the stilling wells were finished and the stations commissioned (Lugh and Bardheere in March; Kamsuma in May). They should be able to record the full range of river levels experienced at the stations. Details of the stations and their installation are given in Appendices I.2, I.3, I.4 and I.7.

The stations at Lugh and Bardheere were visited at the beginning of June and both were operating correctly (see Appendix I.7). The first retrieval of automatically recorded data from these stations was scheduled for July 1986.

(ii) Beled Weyn

At Beled Weyn the high river levels during the initial construction period resulted in the recorder and stilling well being inadvertently installed above the right bank bridge footing, effectively preventing its downward extension to measure the lowest flows. Moving the stilling well further out into the river to clear the bridge footing would require a more complicated structure which would be exposed to much floating debris (see Appendix I.1).

The fact that the automatic station will not be able to record the lowest flows is regrettable but not serious as the station has an experienced and reliable observer whose readings will complete the record.

The station has experienced two unexplained failures of the float-wire-counterweight system (see Appendices I.1 and IV.3). A new float and counterweight were installed at the end of May and the station was operating correctly when visited at the beginning of June (see Appendix I.7).

(iii) Kurten Warey

This new site is hydrologically important as it is below most of the major water abstractions in the Shebelli and upstream of the swamp which absorbs most of the remaining flow in the river. The construction of an automatic station at the site, however, was forestalled by the arrival of the gu flood waters from Ethiopia.

The proposed position of the station is downstream of the Kurten Warey barrage just before the end of the gabion revetment. This revetment protects the channel against erosion by the high water velocities which can result from operation of the barrage gates. A free-standing structure built in the middle of the channel and accessible only by boat is probably the most practical option at this site.

During the day before the arrival of the gu flood wave, a set of staff gauges was installed in the natural channel 100 m downstream of the proposed site (see Appendix I.7). This allowed the initiation of data collection at this hydrologically important site (see Section II.3 (iii)).

(iv) Observers at Automatic Stations

Until recently the total reliance on part-time local field observers has been the main cause of poor quality and the lack of continuity of station records. At the new automatic stations, the electronic logging equipment will provide a record which should be more accurate and reliable than an observer record. Although the equipment is automatic, it is not, however, infallible and the necessity of a parallel observer record has indeed already been proved at the Beled Weyn station where the float-wire-counterweight system failed and observer data had to be used to complete the record.

The delay in installing the automatic stations has, unfortunately, not allowed sufficient time to monitor the performance of this innovative equipment under the extreme conditions of heat, humidity and dust encountered in Somalia. Some

Figure 2.1
Location Map

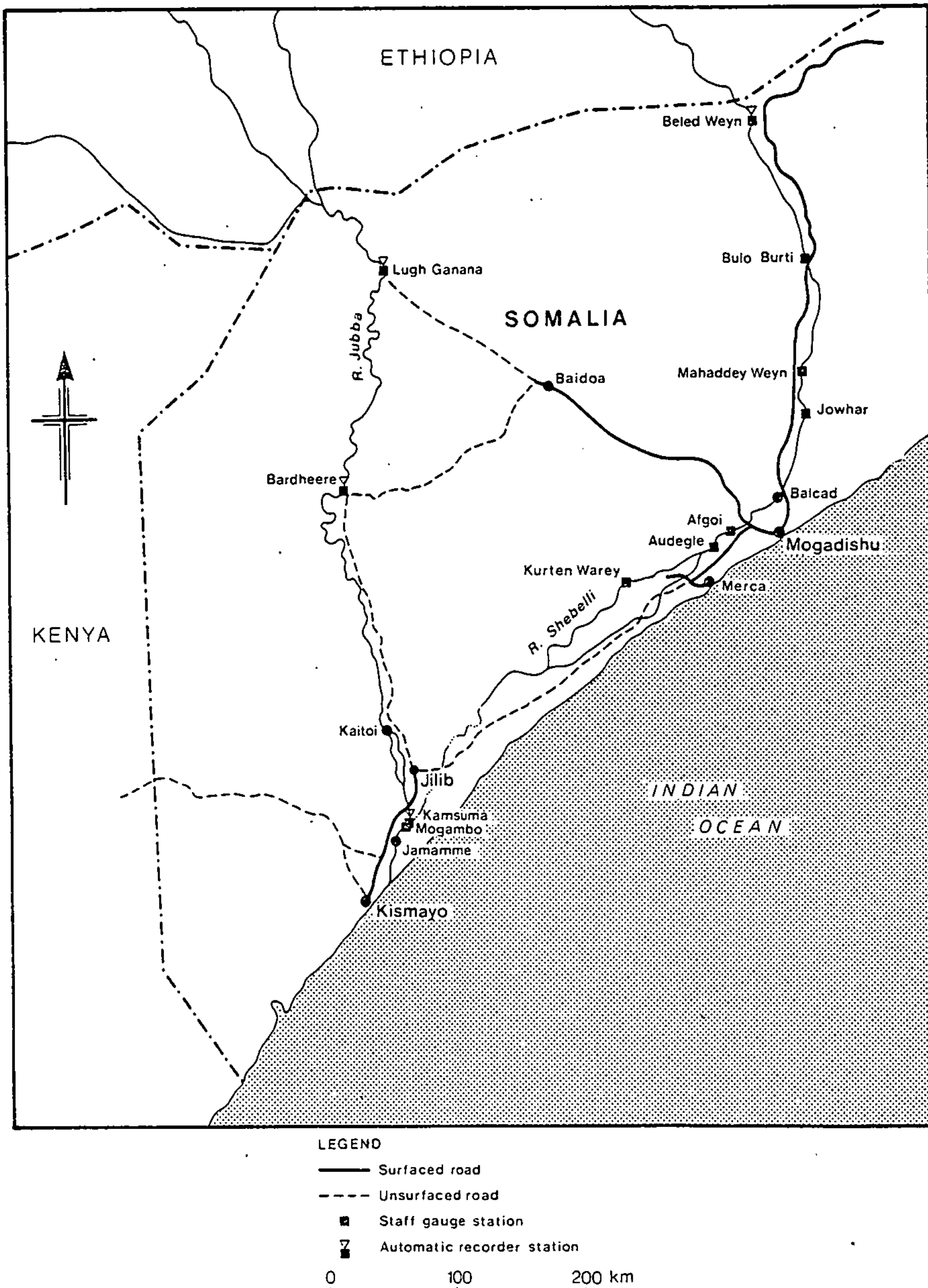
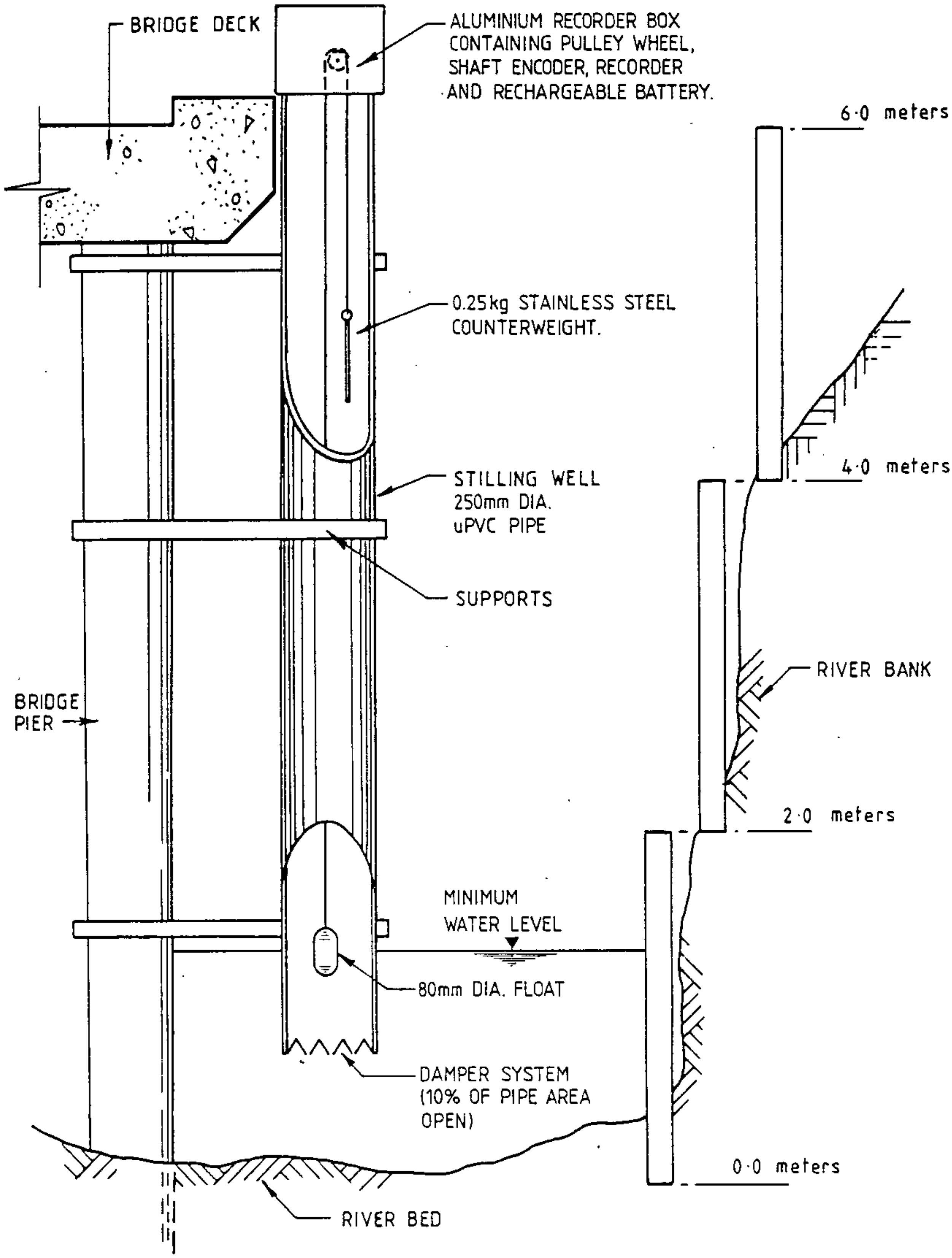


Figure 2.2

Schematic Layout of Automatic Water Level Recorder Station



NOT TO SCALE

operational problems, however, have been experienced; the retriever failed during the September to November 1985 visit of the IH hydrologist and the recorder at Kamsuma failed in April 1986 (Appendix I.4). Both units were returned to the manufacturer and repaired. The recorder proved to have a manufacturing defect. These failures confirm once again the necessity of a parallel observer record at automatic stations.

All automatic stations are currently equipped with a standard staff gauge read by an observer except Kamsuma where a staff gauge exists but the MOA are currently not in a position to recruit a new observer. To compensate for this and to generally strengthen the hydrological record of this part of the lower Jubba, the systematic return of data from the secondary (non-MOA) stations at Mareere (Juba Sugar Project) and Mogambo (Mogambo Irrigation Project/MMP) was re-established (see Appendix I.7).

2.3 Staff Gauge Stations

The staff gauges are the mainstay of the hydrometric network. Even at automatic stations it is against the staff gauge that the automatic equpment is calibrated and controlled. The histories of all the staff gauge stations up to May 1985 and a log of gauge zeros are presented in Appendix IV.1. Work carried out on the stations during the February to June 1986 mission is described below.

Some of the network's staff gauges were originally installed over 20 years ago and almost all sorely required maintenance. Several stations on the Shebelli River have old but very solid cast iron gauge plates. These were heavily rusted and difficult to read. They were systematically cleaned with a wire brush and repainted white after which the graduations and figures were highlighted in black and red respectively. Five spare plates in the MOA store were similarly renovated.

(i) Afgoi, Mahaddey Weyn and Audegle

The lower staff gauges which are submerged the most consequently suffer the worst rusting. At Afgoi, Mahaddey Weyn and Audegle the fixings securing the lower gauge plates to their supports had completely rusted away and the plates had fallen off. The plates were replaced and securely bolted to their supports (see Appendices I.3 and I.4).

At Mahaddey Weyn the overlap of the 2 to 4 m and 4 to 6 m staff gauges first noted by Gemmell in 1980 (Gemmell BAP, 1982) was confirmed by levelling. The 4 to 6 m plates were moved 84 mm further up their support to make them consistent with the 0 to 2 m and 2 to 4 m staff gauges (see Appendix I.4).

(ii) Bardheere

At Bardheere the gauge plates are fixed to the trash-rack on the upstream side of the bridge. The 0 to 1 m section of plate which extended below the bottom of the trash-rack had been broken off by floating debris as the river level dropped in December 1985. It was replaced with a new 0 to 1 m plate incorporated in the structure built to support the lowest section of the stilling well for the automatic station (see Appendices I.3 and I.6).

(iii) Kurten Warey and Sablaale

A new staff gauge station was set up at the hydrologically important site of Kurten Warey. As the river level had begun to rise it was not possible to construct in the lowest part of the river bed. The installed staff gauges cover the range 1 to 6 m (see Section 2.2 (iii) and Appendices I.4 and I.7). The Kurten Warey barrage attendant is currently acting as station observer on a trial basis.

During his visit in March and April 1986, the IH hydrologist assisted the UNHCR and Euro Action Accord install staff gauges both at Sablaale, just below the swamp, and in the bottom end of the swamp itself. It is intended that these stations will be taken over by the MOA network in the next twelve months.

Data from the Kurten Warey and Sablaale stations will greatly improve the understanding of the hydrological behaviour of the lower Shebelli and the swamp. The stations, however, have not as yet been rated.

(iv) Kasuma and Jamamme

The staff gauge at Kasuma was completed by attaching the 0 to 4 m section to the newly installed stilling well. This automatic station supported by data from Mogambo and Mareere (see Sections 2.2 (iv) and 2.5 (i)) replaced the problematic station at Jamamme where no sign of either the staff gauges or the observer could be found.

The station at Jamamme will, however, need to be temporarily rehabilitated in the future, or a programme of bridge dips carried out, so that its data can be correlated with that of Mogambo and Kamsuma for infilling past records.

(v) Metre Figures

Few of the staff gauges in the MOA network have metre figures. It is perhaps surprising that this has not caused more problems when the water levels can vary by as much as 8 m. At several stations metre figures were added to minimise the risk of confusion.

2.4 Discharge Measurements

During the mission discharge measurements were carried out on the Jubba at Bardheere and on irrigation canals in the Janaale area. A gauging at Afgoi bridge to train the Hydrology Section staff in the use of the Braystoke current meters with the suspension derrick and winch was abandoned because of the unbearable stench of rotting fish killed by a discharge of toxic effluent (see Appendix I.3).

(i) Bardheere

Until recently, the rating curve at Bardheere has been the least satisfactory of the network (see Final Report - Stage 1 and the station history in Appendix IV.1). However, during July 1985 a cableway for suspending current meters was constructed 100 m downstream of the bridge as part of the Bardheere Dam Project (BDSP) of the Ministry of Jubba Valley Development. The British engineer who installed the cableway also trained a team of operators who have since been undertaking discharge measurements at the rate of approximately three per month.

The data from the cableway should allow the development of a good rating curve for the Hydrology Section's automatic station installed on the upstream side of the bridge. They will also provide information on movement of the river bed. Co-operation was therefore established between the Bardheere Dam Project and the Hydrology Section. The BDP send copies of the gauging result sheets to the Hydrology Section where the discharges are calculated by the mean section method using the computer program GAGCAL (GAuGing CALculations) specifically developed for the Hydrometry Project. Copies of the program's output are then returned to the BDP.

As a training exercise for the Hydrology Section staff and as a control on the quality of the data returned from Bardheere, a joint Hydrology Section - BDP gauging was undertaken using the cableway and associated equipment. The exercise is described in detail in Appendix I.6. Bardheere Hydrometric Station - MJVD Cableway Discharge Measurements and Rating Curve Development. The equipment was in good condition and the BDP operators led the gauging competently. This, together with the consistency of the results so far processed with the existing rating curve lends confidence to the data currently being received by the Hydrology Section.

(ii) Janaale

At the beginning of May, the Hydrology Section was asked to undertake discharge measurements on canals in the Janaale and Faraxaane Irrigation Projects. The objective of the exercise was to determine the flows of water entering and leaving the different project areas and to estimate seepage losses. This information was required for a feasibility study of the rehabilitation of the Janaale and Faraxaane projects.

Measurements were taken both from a boat and by wading and the results were calculated using the computer program GAGCAL. The silt load of the waters was extremely high as the gu flood waters had arrived from Ethiopia only nine days previously. This resulted in an interesting example of stratified flow in a canal on the Faraxaane project (see Appendix I.5, Discharge Measurements on Irrigation Canals in the Janaale Area).

As the river intake sluices were shut progressively during the field trip, hydraulic theory had to be used to try to get some meaningful results from the measurements. Furthermore, problems with the current meter meant that the results could only be used as a rough guide.

2.5 Processing of Hydrological Data

During the mission priority was given to fieldwork which, together with associated preparatory work and the writing up of field reports, occupied most of the time. However, time was found to supervise the routine processing of all incoming stage and discharge measurement data and the task of checking the many station-years of historic data already on the computer's hydrological data base was embarked upon.

The screen and paper plotting capabilities of the hydrological data base proved to be very useful for data checking. An average of approximately four errors per year were detected when the 1985 data from the five Jowhar Offstream Storage Scheme stations were entered.

To accept data from the new stations commissioned during the mission, two new stations were created on the database; the Shebelli at Kurten Warey and the Jubba at Mogambo.

(i) Mogambo

The MMP engineers supervising the construction of the Mogambo Irrigation Project have kept records of the river level since September 1983. Except for the year 1985, most of the historic data had to be digitised from graphical records kept in the MMP site office. Inconsistencies between the graphical record and the occasional readings returned on weekly cards suggest that, although the form of the hydrograph is probably correct, there are periods when the data are only accurate to within +/- 0.20 m. These data have been included in the data base (with appropriate comments) as it should still be useful for producing a continuous record for this part of the lower Jubba during the period after the station at Jamamme ceased to return data and 10th May 1986 when the automatic station at Kamsuma was commissioned. With this aim in mind, the systematic return of stage data from both Mogambo and Mareere was re-established. This should allow the future setting up of some sort of inter-station model similar to the 'Shebelli model' mentioned below which will allow retrospective infilling of records for the lower Jubba.

(ii) Shebelli Model

The 'Shebelli model' was installed in the Section's microcomputer at the beginning of the mission. It is a useful river basin management tool which should provide a greater understanding of the behaviour of the Shebelli river. In particular it can be used to predict flood levels and check and infill data records. The theory behind the model, its development and application are explained in Appendix II.6.

To make useful predictions the model required the input of real time discharge data from upstream stations. An attempt was therefore made to get water levels at Beled Weyn and Jowhar transmitted to Mogadishu using the Ministry's radio links. This was not particularly successful partly because of technical problems with the transmitter at Beled Weyn. However, information on water levels at Beled Weyn brought in by travellers, together with data transmitted from Jowhar, were used to make predictions and train the Hydrology Section staff. One practical application of the model was its use to estimate the amount of time available for construction work at Kurten Warey before the arrival of the gu flood wave.

(iii) Bardheere Rating Development

A new improved rating curve for the Bardheere station was developed during the mission. Since the installation of the cableway in July 1985, some thirty-one discharge measurements had been undertaken by the Electroconsult engineer, Tomlinson, and the Bardheere Dam Project's gauging team in Bardheere.

The gauging calculations program, GAGCAL, was used to calculate the corresponding discharges which were then examined critically before the station on the Hydrological Database (HDB). The HDB curve fitting facility was then used to establish a new logarithmic rating equation. A single segment equation was found to fit the data well (see Appendix I.6).

The new rating curve was used to produce a revised and up-dated daily flow record for the Bardheere station. Renewed interest in the proposed Bardheere Dam makes these data of particular interest and they have therefore been published as a separate data book, Daily Flows of the Jubba River at Bardheere 1963-1986.

(iv) Historic Data and Data Books

The priorities of the mission resulted in there being very little time available for the task of checking the historic data already entered during the mission (notably 1985 data for the five Jowhar OSR stations and the entire record for Mogambo) were verified using the screen and paper plotting facilities of the HDB.

The Hydrology Section staff were trained in the basic techniques used for checking for data entry and observer errors (described in Appendix II.1) and a start was made on the systematic checking of the historic data on the database. This task was to be continued by the Section's staff after the departure of the MMP hydrologist.

All the flow data on the database at the end of Stage 2 has been published in two data books:

- Annual Summaries of Daily Flow of the Jubba River at Bardheere (1983-86) - August, 1986.

- Annual Summaries of Daily Flow for the Primary Gauging Stations operated on the Jubba and Shebelli Rivers (1984-86).

Although the data presented in these books are considered to be of good quality, they are marked provisional because an appreciable part of the computerised stage data had not been checked by the end of Stage 2.

2.6 Training

It has been appreciated from the beginning of the project that the full benefits of installing the new hydrometric equipment and computer system will only be realised if the Hydrometry Section staff are capable of using them efficiently. As such, training has been an important part of the work of the visiting hydrologists. This was particularly true on the February to June 1986 mission at the end of which the project and associated equipment were formally handed over to the Ministry of Agriculture.

During the mission a general pedagogic approach was adopoted and all activities treated as training exercises. Practical training was backed up by the study of the latest hydrology textbooks and consolidated by preparing and discussing 'activity reeports', all of which are reproduced in Appendix I. Towards the end of the mission the Hydrology Section staff were sent out on field trips on their own to ensure that they could undertake routine fieldwork unaccompanied.

(i) Fieldwork

During the installation of the automatic stations and renovations of existing staff gauge stations the staff has the opportunity of acquiring practical skills which will be required for the maintenance of the network. This type of essential fieldwork often involved physically demanding and dirty work for which, unfortunately, educated Somali staff do not always show much enthusiasm. In this respect the Hydrology Section would most certainly benefit from the presence of a practically minded, senior hydrologist.

The automatic stations need to be visited on a regular basis to retrieve the data from the solid-state recorders and replace the batteries. Once the basic principles behind the operation of the units have been understood, they are relatively simple to use. Operations, however, tend to involve the careful execution of a large number of steps which must be carried out in a strict sequence. Staff were trained in the office using the spare recorder destined for Kurten Warey and a step-by-step 'Guide to Routine Operations at Automatic Recorder Stations' (see Appendix II.2) was prepared for use in the field.

To consolidate the training, towards the end of the mission the counterpart staff undertook two unsupervised field trips to the stations at Mahaddey Weyn, Bulo Burti, Beled Weyn, Bardheere and Lugh. The fieldwork was generally carried out successfully although the failure of the battery in the retriever during the second trip prevented the collection of recorder data from the Bardheere and Lugh stations (see Appendix I.7).

(ii) Office Work

During the mission most of the office work was centered around the entry and checking of data on the Hydrological Database. The staff also learned how to use the program GAGCAL for calculating the results of discharge measurements and exercises in rating curve development were undertaken. Repetition led to the assimilation of general techniques but attempts to instil the methodical and rigorous approach required for the processing of hydrological data were probably less successful. The current staff's hydrological judgement is poor as they have not been in the Section long enough to acquire much 'hydrological feeling'. Textbooks purchased for the project were used to explain theory and to broaden the staff's knowledge of the field of hydrology.

It is thought that increased staff awareness of why hydrometric data are collected and how they are used would lead to a parallel increase in diligence and motivation. In this respect, senior staff would benefit from formal courses in hydrology or periods spent working in an active hydrological section of an engineering consultancy or similar organisation.

(iii) Staff Turnover and Motivation

Despite the effort put into training during the project, the level of hydrological expertise in the Section has not reached the level hoped for and, indeed, has barely attained the minimum required. This is primarily attributed to the high turnover of staff. As explained in the Final Report - Stage 1, considerable time was spent during the early stages of the project explaining and demonstrating basic hydrological principles and techniques used both in the field and in the office. Unfortunately, of the staff trained, only one junior technician remained in the Section at the beginning of the 1986 mission and time had to be spent repeating the training from the beginning.

If the level of expertise is to be improved and maintained in the future then the motivation of the staff will need to be increased and the rate of turnover reduced. This is unlikely to be achieved without providing some further incentives to encourage diligent work and long-term service in the Section.

SECTION 3 - REVIEW AND OBSERVATIONS

The review and observations presented in this section are primarily concerned with the February to June 1986 mission, but, as this mission brought to an end Stage 2 of the Hydrometry Project, they often extend to cover the project as a whole.

The main aim of the Hydrometry Project was to increase the quantity and improve the quality of hydrometric data in Somalia by providing assistance to the Hydrology Section of the Ministry of Agriculture.

The project was concerned with both men and materials. The latter involved the improvement of the hydrometric network and the installation of a microcomputer for data processing and archiving, the former, the training of the Hydrology Section staff.

3.1 Hydrometric Network and Project Equipment

By the end of Stage 2 the gauging stations comprising the hydrometric network on the Jubba and Shebelli rivers were in good condition and new automatic water level recorders had been installed and commissioned at Lugh, Bardheere, Kamsuma and Beled Weyn. Although the arrival of the gu floods forestalled the replacement of the upper staff gauge at Bulo Burti and the construction of the proposed new automatic station at Kurten Warey, the installation of a staff gauge station at the latter site allowed the initiation of data collection at this hydrologically important point on the Shebelli river.

All the new automatic water level stations were working correctly at the end of the mission although several teething problems had been experienced because of the delivery of faulty recorder and retriever units. The stations have not yet been operating long enough to permit a meaningful appraisal of the performance of such state-of-the-art equipment under Somalian conditions.

In the office the final version of the Hydrological Database was installed on the microcomputer during the mission. Unfortunately no improvements have been made to the unsuitable environmental conditions under which the computer has to operate. It is probable that the capricious electricity supply and extremes of temperature, dust and humidity were at least partly responsible for the failure during the mission of an internal circuit board linked to the hard disk. Although the circuit board has been replaced, there is no doubt that the useful life of the computer has been and will continue to be shortened if its operating environment is not improved. More thorough and regular cleaning of the computer room and the installation of an air-conditioner are considered essential.

The Land Rover, to which a roof-rack was added at the beginning of the mission, ran satisfactorily. As the sole project vehicle, it has covered long distances (12 000 km during the last 4 month mission alone) on very poor roads and tracks and this is beginning to tell by the increasing number of small repairs required.

At the end of the mission, all the project equipment was formally handed over to the Ministry of Agriculture. Copies of the hand-over letter and accompanying equipment inventory are included in Appendix III.

3.2 The Hydrology Section and the Hydrometry Project

At the end of Stage 2 of the project the Hydrology Section was in possession of a good hydrometric network of both manual and automatic stations which, together with the introduction of improved data collection and processing techniques, has already resulted in significant improvements in available hydrometric data.

The permanence of these gains probably depends more on the staff of the Hydrology Section than on the equipment installed. The training aspect of the project was unable to raise the level of hydrological expertise as much as was hoped, primarily because of the high rate of staff turnover in the Section. Although the current staff have acquired the basic skills required for their work, the situation is rather fragile and further training and supervision would be most desirable. This would consolidate the achievements of the project, ensure the independence of the Hydrology Section and provide the good quality hydrometric data essential for planning the future development of Somalia.

REFERENCES

Agrar-und Hydro-technik GmbH	1984	Advisory Assistance to the Ministry of Juba Valley Development - Hydrology of the Juba River.
Agrar-und Hydro-technik GmbH	1985	Advisory Assistance to the Ministry of Juba Valley Development - Progress Report, Hydrology and Water Management.
Gemmell, B.A.P.	1982	Hydrological Data Collection and Upgrading of the National Hydrometric Network on the Juba and Shebelli rivers, also the in-service training of the field operational staff.
ELC-Electroconsult	1985	Baardheere Dam Project - River Gauging Station, Mission Report of Mr. J.J. Tomlinson, July-August, 1985.
Institute of Hydrology	1984a	Hydrometry for Somalia, Report and Recommendations by C.S. Green, July.
Institute of Hydrology	1984b	Computer System and Hydrological Database, Version MG1.1, September.
Lockwood Survey Corporation Ltd.	1966	Agricultural and Water Survey for the Somali Republic, Volume 2, Water Resources, June.
Sir M. MacDonald & Partners	1969	Project for the Water Control and Management of the Shebelli River, Volume 4, Water Resources and Engineering, November.
Sir M. MacDonald & Partners	1981	Jowhar Offstream Storage Project - Operation and Maintenance Manual.
Sir M. MacDonald & Partners with Institute of Hydrology	1984	Hydrometry Project - Somalia, Progress Report.
Sir M. MacDonald & Partners with Institute of Hydrology	1985a	Hydrometry Project - Somalia, Final Report - Stage 1.

Sir M. MacDonald & Partners with Institute of Hydrology	1985b	Hydrometry Project - Somalia, Annual Summaries of Daily River Flow for the Primary Gauging Stations operated on the Jubba and Shebelli Rivers (to 1984).
Sir M. MacDonald & Partners with Institute of Hydrology	1986a	Hydrometry Project - Somalia, Project Review and Proposal for Stage 3.
Sir M. MacDonald & Partners with Institute of Hydrology	1986b	Hydrometry Project - Somalia, Annual Summaries of Daily Flow of the Jubba River at Bardheere (1962-1986).
Sir M. MacDonald & Partners with Institute of Hydrology	1986c	Hydrometry Project - Somalia, Annual Summaries of Daily River Flow for the Primary Gauging Stations operated on the Jubba and Shebelli Rivers (1984-1986)
Selchozpromexport	1973	Headworks on the River Juba.

APPENDIX I

ACTIVITY REPORTS FROM THE FEBRUARY TO JUNE 1986 MISSION

APPENDIX I.1

MAHADDEY WEYN, BELED WEYN AND JOWHAR
FIELD TRIP 12/02/86 to 13/02/86

Somalia Hydrometry Project February 1986

Mahaddey Weyn, Beled Weyn & Jowhar Field Trip
12/02/86 to 13/02/86

Participants

Keith Stallard
Zakia
Anab
Ali
Said
Mohamoud (driver)

12/02/86 Mahaddey Weyn

Arrived 10.30, told that observer was in Jowhar.

The water level was well below the 2-4m staff gauge and, as the 0-2m gauge plates still need to be reinstalled, no direct reading of the water level could be made.

Bridge dip at 10.40 - water level 6.49m below MB mark on bridge. As the staff gauge zero is 104.57m AMSL and the MB is at 112.09m,the bridge corresponds to a gauge reading of 0.93m.

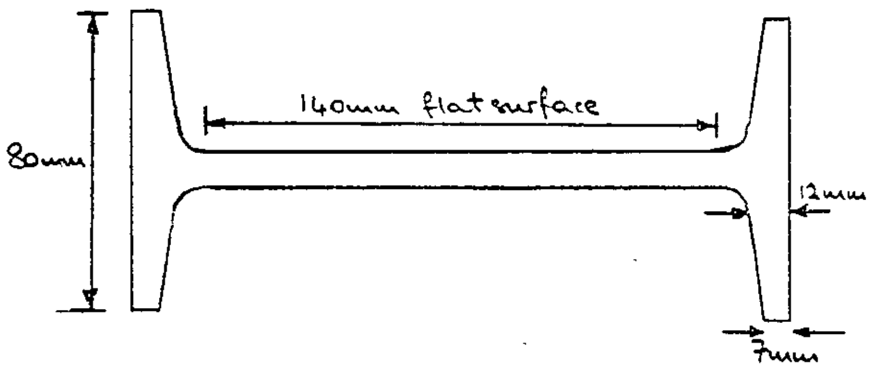
There are two corroded but apparently solid reinforced steel joists (RSJs) in the river which in the past have supported gauge plates. From a photograph taken at extremely low water level (FAO project report volume 3, 1982) the RSJ near the left bank is seen to be in the deepest part of the channel and should be used for reinstallation of the 0-2m gauge plates.

The 2-4m gauge plates are plastic whereas the 4-6m plates are enamelled metal. Plates are fixed to the RSJs by 4mm diameter thread bolts. In direct relation to their durations of submergence the highest RSJ is slightly corroded whereas those in the river bed are extremely corroded. For future installation of gauge plates the dimensions of the RSJs on the bank were taken and are assumed to be the same as those in the river (see sketch below).

The reported overlap of 70mm between the 2-4m plates and the 4-6m plates (p3-3 MMPL & IOH Hydrometry Project Final Report - Stage 1) needs to be investigated and rectified if possible.

Metre figures need to be added to the plates.

Some soil needs to be dug out of the bank to improve line of sight from bridge to 4-6m staff.



Photographs were taken of the site.

A message was left for the observer informing him that we would return the following day.

Beled Weyn 12/02/86

The station is on a busy bridge in the town so firstly police assistance was sought and granted.The observer turned up at the bridge.

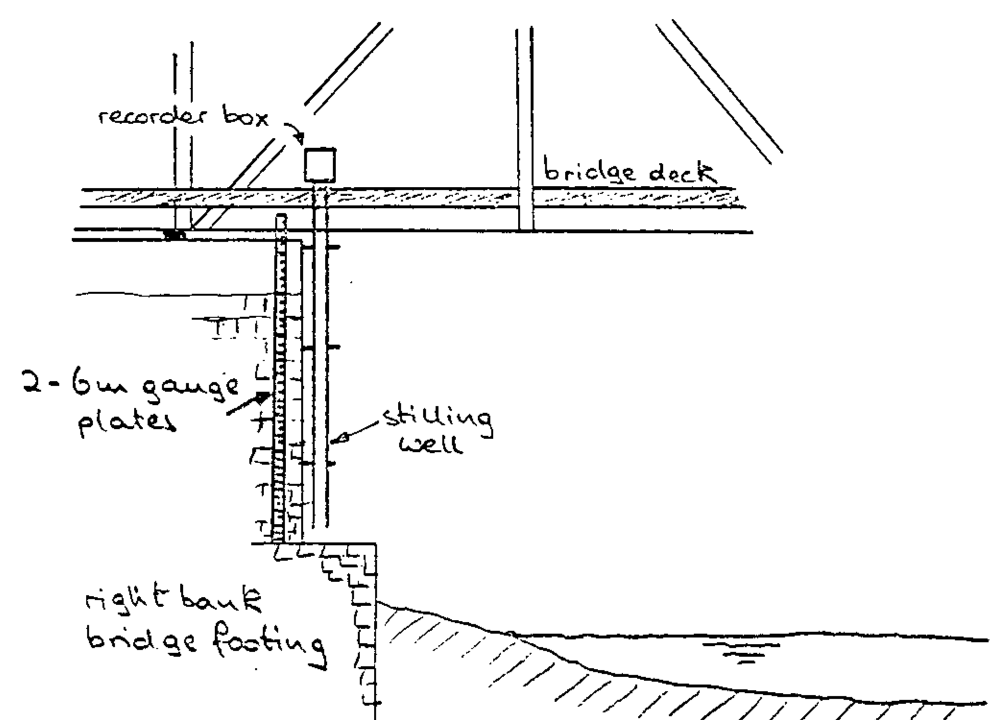
The observer complained that the Ministry of Agriculture had stopped paying him eight months ago and informed us that he would no longer continue reading the gauge. Good observers are indispensable for the efficient operation of hydrometric stations, even those containing automatic recorders. According to the Hydrology Department staff, the Beled Weyn observer has returned reliable data for many years and is conscientious. An exceptional "encouragement payment" of 250/= was therefore made to him from MMP project funds and we promised to take up his case with the Director of Land and Water Resources. The observer agreed to continue reading the gauge on a "wait-and-see" basis.

The staff gauge showed a water level of 0.17m at 17.40hrs.

A bridge dip at the same time gave the water level as 6.50m below the MB. This MB is assumed to be the one created by Dr.C Green on 15/10/85 when he could not find the original and has not as yet been levelled. Assuming, however, that it is at approximately the same altitude as the MB mentioned in the Stage 1 Final Report ie. 183.69m AMSL and given that the zero of the staff gauge is at 176.11m, the bridge dip should have corresponded to a gauge reading of 1.08m. Obviously either an error was made whilst using the improvised dipper or the new MB is much lower than the original.This will become clear when the new MB is levelled.

We confirmed the observer's complaint that the old metal 4-6m gauge plates on the downstream face of the right bank bridge abutment were completely rusted and difficult to read. Without a ladder it was possible to rub down and give a first coat of white paint to the bottom 2.5m (ie 2.0-4.5m).

On previous visits a "large, flat stone" had been perceived below the bottom of the installed stilling well. We arrived with the intention of removing the stone to allow extension of the stilling well but in fact the stone turned out to be the footing of the bridge abutment. The stilling well and recorder could possibly be moved out from the bridge abutment towards the middle of the river but, as the apparatus would still have to be anchored to the abutment, this would require extensive reinstallation work. Deposits next to the bridge footing would also need to be removed, presumably during each low flow season, and small holes drilled in the lower sections of the stilling well to allow the station to continue functioning should the bottom inlet be closed by sediment. The following is a sketch of the station viewed from downstream as it was seen during the visit:



For the moment, when the water level is below the bottom of the stilling well, the apparently reliable observer data will be used.

The electronic logger was still working on the battery replaced on the 7th/8th August 1985 by Peter Ede. Unfortunately the float-wire-counterweight system had again failed and the logger was only recording spurious data.
All data on the logger was transferred to the logger. Back in Mogadishu the data was transferred onto a computer floppy disk. A preliminary examination gave the impression that much of the data is dubious. To extract any useful information it will be necessary to closely compare the logger data with the observer data which has been entered into the hydrometric database system. As the current priority is to complete the installation of the measuring stations before the end of the low flow season, this latter task will be left until the arrival of the Institute of Hydrology hydrologist/programmer on 06/03/86.

Photographs were taken of the site.

Beled Weyn 12/02/86

The water level on the staff gauge was 0.16m at 07.00hrs.

A second coat of white paint was applied to the accessible parts of the gauge plates.

The bottom of the stilling well was opened to remove the float. The counterweight and wire were not found either at the top or at the bottom of the well.

Bulo Burti 24/02/86

At the army checkpost before Bulo Burti we were informed that there was a serious outbreak of cholera in the town and that we should return to Beled Weyn. Fortunately we managed to persuade the officials to let us drive through the town without stopping. Consequently neither the observer could not be contacted and the station was not visited.

Mahaddey Weyn 13/02/86

We met the observer who explained how he estimated the water level in the 0-2m range for which there are no gauge plates. His estimates can probably be taken as accurate within +/- 0.20m.

Jowhar Offstream Storage Scheme 24/02/86

Mr Hajir, the director of the scheme was unable to accompany us. We visited the reservoir outlet where the upstream water level was 2.60m at 17.30hrs. Downstream the water was above the 0-2m gauge plates and, as the 2-3m plate is missing, the water level could not be determined.

Trip logistics

Total distance travelled = 810kms
Approximately petrol consumption = 150 litres
Accommodation at the Italian Medical Team centre at Beled Weyn was arranged in advance by radio telephone through their Mogadishu office.

Keith Stallard 24/02/86

APPENDIX I.2

LUGH AND BARDHEERE FIELD TRIP
25/02/86 to 04/03/86

Somalia Hydrometry Project March 1986

Lugh and Bardheere Field Trip 25/02/86 to 04/03/86

Participants

Keith Stallard	(MMP hydrologist)
Ali	(MOA hydrology counterpart)
Said	(MOA hydrology technician)
Maxamed Nuur Suldaan	(MOA district coordinator in Lugh)
Mahamuud	(project driver)

25/02/86 Mogadishu-Lugh

Drove from Mogadishu to Lugh (395kms), one puncture.

25/02/86 a.m. Lugh Observer

07.20 Observer turned up at district coordinator's house:

name	: Hassan Ali Abdi-Karim
status	: permanent MOA employee
gross monthly salary	: 560/=
allowance	: none (requested)
comment	: also observer for meteorological station in morning (afternoon girl observer: Faduma Sh.Siidow)

09.00 Obtained permission to work on bridge from the representative of the District Commissioner and the Force Commander responsible for the military surveillance of the bridge. Permission was also granted for photographing the gauging station but not the whole bridge.

10.00 Water level 1.01m on gauge plates. Observer tested and found to be good.

11.00 Installed very heavy ladder (porter's fees 150/=) borrowed from mayor which, together with own ladder gave, access to bottom of stilling well.

Existing Situation

The stilling well is attached to the downstream side of a 0.41m diameter, circular, concrete filled, steel pile driven into the river bed just upstream of one of the central bridge piers. The pile protects the pier from damage by floating debris and, hopefully, it will do the same for the stilling well.

The existing stilling well stopped 2.6m above the water surface, the water was 1.0m deep at the station.

Installation work 26/02/86 - 01/03/86

Over the 4 day period, 2 further sections of 2.0m and 1.4m pipe were added to the bottom of the stilling well. The bottom of the well was partially closed, leaving only about 10% of its surface area, open to minimize oscillations of the water column in the well. The "dampers" closing the bottom of the well were constructed in such a way that sediment should not build up but will drain out of the bottom. Holes (2 x 11mm) were drilled at 100mm centres up the bottom length of pipe to allow water to enter and leave the stilling well if deposits in the river bed shut off the bottom of the well.

The stilling well terminates 0.2m above the river bed and, taking into account the damping system and the size of the float, the station will be able to record water levels over the staff gauge range 0.40m to 9.00m. The river will almost certainly have stopped flowing before the level drops to 0.4m.

The bottom section of the stilling well was further supported by bolting it to two x 2m angle aluminium (75mm) driven into the river bed.

No data retrieved

The battery installed by Peter Ede (MMP hydrologist) in July was flat. No intelligible data could be retrieved from the logger either before or after replacing the battery (The spurious data transferred to the retriever filled the latter's store one and a half times and bore no resemblance to data expected). This is worrying as the type of logger used is supposedly fitted with a primary lithium-thionyl chloride cell at manufacture which should ensure storage of data for five years after main battery failure.

The battery was replaced, the logger initialized and the station put into operation at 18.00hrs on saturday 01/03/86 with the water level at 1.005m.

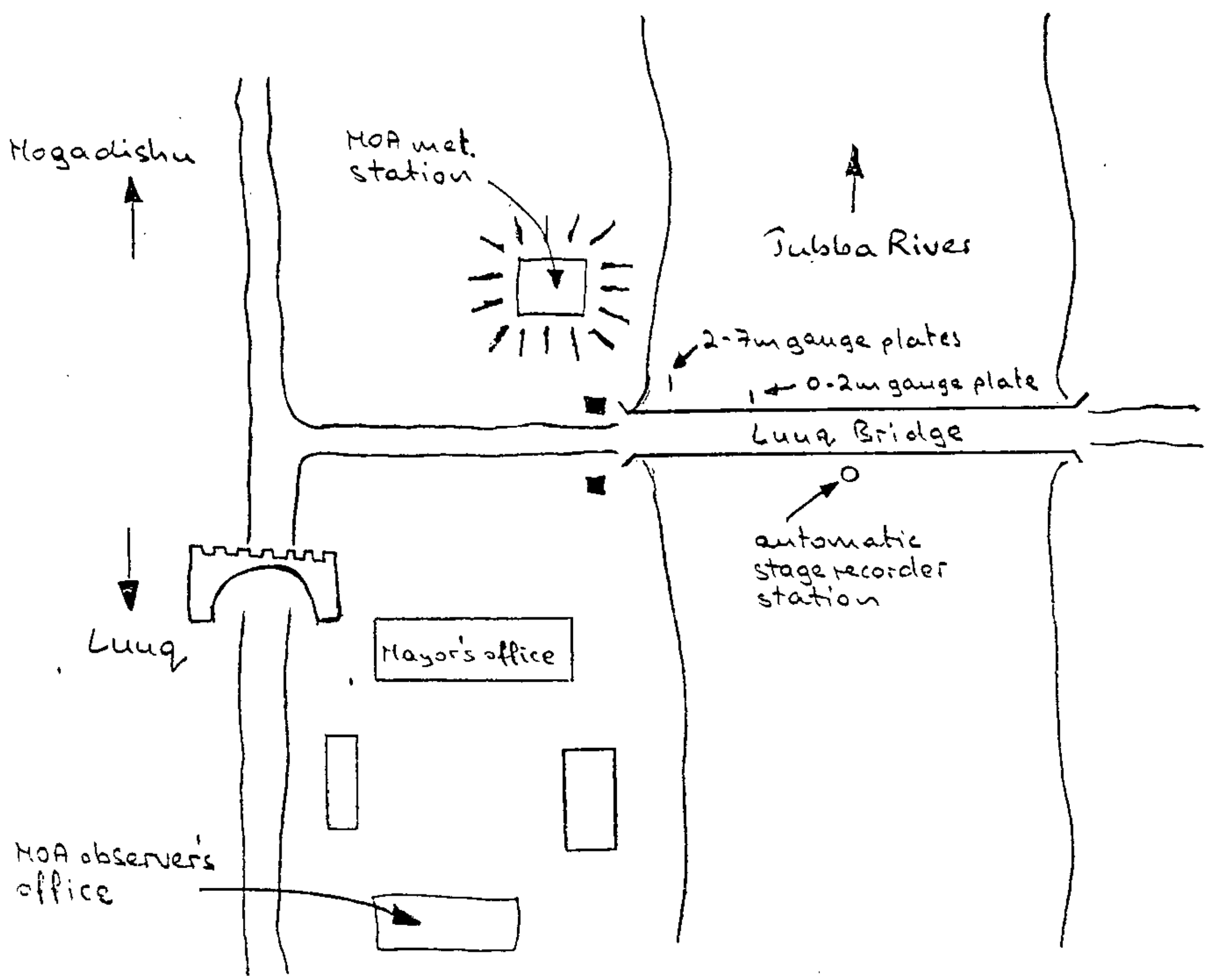
Longer pulley wire required

The float and counterweight system were reinstalled using the same, rather short wire used by Peter Ede. The counterweight was at the top of the stilling well and will block against the pulley system if the water level drops more than another 30mm. The water level may not drop this far before rising again but data retrieved from the logger for the beginning of March should be examined for a plateau at approximately h = 0.997m. At the next opportunity the wire should be replaced by one about 0.75m longer.

Meteorological Station

Sunday 02/03/86 am : Water level data for the month of February was collected from the observer's office.

Following a request from Peter Hutchinson of the Meteorological Department of the Ministry of Agriculture in Mogadishu a brief visit was made to the meteorological station at Lugh. The proximity of the station to the level recorder is shown on the sketch map below:



The meteorological station contained the following equipment:

1 metal (German) screen (thermometers: wet dry max min)
1 Fresnel type screen (thermometers: wet dry max min)
1 soil thermometer
2 raingauges
1 anemometer
1 wind vane

Much of the equipment was in poor condition and the observers were not confident of how to use it correctly.

Lugh to Bardheere

After taking local advice the road to Bardheere through Gherbahaare was taken. Apart from a dozen kilometres of new road (*) built to serve refugee camps on the west bank of the Jubba River south of Gherbahaare and forty kilometres of similar road on arrival at Bardheere the route is very rough and certainly impracticable in the rainy seasons.

6hrs driving - 1 puncture.

17.00hrs: Arrived Bardheere, met the acting MOA district coordinator, Mr Abdi Bary and installed ourselves in the MJVD Rest House as pre-arranged in Mogadishu.

(* Leave good road on right when it turns sharp left at the end of a long straight to run along the flank of a hill)

Observers

MOA:	name	: Abdul-Kadir Aden Mohamed
	status	: permanent
	gross salary	: 560/=
	allowance	: none
	comment	: observer ill; not met
MJVD:	name	: Abdi Mohamud Suleyman
	status	: District Officer of Department of Land and Water Resources and part-time observer for MJVD gauging station
	gross salary	: n/a
	allowance	: receives 400/= (800/2) from MJVD for each complete flow measurement using cableway

name : Mohamud Abdi Salan
status : permanent MJVD observer
gross salary : n/a
allowance : n/a also receives 400/= for completed flow measurement using cableway.

MOA Gauging Station

The 0-1m gauge plate was missing. It had been bolted to a plank which had, in turn, been bolted to the outside of the trash-rack protecting the left-central bridge pier. The plank had been broken off where it extended below the bottom of the trash-rack. Records show that it failed when the water level dropped below the bottom of the trash-rack, presumably from the impact or accumulation of floating debris.

A section of enamelled metal gauge plate was borrowed from the MJVD station and temporarily installed by wiring it to a bridge pier.

The water level at 15.30 02/03/86 was 0.09m. The water depth at the station was 3.6m.

The stilling well terminated 0.38m below the bottom of the trash-rack and 0.46m above the water surface. Measurements were taken and possible methods of extending the stilling well in such a way that it would not succumb to the same fate as the staff gauge were studied.

As at Lugh, the recorder battery was dead. It was left as it was.

MJVD station

Following a request from Mr Bashir of the MJVD Bardheere Dam Project, the pneumatic station was visited and the equipment inspected.

The cableway, current metering equipment and the pneumatic stage recorder all appeared to be in good condition. The observers were able to explain how they maintained and operated the cableway and presented several completed flow gauging sheets lacking only the staff gauge readings because of the missing plate.

The pneumatic stage recorder, however, was not working and, according to the observers, had never worked, even immediately after installation.

The following problems were immediately obvious:

- the bubble emitter was approximately 1.5m above the river level

- the pneumatic line to the emitter was broken off at its junction with the emitter

- the compressed air bottles were completely depressurized

The foot pump provided to repressurize the bottles worked but the operators do not seem to understand how to use the various valves. Repressurizing the bottles by the pump is, however, extremely slow and there was not sufficient time to reach a pressure sufficient to test the apparatus.

Meteorological Station

04/03/86 09.00hrs: A visit was made to the MOA meteorological station just outside the town towards Baidoa. It contained:

1 screen containing wet, dry, max and min thermometers
1 soil thermometer stand (thermometer missing)
2 raingauges
1 evaporation pan (MJVD)
2 anemometers
1 sunshine recorder
1 bimetallic radiation recorder

The thermometers appeared to be reasonably well maintained and the charts in the sunshine recorder are replaced every day. The evaporation pan and radiation recorder were not in use.

The station is run by 2 permanent girl observers who receive a gross salary of 560/= each. They should also receive an allowance of 240/= but this has not been paid for almost year. The station is approximately 800m from the centre of the town.

Trip logistics

8 days - 7 nights
1240kms - 250l petrol

Keith Stallard 12/03/86

APPENDIX I.3

AFGOI (13/03/86) AND BARDHEERE (15/02/86 to 20/02/86) FIELD TRIPS

Somalia Hydrometry Project March 1986

Afgoi (13/03/86) and Bardheere (15/02/86 to 20/03/86) Field Trips

Afgoi

Participants: Keith Stallard
Zakia
Anab
Ali
Mohamuud (driver)

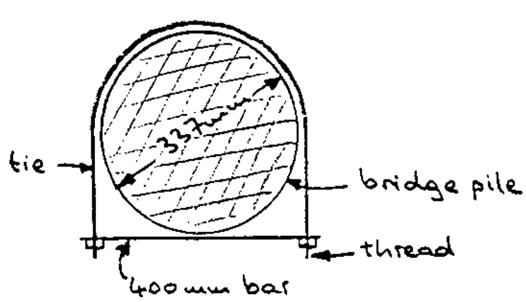
Observer: name : Siidow Maxid Xaoji
status : permanent
gross salary : 750/=
allowance : none

Data was collected from the observer's office. The observer said that the 2-3m gauge plate had broken off during the 1985 der floods. When the water level is in this range the observer takes a bridge dip and subtracts the result from 7.50 to obtain the equivalent staff gauge reading.

With the staff gauge zero being at 77.42m AMSL and the bridge MB at 84.89m, the bridge dip should be subtracted from 7.47m. This needs to be explained to the observer and data already entered into the data base modified accordingly.

The gauge plates at Afgoi are made of cast iron and were very corroded. The 2-3m plate section was recovered from the river bed and, together with the 3-7m plates, was cleaned with a wire brush and given a coat of white paint. When the white paint was dry, the graduations were painted black and the figures red.

The 2-3m plate needs to be fixed to the 0.34m diameter pile using a tie:



Mohamuud the driver said that he knew where to obtain the necessary pieces in Mogadishu and the observer said that he could install it.

The planned flow measurement was not carried out because of the unbearable stench caused by the decomposition of hundreds of dead fish in the river. (Supposedly caused by a release of effluent from the sugar refinery in Jowhar)

Bardheere

Participants: Keith Stallard
Zakia
Anab
Ali
Mohamuud (driver)

During the visit the water level rose slowly from 0.18m on the evening of Saturday 15/03/86 to 0.20m on Wednesday morning 19/03/86. during the day of Wednesday the level rose to 0.28m by 19.00hrs.

Stilling well

A bottom section of pipe 0.95m long was added to the stilling well. A damping system partially (90%) closed the bottom of the stilling well but was constructed in such a way that sediment will not accumulate inside the well.

Previous sections of pipe had been attached to the inside of the trash-rack. The bottom section however extended well below the bottom of the trash-rack and the fabrication and fixing of supports was quite complex. The final structure was photographed both before and after installation.

Staff gauge

A new 0-1m section of gauge plate was installed on the structure supporting the stilling well.

Logger

As at Lugh, the battery was flat and no intelligible data could be retrieved from the logger. The battery was replaced, a longer wire fitted to the float-counterweight system and the logger started at 17.00hrs on 19/03/86 with a water level of 0.285m.

Automatic station

The automatic station will be able to record water levels over the staff gauge range -0.30 to 7.50m. The interception constant of the rating equation established for the station indicates that the river stops flowing at a gauge board height of approx -0.35m. The absolute lowest water level ever recorded was -0.28m on 14/04/81.

Discharge measurement

On 19/04/86 and with the help of Mr Abdi Mohamed Suleyman (MOA employee and assistant observer for the Ministry of Jubba Valley Development's pneumatic hydrometric station and cableway) the discharge in the river was measured using the MJVD cableway. The water velocity was measured at 0.2 and 0.8 of the depth at 17 verticals spaced at 6m intervals across the river. Back in Mogadishu the flow was calculated firstly by hand and then with the aid of the program GAGCAL. The latter gave a discharge of 12.8m3/s for a water level of 0.20m.

Since the disappearance of the 0-1m gauge plate, the MJVD observers had continued to undertake discharge measurements. Unfortunately, all 6 such measurements were taken when the water level was between 0-1m so the corresponding stages were missing. In an attempt to recuperate the potentially useful information represented by these gaugings, the bottom of the river was sounded at each vertical used during the measurements. The difference between the depths at each vertical for the day of measurement and the 19/03/86 were calculated. If for, a particular gauging, these differences were reasonably constant across the section then an average was taken and an estimate of the water level on the day of measurement made by reference to the level of 0.20m on the 19/04/86.

In this way 4 out of the 6 discharge measurements were recovered. For the remaining 2, however, the form of the bed on the day of measurement was considered to differ too much from that on the 20/04/86 for a reliable estimation of the water level to be made.

Work to be done

A suspectly diagnosed case of acute appendicitis (Ali) obliged the team to return to Mogadishu during the night of wednesday 19/04/86 to thursday 20/04/86 leaving the following work to be done:

1. Several pieces of angle aluminium fixing the bottom of

the stilling well need to be sawn to length. At the moment the structure will trap more floating debris than is necessary and has an unfinished appearance.

2. The bottom section of the stilling well protruding below the bottom of the trash-rack needs to be protected from floating debris. It was planned to do this by bolting a couple of 2m lengths of angle aluminium onto the bottom of the trash-rack.

3. A complete test of the currently out of action MJVD pneumatic stage recorder still needs to be undertaken.

4. Stage data from the MOA station needs to be collected from the observer.

Keith Stallard March 1986

APPENDIX I.4

FIELDWORK UNDERTAKEN DURING APRIL 1986

Somalia Hydrometry Project May 1986

Field Work undertaken during April 1986

The following field trips were undertaken during April 1986:

01/04/86 - 08/04/86	:	Afgoi, Kurten Warey, Mogambo, Kamsuma
13/04/86	:	Audegle, Kurten Warey
14/04/86	:	Jowhar, Mahaddey Weyn
24/04/86 - 26/04/86	:	Kurten Warey
28/04/86 & 29/04/86	:	AFMET, Afgoi

01/04/86 - 08/04/86 : Afgoi, Kurten Warey, Mogambo & Kamsuma

At Afgoi (01/04/86) the 2-3m gauge plate was re-attached to the bridge pillar using two tie bars as described in the Afgoi (13/03/86) and Bardheere (15/03/86) field trip report. The ties were made by the Masha-Allah workshop.

The proposed new site at Kurten Warey was visited and measurements of the barrage were taken so that the new station and its method of attachment to the barrage structure could be designed.

The MMP site office at Mogambo Irrigation Project was reached at approximately 21.00hrs. The MMP Resident Engineer, Mr D Higgins kindly arranged accommodation in the MMP compound.

To complete the installation of the stilling well at the Mogambo automatic water level station it was necessary to borrow an inflatable boat from Bingles, a Tirfor from Holtzmann-Astaldi and a pulley system from MMP. Over the period 02/04/86 to 07/04/86, the stilling pipe was extended down a further 4.65m. The bottom of the pipe finishes approximately 250mm above the river bed and the station should be able to measure water levels over the staff gauge range -0.40m to +9.50m.

In the future the installation would probably benefit from some strengthening. The Juba Sugar Project Training Centre was approached and they would be willing to manufacture special brackets for fixing the pipe more firmly to the hexagonal bridge pier.

Before starting the installation work on 02/04/86 the recorded data was copied from the data logger to the retriever. The recorder system had operated correctly for 255 days from its initial installation on 22/07/86 although, for the greater part of the period, the water level had been below the bottom of the pipe. This data was subsequently transferred to the database in Mogadishu after removing the periods when the float was sitting at the bottom of the stilling well. This operation was treated as a training exercise.

Although the recorder system had previously operated correctly it malfunctioned when set in operation after completion of the stilling well. Sometimes it would not follow changes in the water level and, later, it would not function at all. Both the shaft encoder and the recorder unit were removed for closer examination back in Mogadishu where it was found that the solid-state recorder was at fault. The unit was taken back to Britain for repair on 16/04/86 by the IH hydrologist.

The water level at the station, which had been 0.53m on the evening of 07/04/86, had risen to 0.88m by 10.00hrs on the morning of 08/04/86 when the team left.

13/04/86 : Audegle & Kurten Warey

The **Audegle** observer, Muridi Mukta Caliow, was paid three months of salary; 2120/=.

The joists, gauge plates and bolts installed by Gemmel on 19/03/81 were still solid but the welded on lugs to which the gauge plates were bolted were completely corroded. The 1-2m gauge plate had fallen off and had been removed to the observer's house. The gauge plates were repainted and fixed firmly to the joists by drilling and bolting the plates directly to the joists.

The 1-3m and 3-5m stands were renovated. The 0-1m stand originally installed in the river bed and the 5-6m plate bolted to the old bridge had both disappeared completely. As the river had almost stopped flowing and the water was still part way up the lower of the renovated stands it was erroneously assumed that this was a 0-2m stand and metre figures were painted on accordingly. The observer, unfortunately, only pointed this out during his next trip to Mogadishu. Readings are still being recorded using the original system and the meter figures on the staff gauges need to be reduced by 1m and repainted as soon as possible to prevent confusion.

Kurten Warey - Initially it had been thought that the automatic station would be attached to the downstream side of the barrage. It became evident, however, that this site was not hydraulically suitable and an alternative site, at the downstream end of the gabion mattress was chosen. This site was surveyed.

Assistance with the construction of the proposed new automatic recorder station was discussed with Mr Haji Ba'ad, site manager for the Kurten Warey Pilot Project of the

Settlement Development Agency (SDA). He said he could provide treated timber, a mobile welder and operator and skilled and unskilled labour provided he received a letter from the General Manager of the SDA (Mr Mursal) in Mogadishu.

14/04/86 : Jowhar & Mahaddey Weyn

The water level information which we wished to be radioed to Mogadishu on a regular, preferably daily, basis was explained to Mr Hajir, manager of the Jowhar Offstream Storage Reservoir. He was also given a radio data book from which the recorded data would be read to the radio operator in Mogadishu who would note it down in an identical book. In this way transcription errors should be kept to a minimum.

At **Mahaddey Weyn** we were told yet again that the observer was in Jowhar. At 12.00 hrs the water level was 0.86m on the staff gauge.

The joist of the 0-2m stand was very corroded and the 0-1m plate was also in very poor condition. The missing 1-2m plate was replaced by drilling and bolting an enamelled plate directly to the joist. The extensive corrosion of the joist means that this can only be considered a temporary measure and the whole 0-2m stand should be replaced next time the water levels are low enough.

In 1980 Gemmel reported an overlap between the 2-4m and 4-6m stands. This has subsequently been confirmed several times although estimates of the degree of overlap have varied. The stands were relevelled. The 0-2m and the 2-4m stands were found to be in agreement but the 4-6m stand was 84mm too low. The 4-6m plates were therefore removed and bolted 84mm further up the joist.

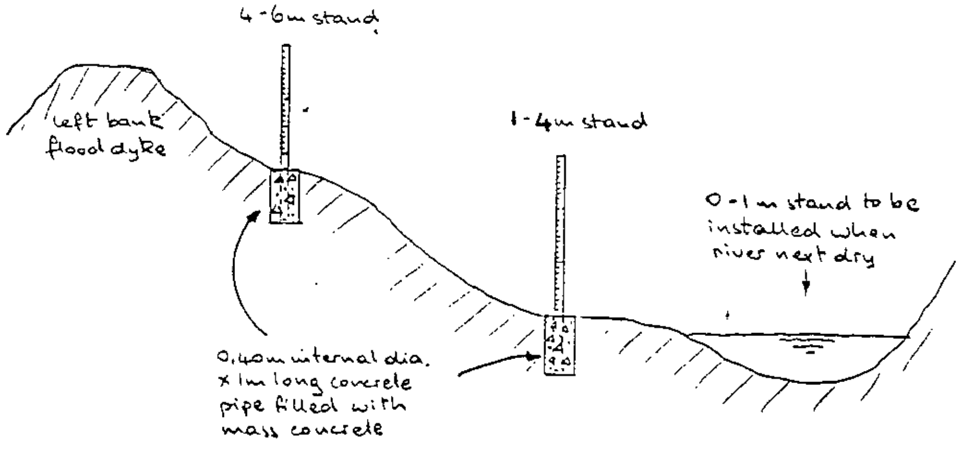
24/04/86 - 26/04/86 : Kurten Warey

From 19/04/86 to 23/04/86 attempts were made to organize assistance from the Settlement Development Agency with the construction of the proposed automatic recorder station at Kurten Warey. As no progress had been made by the time the Gu flood wave passed Afgoi on 23/04/86, it was decided that an attempt should be made to install at least a set of staff gauges at the proposed site before the arrival of the flood waters.

The acquisition and preparation of material was organized through a small construction company, SOMES (Societa Metalmeccanica Somala of via Mecca Mucarama). Gauge stands were fabricated by welding angle iron to two steel joists and were painted (blue) to reduce corrosion. Two 1m long x 0.4m internal diameter concrete pipe sections were purchased and the necessary quantities of cement, sand and aggregate bagged. Transport to the site was arranged through the kind co-operation of the United Nations High Commission for Refugees (UNHCR).

When the site was reached in the evening of 24/04/86 the river had started flowing but the level was still very low. The following morning the level had only risen slightly so local labour was recruited and work begun immediately on the installation of two stands covering the range 1m to 6m. A 0-1m stand should be installed in the lowest part of the river bed during the next dry season when the river has stopped flowing completely.

It had been intended that the stands be installed at the downstream end of the gabion mattress at the site proposed for the automatic station. However, because of the risk of damage to the revetement which would occur if the flood waters arrived before the gabions were reclosed, a site further downstream was chosen. The channel at this downstream site has changed since the construction of the revetement but it is hoped that it has now attained a new equilibrium. When the automatic station (with, presumably, new staff gauges) is finally installed, it is recommended that the proposed site at the downstream end of the revetment be used. After further consideration, it is thought that a free-standing structure accessibble by boat offers the most practical solution.



A 1-4m stand was installed in the river bed and a 4-6m stand part way up the left bank. The water level, which had risen only 0.1m during the day of 25/04/86 abruptly rose 1.7m at 07.00 hrs on the following morning with the arrival of the Gu flood waters. The level continued to rise at about 0.1m/hr throughout the day and a diver was required to release the ropes used to secure the stands while the concrete bases were setting. When the site was left at 14.00hrs the level on the staff gauge was 2.58m.

The MOA barrage attendant, Mr Ali Mohamed Haji, was trained as the staff gauge observer and given 3 weeks of specially prepared sheets for recording his readings. As nobody could speak English, considerable effort was required to train Mr Haji who had no understanding of decimal notation. He was, however, enthusiastic and will probably make a reliable observer after further training.

The installation of the staff gauges at Kurten Warey will provide useful data at this hydrologically important site just upstream of the Shebelli swamps. The staff gauge zero needs to be determined by levelling and discharge measurements undertaken so that a rating curve can be established. In the interim, theoretical estimations of steady state discharges through the barrage from upstream and downstream water levels and gate openings could provide the basis for a provisional rating.

It is considered most regrettable that none of the Hydrology Section staff were available to participate in the installation of the staff gauges at Kurten Warey as it would have provided useful training in the practical techniques required in hydrology fieldwork.

28/04/86 & 29/04/86 : AFMET, Afgoi

Staff of the Hydrology Section accepted an invitation to participate in a training programme covering the installation and operation of automatic weather stations. The training formed part of the Agricultural Extension & Farm Management Project (AFMET) and was undertaken by Dr Hill of Utah State University, USA. It involved the assembly and demonstration of an automatic weather station manufactured by Campbell Scientific Inc. (PO Box 551, Logan, Utah 84321, USA) and its subsequent installation at the MOA meteorological station on the Afgoi experimental farm.

Of particular interest to the Hydrology Section was the tipping bucket raingauge. In the system demonstrated, data is temporarily stored in a solid state memory before being transferred to a cassette. As the internal memory is very small and acts primarily as a buffer, the cassette unit is activated frequently. The cassettes must be collected and replaced regularly. The reliability of this system in the arduous Somalian conditions has yet to be proved. There are certainly more things that can go wrong with it than in the solid-state recorders used in the Hydrology Section's automatic water level stations.

Keith Stallard May 1986

APPENDIX 1.5

DISCHARGE MEASUREMENTS ON IRRIGATION CANALS IN THE JANAALE AREA

Somalia Hydrometry Project May 1986

Discharge Measurements on Irrigation Canals in the Janaale area

The Hydrology Section was asked to undertake discharge measurements on canals on the Janaale and Faraxaane irrigation projects. The objective of the exercise, which took place from 04/05/86 to 06/05/86, was to estimate the flows of water into the different project areas and to estimate seepage losses in the Dhamme Yassin canal. The information was required by TAMS, a US engineering firm who are studying the feasibility of rehabilitating the Janaale and Faraxaane projects.

Current meter

The Hydrology Section possesses 2 Braystoke BFM.001 current meters with associated counters, tailfins, sinker weights, etc. Unfortunately, the equipment was found to be in poor condition; the best electronic revolution counter worked erratically and all the meter impellers were damaged (replacements were ordered immediately from the UK).

In the field we were able to make do with the revolution counter but the faulty impeller must have revolved more slowly than it should have done, particularly at low water velocities. **The calculated discharges are therefore underestimates, perhaps by as much as 50% and this should be borne in mind when studying the results.**

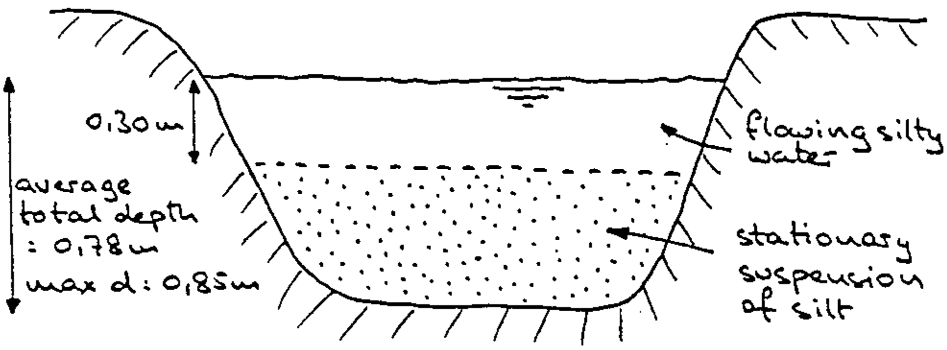
Results

The total discharges were calculated by computer using the Hydrology Section`s program GAGCAL (GAuGing CALculations) which uses the mean section method. The program first had to be modified so that it could accept results from the Braystoke BFM.001 current meter with the 475 series impellers.

Faraxaane Canal

This is the largest canal feeding the Faraxaane irrigated area. The water in the canal had an extremely high silt content (the Gu flood waters from Ethiopia had arrived at Corioli only 9 days previously).

Whilst taking the current meter readings (at 0.2 & 0.8 of the depth) it became obvious that the "water" in the canal was stratified; the lower part of the channel contained a stationary, thick, colloidal suspension of silt over the top of which a slightly less dense but still highly silt laden water was flowing.



When calculating the discharge, the lower fluid was ignored and the channel assumed to have an effective depth of 0.30m. The measurement points at 0.2 of the real depth correspond approximately to 0.6 of the effective depth and thus the velocities calculated for these points were assumed to represent the average velocities in the "effective" verticals.

The results are presented in listing 1. The total discharge was 0.13 cumecs.

The Fuquwow Canal

There are a number of small canals which feed water directly from the left bank of the Shebelli River into the Faraxaane Project. On 04/05/1986 only the 1m wide Fuquwow canal was flowing, its discharge was measured as 0.02 cumecs (listing 2).

Seepage losses from the Dhamme Yaasiin Canal

The Dhamme Yaasiin Canal is one of the two main canals leaving the left bank of the Shebelli River above the Janaale Barrage. It was built by the Italians in 1930. In an attempt to estimate the seepage losses, discharge measurements were taken at the upstream and downstream ends of a 2km reach containing no outlets.

The depth of flow in the canal required the measurements to be taken from a boat which was pulled across the section using a rope anchored on each bank. Floating foliage near the banks sometimes caused an inversion of the vertical velocity profile with low velocities near the surface but greater velocities at depth.

Upon arrival at the downstream site (just upstream of the Fratelli Bassi offtake) it was noticed that the water level had dropped several decimetres since the previous day. After completing the measurement at the upstream end of the reach (just downstream of the Aba Nur outlet), a visit was made to the river intake at the Janaale barrage. Here we learnt that the District Commissioner had ordered the closing of the inlet sluices because of flooding at the downstream end of the canal and, indeed, the shutting of the sluices was just being completed when we arrived.

The resulting "unsteady" flow in the canal is reflected in the results (listings 3 & 4) where the upstream discharge of 0.62 cumecs is seen to be less than the 0.97 cumecs measured at the downstream site two hours previously. The results can thus not be used directly to estimate seepage losses.

Flow leaving the project area

In an attempt to get some useful information from the day's work it was decided to measure the flow at the point where the canal leaves the project area. Being almost 12km downstream of the river intake it was hoped that the effect of shutting the sluices would not yet have reached that point. Unfortunately they must have begun closing the sluices earlier than we had thought as, at our arrival, the water level had already dropped some 0.54m below the operating level of the previous day.

A discharge measurement was, nevertheless, made and the results (listing 5) show a flow of 0.81 cumecs.

During the hour when the measurements were being taken the water level did not vary; the flow was therefore "steady". Assuming that the flow was also approximately "uniform" (*), it can be described by the generalized, steady uniform flow equation:

$$Q = KS^{Y}$$

(*) see footnote on p4 for definition of uniform flow

where Q = discharge
K = the **conveyance** of the channel
S = slope of the energy line
(= surface slope = bed slope)
y = an exponent (usually 0.5)

It is seen that, when uniform flow conditions prevail, the conveyance is a direct measure of the carrying capacity of the channel and that the discharge is directly proportional to the conveyance (since, by definition, S is equal to the bed slope and cannot vary).

If we use the Manning formula as the uniform flow equation,

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

then the conveyance is expressed as,

$$K = \frac{1}{n} A R^{2/3}$$

where n = Manning's roughness coefficient
A = the wetted area
R = the hydraulic radius (= A/(wetted perimeter))

Assuming that Manning's n remains constant, the ratio of the conveyance, K(4) of the Dhamme Yassin Canal at operational flow level (as on previous day, 04/05/86) to the conveyance, K(5) at the time of measurement (on 05/05/86) can be calculated from the geometry of the channel (see table and channel cross-section in Figure 1).

$$K(4)/K(5) = (12.97/n)/(5.84/n) = 2.22$$

As the discharge is directly proportional to the conveyance, the flow on 04/05/86 can be estimated as,

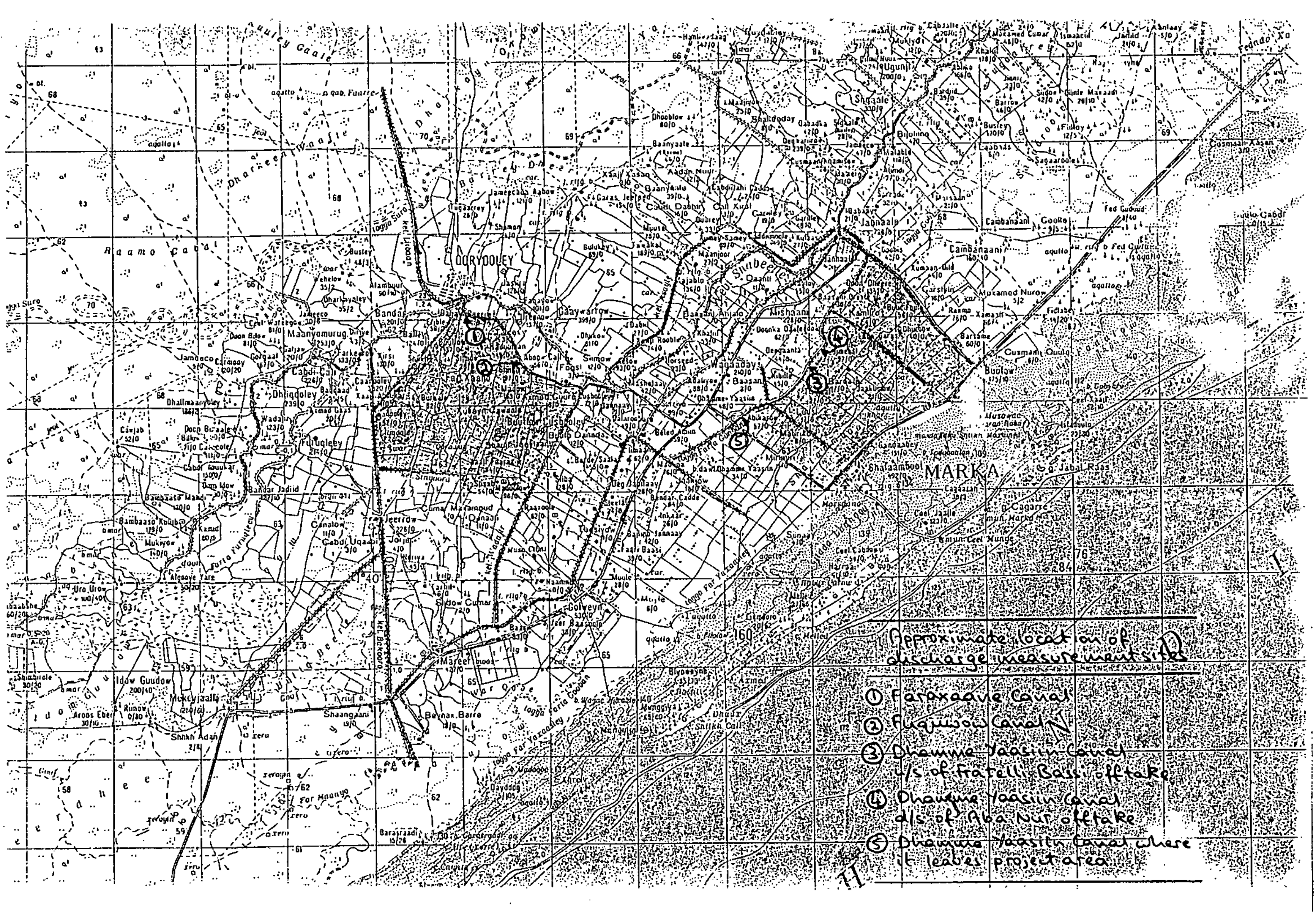
$$Q(4) = Q(5) \times K(4)/K(5) = 0.81 \times 2.22 = 1.80 \text{ cumecs}$$

(*)
By definition "uniform" flow has the following main features:
- the depth, wetted area, velocity and discharge at every section of the channel reach are constant;
- the energy line, water surface and channel bed are all parallel; that is their slopes are equal, or
  Sf = Sw = So = S

Thus the flow leaving the project area in the Dhamme Yaasiin Canal flowing under operating conditions with all offtakes closed is estimated as 1.8 cumecs.

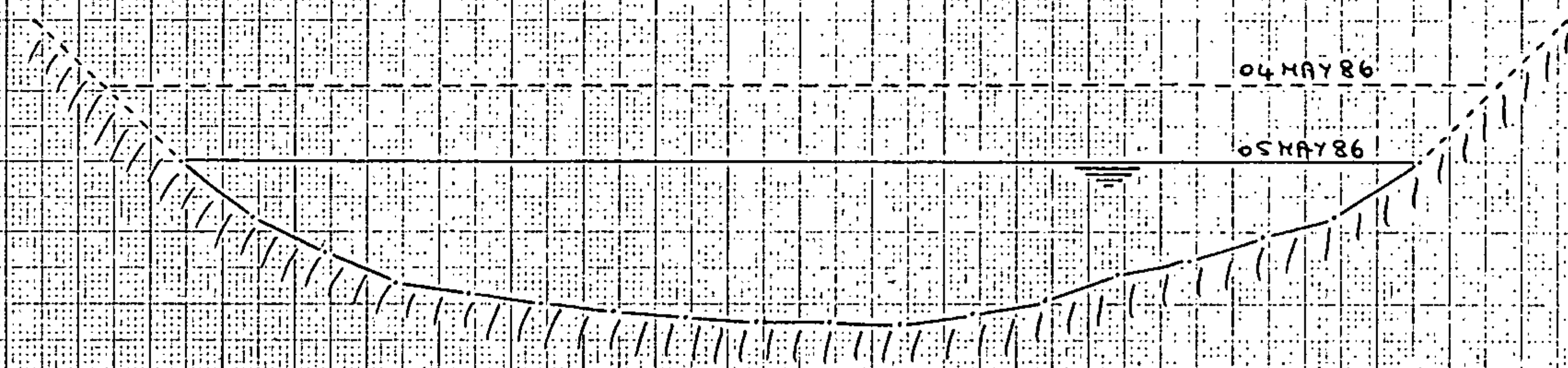
NB. When studying the results presented in this report it must always be borne in mind that, for the reasons given on page 1, the flows are probably underestimated.

Keith Stallard 16/05/86


Approximate location of discharge measurement sites
① Faraxaane Canal
② Fuquwow Canal N
③ Dhamme Yaasiin Canal u/s of Fratelli Bassi offtake
④ Dhamme Yaasiin Canal d/s of Aba Nur offtake
⑤ Dhamme Yaasiin Canal where it leaves project area
MARKA
QORYOOLEY
kel. Bakooro
kel. Liibaan

SHALAMBOOT DHAMME YAASIIN CANAL DOWNSTREAM OF ZOBBE'S INTAKE

Scale 1:50



date		05 MAY 86	04 MAY 86
surface width	b (m)	8.60	9.68
max depth	d (m)	1.14	1.68
wetted perimeter	p (m)	9.00	10.41
wetted area	A (m^2)	6.94	11.88
hydraulic radius	$R = A/p$ (m)	0.77	1.14
conveyance	$k = \frac{1}{n} A R^{2/3}$	$\frac{5.84}{n}$	$\frac{12.97}{n}$

KEITH STALLARD 06 MAY 86

LISTING 1

CURRENT METER FLOW GAUGING RESULTS

STATION : Faraxaane Canal
LOCATION : d/s of road bridge below intake
GAUGED BY : K Stallard & R A Sopariwala
DATE : 04/05/1986
METER : Braystoke Model BFM.001 with series 475 prop
METHOD : Wading
ORIGIN : Right Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.6 of depth below water surface

		START	FINISH
TIME	:	16.00	17.00
STAGE	:	0.00	0.00

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	0.000	0.000	0	0.00000			
					0.07971	0.07500	0.00598
2	0.500	0.300	21	0.11956			
					0.12226	0.15000	0.01834
3	1.000	0.300	22	0.12496			
					0.12226	0.15000	0.01834
4	1.500	0.300	21	0.11956			
					0.13035	0.15000	0.01955
5	2.000	0.300	25	0.14115			
					0.13305	0.15000	0.01996
6	2.500	0.300	22	0.12496			
					0.10606	0.15000	0.01591
7	3.000	0.300	15	0.08717			
					0.08717	0.15000	0.01308
8	3.500	0.300	15	0.08717			
					0.08447	0.15000	0.01267
9	4.000	0.300	14	0.08177			
					0.05452	0.07500	0.00409
10	4.500	0.000	0	0.00000			

TOTAL DISCHARGE (CUMECS)	=	0.12791
TOTAL AREA (SQ. M.)	=	1.20000
MEAN VELOCITY (M/SEC)	=	0.10659

LISTING 2

CURRENT METER FLOW GAUGING RESULTS

STATION : Fuquwow Canal
LOCATION : u/s Coridli road culvert
GAUGED BY : K Stallard & R A Sopariwala
DATE : 04/05/1986
METER : Braystoke Model BFM.001 with series 475 prop
METHOD : Wading
ORIGIN : Right Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.6 of depth below water surface

		START	FINISH
TIME	:	17.30	17.40
STAGE	:	0.00	0.00

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	0.000	0.000	0	0.00000			
					0.04098	0.01500	0.00061
2	0.100	0.300	10	0.06146			
					0.07971	0.12600	0.01004
3	0.500	0.330	17	0.09797			
					0.07971	0.12600	0.01004
4	0.900	0.300	10	0.06146			
					0.04098	0.01500	0.00061
5	1.000	0.000	0	0.00000			

TOTAL DISCHARGE (CUMECS)	=	0.02132
TOTAL AREA (SQ. M.)	=	0.28200
MEAN VELOCITY (M/SEC)	=	0.07559

LISTING 3

CURRENT METER FLOW GAUGING RESULTS

```
STATION     :  Dhamme Yaasiin Canal
LOCATION    :  u/s of Fratelli Bassi outlet
GAUGED BY   :  K Stallard & R A Sopariwala
DATE        :  05/05/1986
METER       :  Braystoke Model BFM.001 with series 475 prop
METHOD      :  Boat
ORIGIN      :  Right Bank
```

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	10.00	11.00
STAGE	:	0.00	0.00

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	1.400	0.000	0	0.00000			
			0	0.00000	0.01068	0.12750	0.00136
2	1.900	0.510	4	0.03202			
			0	0.00000	0.05706	0.31750	0.01812
3	2.400	0.760	12	0.07127			
			22	0.12496	0.18036	0.43750	0.07891
4	2.900	0.990	67	0.36787			
			28	0.15734	0.30714	0.53750	0.16509
5	3.400	1.160	79	0.43264			
			49	0.27070	0.36112	0.59500	0.21487
6	3.900	1.220	83	0.45423			
			52	0.28690	0.36517	0.49600	0.18112
7	4.300	1.260	74	0.40565			
			57	0.31389	0.31389	0.59750	0.18755
8	4.800	1.130	61	0.33548			
			36	0.20053	0.18703	0.53250	0.09960
9	5.300	1.000	18	0.10336			
			19	0.10876	0.05303	0.45250	0.02400
10	5.800	0.810	0	0.00000			
			0	0.00000	0.00000	0.35250	0.00000
11	6.300	0.600	0	0.00000			
			0	0.00000	0.00000	0.24000	0.00000
12	7.100	0.000	0	0.00000			
			0	0.00000			

```
TOTAL DISCHARGE (CUMECS) =    0.97060
TOTAL AREA (SQ. M.)      =    4.68600
MEAN VELOCITY (M/SEC)    =    0.20713
```

LISTING 4

CURRENT METER FLOW GAUGING RESULTS

STATION : Dhamme Yaasiin Canal
LOCATION : d/s of Aba Nur outlet
GAUGED BY : K Stallard & R A Sopariwala
DATE : 05/05/1986
METER : Braystoke Model BFM.001 with series 475 prop
METHOD : Boat
ORIGIN : Right Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	12.00	13.00
STAGE	:	0.00	0.00

VERT NO	TAPE DIST M.	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	1.000	0.000	0	0.00000			
			0	0.00000	0.00000	0.21500	0.00000
2	1.500	0.860	0	0.00000			
			0	0.00000	0.04256	0.42500	0.01809
3	2.000	0.840	19	0.10876			
			10	0.06146	0.13337	0.46000	0.06135
4	2.500	1.000	43	0.23831			
			22	0.12496	0.19918	0.53000	0.10556
5	3.000	1.120	53	0.29229			
			25	0.14115	0.24236	0.54250	0.13148
6	3.500	1.050	70	0.38406			
			27	0.15195	0.22772	0.50250	0.11443
7	4.000	0.960	56	0.30849			
			11	0.06637	0.21287	0.48250	0.10271
8	4.500	0.970	48	0.26530			
			38	0.21132	0.17604	0.24250	0.04269
9	5.000	0.000	41	0.22752			
			0	0.00000	0.10721	0.20750	0.02225
10	5.500	0.830	22	0.12496			
			13	0.07637	0.05033	0.36500	0.01837
11	6.000	0.630	0	0.00000			
			0	0.00000	0.00000	0.25200	0.00000
12	6.800	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS)	=	0.61693
TOTAL AREA (SQ. M.)	=	4.22450
MEAN VELOCITY (M/SEC)	=	0.14604

LISTING 5

CURRENT METER FLOW GAUGING RESULTS

STATION : Dhamme Yaasiin Canal
LOCATION : d/s of Zubbe's intake
GAUGED BY : K Stallard & R A Sopariwala
DATE : 05/05/1986
METER : Braystoke Model BFM.001 with series 475 prop
METHOD : Boat
ORIGIN : Right Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	17.00	18.00
STAGE	:	0.00	0.00

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M.	DISCHARGE CUMECS
1	1.700	0.000	0	0.00000			
			0	0.00000	0.00577	0.10000	0.00058
2	2.200	0.400	1	0.01731			
			0	0.00000	0.00433	0.26250	0.00114
3	2.700	0.650	0	0.00000			
			0	0.00000	0.00000	0.37750	0.00000
4	3.200	0.860	0	0.00000			
			0	0.00000	0.00555	0.44750	0.00248
5	3.700	0.930	2	0.02221			
			0	0.00000	0.00555	0.48250	0.00268
6	4.200	1.000	0	0.00000			
			0	0.00000	0.02828	0.51250	0.01449
7	4.700	1.050	9	0.05655			
			9	0.05655	0.09480	0.53750	0.05096
8	5.200	1.100	32	0.17894			
			15	0.08717	0.18298	0.55750	0.10201
9	5.700	1.130	36	0.20053			
			48	0.26530	0.20458	0.56500	0.11559
10	6.200	1.130	15	0.08717			
			48	0.26530	0.21132	0.56750	0.11993
11	6.700	1.140	47	0.25991			
			42	0.23292	0.24236	0.55250	0.13391
12	7.200	1.070	54	0.29769			
			32	0.17894	0.24776	0.51250	0.12698
13	7.700	0.980	54	0.29769			
			39	0.21672	0.20728	0.44500	0.09224
14	8.200	0.800	34	0.18973			
			22	0.12496	0.09911	0.37500	0.03717
15	8.700	0.700	14	0.08177			
			0	0.00000	0.02044	0.31000	0.00634
16	9.200	0.540	0	0.00000			
			0	0.00000	0.00000	0.23500	0.00000
17	9.700	0.400	0	0.00000			
			0	0.00000	0.00000	0.12000	0.00000
18	10.300	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS)	=	0.80648
TOTAL AREA (SQ. M.)	=	6.96000
MEAN VELOCITY (M/SEC)	=	0.11587

APPENDIX I.6

BARDHEERE HYDROMETRIC STATION - CABLEWAY DISCHARGE MEASUREMENTS AND RATING CURVE DEVELOPMENT

Somalia Hydrometry Project May 1986

Bardheere Hydrometric Station
Cableway Discharge Measurements and Rating Curve Development

This note covers the acquisition, processing and use of the discharge measurement data obtained from the Ministry of Jubba Valley Development's (MJVD) cableway at Bardheere. The cableway was installed by J J Tomlinson of the Italian engineering consultancy ELC-Electroconsult during July 1985 as part of the MJVD's "Bardheere Dam Project" (BDP).

The cableway and associated equipment

The cableway is situated approximately 100m downstream of the Ministry of Agriculture's (MOA) staff gauges and automatic stage recorder (installation completed March 1986) which are fixed to the upstream side of the Bardheere Bridge. As explained in Tomlinson's "Mission Report" to the BDP , he also installed a pneumatic stage recorder in the cableway winding gear cabin and an inclined river gauge.

The pneumatic stage recorder is a sophisticated piece of equipment and has apparently never operated correctly (ref: "Lugh and Bardheere Field Trip 25/02/86 to 04/03/86" by Keith Stallard, Hydrology Section, MOA). Furthermore, but fortunately, the cableway operating staff do not use the inclined river gauge but use the MOA's staff gauges to determine the river level when undertaking discharge measurements.

The cableway is used to suspend a SIAP 4002 no. 601036 current meter and counterweight. The current meter was provided with 2 impellers; a type 7404 and a type 7405. The observers unfortunately omit to note the impeller used for discharge measurements on the result sheets but the results indicate that, up until now, they have always used the type 7404 impeller.

Observers and results

During Tomlinson's visit a supervisor (Mohamoud Sheikh Abdi Salaam) and an operator (Abdi Muhamed Suleiman) were recruited and trained in the operation of the cableway, etc. They were instructed to undertake discharge measurements whenever the river level changes appreciably. Upon receipt of a satisfactory result sheet, the BDP pay each observer 400/=.

Since Tomlinson's departure, the observers have returned 26 result sheets corresponding to discharge measurements undertaken during the period 27/07/85 to 18/03/86 (Annex 1).

Copies of the result sheets are taken by the MOA's Hydrology Section who calculate the total discharges by a modified mean-section method using the computer program GAGCAL (GAuGing CALculation) and return copies of the output listings to the BDP.

Control measurement of 18/03/86

To see whether the gauging equipment was being used correctly and to serve as a training exercise for MOA Hydrology Section staff, a joint discharge measurement was carried out on 18/03/86. The exercise was led by the MJVD operator, Abdi Suleiman, assisted by the MOA's Zakia Abdisalaam Alin, Anab Mohamed Ahmed and Keith Stallard (Sir M MacDonald & Partners' hydrologist on the ODA Hydrometry Project).

Following the standard practice established by Tomlinson, the water velocity was measured at 0.2 and 0.8 of the depth at verticals spaced at 6m intervals across the width of the river.

The MJVD operator used the equipment confidently and efficiently although, on his own, he was unable to repair one of the distance counters which became disconnected during the measurement.

Back in Mogadishu the MOA staff calculated the total discharge by hand using the mid-section method for which the BDP result sheets are prepared. This indicated a river discharge of 13.2 m3/s. The results were then processed by the program GAGCAL which gave a river discharge of 12.8 m3/s (listing 26, Annex 1).

The slight difference between the two results reflects the different ways that the two methods divide the river cross-section into vertical strips and estimate the mean velocity for each strip. The method used in the program GAGCAL is mathematically slightly more rigorous than the mid section method. In the Hydrology Section all discharge measurement data are processed using the program GAGCAL.

Missing staff gauge

The 0-1m section of the MOA's staff gauge was broken off by floating debris on 11/12/85. It was replaced temporarily on 03/03/86 by strapping a spare MJVD gauge plate to one of the bridge piers. Two weeks later, a permanent 0-1m plate was incorporated in the structure built to support the bottom section of the stilling well used with the MOA's automatic stage recorder.

During the 12 week period when the gauge plate was missing the MJVD observers continued to undertake discharge measurements (DMs). Unfortunately, all 6 such DMs were taken with river levels between 0-1m so the corresponding stages are missing.

On 19/03/86, in an attempt to recuperate the useful information represented by these gaugings, the bottom of the river bed was sounded at the positions used for each of the verticals during the 6 discharge measurements. The difference between the depths at each vertical on the day of measurement and on 19/03/86 were calculated. If, for a particular DM, these differences were reasonably constant across the section then an average was taken and an estimate of the water level on the day of measurement made by reference to the staff gauge reading of 0.20m on the 19/03/86.

In this way 4 out of the 6 DMs were recovered (numbers 72 to 75 in the discharge measurement table). For the gaugings taken on 06/02/86 and on 12/02/86, however, the form of the bed on the day of measurement was considered to differ too much from that on the 19/03/86 for a reliable estimation of the water level to be made.

GAGCAL calculations

All the discharge measurements in Tomlinson's Mission Report, with the exception of his wading measurement on 31/03/85, were re-calculated using the program GAGCAL (Annex 1, listings A-E). Despite appearing reasonable, the measurement of 18/07/86 was rejected following Tomlinson's advice. The 24 usable DMs undertaken since Tomlinson's departure by the MJVD observers were similarly calculated. (The output listings from program GAGCAL are included in Annex 1. They are numbered 1-26 according to the numbers on the original gauging sheets. Numbers 22 & 23 are missing as they correspond to the DMs of 06/02/86 & 12/02/86 for which it was not possible to establish the water level.) All the results were added to the table of Bardheere discharge measurements stored on the dedicated hydrological database (HDB) on the Hydrology Section's micro-computer (see Table 1). The new data were initially assigned the rating letter B to separate them from existing 47 DMs taken since 1963 and used for developing the existing rating curve (A).

Verification

The new DMs were first checked visually using the HDB plotting facilities. Fig 1 shows that the data are consistent among themselves and form a good curve. The data were then compared graphically with the existing data by using different colours for each rating. The cableway data were seen to be consistent with the existing data (Fig 2) and were therefore incorporated in the original data set used for developing rating A. The DMs making up the original data set were also re-examined. This lead to the dubious result of 02/11/64 being rejected whereas the previously unused DMs of 25/05/80, 10/12/84 & 21/05/85 were added resulting in a rating A data set of 71 DMs (see Table 1).

Development of the Rating Equation

A number of single-segment and multi-segment curves were fitted to the data set using the HDB curve fitting facilities. Multi-segment curves could not be said to provide a better fit to the data which still lacks values for higher discharges and the single-segment curve shown in Figs 3 & 4 was adopted as the new rating. The equation to this curve is:

$$Q = 47.204 \times (h + 0.379)^{1.897}$$

Flow Conversion

The new rating equation was used to reconvert the entire record (1963-86) of river stages at Bardheere to daily mean flows. These data are particularly relevant to current studies related to the Bardheere Dam project and will therefore shortly be published in the form of a separate data book, "Annual Summaries of Daily Flow of the Jubba River at Bardheere (1963-85)".

Conclusions

The BDP operators and the new cableway equipment at Bardheere are currently producing good quality discharge measurement data which have already been used to improve the rating curve for the MOA gauging station. In the future the cableway should provide reliable measurements of high gu season flows which are required to strengthen the upper part of the rating curve.

With the recent installation of an automatic water level recorder, the Bardheere station should, in the future, provide top quality flow data over the whole range of flows.

Keith Stallard May 1986

Table 1 Bardheere Discharge Measurement Table

Discharge measurements for station 2 : Jubba at Bardheere

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot
1	29 May 1963	A	2.180	0.776	384.79	298.600	-0.09/A	<-
2	20 Jun 1963	A	1.670	0.580	312.53	181.270	0.02/A	-
3	4 Jul 1963	A	1.520	0.598	314.82	188.260	-0.17/A	<<-
4	4 Sep 1963	A	1.880	0.782	253.80	198.470	0.13/A	->>
5	19 Oct 1963	?	2.100	0.707	248.19	175.470	0.48/A	->>>>
6	20 Nov 1963	A	2.200	1.052	247.31	260.170	0.12/A	->
7	10 Dec 1963	A	2.440	1.067	299.85	319.940	0.08/A	->
8	26 Dec 1963	A	1.680	0.643	245.38	157.780	0.17/A	->>
9	17 Jan 1964	A	1.130	0.455	206.90	94.140	0.07/A	->
10	1 Feb 1964	A	0.770	0.309	200.16	61.850	-0.00/A	-
11	11 Mar 1964	A	0.280	0.198	154.55	30.600	-0.14/A	<<-
12	29 Mar 1964	A	0.130	0.079	133.80	10.570	0.05/A	->
13	19 May 1964	A	1.920	0.783	246.91	193.330	0.20/A	->>
14	1 Aug 1964	A	1.250	0.600	172.88	103.730	0.11/A	->
15	2 Nov 1964	?	2.860	0.992	315.01	312.490	0.53/A	->>>>
16	18 Mar 1965	A	0.210	0.116	120.60	13.990	0.06/A	->
17	14 Dec 1965	A	1.430	0.522	282.09	147.250	-0.01/A	-
18	8 Jun 1967	A	1.180	0.607	237.22	143.990	-0.24/A	<<<-
19	5 Oct 1969	A	1.690	0.715	267.43	191.210	-0.02/A	<-
20	5 Oct 1969	A	1.660	0.865	270.52	234.000	-0.29/A	<<<-
21	10 Jan 1970	A	0.190	0.320	144.81	46.340	-0.42/A	<<<<-
22	29 Jun 1971	A	1.430	0.448	290.78	130.270	0.10/A	->
23	20 Mar 1972	A	0.370	0.207	208.74	43.210	-0.21/A	<<-
24	22 Mar 1980	A	-0.099	0.165	26.12	4.310	-0.00/A	-
25	30 Apr 1980	A	0.570	0.278	176.87	49.170	-0.07/A	<-
26	24 May 1980	A	1.500	0.484	339.79	164.460	-0.05/A	<-
27	25 May 1980	A	1.480	0.478	335.82	160.520	-0.05/A	<-
28	3 Jun 1980	A	0.900	0.287	264.29	75.850	-0.01/A	-
29	8 Jul 1980	A	1.400	0.545	295.65	161.130	-0.13/A	<<-
30	17 Aug 1980	A	1.270	0.577	249.57	144.000	-0.15/A	<<-
31	10 Oct 1980	A	1.710	0.809	304.77	246.560	-0.30/A	<<<-
32	29 Oct 1980	A	1.250	0.606	224.16	135.840	-0.12/A	<-
33	16 Dec 1980	A	0.510	0.251	149.88	37.620	0.00/A	-

Table 1 (contd.)

Discharge measurements for station 2 : Jubba at Bardheere

Order Number	Date	Rating	Stage (m)	Velocity (m/s)	Area (sq m)	Discharge (cumecs)	--- Comparison --- Diff./Rat.	Plot	
34	25 Feb 1981	A	-0.189	0.186	11.45	2.130	-0.01/A	-	
35	11 Jun 1981	?	1.670	0.303	367.79	111.440	0.48/A	->>>>	
36	13 Jun 1981	?	1.590	0.318	341.45	108.580	0.42/A	->>>>	
37	18 Aug 1981	A	1.930	0.514	412.55	212.050	0.10/A	->	
38	19 Aug 1981	A	1.660	0.427	455.62	194.550	-0.07/A	<-	
39	28 Sep 1981	A	3.350	1.018	469.72	478.170	0.34/A	->>>>	
40	29 Sep 1981	A	2.950	1.053	440.53	463.880	-0.01/A	-	
41	15 Nov 1981	A	1.700	0.613	361.97	221.890	-0.18/A	<<-	
42	16 Nov 1981	A	1.560	0.598	350.42	209.550	-0.26/A	<<<-	
43	31 Dec 1981	A	0.650	0.119	212.27	25.260	0.31/A	->>>	
44	24 Jan 1982	A	0.450	0.479	60.00	28.740	0.06/A	->	
45	12 Mar 1984	?	0.290	0.263	40.95	10.770	0.21/A	->>	
46	10 Dec 1984	A	0.780	0.225	225.20	50.670	0.12/A	->>	
47	31 Mar 1985	A	0.360	0.353	58.36	20.600	0.09/A	->	Tomlinson wading
48	21 May 1985	A	3.750	0.930	721.23	670.740	0.08/A	->	
49	21 Jul 1985	A	1.780	0.635	329.02	208.930	-0.03/A	<-	Discharge measurements undertaken using MJVD cableway
50	23 Jul 1985	A	1.860	0.604	370.89	224.020	-0.03/A	<-	
51	27 Jul 1985	A	2.100	0.692	357.10	247.110	0.09/A	->	
52	30 Jul 1985	A	1.770	0.630	334.95	211.020	-0.05/A	<-	
53	31 Jul 1985	A	1.770	0.600	342.18	205.310	-0.02/A	<-	
54	4 Aug 1985	A	2.380	0.801	391.95	313.950	0.04/A	->	
55	10 Aug 1985	A	2.070	0.734	354.60	260.280	-0.01/A	-	
56	14 Aug 1985	A	2.590	0.821	443.13	363.810	0.03/A	->	
57	19 Aug 1985	A	2.400	0.713	414.45	295.500	0.15/A	->>	
58	31 Aug 1985	A	1.950	0.647	335.22	216.890	0.09/A	->	
59	5 Sep 1985	A	1.760	0.620	307.85	190.870	0.05/A	->	
60	12 Sep 1985	A	1.500	0.529	284.42	150.460	0.04/A	->	
61	26 Sep 1985	A	1.670	0.608	302.19	183.730	0.00/A	-	
62	30 Sep 1985	A	2.000	0.734	328.45	241.080	0.02/A	-	
63	6 Oct 1985	A	2.160	0.781	348.89	272.480	0.02/A	-	
64	12 Oct 1985	A	2.080	0.841	332.44	279.580	-0.10/A	<-	
65	20 Oct 1985	A	2.660	0.916	404.12	370.170	0.08/A	->	
66	26 Oct 1985	A	2.230	0.817	345.35	282.150	0.04/A	->	
67	1 Nov 1985	A	1.730	0.646	299.98	193.790	0.00/A	-	
68	9 Nov 1985	A	1.870	0.724	311.78	225.730	-0.03/A	<-	
69	18 Nov 1985	A	1.550	0.647	260.97	168.850	-0.03/A	<-	
70	26 Nov 1985	A	1.380	0.623	234.21	145.910	-0.05/A	<-	
71	7 Dec 1985	A	1.060	0.486	190.76	92.710	0.01/A	-	
72	23 Jan 1986	A	0.300	0.163	123.74	20.170	0.04/A	->	
73	30 Jan 1986	A	0.210	0.155	115.87	17.960	-0.01/A	-	
74	18 Feb 1986	A	0.120	0.088	105.57	9.290	0.07/A	->	
75	24 Feb 1986	A	0.090	0.078	103.21	8.050	0.08/A	->	
76	18 Mar 1986	A	0.200	0.113	113.19	12.790	0.08/A	->	

Total number of gaugings available = 76

Note : A comparison is made if a rating exists for the date of the discharge measurement (dm) and the stage of the dm is within the rating range.

Diff. = Difference in metres between dm and rating
Rat. = Rating used in comparison
Plot = Plot of Diff. to help determine shift point

---ih

Figure 1

Jubba at Barheere
MJUD Cableway Discharge Measurements

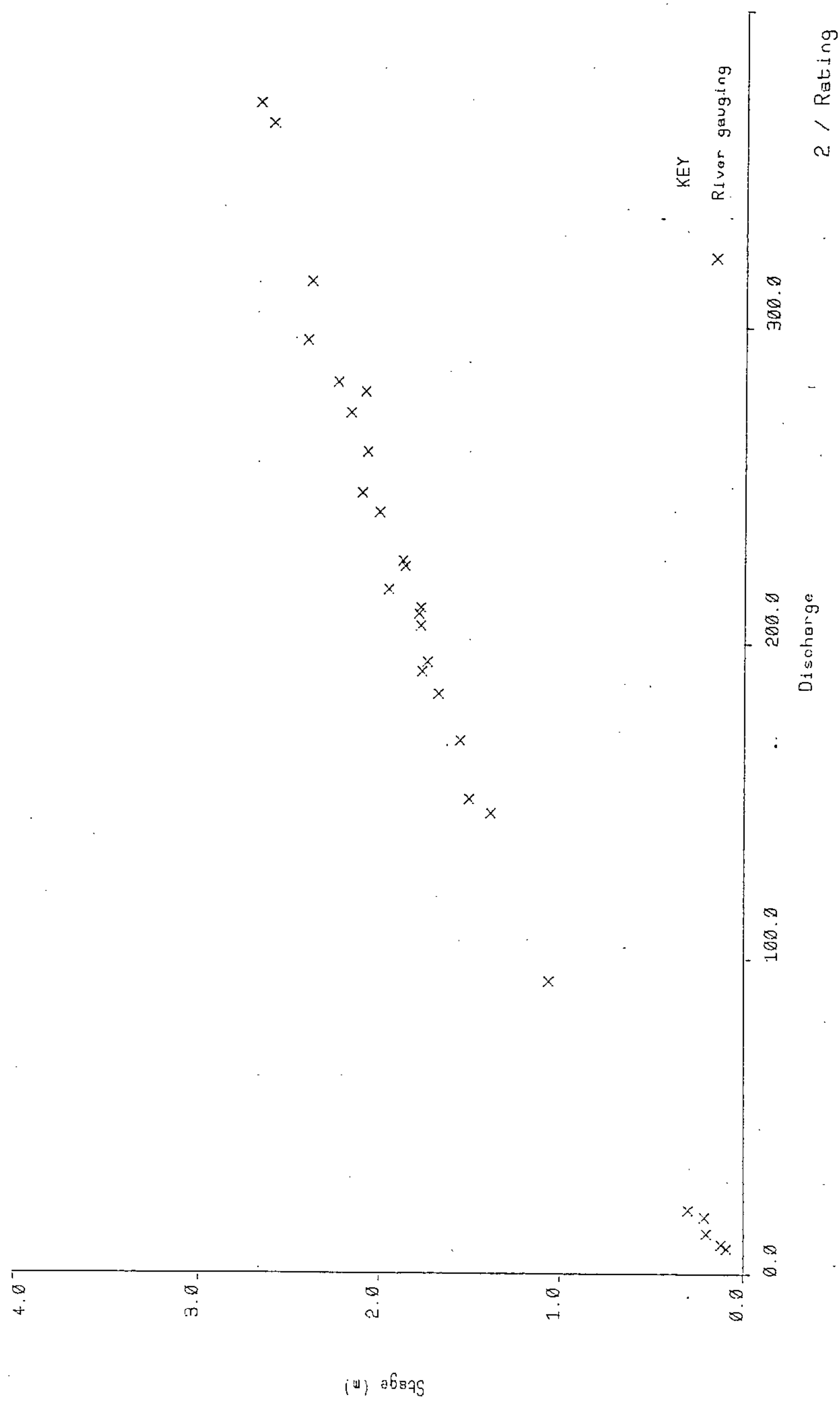


Figure 2

Jubba at Bardheere
Discharge Measurements May 1963 – March 1986

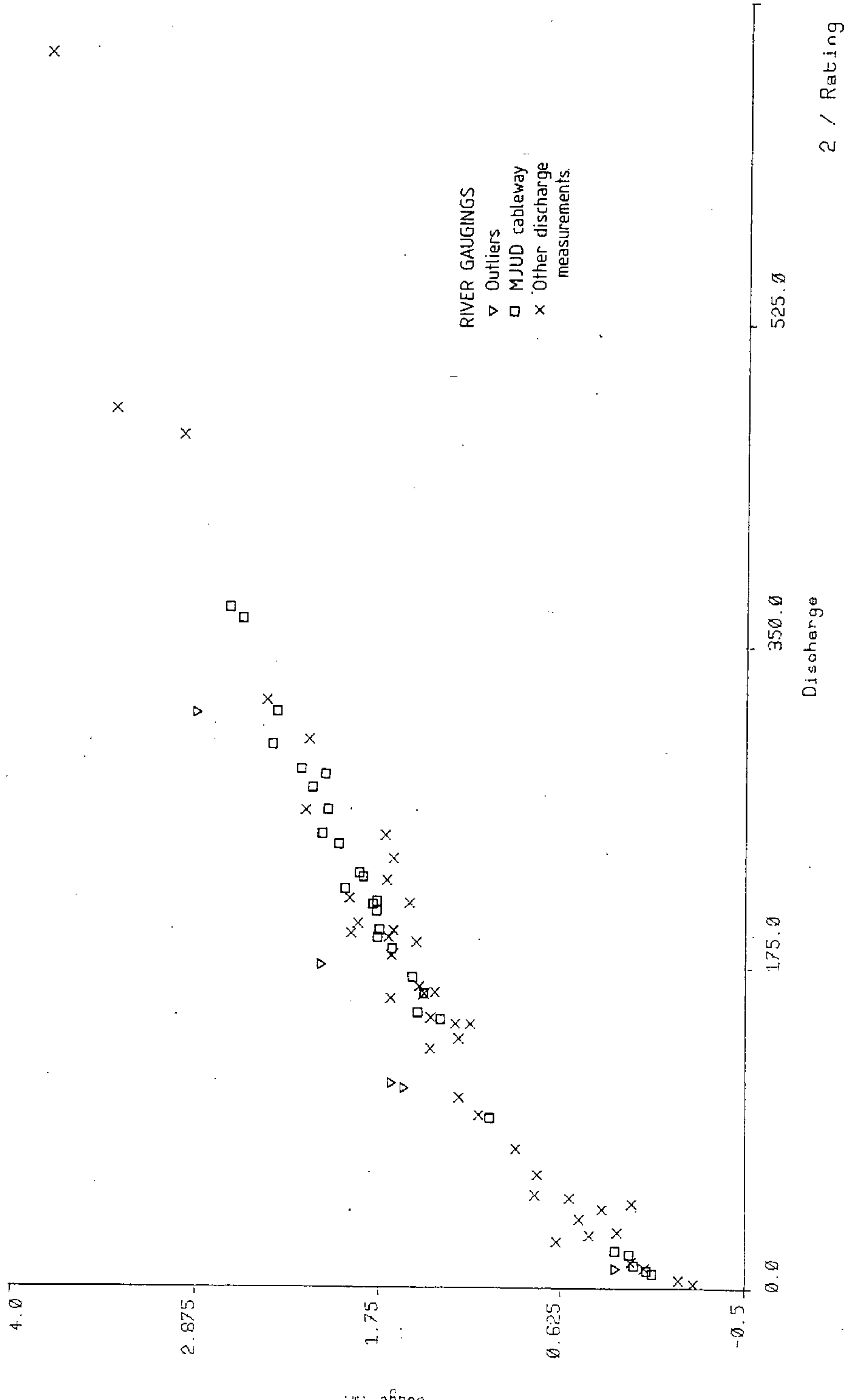


Figure 3

Jubba at Bardheere, Rating Curve – May 1986

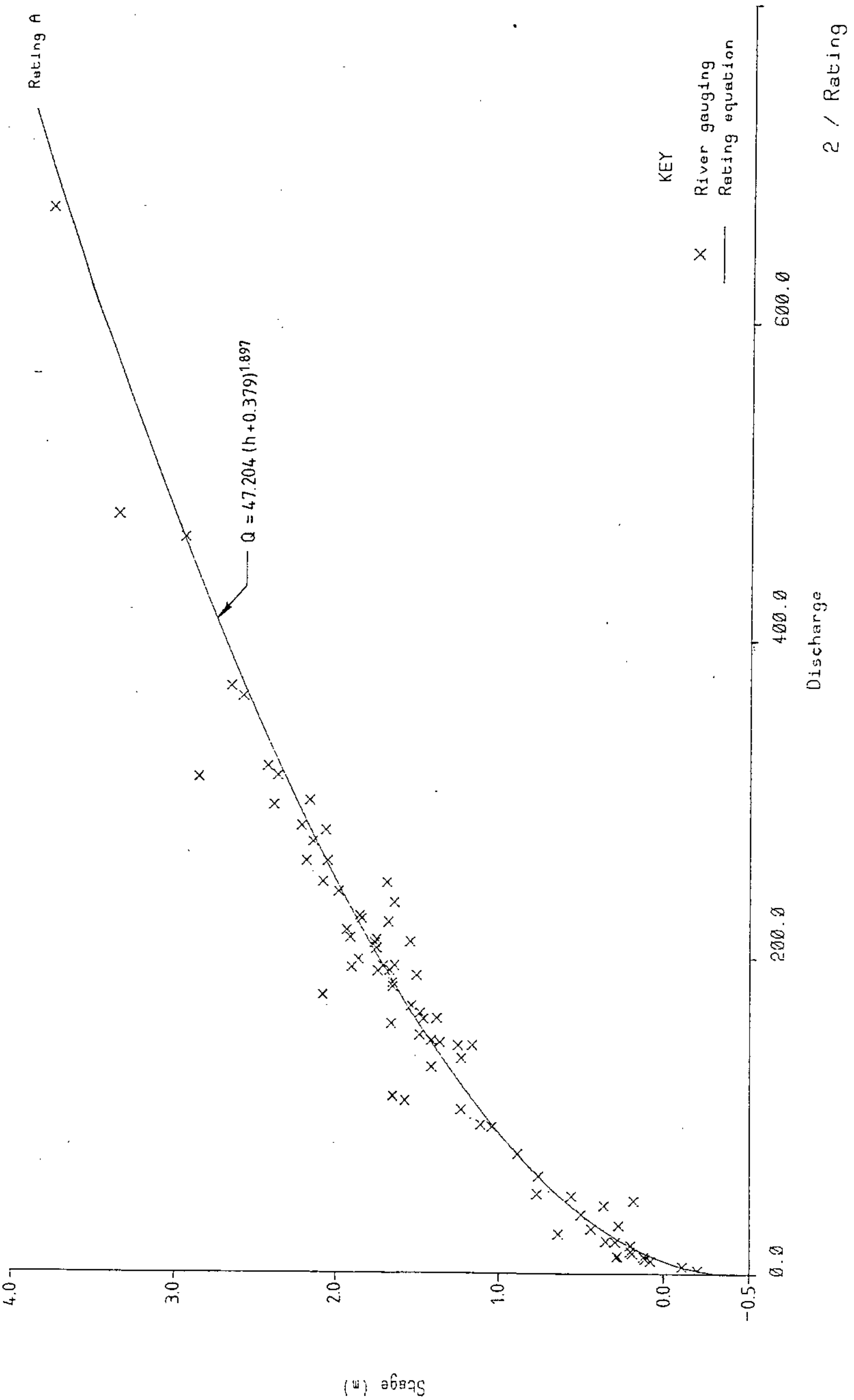
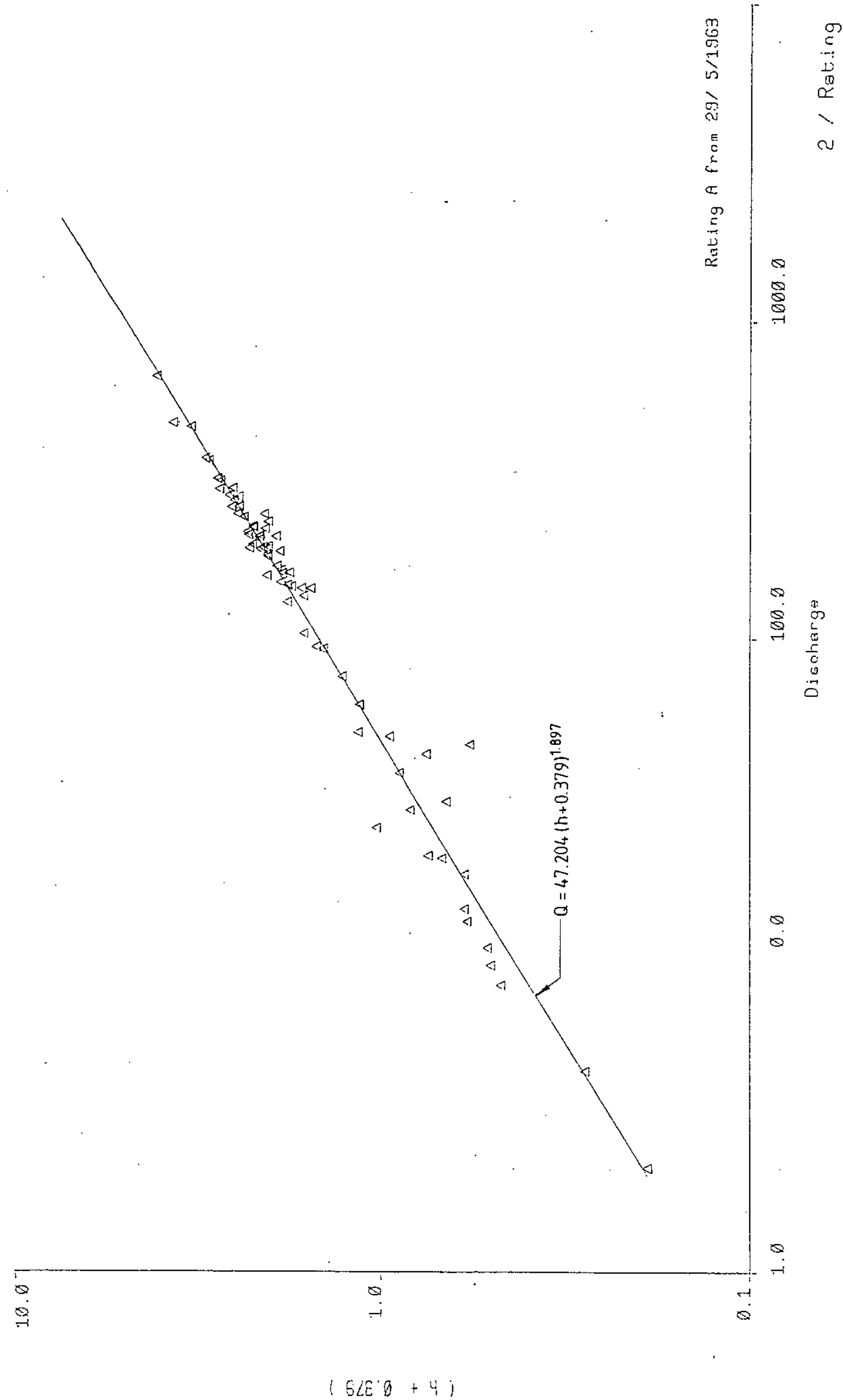


Figure 4

Jubba at Bardheere, Rating Curve – May 1986 (Logarithmic Plot)



ANNEX 1

Listings of computer output from gauging calculations program, GAGCAL:

A-E Re-calculation of DMs undertaken by Mr Tomlinson over the period 18/07/85 - 31/07/85. Tomlinson suggested that the 21/07/85 DM was the first accurate measurement made using the cableway.

1-26 DMs undertaken by BDP operators 27/07/85 - 18/03/86. Numbers 22 & 23 are missing as no corresponding water levels.

Recalculation of Tomlinson's
flow measurements over
period 18/07 to 21/07/85.

Tomlinson suggests that
measurements taken on 21/07
was first accurate one using
cableway

KS 20/04/86

(A)

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Tomlinson (ELC) et al
DATE : 18/07/1985
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	14.00	16.30
STAGE :	1.59	1.60

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	0.000	0.000	0	0.00000			
			0	0.00000	0.28646	5.58000	1.59846
2	6.000	1.860	86	0.43969			
			82	0.41966	0.43844	12.72000	5.57691
3	12.000	2.380	96	0.48977			
			79	0.40463	0.39712	14.22000	5.64705
4	18.000	2.360	73	0.37458			
			62	0.31950	0.32951	14.22000	4.68566
5	24.000	2.380	63	0.32450			
			58	0.29946	0.33953	14.19000	4.81790
6	30.000	2.350	77	0.39462			
			66	0.33953	0.46222	14.67000	6.78083
7	36.000	2.540	115	0.58492			
			104	0.52983	0.57115	15.93000	9.09839
8	42.000	2.770	130	0.66004			
			100	0.50980	0.63625	17.49000	11.12805
9	48.000	3.060	138	0.70010			
			133	0.67506	0.79275	18.78000	14.88789
10	54.000	3.200	195	0.98556			
			160	0.81028	0.86036	20.85000	17.93851
11	60.000	3.750	181	0.91545			
			144	0.73015	0.78649	22.65000	17.81405
12	66.000	3.800	175	0.88540			
			121	0.61497	0.79025	22.80000	18.01766
13	72.000	3.800	184	0.93047			
			144	0.73015	0.77773	23.28000	18.10551
14	78.000	3.960	152	0.77022			
			134	0.68007	0.69635	23.88000	16.62879
15	84.000	4.000	132	0.67006			
			131	0.66505	0.58742	23.88000	14.02769
16	90.000	3.960	103	0.52482			
			96	0.48977	0.45221	21.69000	9.80839
17	96.000	3.270	80	0.40964			
			75	0.38460	0.33577	15.21000	5.10709
18	102.000	1.800	72	0.36958			
			34	0.17927	0.18296	5.40000	0.98798
19	108.000	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 182.65679
TOTAL AREA (SQ. M.) = 307.44001
MEAN VELOCITY (M/SEC) = 0.59412

8

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Tomlinson (ELC), Mohamoud, Abdi
DATE : 21/07/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	8.35	11.50
STAGE	:	1.77	1.80

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	0.000	0.000	0	0.00000			
			0	0.00000	0.28312	7.08000	2.00451
2	6.000	2.360	108	0.54986			
			58	0.29946	0.44344	15.24000	6.75809
3	12.000	2.720	93	0.47474			
			88	0.44970	0.45221	15.33000	6.93235
4	18.000	2.390	87	0.44470			
			86	0.43969	0.45096	14.10000	6.35848
5	24.000	2.310	83	0.42466			
			97	0.49478	0.43844	14.55000	6.37924
6	30.000	2.540	88	0.44970			
			75	0.38460	0.46222	15.51000	7.16910
7	36.000	2.630	112	0.56990			
			87	0.44470	0.58617	16.92000	9.91803
8	42.000	3.010	143	0.72514			
			119	0.60495	0.69885	19.56000	13.66955
9	48.000	3.510	158	0.80026			
			131	0.66505	0.78148	21.69000	16.95039
10	54.000	3.720	196	0.99057			
			132	0.67006	0.85786	23.07000	19.79074
11	60.000	3.970	194	0.98055			
			156	0.79025	0.88039	24.09000	21.20864
12	66.000	4.060	193	0.97554			
			153	0.77522	0.87163	23.91000	20.84063
13	72.000	3.910	184	0.93047			
			159	0.80527	0.82656	24.15000	19.96133
14	78.000	4.140	172	0.87038			
			138	0.70010	0.75895	24.87000	18.87504
15	84.000	4.150	147	0.74518			
			142	0.72014	0.65754	24.60000	16.17539
16	90.000	4.050	121	0.61497			
			108	0.54986	0.45847	22.38000	10.26052
17	96.000	3.410	82	0.41966			
			48	0.24938	0.29070	15.99000	4.64829
18	102.000	1.920	54	0.27943			
			41	0.21433	0.16459	6.24000	1.02707
19	108.500	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 208.92739
TOTAL AREA (SQ. M.) = 329.27998
MEAN VELOCITY (M/SEC) = 0.63450

c

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Tomlinson et al
DATE : 23/07/1985
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	8.40	11.20
STAGE	:	1.86	1.85

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	0.000	0.000	0	0.00000			
			0	0.00000	0.14456	7.23000	1.04518
2	6.000	2.410	36	0.18929			
			47	0.24438	0.29946	15.45000	4.62672
3	12.000	2.740	68	0.34954			
			81	0.41465	0.37083	15.33000	5.68479
4	18.000	2.370	72	0.36958			
			68	0.34954	0.31950	15.39000	4.91704
5	24.000	2.760	57	0.29446			
			51	0.26441	0.34203	15.54000	5.31518
6	30.000	2.420	69	0.35455			
			89	0.45471	0.44595	15.48000	6.90328
7	36.000	2.740	106	0.53985			
			85	0.43468	0.56739	17.73000	10.05986
8	42.000	3.170	140	0.71012			
			115	0.58492	0.72139	20.43000	14.73796
9	48.000	3.640	174	0.88039			
			140	0.71012	0.84784	23.25000	19.71228
10	54.000	4.110	188	0.95050			
			168	0.85034	0.92171	24.84000	22.89523
11	60.000	4.170	200	1.01060			
			173	0.87538	0.90168	25.71000	23.18209
12	66.000	4.400	186	0.94049			
			154	0.78023	0.84408	26.37000	22.25850
13	72.000	4.390	182	0.92046			
			145	0.73516	0.84408	25.95000	21.90398
14	78.000	4.260	179	0.90543			
			161	0.81529	0.79150	25.53000	20.20700
15	84.000	4.250	147	0.74518			
			138	0.70010	0.65002	25.02000	16.26360
16	90.000	4.090	123	0.62498			
			104	0.52983	0.51481	22.44000	11.55229
17	96.000	3.390	91	0.46473			
			86	0.43969	0.33702	28.92000	9.74673
18	102.000	6.250	51	0.26441			
			34	0.17927	0.14790	20.31250	3.00423
19	108.500	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 224.01593
TOTAL AREA (SQ. M.) = 370.92250
MEAN VELOCITY (M/SEC) = 0.60394

D

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Tomlinson (ELC), Mohamoud, Abdi
DATE : 30/07/85
METER : SIAF 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	9.45	13.10
STAGE	:	1.77	1.77

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.360	0.000	0	0.00000			
			0	0.00000	0.16793	6.87000	1.15370
2	23.360	2.290	54	0.27943			
			43	0.22434	0.25064	15.06000	3.77458
3	29.360	2.730	52	0.26942			
			44	0.22935	0.25314	15.30000	3.87304
4	35.360	2.370	48	0.24938			
			51	0.26441	0.27317	13.89000	3.79436
5	41.360	2.260	68	0.34954			
			44	0.22935	0.32450	14.07000	4.56577
6	47.360	2.430	83	0.42466			
			57	0.29446	0.43468	15.15000	6.58540
7	53.360	2.620	111	0.56489			
			89	0.45471	0.56990	17.94000	10.22393
8	59.360	3.360	126	0.64001			
			122	0.61998	0.72640	20.97000	15.23252
9	65.360	3.630	169	0.85535			
			156	0.79025	0.85410	23.43000	20.01156
10	71.360	4.180	199	1.00559			
			151	0.76521	0.89792	25.02000	22.46596
11	77.360	4.160	196	0.99057			
			164	0.83031	0.89041	26.34000	23.45335
12	83.360	4.620	181	0.91545			
			163	0.82530	0.85786	27.54000	23.62536
13	89.360	4.560	180	0.91044			
			154	0.78023	0.83782	27.48000	23.02341
14	95.360	4.600	168	0.85034			
			160	0.81028	0.74392	26.58000	19.77350
15	101.360	4.260	135	0.68508			
			124	0.62999	0.61622	24.21000	14.91869
16	107.360	3.810	115	0.58492			
			111	0.56489	0.48852	20.76000	10.14159
17	113.360	3.110	84	0.42967			
			73	0.37458	0.33202	11.82000	3.92443
18	119.360	0.830	62	0.31950			
			39	0.20431	0.17461	2.69750	0.47101
19	125.860	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS)	=	211.01213
TOTAL AREA (SQ. M.)	=	335.12750
MEAN VELOCITY (M/SEC)	=	0.62965

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Tomlinson (ELC), Mohamoud, Abdi
DATE : 31/07/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	8.30	11.30
STAGE :	1.77	1.77

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.360	0.000	0	0.00000			
			0	0.00000	0.26309	6.75000	1.77586
2	23.360	2.250	80	0.40964			
			74	0.37959	0.41966	14.70000	6.16894
3	29.360	2.650	88	0.44970			
			86	0.43969	0.47975	14.85000	7.12432
4	35.360	2.300	101	0.51481			
			101	0.51481	0.53359	13.56000	7.23545
5	41.360	2.220	122	0.61998			
			95	0.48476	0.57365	13.71000	7.86477
6	47.360	2.350	122	0.61998			
			112	0.56990	0.56864	15.09000	8.58084
7	53.360	2.680	121	0.61497			
			92	0.46974	0.51982	18.15000	9.43466
8	59.360	3.370	104	0.52983			
			91	0.46473	0.58116	3.56500	2.07185
9	60.360	3.760	140	0.71012			
			122	0.61998	0.68758	42.73500	29.38390
10	71.360	4.010	156	0.79025			
			124	0.62999	0.73641	25.92000	19.08780
11	77.360	4.630	160	0.81028			
			141	0.71513	0.78274	27.30000	21.36869
12	83.360	4.470	163	0.82530			
			154	0.78023	0.82030	26.55000	21.77886
13	89.360	4.380	179	0.90543			
			152	0.77022	0.76646	26.91000	20.62544
14	95.360	4.590	145	0.73516			
			129	0.65503	0.63876	26.43000	16.88232
15	101.360	4.220	114	0.57991			
			115	0.58492	0.52733	24.03000	12.67169
16	107.360	3.790	95	0.48476			
			90	0.45972	0.40463	20.82000	8.42444
17	113.360	3.150	72	0.36958			
			59	0.30447	0.26691	15.09000	4.02770
18	119.360	1.880	47	0.24438			
			28	0.14922	0.13121	6.11000	0.80167
19	125.860	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 205.30921
TOTAL AREA (SQ. M.) = 342.27001
MEAN VELOCITY (M/SEC) = 0.59985

Bardheere discharge measurements
calculated using program GAGCAL
from HSUO sheets found in black
folder in Dept of Hydrology office.

CURRENT METER FLOW GAUGING RESULTS

(1)

STATION : Jubba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & mahamud
DATE : 27/7/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	8.25	11.30
STAGE	:	2.10	2.10

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.160	0.000	0	0.00000			
			0	0.00000	0.29147	7.02000	2.04612
2	23.160	2.340	101	0.51481			
			70	0.35956	0.47224	15.84000	7.48028
3	29.160	2.940	115	0.58492			
			84	0.42967	0.56614	17.28000	9.78290
4	35.160	2.820	149	0.75519			
			97	0.49478	0.61622	17.28000	10.64828
5	41.160	2.940	137	0.69510			
			102	0.51982	0.58367	18.30000	10.68112
6	47.160	3.160	125	0.63500			
			95	0.48476	0.58116	20.25000	11.76857
7	53.160	3.590	133	0.67506			
			104	0.52983	0.60871	23.94000	14.57247
8	59.160	4.390	141	0.71513			
			101	0.51481	0.69510	26.04002	18.10031
9	65.160	4.290	172	0.87038			
			134	0.68007	0.86787	24.69000	21.42776
10	71.160	3.940	199	1.00559			
			181	0.91545	0.97429	24.36000	23.73376
11	77.160	4.180	212	1.07070			
			179	0.90543	0.94550	25.92000	24.50726
12	83.160	4.460	200	1.01060			
			157	0.79526	0.87538	27.15000	23.76668
13	89.160	4.590	181	0.91545			
			154	0.78023	0.81153	27.75000	22.52001
14	95.160	4.660	169	0.85535			
			137	0.69510	0.77272	27.03000	20.88662
15	101.160	4.350	152	0.77022			
			152	0.77022	0.65378	23.67000	15.47497
16	107.160	3.540	113	0.57490			
			98	0.49978	0.42967	16.71000	7.17982
17	113.160	2.030	69	0.35455			
			56	0.28945	0.22810	9.48000	2.16239
18	119.160	1.130	41	0.21433			
			9	0.05407	0.08947	4.13015	0.36953
19	126.470	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 247.10889
TOTAL AREA (SQ. M.) = 356.84022
MEAN VELOCITY (M/SEC) = 0.69249

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 4/8/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	9.60	12.05
STAGE	:	2.38	2.37

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	16.680	0.000	0	0.00000			
			0	0.00000	0.38496	8.13000	3.12971
2	22.680	2.710	122	0.61998			
			105	0.53484	0.64251	16.80000	10.79420
3	28.680	2.890	143	0.72514			
			136	0.69009	0.78399	17.64000	13.82955
4	34.680	2.990	181	0.91545			
			159	0.80527	0.83657	17.55000	14.68184
5	40.680	2.860	195	0.98556			
			126	0.64001	0.84158	17.25000	14.51726
6	46.680	2.890	196	0.99057			
			148	0.75018	0.84283	17.97000	15.14569
7	52.680	3.100	182	0.92046			
			140	0.71012	0.83782	20.13000	16.86540
8	58.680	3.610	188	0.95050			
			152	0.77022	0.83782	23.28000	19.50455
9	64.680	4.150	165	0.83532			
			157	0.79526	0.90042	25.23000	22.71770
10	70.680	4.260	208	1.05066			
			182	0.92046	0.99683	26.34000	26.25645
11	76.680	4.520	190	0.96052			
			209	1.05567	0.98306	28.35000	27.86964
12	82.680	4.930	199	1.00559			
			180	0.91044	0.96678	29.70000	28.71337
13	88.680	4.970	203	1.02562			
			183	0.92546	0.93423	30.69000	28.67146
14	94.680	5.260	185	0.93548			
			168	0.85034	0.85786	30.57000	26.22466
15	100.680	4.930	174	0.88039			
			151	0.76521	0.77022	27.63000	21.28107
16	106.680	4.280	149	0.75519			
			134	0.68007	0.60245	23.76000	14.31417
17	112.680	3.640	105	0.53484			
			86	0.43969	0.37959	19.23000	7.29955
18	118.680	2.770	64	0.32951			
			41	0.21433	0.18129	11.75865	2.13171
19	127.170	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 313.94800
TOTAL AREA (SQ. M.) = 392.00866
MEAN VELOCITY (M/SEC) = 0.80087

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 10/8/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	8.35	12.35
STAGE	:	2.06	2.08

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	16.900	0.000	0	0.00000			
			0	0.00000	0.29481	7.26000	2.14032
2	22.900	2.420	100	0.50980			
			73	0.37458	0.48601	16.32000	7.93172
3	28.900	3.020	113	0.57490			
			95	0.48476	0.58492	17.19001	10.05478
4	34.900	2.710	141	0.71513			
			111	0.56489	0.67256	15.87000	10.67353
5	40.900	2.580	146	0.74017			
			132	0.67006	0.69635	16.02000	11.15550
6	46.900	2.760	139	0.70511			
			132	0.67006	0.66004	16.65000	10.98967
7	52.900	2.790	134	0.68007			
			115	0.58492	0.69259	18.03000	12.48743
8	58.900	3.220	157	0.79526			
			140	0.71012	0.77773	20.46000	15.91232
9	64.900	3.600	171	0.86537			
			146	0.74017	0.83908	22.56000	18.92956
10	70.900	3.920	174	0.88039			
			172	0.87038	0.92421	23.97000	22.15337
11	76.900	4.070	201	1.01561			
			184	0.93047	0.96052	25.65000	24.63734
12	82.900	4.480	203	1.02562			
			172	0.87038	0.95802	27.00000	25.86643
13	88.900	4.520	200	1.01060			
			183	0.92546	0.91420	30.03000	27.45330
14	94.900	5.490	186	0.94049			
			154	0.78023	0.81153	30.54000	24.78419
15	100.900	4.690	155	0.78524			
			146	0.74017	0.71012	25.95000	18.42761
16	106.900	3.960	125	0.63500			
			134	0.68007	0.54861	20.64000	11.32335
17	112.900	2.920	99	0.50479			
			73	0.37458	0.33202	13.86000	4.60174
18	118.900	1.700	61	0.31449			
			25	0.13420	0.11217	6.80000	0.76277
19	126.900	0.000	0	0.00000			
			0	0.00000	0.00000	0.00000	0.00000
20	0.000	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 260.28490
TOTAL AREA (SQ. M.) = 354.80007
MEAN VELOCITY (M/SEC) = 0.73361

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Badheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 14/8/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	9.30	2.00
STAGE	:	2.60	2.58

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	16.300	0.000	0	0.00000			
			0	0.00000	0.31150	9.06000	2.82222
2	22.300	3.020	117	0.59494			
			66	0.33953	0.53108	19.50000	10.35614
3	28.300	3.480	139	0.70511			
			95	0.48476	0.72264	20.37000	14.72018
4	34.300	3.310	185	0.93548			
			151	0.76521	0.85034	19.89000	16.91334
5	40.300	3.320	200	1.01060			
			136	0.69009	0.82656	20.82000	17.20890
6	46.300	3.620	204	1.03063			
			113	0.57490	0.79651	22.38000	17.82585
7	52.300	3.840	164	0.83031			
			148	0.75018	0.78900	24.90000	19.64600
8	58.300	4.460	161	0.81529			
			150	0.76020	0.86161	29.28002	25.22802
9	64.300	5.300	189	0.95551			
			181	0.91545	0.93924	31.77498	29.84421
10	70.500	4.950	204	1.03063			
			169	0.85535	0.99808	29.72502	29.66795
11	76.300	5.300	204	1.03063			
			213	1.07570	1.03564	32.82000	33.98971
12	82.300	5.640	213	1.07570			
			190	0.96052	1.00810	34.56000	34.83980
13	88.300	5.880	199	1.00559			
			196	0.99057	0.92922	33.81000	31.41693
14	94.300	5.390	171	0.86537			
			169	0.85535	0.84158	31.95000	26.88848
15	100.300	5.260	163	0.82530			
			162	0.82030	0.80152	29.31000	23.49244
16	106.300	4.510	158	0.80026			
			150	0.76020	0.70136	23.82000	16.70630
17	112.300	3.430	136	0.69009			
			109	0.55487	0.50354	16.50000	8.30841
18	118.300	2.070	62	0.31950			
			88	0.44970	0.33202	10.65000	3.53597
19	124.300	1.480	66	0.33953			
			42	0.21934	0.18630	2.14600	0.39979
20	127.200	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 363.81065
TOTAL AREA (SQ. M.) = 443.26603
MEAN VELOCITY (M/SEC) = 0.82075

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 19/8/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	8.20	11.20
STAGE :	2.40	2.39

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	16.600	0.000	0	0.00000			
			0	0.00000	0.26476	7.47000	1.97776
2	22.600	2.490	87	0.44470			
			68	0.34954	0.44470	17.31000	7.69769
3	28.600	3.280	105	0.53484			
			88	0.44970	0.56364	19.52999	11.00781
4	34.600	3.230	136	0.69009			
			114	0.57991	0.71888	18.48000	13.28498
5	40.600	2.930	161	0.81529			
			156	0.79025	0.80026	18.06000	14.45277
6	46.600	3.090	170	0.86036			
			145	0.73516	0.79901	19.80000	15.82044
7	52.600	3.510	173	0.87538			
			143	0.72514	0.71137	23.07000	16.41135
8	58.600	4.180	141	0.71513			
			104	0.52983	0.71513	27.54000	19.69462
9	64.600	5.000	164	0.83031			
			155	0.78524	0.83031	30.36000	25.20827
10	70.600	5.120	170	0.86036			
			167	0.84534	0.88415	31.77000	28.08938
11	76.600	5.470	184	0.93047			
			178	0.90042	0.94925	44.84000	42.56446
12	84.600	5.740	216	1.09073			
			173	0.87538	0.89166	34.17000	30.46802
13	90.600	5.650	162	0.82030			
			154	0.78023	0.79776	32.52000	25.94316
14	96.600	5.190	161	0.81529			
			153	0.77522	0.69885	30.27000	21.15425
15	102.600	4.900	120	0.60996			
			117	0.59494	0.47975	25.95000	12.44957
16	108.600	3.750	73	0.37458			
			66	0.33953	0.32576	18.48000	6.01997
17	114.600	2.410	63	0.32450			
			51	0.26441	0.24813	11.28000	2.79893
18	120.600	1.350	41	0.21433			
			36	0.18929	0.13455	3.37500	0.45409
19	125.600	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 295.49750
TOTAL AREA (SQ. M.) = 414.27502
MEAN VELOCITY (M/SEC) = 0.71329

(6)

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 31/8/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN - : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	2.30	11.20
STAGE	:	1.95	1.95

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.000	0.000	0	0.00000			
			0	0.00000	0.18296	6.57000	1.20204
2	23.000	2.190	68	0.34954			
			38	0.19930	0.38836	14.94000	5.80204
3	29.000	2.790	107	0.54486			
			90	0.45972	0.53359	16.50000	8.80420
4	35.000	2.710	125	0.63500			
			97	0.49478	0.58742	16.68000	9.79823
5	41.000	2.850	137	0.69510			
			103	0.52482	0.52482	18.09000	9.49407
6	47.000	3.180	139	0.70511			
			33	0.17426	0.49227	21.18000	10.42632
7	53.000	3.880	146	0.74017			
			68	0.34954	0.58492	22.56000	13.19580
8	59.000	3.640	140	0.71012			
			106	0.53985	0.70136	21.69000	15.21241
9	65.000	3.590	163	0.82530			
			144	0.73015	0.84909	21.93000	18.62059
10	71.000	3.720	192	0.97054			
			172	0.87038	0.90794	23.22000	21.08227
11	77.000	4.020	186	0.94049			
			168	0.85034	0.85410	24.87000	21.24147
12	83.000	4.270	177	0.89542			
			144	0.73015	0.80527	26.10000	21.01760
13	89.000	4.430	173	0.87538			
			142	0.72014	0.78274	26.52000	20.75816
14	95.000	4.410	158	0.80026			
			145	0.73516	0.69885	26.10000	18.24004
15	101.000	4.290	135	0.68508			
			113	0.57490	0.56489	22.86000	12.91334
16	107.000	3.330	105	0.53484			
			91	0.46473	0.44970	15.27000	6.86698
17	113.000	1.760	83	0.42466			
			73	0.37458	0.29821	5.44000	1.62227
18	117.000	0.960	50	0.25940			
			25	0.13420	0.13121	4.50240	0.59074
19	126.380	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 216.88857
TOTAL AREA (SQ. M.) = 335.02241
MEAN VELOCITY (M/SEC) = 0.64739

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 5/9/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	8.30	11.10
STAGE :	1.76	1.76

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL. M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.380	0.000	0	0.00000			
			0	0.00000	0.17127	6.18000	1.05846
2	23.380	2.060	59	0.30447			
			40	0.20932	0.36206	14.01000	5.07252
3	29.380	2.610	106	0.53985			
			77	0.39462	0.48977	15.30000	7.49345
4	35.380	2.490	121	0.61497			
			80	0.40964	0.54736	14.58000	7.98051
5	41.380	2.370	140	0.71012			
			89	0.45471	0.59118	13.98000	8.26470
6	47.380	2.290	139	0.70511			
			97	0.49478	0.59118	16.17000	9.55938
7	53.380	3.100	118	0.59994			
			111	0.56489	0.59869	19.05000	11.40508
8	59.380	3.250	127	0.64502			
			115	0.58492	0.67131	20.78999	13.95649
9	65.380	3.680	154	0.78023			
			133	0.67506	0.77022	22.20000	17.09880
10	71.380	3.720	173	0.87538			
			148	0.75018	0.85660	23.04000	19.73616
11	77.380	3.960	192	0.97054			
			164	0.83031	0.87413	24.45000	21.37253
12	83.380	4.190	172	0.87038			
			163	0.82530	0.78900	25.56000	20.16674
13	89.380	4.330	148	0.75018			
			140	0.71012	0.71012	25.50000	18.10806
14	95.380	4.170	143	0.72514			
			129	0.65503	0.59869	24.54000	14.69190
15	101.380	4.010	110	0.55988			
			89	0.45471	0.44094	20.85000	9.19360
16	107.380	2.940	78	0.39962			
			68	0.34954	0.32075	13.11000	4.20501
17	113.380	1.430	68	0.34954			
			35	0.18428	0.20056	6.51000	1.30562
18	119.380	0.740	31	0.16425			
			19	0.10415	0.08947	2.22000	0.19863
19	125.380	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 190.86764
TOTAL AREA (SQ. M.) = 308.04002
MEAN VELOCITY (M/SEC) = 0.61962

(8)

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 12/9/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	2.30	11.00
STAGE :	1.50	1.50

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	18.000	0.000	0	0.00000			
			0	0.00000	0.13788	5.94000	0.81903
2	24.000	1.980	49	0.25439			
			30	0.15924	0.23186	12.93000	2.99790
3	30.000	2.330	56	0.28945			
			43	0.22434	0.30072	13.80000	4.14988
4	36.000	2.270	78	0.39962			
			56	0.28945	0.40088	12.48000	5.00293
5	42.000	1.890	93	0.47474			
			86	0.43969	0.47474	12.09000	5.73966
6	48.000	2.140	101	0.51481			
			92	0.46974	0.48726	14.13000	6.88504
7	54.000	2.570	101	0.51481			
			88	0.44970	0.50229	17.04000	8.55899
8	60.000	3.110	112	0.56990			
			93	0.47474	0.57115	19.35000	11.05171
9	66.000	3.340	127	0.64502			
			117	0.59494	0.73516	21.15000	15.54863
10	72.000	3.710	174	0.88039			
			162	0.82030	0.80652	23.49000	18.94525
11	78.000	4.120	174	0.88039			
			127	0.64502	0.74392	25.08000	18.65761
12	84.000	4.240	152	0.77022			
			134	0.68007	0.69134	25.44000	17.58769
13	90.000	4.240	131	0.66505			
			128	0.65002	0.62123	24.63000	15.30085
14	96.000	3.970	130	0.66004			
			100	0.50980	0.48852	22.59000	11.03558
15	102.000	3.560	82	0.41966			
			71	0.36457	0.32576	18.36000	5.98088
16	108.000	2.560	52	0.26942			
			48	0.24938	0.17552	10.74000	1.88504
17	114.000	1.020	20	0.10916			
			13	0.07410	0.06109	5.10000	0.31156
18	124.000	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 150.45824
TOTAL AREA (SQ. M.) = 284.34002
MEAN VELOCITY (M/SEC) = 0.52915

9

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 26/9/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	2.30	11.00
STAGE	:	1.67	1.67

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.550	0.000	0	0.00000			
			0	0.00000	0.26476	6.18000	1.63622
2	23.550	2.060	88	0.44970			
			67	0.34454	0.43718	13.68000	5.98068
3	29.550	2.500	104	0.52983			
			83	0.42466	0.56864	13.92000	7.91552
4	35.550	2.140	142	0.72014			
			118	0.59994	0.69259	12.48000	8.64355
5	41.550	2.020	160	0.81028			
			126	0.64001	0.70887	12.51000	8.86794
6	47.550	2.150	157	0.79526			
			116	0.58993	0.65754	14.49000	9.52770
7	53.550	2.680	146	0.74017			
			99	0.50479	0.62123	17.79000	11.05165
8	59.550	3.250	130	0.66004			
			114	0.57991	0.66004	20.52001	13.54403
9	65.550	3.590	151	0.76521			
			125	0.63500	0.70386	22.47000	15.81573
10	71.550	3.900	144	0.73015			
			135	0.68508	0.75018	24.15000	18.11695
11	77.550	4.150	172	0.87038			
			141	0.71513	0.80152	25.32000	20.29439
12	83.550	4.290	173	0.87538			
			147	0.74518	0.71763	26.22000	18.81631
13	89.550	4.450	141	0.71513			
			105	0.53484	0.62373	25.86000	16.12971
14	95.550	4.170	128	0.65002			
			117	0.59494	0.58742	23.61000	13.86908
15	101.550	3.700	117	0.59494			
			100	0.50980	0.44470	18.78000	8.35139
16	107.550	2.560	70	0.35956			
			61	0.31449	0.30197	11.01000	3.32467
17	113.550	1.110	67	0.34454			
			36	0.18929	0.18678	7.89000	1.47373
18	119.550	1.520	25	0.13420			
			14	0.07911	0.07111	5.21360	0.37073
19	126.410	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 183.72996
TOTAL AREA (SQ. M.) = 302.09365
MEAN VELOCITY (M/SEC) = 0.60819

(10)

CURRENT METER FLOW GAUGING RESULTS

STATION : Jaba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 30/9/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	7.40	1.10
STAGE :	2.00	2.00

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.000	0.000	0	0.00000			
			0	0.00000	0.32820	6.87000	2.25472
2	23.000	2.290	117	0.59494			
			76	0.38961	0.58367	15.06000	8.79004
3	29.000	2.730	148	0.75018			
			118	0.59994	0.72890	15.42000	11.23964
4	35.000	2.410	182	0.92046			
			127	0.64502	0.82781	14.16000	11.72176
5	41.000	2.310	199	1.00559			
			146	0.74017	0.88790	13.71000	12.17316
6	47.000	2.260	223	1.12578			
			134	0.68007	0.82280	15.54000	12.78631
7	53.000	2.920	163	0.82530			
			130	0.66004	0.72890	19.11000	13.92928
8	59.000	3.450	151	0.76521			
			131	0.66505	0.76145	22.08000	16.81286
9	65.000	3.910	173	0.87538			
			146	0.74017	0.86537	24.30000	21.02845
10	71.000	4.190	195	0.98556			
			170	0.86036	0.92546	25.47000	23.57157
11	77.000	4.300	204	1.03063			
			163	0.82530	0.89416	26.70000	23.87418
12	83.000	4.600	191	0.96553			
			149	0.75519	0.83282	27.99000	23.31052
13	89.000	4.730	176	0.89041			
			142	0.72014	0.76896	27.84000	21.40796
14	95.000	4.550	153	0.77522			
			136	0.69009	0.67882	25.56000	17.35064
15	101.000	3.970	126	0.64001			
			120	0.60996	0.55863	20.88000	11.66415
16	107.000	2.990	110	0.55988			
			83	0.42466	0.42341	13.35000	5.65255
17	113.000	1.460	88	0.44970			
			50	0.25940	0.29821	8.91000	2.65707
18	119.000	1.510	50	0.25940			
			43	0.22434	0.16126	5.29255	0.85346
19	126.010	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 241.07831
TOTAL AREA (SQ. M.) = 328.24254
MEAN VELOCITY (M/SEC) = 0.73445

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Badheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 6/10/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	1.30	4.00
STAGE :	2.16	2.16

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	16.580	0.000	0	0.00000			
			0	0.00000	0.37661	7.41000	2.79069
2	22.580	2.470	116	0.58993			
			106	0.53985	0.62999	15.84000	9.97907
3	28.580	2.810	154	0.78023			
			120	0.60996	0.81779	15.78001	12.90476
4	34.580	2.450	193	0.97554			
			179	0.90543	0.95176	14.70000	13.99081
5	40.580	2.450	206	1.04065			
			175	0.88540	0.98932	14.46000	14.30551
6	46.580	2.370	235	1.18588			
			167	0.84534	0.95551	15.06000	14.39001
7	52.580	2.650	209	1.05567			
			145	0.73516	0.84909	18.72000	15.89500
8	58.580	3.590	166	0.84033			
			151	0.76521	0.78399	22.98000	18.01605
9	64.580	4.070	161	0.81529			
			141	0.71513	0.88164	24.75000	21.82069
10	70.580	4.180	224	1.13079			
			171	0.86537	1.04065	25.44000	26.47409
11	76.580	4.300	238	1.20090			
			191	0.96553	1.06694	26.34000	28.10320
12	82.580	4.480	216	1.09073			
			200	1.01060	0.96553	27.00000	26.06926
13	88.580	4.520	196	0.99057			
			152	0.77022	0.83908	27.00000	22.65505
14	94.580	4.480	168	0.85034			
			147	0.74518	0.75519	25.95000	19.59723
15	100.580	4.170	153	0.77522			
			128	0.65002	0.62624	22.14000	13.86487
16	106.580	3.210	111	0.56489			
			101	0.51481	0.41840	14.46000	6.05012
17	112.580	1.610	69	0.35455			
			46	0.23937	0.23686	7.98000	1.89017
18	118.580	1.050	42	0.21934			
			25	0.13420	0.16049	22.95000	3.68329
19	124.580	6.600	30	0.15924			
			24	0.12919			

TOTAL DISCHARGE (CUMECS) = 272.47986
TOTAL AREA (SQ. M.) = 348.96004
MEAN VELOCITY (M/SEC) = 0.78083

(12)

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 18/11/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	2.10	10.15
STAGE :	1.56	1.54

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.660	0.000	0	0.00000			
			0	0.00000	0.29648	6.27000	1.85892
2	23.660	2.090	109	0.55487			
			65	0.33452	0.49478	13.41000	6.63495
3	29.660	2.380	125	0.63500			
			89	0.45471	0.62498	14.37000	8.98102
4	35.660	2.410	177	0.89542			
			101	0.51481	0.75895	12.69000	9.63105
5	41.660	1.820	182	0.92046			
			139	0.70511	0.77773	11.07000	8.60945
6	47.660	1.870	179	0.90543			
			114	0.57991	0.68758	12.24000	8.41603
7	53.660	2.210	141	0.71513			
			108	0.54986	0.61872	14.70000	9.09524
8	59.660	2.690	130	0.66004			
			108	0.54986	0.63625	16.44001	10.45999
9	65.660	2.790	152	0.77022			
			111	0.56489	0.74017	16.83000	12.45703
10	71.660	2.820	168	0.85034			
			153	0.77522	0.82530	17.97000	14.83071
11	77.660	3.170	186	0.94049			
			145	0.73516	0.79150	19.86000	15.71919
12	83.660	3.450	169	0.85535			
			125	0.63500	0.74768	21.42000	16.01531
13	89.660	3.690	173	0.87538			
			123	0.62498	0.72640	21.93000	15.92986
14	95.660	3.620	155	0.78524			
			122	0.61998	0.64627	22.11000	14.28899
15	101.660	3.750	119	0.60495			
			113	0.57490	0.48977	21.03000	10.29982
16	107.660	3.260	78	0.39962			
			74	0.37959	0.33828	13.89000	4.69865
17	113.660	1.370	60	0.30948			
			51	0.26441	0.19131	4.87720	0.93303
18	120.780	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 168.85925
TOTAL AREA (SQ. M.) = 261.10723
MEAN VELOCITY (M/SEC) = 0.64670

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamuud
DATE : 12/10/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	8.00	11.00
STAGE :	1.90	2.26

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	16.900	0.000	0	0.00000			
			0	0.00000	0.44840	9.72000	4.35841
2	22.900	3.240	122	0.61998			
			143	0.72514	0.69259	17.70000	12.25888
3	28.900	2.660	144	0.73015			
			137	0.69510	0.82030	15.30000	12.55053
4	34.900	2.440	200	1.01060			
			167	0.84534	0.95176	14.34000	13.64818
5	40.900	2.340	224	1.13079			
			162	0.82030	1.03814	13.47000	13.98380
6	46.900	2.150	222	1.12078			
			214	1.08071	1.03439	14.31000	14.80209
7	52.900	2.620	213	1.07570			
			170	0.86036	0.87538	18.27000	15.99327
8	58.900	3.470	174	0.88039			
			135	0.68508	0.81654	22.32000	18.22517
9	64.900	3.970	179	0.90543			
			157	0.79526	0.92546	23.76000	21.98903
10	70.900	3.950	200	1.01060			
			196	0.99057	1.02312	25.38000	25.96679
11	76.900	4.510	239	1.20591			
			175	0.88540	1.03439	27.87000	28.82840
12	82.900	4.780	239	1.20591			
			166	0.84033	0.95551	28.77000	27.49008
13	88.900	4.810	204	1.03063			
			147	0.74518	0.86912	27.54000	23.93568
14	94.900	4.370	174	0.88039			
			162	0.82030	0.81904	25.38000	20.78734
15	100.900	4.090	156	0.79025			
			155	0.78524	0.67882	22.38000	15.19199
16	106.900	3.370	115	0.58492			
			109	0.55487	0.46723	14.58000	6.81224
17	112.900	1.490	85	0.43468			
			57	0.29446	0.29446	7.38000	2.17309
18	118.900	0.970	50	0.25940			
			36	0.18929	0.14957	3.92850	0.58759
19	127.000	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 279.58258
TOTAL AREA (SQ. M.) = 332.39850
MEAN VELOCITY (M/SEC) = 0.84111

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamoud
DATE : 20/10/1985
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	8.20	11.00
STAGE	:	2.66	2.66

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	16.560	0.000	0	0.00000			
			0	0.00000	0.38997	8.61000	3.35761
2	22.560	2.870	126	0.64001			
			104	0.52983	0.67256	18.87000	12.69121
3	28.560	3.420	179	0.90543			
			121	0.61497	0.87288	19.92001	17.38778
4	34.560	3.220	214	1.08071			
			176	0.89041	1.01185	19.23000	19.45791
5	40.560	3.190	245	1.23596			
			166	0.84033	0.99307	19.02000	18.88823
6	46.560	3.150	257	1.29606			
			118	0.59994	0.93047	20.76000	19.31660
7	52.560	3.770	208	1.05066			
			153	0.77522	0.88540	23.19000	20.53243
8	58.560	3.960	186	0.94049			
			153	0.77522	0.89416	25.64998	22.93529
9	64.560	4.590	215	1.08572			
			153	0.77522	0.96428	27.99000	26.99009
10	70.560	4.740	238	1.20090			
			157	0.79526	1.09448	28.83000	31.55398
11	76.560	4.870	264	1.33111			
			208	1.05066	1.18212	30.69000	36.27939
12	82.560	5.360	267	1.34614			
			198	1.00058	1.15082	32.04000	36.87241
13	88.560	5.320	248	1.25098			
			199	1.00559	1.07696	30.87000	33.24563
14	94.560	4.970	209	1.05567			
			197	0.99558	0.93548	30.54000	28.56956
15	100.560	5.210	179	0.90543			
			155	0.78524	0.75644	28.86000	21.83098
16	106.560	4.410	139	0.70511			
			124	0.62999	0.60245	20.73000	12.48875
17	112.560	2.500	118	0.59994			
			93	0.47474	0.49227	11.88000	5.84819
18	118.560	1.460	112	0.56990			
			63	0.32450	0.29815	6.45320	1.92401
19	127.400	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 370.17005
TOTAL AREA (SQ. M.) = 404.13326
MEAN VELOCITY (M/SEC) = 0.91596

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamud
DATE : 26/10/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	8.30	11.55
STAGE	:	2.26	2.20

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	16.620	0.000	0	0.00000			
			0	0.00000	0.31484	7.35000	2.31409
2	22.620	2.450	108	0.54986			
			77	0.39462	0.53985	16.47000	8.89130
3	28.620	3.040	135	0.68508			
			104	0.52983	0.74768	17.43000	13.03206
4	34.620	2.770	183	0.92546			
			168	0.85034	0.93673	16.62000	15.56849
5	40.620	2.770	226	1.14081			
			164	0.83031	1.01185	16.71000	16.90805
6	46.620	2.800	235	1.18588			
			176	0.89041	0.95927	17.55000	16.83515
7	52.620	3.050	195	0.98556			
			153	0.77522	0.82405	19.20000	15.82180
8	58.620	3.350	165	0.83532			
			138	0.70010	0.80026	21.09001	16.87758
9	64.620	3.680	166	0.84033			
			163	0.82530	0.88540	22.56000	19.97462
10	70.620	3.840	206	1.04065			
			165	0.83532	0.97304	23.61000	22.97348
11	76.620	4.030	234	1.18087			
			165	0.83532	0.99683	24.60000	24.52197
12	82.620	4.170	230	1.16084			
			160	0.81028	0.98431	25.62000	25.21798
13	88.620	4.370	219	1.10575			
			170	0.86036	0.93798	26.94000	25.26929
14	94.620	4.610	193	0.97554			
			160	0.81028	0.82405	28.62000	23.58437
15	100.620	4.930	150	0.76020			
			148	0.75018	0.69009	27.54000	19.00503
16	106.620	4.250	118	0.59994			
			128	0.65002	0.55362	19.65000	10.87863
17	112.620	2.300	97	0.49478			
			92	0.46974	0.38084	9.81000	3.73608
18	118.620	0.970	67	0.34454			
			41	0.21433	0.18630	3.94790	0.73548
19	126.760	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 282.14541
TOTAL AREA (SQ. M.) = 345.31792
MEAN VELOCITY (M/SEC) = 0.81706

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheera
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mahamud
DATE : 1/11/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	9.30	12.25
STAGE	:	1.74	1.72

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.400	0.000	0	0.00000			
			0	0.00000	0.26476	6.33000	1.67593
2	23.400	2.110	84	0.42967			
			71	0.36457	0.45596	13.77000	6.27862
3	29.400	2.480	118	0.59994			
			84	0.42967	0.59368	14.82000	8.79840
4	35.400	2.460	147	0.74518			
			118	0.59994	0.55151	14.46000	7.97487
5	41.400	2.360	170	0.86093			
			0	0.00000	0.58031	14.82000	8.60017
6	47.400	2.580	173	0.87538			
			115	0.58492	0.74017	16.02000	11.85749
7	53.400	2.760	170	0.86036			
			126	0.64001	0.67006	17.55000	11.75948
8	59.400	3.090	129	0.65503			
			103	0.52482	0.63250	19.71000	12.46650
9	65.400	3.480	141	0.71513			
			125	0.63500	0.71137	20.97000	14.91747
10	71.400	3.510	169	0.85535			
			126	0.64001	0.76771	21.27000	16.32924
11	77.400	3.580	178	0.90042			
			133	0.67506	0.80277	22.47000	18.03820
12	83.400	3.910	182	0.92046			
			141	0.71513	0.81028	23.67000	19.17933
13	89.400	3.980	171	0.86537			
			146	0.74017	0.74768	24.39000	18.23592
14	95.400	4.150	140	0.71012			
			133	0.67506	0.65128	24.51000	15.96278
15	101.400	4.020	115	0.58492			
			125	0.63500	0.55738	23.58000	13.14293
16	107.400	3.840	101	0.51481			
			97	0.49478	0.45596	16.56000	7.55076
17	113.400	1.680	85	0.43468			
			74	0.37959	0.20357	5.04000	1.02598
18	119.400	0.000	0	0.00000			
			0	0.00000	0.00000	0.00000	0.00000
19	123.980	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 193.79410
TOTAL AREA (SQ. M.) = 299.93999
MEAN VELOCITY (M/SEC) = 0.64611

(17)

CURRENT METER FLOW GAUGING RESULTS

STATION : Jubba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamoud
DATE : 9/11/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	7.45	11.05
STAGE	:	1.86	1.88

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.070	0.000	0	0.00000			
			0	0.00000	0.32987	6.90000	2.27608
2	23.070	2.300	118	0.59994			
			76	0.38961	0.59368	15.18000	9.01212
3	29.070	2.760	163	0.82530			
			110	0.55988	0.75895	16.14000	12.24942
4	35.070	2.620	179	0.90543			
			147	0.74518	0.85160	15.30000	13.02942
5	41.070	2.480	216	1.09073			
			131	0.66505	0.87288	15.15000	13.22413
6	47.070	2.570	207	1.04566			
			136	0.69009	0.83156	16.26000	13.52123
7	53.070	2.850	174	0.88039			
			140	0.71012	0.73140	17.73000	12.96779
8	59.070	3.060	143	0.72514			
			120	0.60996	0.69009	19.26000	13.29109
9	65.070	3.360	156	0.79025			
			125	0.63500	0.76020	20.76000	15.78175
10	71.070	3.560	176	0.89041			
			143	0.72514	0.82781	21.57000	17.85582
11	77.070	3.630	194	0.98055			
			141	0.71513	0.87163	23.04000	20.08231
12	83.070	4.050	206	1.04065			
			148	0.75018	0.87664	24.45000	21.43376
13	89.070	4.100	194	0.98055			
			145	0.73516	0.79526	24.87000	19.77802
14	95.070	4.190	151	0.76521			
			138	0.70010	0.69009	24.87000	17.16249
15	101.070	4.100	131	0.66505			
			124	0.62999	0.57240	23.43000	13.41133
16	107.070	3.710	96	0.48977			
			99	0.50479	0.45221	17.04000	7.70563
17	113.070	1.970	85	0.43468			
			74	0.37959	0.33076	7.74000	2.56011
18	119.070	0.610	57	0.29446			
			41	0.21433	0.16960	2.27225	0.38538
19	126.520	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 225.72790
TOTAL AREA (SQ. M.) = 311.96224
MEAN VELOCITY (M/SEC) = 0.72357

GAGCAL output for flow gaugings at Bardhere over period 26/11/86 to 18/03/86 thus covering period when 0 - 1m gauge plate missing.

Out of six discharge measurements taken without gauge plate, four have been recovered by comparing the water depth at the same verticals for on 18/03/86 and calculating average difference in depth. Two rejected because bed profile seemed too different from that on 18/03/86

20/04/86 RS.

(18)

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamed
DATE : 26/11/85
METER : SIAF 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	9.10	11.00
STAGE :	1.38	1.38

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	17.770	0.000	0	0.00000			
			0	0.00000	0.25641	6.15000	1.57694
2	23.770	2.050	93	0.47474			
			57	0.29446	0.48351	12.93000	6.25176
3	29.770	2.260	123	0.62498			
			106	0.53985	0.63750	13.05000	8.31943
4	35.770	2.090	157	0.79526			
			116	0.58993	0.74017	10.83000	8.01602
5	41.770	1.520	177	0.89542			
			134	0.68007	0.77773	9.18000	7.13954
6	47.770	1.540	169	0.85535			
			134	0.68007	0.70261	10.32000	7.25091
7	53.770	1.900	132	0.67006			
			119	0.60495	0.61747	12.75000	7.87277
8	59.770	2.350	134	0.68007			
			101	0.51481	0.63250	14.03999	8.88024
9	65.770	2.330	142	0.72014			
			121	0.61497	0.70386	15.00000	10.55790
10	71.770	2.670	162	0.82030			
			130	0.66004	0.73766	16.98000	12.52554
11	77.770	2.990	177	0.89542			
			113	0.57490	0.74643	18.00000	13.43570
12	83.770	3.010	172	0.87038			
			127	0.64502	0.73766	19.08000	14.07463
13	89.770	3.350	153	0.77522			
			130	0.66004	0.69259	20.94000	14.50288
14	95.770	3.630	143	0.72514			
			120	0.60996	0.57741	20.85000	12.03896
15	101.770	3.320	100	0.50980			
			91	0.46473	0.44595	18.90000	8.42842
16	107.770	2.980	78	0.39962			
			80	0.40964	0.36206	12.36000	4.47511
17	113.770	1.140	79	0.40463			
			45	0.23436	0.21301	2.65620	0.56579
18	118.430	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 145.91255
TOTAL AREA (SQ. M.) = 234.01622
MEAN VELOCITY (M/SEC) = 0.62351

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamed
DATE : 7/12/85
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	8.30	11.10
STAGE	:	1.06	1.06

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	19.310	0.000	0	0.00000			
			0	0.00000	0.23137	5.28000	1.22164
2	25.310	1.760	86	0.43969			
			49	0.25439	0.37709	10.56000	3.98205
3	31.310	1.760	79	0.40463			
			80	0.40964	0.43969	9.75000	4.28696
4	37.310	1.490	109	0.55487			
			76	0.38961	0.45972	8.07000	3.70994
5	43.310	1.200	94	0.47975			
			81	0.41465	0.45471	7.65000	3.47855
6	49.310	1.350	93	0.47474			
			88	0.44970	0.43468	9.15000	3.97732
7	55.310	1.700	98	0.49978			
			61	0.31449	0.37959	11.10000	4.21347
8	61.310	2.000	82	0.41966			
			55	0.28444	0.46222	12.32999	5.69922
9	67.310	2.110	116	0.58993			
			109	0.55487	0.56864	12.90000	7.33551
10	73.310	2.190	134	0.68007			
			88	0.44970	0.57741	13.35000	7.70840
11	79.310	2.260	132	0.67006			
			100	0.50980	0.62498	14.19000	8.86852
12	85.310	2.470	152	0.77022			
			108	0.54986	0.62624	15.84000	9.91958
13	91.310	2.810	139	0.70511			
			94	0.47975	0.55237	18.06000	9.97577
14	97.310	3.210	116	0.58993			
			85	0.43468	0.49603	18.42000	9.13684
15	103.310	2.930	103	0.52482			
			85	0.43468	0.43969	15.90000	6.99104
16	109.310	2.370	87	0.44470			
			69	0.35455	0.26643	8.29500	2.21003
17	116.310	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 92.71484
TOTAL AREA (SQ. M.) = 190.84498
MEAN VELOCITY (M/SEC) = 0.48581

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamed
DATE : 23/01/86
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	8.30	10.40
STAGE :	0.30	0.30

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	20.960	0.000	0	0.00000			
			0	0.00000	0.08446	3.48000	0.29393
2	26.960	1.160	28	0.14922			
			19	0.10415	0.13170	6.36000	0.83759
3	32.960	0.960	31	0.16425			
			20	0.10916	0.15173	4.77000	0.72374
4	38.960	0.630	39	0.20431			
			24	0.12919	0.13796	3.33000	0.45939
5	44.960	0.480	25	0.13420			
			15	0.08412	0.10666	3.72000	0.39676
6	50.960	0.760	27	0.14422			
			11	0.06409	0.12418	5:55000	0.68922
7	56.960	1.090	34	0.17927			
			20	0.10916	0.18303	6.99000	1.27937
8	62.960	1.240	46	0.23937			
			39	0.20431	0.21308	8.22000	1.75148
9	68.960	1.500	52	0.26942			
			26	0.13921	0.18678	8.76000	1.63623
10	74.960	1.420	42	0.21934			
			22	0.11918	0.18428	9.36000	1.72486
11	80.960	1.700	47	0.24438			
			29	0.15423	0.18428	10.47000	1.92941
12	86.960	1.790	38	0.19930			
			26	0.13921	0.18553	12.09000	2.24308
13	92.960	2.240	44	0.22935			
			33	0.17426	0.19054	14.10000	2.68661
14	98.960	2.460	40	0.20932			
			28	0.14922	0.15674	14.04000	2.20057
15	104.960	2.220	31	0.16425			
			19	0.10415	0.11542	10.38000	1.19806
16	110.960	1.240	19	0.10415			
			16	0.08913	0.06443	1.87240	0.12064
17	113.980	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 20.17095
TOTAL AREA (SQ. M.) = 123.49241
MEAN VELOCITY (M/SEC) = 0.16334

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamed
DATE : 30/01/86
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	8.30	11.30
STAGE	:	0.21	0.21

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	20.980	0.000	0	0.00000			
			0	0.00000	0.10450	3.24000	0.33857
2	26.980	1.080	41	0.21433			
			18	0.09914	0.14797	5.91000	0.87451
3	32.980	0.890	31	0.16425			
			21	0.11417	0.14046	4.44000	0.62364
4	38.980	0.590	30	0.15924			
			23	0.12418	0.13170	3.15000	0.41484
5	44.980	0.460	25	0.13420			
			20	0.10916	0.13921	3.45000	0.48027
6	50.980	0.690	33	0.17426			
			26	0.13921	0.14797	5.13000	0.75910
7	56.980	1.020	31	0.16425			
			21	0.11417	0.14046	6.45000	0.90597
8	62.980	1.130	34	0.17927			
			19	0.10415	0.15048	7.50000	1.12857
9	68.980	1.370	36	0.18929			
			24	0.12919	0.15548	8.13000	1.26409
10	74.980	1.340	35	0.18428			
			22	0.11918	0.18678	8.67000	1.61942
11	80.980	1.550	36	0.18929			
			49	0.25439	0.21182	9.69000	2.05257
12	86.980	1.680	40	0.20932			
			37	0.19430	0.18428	11.46000	2.11185
13	92.980	2.140	37	0.19430			
			26	0.13921	0.14797	13.65000	2.01982
14	98.980	2.410	25	0.13420			
			23	0.12418	0.14296	13.62000	1.94717
15	104.980	2.130	32	0.16926			
			27	0.14422	0.13420	9.72000	1.30442
16	110.980	1.110	25	0.13420			
			16	0.08913	0.07445	1.61505	0.12023
17	113.890	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 17.96504
TOTAL AREA (SQ. M.) = 115.82507
MEAN VELOCITY (M/SEC) = 0.15510

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamed
DATE : 18/02/86
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	9.30	12.05
STAGE :	0.12	0.12

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	22.200	0.000	0	0.00000			
			0	0.00000	0.04774	2.94000	0.14034
2	28.200	0.980	17	0.09414			
			8	0.04906	0.06409	5.22000	0.33454
3	34.200	0.760	13	0.07410			
			6	0.03905	0.06409	3.57000	0.22879
4	40.200	0.430	15	0.08412			
			10	0.05908	0.07160	2.43000	0.17399
5	46.200	0.380	15	0.08412			
			10	0.05908	0.08162	3.00000	0.24485
6	52.200	0.620	19	0.10415			
			14	0.07911	0.08537	4.92000	0.42003
7	58.200	1.020	16	0.08913			
			12	0.06910	0.08287	6.48000	0.53698
8	64.200	1.140	22	0.11918			
			9	0.05407	0.08287	7.20000	0.59665
9	70.200	1.260	16	0.08913			
			12	0.06910	0.09664	7.50000	0.72480
10	76.200	1.240	27	0.14422			
			15	0.08412	0.11792	8.01000	0.94457
11	82.200	1.430	28	0.14922			
			17	0.09414	0.11417	9.24000	1.05491
12	88.200	1.650	26	0.13921			
			13	0.07410	0.09789	11.25000	1.10128
13	94.200	2.100	23	0.12418			
			9	0.05407	0.08913	12.87000	1.14708
14	100.200	2.190	21	0.11417			
			11	0.06409	0.08913	12.45000	1.10964
15	106.200	1.960	21	0.11417			
			11	0.06409	0.06784	7.68000	0.52104
16	112.200	0.600	9	0.05407			
			6	0.03905	0.03104	0.38400	0.01192
17	113.480	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 9.29143
TOTAL AREA (SQ. M.) = 105.14402
MEAN VELOCITY (M/SEC) = 0.08837

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Abdi & Mohamed
DATE : 24/02/86
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

	START	FINISH
TIME :	8.30	10.30
STAGE :	0.09	0.09

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	22.230	0.000	0	0.00000			
			0	0.00000	0.04607	3.03000	0.13958
2	28.230	1.010	17	0.09414			
			7	0.04406	0.07160	5.25000	0.37590
3	34.230	0.740	17	0.09414			
			9	0.05407	0.06659	3.27000	0.21776
4	40.230	0.350	10	0.05908			
			10	0.05908	0.05908	2.01000	0.11875
5	46.230	0.320	10	0.05908			
			10	0.05908	0.06534	2.61000	0.17054
6	52.230	0.550	13	0.07410			
			12	0.06910	0.07160	4.62000	0.33079
7	58.230	0.990	17	0.09414			
			8	0.04906	0.07536	6.27000	0.47248
8	64.230	1.100	21	0.11417			
			7	0.04406	0.07786	6.81000	0.53023
9	70.230	1.170	21	0.11417			
			6	0.03905	0.08036	7.02000	0.56416
10	76.230	1.170	23	0.12418			
			7	0.04406	0.08537	7.86000	0.67102
11	82.230	1.450	24	0.12919			
			7	0.04406	0.09038	9.36000	0.84596
12	88.230	1.670	23	0.12418			
			11	0.06409	0.08913	11.31000	1.00804
13	94.230	2.100	22	0.11918			
			8	0.04906	0.08036	13.05000	1.04875
14	100.230	2.250	19	0.10415			
			8	0.04906	0.08412	12.72000	1.07001
15	106.230	1.990	20	0.10916			
			13	0.07410	0.06409	7.56000	0.48451
16	112.230	0.530	6	0.03905			
			5	0.03404	0.02436	0.41340	0.01007
17	113.790	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 8.05853
TOTAL AREA (SQ. M.) = 103.16340
MEAN VELOCITY (M/SEC) = 0.07811

CURRENT METER FLOW GAUGING RESULTS

STATION : Juba at Bardheere
LOCATION : MJVD cableway
GAUGED BY : Keith Stallard, Abdi, Zakia, Ana
DATE : 18/03/86
METER : SIAP 4002 no. 601036 prop. 1 (7404)
METHOD : Cableway
ORIGIN : Left Bank

CALCULATIONS ARE MADE USING THE MEAN SECTION METHOD
MEASUREMENTS TAKEN AT : 0.2 & 0.8 of depth below water surface

		START	FINISH
TIME	:	1.00	13.00
STAGE	:	0.20	0.20

VERT NO	TAPE DIST M	DEPTH M	REVS / 50 SECS	VELOCITY M/SEC	MEAN VEL M/SEC	AREA SQ M	DISCHARGE CUMECS
1	21.010	0.000	0	0.00000			
			0	0.00000	0.06777	3.03000	0.20534
2	27.010	1.010	22	0.11918			
			15	0.08412	0.09539	5.67000	0.54085
3	33.010	0.880	19	0.10415			
			13	0.07410	0.07035	4.32000	0.30390
4	39.010	0.560	11	0.06409			
			6	0.03905	0.05282	2.70000	0.14261
5	45.010	0.340	10	0.05908			
			8	0.04906	0.06284	3.00000	0.18851
6	51.010	0.660	15	0.08412			
			10	0.05908	0.09038	4.98000	0.45009
7	57.010	1.000	26	0.13921			
			14	0.07911	0.12043	6.42000	0.77315
8	63.010	1.140	31	0.16425			
			18	0.09914	0.12669	7.38000	0.93496
9	69.010	1.320	30	0.15924			
			15	0.08412	0.11918	7.65000	0.91170
10	75.010	1.230	24	0.12919			
			19	0.10415	0.12043	8.34000	1.00437
11	81.010	1.550	28	0.14922			
			18	0.09914	0.12919	9.60000	1.24024
12	87.010	1.650	27	0.14422			
			23	0.12418	0.13921	11.49000	1.59950
13	93.010	2.180	29	0.15423			
			25	0.13420	0.13796	13.77000	1.89965
14	99.010	2.410	30	0.15924			
			19	0.10415	0.12794	13.35000	1.70800
15	105.010	2.040	27	0.14422			
			19	0.10415	0.08662	9.54000	0.82639
16	111.010	1.140	11	0.06409			
			5	0.03404	0.03271	1.93230	0.06321
17	114.400	0.000	0	0.00000			
			0	0.00000			

TOTAL DISCHARGE (CUMECS) = 12.79248
TOTAL AREA (SQ. M.) = 113.17230
MEAN VELOCITY (M/SEC) = 0.11304

APPENDIX I.7

FIELDWORK UNDERTAKEN DURING THE MONTHS OF MAY AND JUNE 1986

Fieldwork undertaken during the months of May & June 1986

The following field trips were undertaken during the months of May and June 1986:

04/05/86 - 06/05/86 : Janaale irrigation canals
08/05/86 - 11/05/86 : Mogambo, Kamsuma,Mareere, Kurten Warey
26/05/86 - 27/05/86 : Beled Weyn, Bulo Burti, Mahaddey Weyn
30/05/86 - 02/06/86 : Bardheere, Lugh, Beled Weyn

04/05/86 - 06/05/86 : Janaale irrigation canals

Discharge measurements were undertaken on the Janaale and Faraxaane irrigation projects to determine flows into different irrigation areas and to estimate seepage losses. The exercise was undertaken for a study of irrigation rehabilitation being undertaken by the US engineering consultancy, TAMS, and is fully described in a separate activity report, "Discharge Measurements on Irrigation Canals in the Janaale Area".

08/05/86 - 11/05/86 : Mogambo, Kamsuma, Mareere & Kurten Warey

A visit was made to the Settlement Development Agency office in **Kurten Warey** to try to find information on bench marks on, or near, the barrage to which the recently installed staff gauges could be tied in. Unfortunately, nobody in the Kurten Warey office was aware of the existence of any bench marks.

At **Mogambo** discussions on Jubba river water level data were held with the MMP Resident Engineer, Mr David Higgins, and the engineer responsible for collecting the data, Mr Paul Glass. The objective was to try to bring the observations at Mogambo into line with MOA standard practice as regards the number of readings per day and the times of readings, and to arrange for the systematic return of the data to the Hydrology Section in Mogadishu. Following the discussions a letter was prepared setting out the Hydrology Section's proposals which were accepted verbally by Mr Higgins and Mr Glass. A typed copy of (the originally hand written) letter is attached to this report. An MOA observer's data book was left with Mr Glass and photocopies of MMP's graphical record of river water levels at Mogambo from the setting up of the project in 1983 to the present day were made.

Data recorder Nr.437 was installed in the recorder box at **Kamsuma** Bridge to replace the faulty unit removed at the beginning of April. The original shaft encoder was reinstalled and the recorder started at 12.07hrs on 10/05/86 with fully charged battery Nr.2. The water level was 4.60m.

The Juba Sugar Project (JSP) was visited at **Mareere** with the objective of establishing the regular return of water level data to the Hydrology Section. Discussions were held with the following personnel:

General Manager	- Mr Hilary Currey
Agricultural Manager	- Mr Brian Dyer
Engineering Services Manager	- Mr Richard Orr

It was agreed that the JSP would enter their data in standard MOA observer data books and return the monthly sheets to the Hydrology Section on a regular basis. The JSP also promised to prepare and forward sheets of their 1985 and 1986 (to date) water levels. This data was duly received in Mogadishu.

On the return trip, the new **Kurten Warey** staff gauge station was visited. Data was collected from the observer and he was issued with a standard MOA observer's data book. Examination of the observer's entries showed that he is often confused when the water level is on a decimetre graduation and usually underestimates by 0.1m. He would certainly benefit from further training by one of the Somali speaking staff of the Hydrology Section.

An attempt was made to level the zero of the new staff gauge station to the staff gauge on the upstream side of the barrage but had to be abandoned because of failing light conditions and condensation inside the level.

26/05/86 - 27/05/86 : Beled Weyn, Bulo Burti & Mahaddey Weyn

This trip was undertaken by Miss Anab Mahamed Ahmed and Mr Ali Yusuf Wayrax without the assistance of the MMP hydrologist, Mr Keith Stallard. Apart from routine checking of the stations and data collection, the objectives of the trip were to replace the float & counterweight system at the Beled Weyn automatic station and to determine which of the staff gauges at Bulo Burti had been damaged by floods and whether it could be replaced at current water levels.

At **Beled Weyn** the replacement float, wire and counterweight were installed in the manner demonstrated on the spare unit in Mogadishu before departure. A fully charged battery was installed, the recorder (Nr.436) reset and started at 06.00hrs on 27/05/86 with the water level at 2.43m.

Paint, brushes, etc. were given to the observer so that the repainting of the staff gauges can be completed. Unfortunately, the collection of the monthly data sheets was forgotten.

At **Bulo Burti** the water level had risen from 3.00m recorded at 06.00hrs to 3.05m at 12.00hrs. The observer claimed that he had sent the outstanding monthly data sheets to Mogadishu by post. He also complained that the bridge dipper was broken. A new battery was tried in the dipper but it "beeped" continually. The dipper was, therefore, returned to Mogadishu for further examination. The fault was, however, not obvious and the unit should be taken to an electrician for repair.

The team noted that the "third" staff gauge had been overturned during flooding and could not be replaced at current water levels. It is not clear what range of water levels this third staff gauge corresponds to.

Data sheets were collected from **Mahaddey Weyn** where the water level had risen from 4.83m at 06.00hrs to 4.85 at 12.00hrs.

30/05/86 - 02/06/86 Bardheere, Lugh, Beled Weyn

The objective of this trip was to collect data from the automatic recorders at Bardheere and Lugh. The trip, which should have been typical of the routine fieldwork trips required to run the network of hydrometric stations, was carried out by Mr Ali Yusuf Wayrax and Mr Said Sheekh Abdulle without the aid of the MMP hydrologist. As such, it was the conclusion of the programme of field work training of counterpart staff and aimed at confirming that the Hydrology Section staff can undertake this fundamental, routine work satisfactorily.

To help the staff in the field, a "Guide to Routine Operations at Automatic Recorder Stations" was prepared and the spare unit in the Hydrology Section office used for training.

The team proceeded to **Bardheere** and then on to **Lugh** where they were met by the MMP hydrologist (who had kindly been offered a seat on the UNHCR light plane which serves the refugee camps). In Lugh the team reported that the battery in the data retriever had failed and that they had, therefore, not been able to retrieve any data from Bardheere. As no suitable batteries were to be found in Lugh, no data could be collected there either. The battery had, in fact, been replaced with a spare battery in the Hydrology Section office before setting out. There was therefore either a fault in the retriever or the replacement battery had been defective. As there was no time to find batteries in Mogadishu before the MMP hydrologist's departure, the retriever was returned to Britain where it was tested and found to work satisfactorily. It can therefore probably be assumed that the battery installed before setting off on the field trip had already been used and had carelessly been put back with the equipment rather than discarded.

At 08.55 hrs the water level on the staff gauge at Lugh was 3.29m. The recorder showed 3.27m and was corrected accordingly. The clock also showed 08.43 hrs but, as this can only be changed by reinitializing, it was left as it was.

When the float and counterweight system were installed on 01/03/86 at a water level of 1.005m, there was only 30mm of wire left before the counterweight would have jammed at the top of the stilling pipe (see activity report "Lugh and Bardheere Field Trip 25/02/86 to 04/03/86"). Although the water level may not have fallen this low, when the data from Lugh is collected, it should be examined for a plateau in water levels at approximately 0.97m which would indicate that the counterweight had reached the top of the stilling well thus preventing the float from following the water levels any lower.

To avoid loosing the data stored in the recorders at Bardheere and Lugh, the batteries were not changed. These stations should therefore be visited in priority now that the retriever is working.

Beled Weyn was reached at 11.15 hrs (by MMP hydrologist in UNHCR plane) where the water level at the hydrometric station was 2.68m. It was confirmed that Ali and Anab had reinstalled the float and counterweight system as had been demonstrated on the spare recorder in Mogadishu before departure. The recorder box was, however, evidently not quite the same as the one in Mogadishu as the wire descending to the float was rubbing on the front of the slot cut in the floor of the box. The wire was therefore put round the back of the front small pulley wheel. Otherwise the station was operating correctly.

Keith Stallard June 1986

MEMORANDUM

PROJECT: ODA Somalia Hydrometry Project
TO: Mr David Higgins & Mr Paul Glass (MMP Mogambo)
FROM: Keith Stallard (MMP Hydrologist, MOA Hydrology Section)
DATE: 10/05/86
SUBJECT: River Levels at Mogambo Pump Stations

The Problem

For many years the Department of Land and Water Resources of the Ministry of Agriculture have had difficulties establishing reliable water level data for the Kamsuma-Mogambo-Jamaame reach of the lower Jubba.

An automatic stage recorder has recently been installed at Kamsuma bridge but the MOA are currently not in a position to employ an observer. An observer record is required as the automatic equipment is not infallible and the maintenance it requires may prove to be problematic after the end of the second stage of the ODA Hydrometry Project in June 1986.

Mogambo Data

For several years, reliable stage data have been recorded at Mogambo by staff of Sir M MacDonald & Partners. These data will be invaluable for establishing a continuous flow record for this part of the Jubba River. Past practice has been that the MMP hydrologist working on the ODA Hydrometry Project has retrieved these data, usually in graphical form, for the MOA.

With your help, I would like to establish a system of data collection and retrieval which will continue to function after my departure in June.

Data Collection

I am providing a standard MOA "Gauge Reading Data Book" with sufficient pages for two years of daily water level data. Two sheets are provided for each month (light green and dark green) and data should be entered in duplicate so that you can keep one copy and the other can be returned to the MOA in Mogadishu.

Standard practice in Somalia is to record water levels 3 times each day at 06.00, 12.00 and 18.00 hrs. I understand that you are willing to take readings at 07.00, 12.00, and 16.00 hrs. This is acceptable; it being more important that the levels be taken on a routine basis.

I also understand that taking readings on Fridays may pose a problem. May I therefore suggest that you take only one reading on Fridays at the "reading hour" (07.00, 12.00 or 16.00 hrs) which is most convenient to you. This reading would not necessarily have to be taken at the same reading hour each Friday.

To help detect any drawdown in the intake channel, you should also mark when the pumps are operating and, preferably, their discharge. This is particularly important at low river stages.

Data Retrieval

After the completion of one month of data, the sheet should be returned to the Department of Hydrology at the MOA, Mogadishu as soon as possible. I suggest that the easiest way would be to send the completed forms to the MMP office in Mogadishu with the first available traveller. MOA staff will then visit the MMP office towards the middle of each month to collect the previous month's data.

Long-Term

It is hoped that, in the long-term, the responsibility of recording and forwarding the river level data will be taken over by the MIP pump station attendant. In the meantime, however, your co-operation would be much appreciated.

APPENDIX II

PROJECT FIELD GUIDES AND MANUALS

APPENDIX II.1

ROUTINE OFFICE AND FIELDWORK PROGRAMME

Somalia Hydrometry Project June 1986

Routine Office and Fieldwork Programme

Fieldwork

Each hydrometric station should be visited on average once every 2 months to:

(1) Collect data and supply the observer with new weekly data cards and monthly sheets if required.

(2) Check the staff gauges; remove trapped floating debris, dig out silted up gauges and clean and repaint any badly rusted iron gauge plates.

(3) Do a bridge dip to check the dipper. Replace the bat tery if necessary. Always take spare batteries with you on field trips.

(4) At automatic stations, retrieve the data and replace the rechargeable battery by closely following the instructions in the Guide to Routine Operations at Automatic Stations and in the retriever and recorder user's handbooks. Take a spare battery for the retriever with you.

(5) Undertake a discharge measurement using one of the Braystoke BFM.001 current meters. If the water level is low use the wading equipment, otherwise suspend the meter and counterweight from a bridge using the derrick and gauging reel. At certain stations where there is no bridge you may need to use a boat.

You should collect the stage data for Mogambo from Sir M. MacDonald's Mogadishu office towards the middle of each month. Data from the Jubba Sugar Project at Mareere should arrive at the Ministry by post.

Office Work

Keep the office clean, particularly the computer room which should preferably be cleaned with water every day to minimize dust levels.

(i) Observer Data

Study the incoming observer data critically. Try to detect obvious mistakes and invented data before entering it into the computer.

Once the data has been entered, check it using the plotting facilities of the database program. Change the minimum and maximum values on the plot axes to produce an enlarged paper plot of the data being checked. Look for hydrologically unlikely bumps and dips in the plot and check against the original data. Compare longer periods of dubious data with the corresponding periods at stations upstream and downstream. Note your observations and corrections on the original sheets and use the comment facility of the database.

File the weekly cards and monthly sheets neatly in their proper place.

(ii) Recorder Data

After returning from a field trip transfer any data retrieved from the automatic recorders onto the hydrological database.

First transfer the data from the retriever to a floppy disk then from the floppy disk to the database. Detailed instructions on how to carry out these operations are found in the front of the "Retriever Log Book" kept in the left-hand drawer under the computer. In fact data is not transferred from the retriever to the floppy-disk but copied. The original data still exists in the retriever's memory and can be recopied if necessary. Only when you are sure that the data has been correctly entered into the database should you empty the retriever's memory by using the ERASE command and remove the battery. Keep used and new batteries separate.

(iii) Gauging Calculations

Use the program GAGCAL (GAuGing CALculations) to calculate the results of discharge measurements. File the original sheets and program output in the corresponding files. Enter the results into the discharge measurement table for the station concerned on the database.

(iv) Data back-up

Approximately once every two months, or after having entered a lot of data, a back-up copy of all the data on the database system should be made. Follow the instructions in the manual and use the floppy-disks specifically reserved for the purpose. (The last back-up during the February to June 1986 mission was made on 02/06/86.)

(v) Year Book

As soon as you have received, entered and checked all the stage data for a calendar year you should print it out and file it by station in the cupboard in the computer room (follow the examples already in the cupboard).

You should also produce a "Year Book" of all the converted daily flows and their annual statistics at each station. Use as an example the report "Annual Summaries of Daily River Flow for the Primary Gauging Stations Operated on the Juba and Shebelli rivers" produced in February 1985 for the Hydrometry Project. If you cannot find a copy in the office, the Director of Land and Water Resources should have one.

(vi) Activity Reports

With the rapid turnover of staff in the Hydrology Section it is most important that you make clear notes on everything you do. Follow the example set during the February to June mission of the MMP hydrologist; prepare activity reports describing your field trips and any major exercises you undertake on the computer such as rating curve development. Give a copy of your activity reports to the Director of Land and Water Resources and put a copy in the "Activity Reports" file.

Try preparing your reports using the word processing program, WordStar, on the computer. To enter WordStar leave the database program by typing an exclamation mark '!' then type WS followed by RETURN. You can learn to use the program by following the course entitled "Training Guide" in the WordStar manual in the left-hand drawer. It may seem a little complicated at first, but, after a little experimentation and practice, you should be able to master it. You might even like to try to produce an annual report of the Section's activities modelled on the February to June 1986 Mission Report.

(vii) Handbooks & Hydrology Textbooks

If ever you are not sure of what you are doing, use the many handbooks (Hydrological Database, WordStar, Recorder and Retriever Handbooks, etc.) in the office.

If ever you should find yourselves with some spare time, try increasing your general understanding of hydrology by reading the hydrology textbooks bought for the Section by the Somalia Hydrometry Project.

Keith Stallard 01/06/86

APPENDIX II.2

GUIDE TO ROUTINE OPERATIONS AT AUTOMATIC RECORDER STATIONS

Somalia Hydrometry Project June 1986

Guide to Routine Operations at Automatic Recorder Stations

The following operations need to be undertaken on a routine basis at the automatic recorder stations:

(i) Collect recorded data on retriever
(ii) Clean out recorder box
(iii) Replace battery with one that has been recently fully charged
(iv) Reset and restart the recorder.

These operations should be carried out at intervals of between one and three months. Until the performance of the equipment has been fully monitored under Somalian conditions, the interval should be kept as short as possible.

Sequence of operations

Normally the sequence of operations would be carried out in the order set out above. However, if the station has not been visited for a long time then the battery might be flat in which case the display on the recorder will be blank. In this case the battery must be replaced before retrieving the data which was recorded up until the battery went flat.

If a battery appears to have gone flat very quickly, recharge it and test it on the spare recorder equipment in the office.

Instruction manuals and spare recorder

In the Hydrology Section office there are instruction manuals for both the recorders and the retriever. They explain everything you need to know to operate the equipment. If in doubt about what to do, refer to the appropriate manual - guessing may cause you to loose much valuable data.

The spare recorder in the office can be most usefully used for training. Until you are familiar with the equipment you should try to do all the operations you hope to undertake in the field on the spare recorder before leaving.

To help you I have prepared this guide covering certain standard operations which need to be undertaken. It should be used together with the manufacturers operating manuals. It does not replace the operating manuals which should always be taken with you on field trips.

Retrieve data -> change battery -> restart logger

1.
Open front of recorder box and lift up perspex cover over recorder keys and display.

2.
Determine whether battery is still operating logger. If something is on the display the battery is O.K., if the display is blank the battery is flat.

3.
If the battery is O.K. continue following instructions 4 onwards. If the battery is flat you must first replace it before being able to retrieve the data - jump to step 9 and continue following the sequence - the data will be retrieved at step 10.

4.
Activate the retriever display by pressing any key. If it cannot be activated, change the internal battery. (Open the front of the retriever using the 4 screws in the corners.) Always take a spare battery into the field with you.

5.
If you are at the first or only station from which you wish to retrieve data and all the data transferred onto the retriever during previous trips has been transferred onto computer floppy disks then you should empty the memory of the retriever by using the ERASE command. Follow the instructions in section 2.5 *ERASE command on page 8 of the USER'S HANDBOOK for the RETRIEVER.

6.
Transfer the data from the logger onto the retriever by following the instructions in section 2.2 *READ command on pages 3 & 4 of the USER'S HANDBOOK for the RETRIEVER.

Be careful when plugging the round, 4-way plug into the socket on the bottom of the retriever - it only goes in one way and is quite fragile. Look at both ends and think - don't force it!

7.
Check that the data has been transferred to the retriever by using the CONTENT command. See section 2.3 *CONTENT command on p5 of the retriever user's handbook. If you emptied the retriever's memory in step 5 then the CONTENT command should indicate that the retriever now contains 01 DUMPS.

8.
Switch the retriever display off using the OFF command as described in section 2.6 *OFF command on p8 of the retriever user's handbook.

9.
Replace the battery making sure that the colours of the wires correspond to the coloured marks next to the terminals on the battery. The display on the logger should now read SET DATE but don't set it yet; read on.

10.
If you have not as yet retrieved the data stored in the recorder because the previous battery was flat you should now transfer it to the retriever before setting the date. To retrieve the data follow steps 5 to 8 above then continue to step 11.

If you have already transferred the data at step 6 continue to step 11.

11.
Set the clock (date, hour and minutes) as explained in section IV. LOGGER INITIALIZATION on p9 of the recorder user's handbook.

Note that the INCREMENT key increases the value of the digit which is flashing and that the SELECT key changes the digit which flashes.

After having set the clock the display should read READY.

12.
Check that the clock has been correctly set by using the STATUS command as explained in section 2.5 *STATUS* command on p4 of the recorder user's handbook. Find the STATUS command using the FUNCTION key then press the SELECT key repeatedly to check the state of the recorder (on STANDBY), the DATE the TIME the logging RATE and the amount of space LEFT in the memory. Do not worry if the logging rate is not 60, this will be reset in step 13 below.

If there is a mistake in the date or time, disconnect the battery and start again at step 9.

13.
If the data has already been transferred to the retriever or if there is no data to retrieve you should now empty the memory of the recorder and set the logging rate by using the RESET command. Follow the instructions in section 2.6 *RESET* command on p5 of the recorder user's handbook.

This command also resets the logging rate. The computer programs on the Hydrology Section computer are set up to receive data at hourly intervals. The logging RATE should therefore be set at MINS 60.

14.
Check that the logging rate has been set correctly by using the STATUS command (see step 12 above). If the logging rate is not 60 MIN repeat step 13.

15.
Now set the level on the logger to the water level on the staff gauge.

Read the water level on the staff gauge. Find the LEVEL command using the FUNCTION key and display the level by pressing the SELECT key. Press SELECT a second time and set the level equal to that on the staff gauge using the INCREMENT and SELECT keys as described in section 2.2 *LEVEL* command on pp3-4 of the recorder user's handbook. When you have the correct level push the FUNCTION key to confirm.

16.
The recorder is now ready to be started. Use the START command as described in section 2.3 *START * command on p4 of the recorder user's handbook.

17.
Use the STATUS command to do a final check of the state of the logger (should now be LOGGING and not STANDBY), the date and time, the logging rate (must be 60)and the amount of space left in the memory (which should be 8187 or 8186 if you have used the reset command).

18.
Finally leave the recorder displaying the water level by selecting the LEVEL command.

19.
Leave a note in the recorder box saying what you have done, the date and your names eg."27/05/86 Replaced missing float and counterweight. Battery 3 replaced by battery 8. No data retrieved, recorder memory emptied and restarted at 09.00 with water level at 3.21m. Anab & Ali".

20.
Shut and padlock recorder box.

Keith Stallard 01/06/86

APPENDIX II.3

TINYLOG SERIES MODEL TLI-05 SOLID-STATE LEVEL RECORDER USER'S HANDBOOK

```
*********************************
*        TINYLOG  SERIES        *
*         MODEL TLI-05          *
*  SOLID-STATE LEVEL RECORDER . *
*********************************
```

USER'S HANDBOOK
(Software version TLI-05.V03)

Your logger identification code is ....

I. GENERAL

1.1 Internal structure

The logger is a low-power microcomputer with customized programme & input-output interfaces packaged in a sealed enclosure to IP.55 standards.
Its internal structure is similar to that of any microcomputer system and includes :-

- a central processing unit.
- a read/write memory for data storage.
- a CMOS EPROM containing the application programme.
- a digital output compatible with the EIA/RS232 standard for communication with other computer equipment.

Tinylog TLI-05 series also comprises:-

- a strobed power supply system for connection to a shaft encoder.
- a digital input interface for conversion of shaft encoder incremental output into water-level data.

1.2 Mechanical description

The logger is enclosed in a Noryl case with a hinged transparent top cover (Makrolon) giving access to the keypad during its operation.The cover,which is normally closed,provides protection of the front-panel display/keypad whilst leaving the display visible.

The lower half of the case supports the electronic circuit boards,and the front panel.The upper half of the enclosure can be removed to give access to the battery.

For short-term logging applications,(1 to 2 weeks),the instrument uses a PP3 primary battery which is located in a front-panel mounted holder. In medium-term logging applications,(1 to 2 months),the instrument uses a PP6 primary battery which locates by board and panel cut-outs. For applications requiring longer field life,the external d.c. supply option should be specified.

The connector for the shaft encoder input is situated at the base of the instrument.This is a LEMO 4-way ,size 0,E-series,sealed socket. (Manufacturer's part No. RAE 0304 N).A blanking plug,attached by a chain,is provided to avoid ingress of moisture and dust,during trans--port or whenever the instrument is not connected to a shaft encoder. A suitable mating plug for the 4-way socket, No.FE 0304 NS 4.5 is supplied.

1.3 Functional Description.
The instrument has been preprogrammed to perform the following functions:-

a/ Record a level derived from a shaft encoder,at a preselected rate entered via the logger keyboard, in minutes, from 1 to 99 .

b/ Store the data in Read/Write memory.

c/ Service the user's requests,received by the keypad,to carry out the functions:-
- Reset the instrument(and delete previously recorded data)
- Start/Stop the recording process.
- Initialize and display the current date & time.
- Initialize and display the current water level.
- Initialize and display the logging rate
- display the logger status and amount of unused memory
- display all recorded data

d/ Display the message 'FULL' to indicate a full store and disable further recordings,in this event.

e/ Output the stored data to the serial port.

II COMMAND DESCRIPTION

2.1 Command selection

The front panel keys are,from left to right :FUNCTION,SELECT and INCREMENT.
The FUNCTION key is used to display the following commands :
- * LEVEL*
- *STATUS*
- * DATA *
- * START*
- * STOP *
- * RESET*

Leaving the FUNCTION key depressed will cause the commands to be displayed successively,in the order shown above,a new function appearing on the display every second.
When the desired command is displayed,press the SELECT key to select this command.
To proceed with a selected command,refer to the appropriate command description given below.
To exit a particular command,simply press FUNCTION again until a command is displayed.(Easily recognised by the asterisks)

2.2 *LEVEL* command.

The *LEVEL * command is used to initialize,display,and adjust the water level indicated by the data-logger.

a/ Display of current level.
Press the FUNCTION key until the command *LEVEL * is displayed.
Press the SELECT key to select this command.This is acknowledged by the display : LEV XX.XXX where XX.XXX is the current water level.When left in this position,the logger updates the display every second.To exit,press the FUNCTION key.

b/ Initialize/Adjust the current level
Proceed as in a/ so as to display the water level.Press the SELECT key again,which causes the most significant digit of the reading to blink.(Tens of meters).The blinking digit may now be changed to the desired value using the INCREMENT key.INCREMENT can be left depressed until the correct value of the digit is shown.
At this stage,pressing SELECT will enter this digit and cause the second digit (meters) to blink.
The second digit may then be initialized/adjusted using INCREMENT.
The process is repeated until the desired water level is displayed.
To exit,press FUNCTION.
See overleaf for an example of level entry.

Example:change level from 02.350 to 22.405

key.	display.	Comment.
FUNCTION	*LEVEL *	
SELECT	LEV 02.350	Current water level.
SELECT	LEV 02.350	Digit 0 is flashing.
INCREMENT	LEV 12.350	Increment 0 to 1.
INCREMENT	LEV 22.350	Increment 1 to 2.
SELECT	LEV 22.350	Second digit flashing.
SELECT	LEV 22.350	Third digit flashing.
INCREMENT	LEV 22.450	Increment 3 to 4.
SELECT	LEV 22.450	Fourth digit flashing.
INCREMENT	LEV 22.460	Increment 5 to 6.
INCREMENT	LEV 22.470	Increment 6 to 7.
INCREMENT	LEV 22.480	7 to 8.
INCREMENT	LEV 22.490	8 to 9.
INCREMENT	LEV 22.400	9 to 0.
SELECT	LEV 22.400	Fifth digit flashing
INCREMENT	LEV 22.401	Increment 0 to 1
INCREMENT	LEV 22.402	1 to 2
INCREMENT	LEV 22.403	2 to 3
INCREMENT	LEV 22.404	3 to 4
INCREMENT	LEV 22.405	4 to 5
FUNCTION	*LEVEL *	Exit command : level is now 22.405

2.3 *START * command.

Press the FUNCTION key until the command *START * is displayed. Press the SELECT key to select this command.This is acknowledged by the message LOGGING.
*START * starts the recording at the set rate until the memory is full or until the logger is stopped.

2.4 * STOP * command.

Press the FUNCTION key until the command * STOP * is displayed. Press the SELECT key to select this command.This is acknowledged by the message STANDBY.
* STOP * stops the recording until the logger is started again using *START *.

2.5 *STATUS* command.

Press the FUNCTION key until the command *STATUS* is displayed. Press the SELECT key to select this command.The role of the *STATUS* command is to give information on the logger status i.e.:-
- State of the logger.(Logging or Standby)
- Content of the real time clock.(Date & Time).
- Selected logging rate.
- Amount of unused memory.

Information on the above is displayed as a series of prompts, as follows :-

STANDBY/LOGGING	
DATE	
XX/XX	Month/day.
TIME	
XX-XX	Hour-Min.
RATE	
XX MIN	Rate in Minutes.
STORE	
LEFTXXXX	XXXX unused locations for further readings.

A new prompt is displayed every time the SELECT key is pressed. At any time, the command may be exited by pressing the FUNCTION key.

2.6 *RESET* command.

The role of this command is to restart the programme , reinitialize the logging rate,as would occur when changing the battery.
Some important consequences of the RESET function should be remembered :

-previously recorded data becomes inaccessible as all the data store is made available for subsequent recordings. To prevent accidental loss of data, a code has to be entered to enable this RESET facility.

-the logging rate may be reinitialized after a successful RESET as explained in para. 4.2.

-after a successfull RESET,the logger is in the standby mode.

-a succesfull RESET is acknowledged by the message READY.

To initiate the RESET command :

-Press the FUNCTION key until the command *RESET* is displayed.

-Press the SELECT key to select this command.

-The *RESET* command is then acknowledged by the prompt : CODE 00.

-Select the correct code,(The first two digits of the identification code for the logger),if RESET is required. This is achieved by using the SELECT and INCREMENT keys as described in para. 2.2.b/

-Press the FUNCTION key to exit the command.If RESET has taken place, the message READY should be displayed. If the wrong code was set on the display ,the message BAD CODE will be displayed instead ,and the RESET command will be ignored.

Example : (Assumes logger i.d. code is 20X,so that code for RESET is 20)

key.	display	comment.
FUNCTION	*RESET*	
SELECT	CODE 00	First digit blinking.
SELECT	CODE 00	Second digit blinking.
INCREMENT	CODE 01	Increment 0 to 1.
FUNCTION	BAD CODE	Wrong code was entered.
FUNCTION	*LEVEL*	To get back to *RESET*
FUNCTION	*STATUS*	
FUNCTION	*DATA *	
FUNCTION	*START*	
FUNCTION	*STOP *	
FUNCTION	*RESET*	
SELECT	CODE 00	First digit blinking.
INCREMENT	CODE 10	Increment 0 to 1.
INCREMENT	CODE 20	Increment 1 to 2.
FUNCTION	SET RATE	Correct code: Logger is now reset.

Note :If the RESET function has been selected erroneously, simply press FUNCTION to enter the wrong code 00,which leads to the message BAD CODE and the RESET command will be ignored.

2.7 * DATA * command.

The role of this command is to display recorded data. There are two modes of replay :

-Stepped mode in which data points are displayed one by one, every time the SELECT key is pressed.

-Auto-increment mode where the data points are output automatically.

In the stepped mode ,data is appended with day and time of recording. In the auto-increment mode ,day and time of recordings are omitted. The two modes may be alternated freely as the user wishes.

a/Stepped mode.

To initiate the * DATA * command :

-Press the FUNCTION key until the command * DATA * is displayed.

-Press the SELECT key to select this command.

-Proceed to the replay of data by pressing the SELECT key repeatedly.The following information will appear on the display:

display.	Comment.
START	Indicates beginning of recording.
XX XX-XX	Day Hour-Minute of first reading.
XX.XXX	First recording.
XX-XX-XX	Day and Time of second recording.
XX.XXX	Second recording.
XX XX.XX	etc.........
....	....
....	....
XX.XXX	last recording
END	Indicates end of recording.

b/Auto-increment mode.

To initiate the * DATA * command,proceed as in stepped mode.When the message START is displayed,press the INCREMENT key to start the automatic replay of data.The replay speed will be approximately 3 data points per second if the INCREMENT key is pressed,then released; approximately 60 data points per second if pressed continuously.

c/Example of alternate use of stepped and auto-increment modes.

Assuming that the data logger has a full store,and that the user wants to determine ,on site,at what approximate date and time within the recording period,the water level was maximum :

step1 : Select * DATA * command and read through the data quickly leaving the INCREMENT key depressed and obtain an estimate of the maximum.The INCREMENT key may be released at any time to slow down the replay,and pressed again,if required to revert to fast replay.

step2 : Select * DATA * command again,and start reading through the data quickly using INCREMENT.As the recordings approach the maximum, release the INCREMENT to slow down replay.

step3 : When the recording is very close to the estimated maximum, press SELECT to revert to the stepped mode.Read each data,appended with time until the maximum is detected. Both the maximum level and time of maximum may be inspected in this way.

d/Case of multiple start/stop.

If the logger was started and stopped several times, the prompt START will appear at the beginning of each recording period.
If using the auto-increment mode,the logger will revert to stepped mode when displaying the next START prompt.

III SERIAL OUTPUT

3.1 Output to computer/printer.

This command is not initiated on the keypad,but by inserting the data cable provided to the front panel 9-way D-type socket. This is acknowledged by the messge OUTPUT.

At this stage the logger is prepared to start the serial transmission of data, but will only commence when the SELECT key is pressed.

The fixed identification code for the logger,the selected logging rate and the data are output, following the format shown overleaf.

On completion of the output,the message END is displayed. The user may proceed to another serial output if he has left the data cable connected to the logger,or by replacing it into the front panel socket.

The same data may be output in this way as many times as the user wishes.

Note that the OUTPUT command puts the logger in the standby mode, even if previously recording. On completion of the output, the logger is left in the standby mode.

Baud rate selection :

If the SELECT key is pressed when the message OUTPUT is displayed transmission takes place at 9600 baud (default option).
The Baud rate may also be set by the user, prior to transmission following the sequence below:

key	display	comment
-	OUTPUT	data cable plugged in: logger ready to output data.
FUNCTION	SET RATE	Baud rate may now be selected
FUNCTION	300 BAUD	300 Baud ?
FUNCTION	1200BAUD	1200 Baud ?
FUNCTION	9600BAUD	9600 Baud ?
FUNCTION	QUIT	Exit the output function ?
FUNCTION	300 BAUD	Etc.....

To select the desired Baud rate, press the FUNCTION key until the correct rate is displayed, then press SELECT to select this rate. The logger will acknowledge the entry of the Baud rate by displaying OUTPUT again , and transmission will commence.

Exiting the OUTPUT command :

Proceed as above for Baud rate selection, pressing the FUNCTION until the message QUIT is displayed.
Disconnect the data cable from the logger front panel 9-way socket.

Press the SELECT key to exit. The logger will revert to normal operation (and display *LEVEL*).
Note that the data cable must be unplugged PRIOR to selecting QUIT as the logger would automatically reenter the OUTPUT routine otherwise.

IV. LOGGER INITIALIZATION

4.1 Clock Initialization.

The user must initialize the calendar clock after battery change. This is achieved by following the sequence :-

a/on power-on, the message SET DATE is displayed.

b/press any key to continue. The prompt MONTH 01 will be displayed.

c/use the SELECT and INCREMENT keys as described in para. 2.2.b/ to set the month No. to its correct value.

d/press FUNCTION to enter the Month No. and the prompt DAY 01 will be displayed.

e/proceed as in c/,d/, to initialize day,hour and minute. (Note that a 24 hour clock is used).When the FUNCTION key is pressed after setting minutes, the message SET RATE will be displayed to indicate completion of the clock initialization sequence.

The calendar clock setting may be checked using *STATUS*, after initialization.If an error was made in the initialization disconnect the battery for a short period and resume.

NOTE

When the FUNCTION is pressed to enter minutes, seconds are set to zero.

4.2 Logging rate initialization.

The logging rate must be set in the following circumstances :

- After clock initialization.

- After a succesful RESET.

To set the logging rate, proceed as below:

(i) The message SET RATE is displayed.
(ii) Press the FUNCTION key repeatedly.
The message MIN 01 will be displayed.
Use the SELECT and INCREMENT keys as described in 2.2/b to set the logging rate to its desired value.

(iii)When the desired logging rate is displayed, press the FUNCTION key to enter this rate.
(iv) Initialization of the rate is acknowledged by the message READY.

V. FURTHER SOFTWARE FACILITIES.

5.1 Full store.

When the last location of data store has been used for recording the message FULL is displayed to indicate a full store.
Logging is disabled and the logger reverts to the standby mode.

5.2 Time of first recording.

The first recording is not taken immediately after using the *START * command, but in synchronization with the calendar clock.

LOGGING ONLY COMMENCES WHEN THE TIME IN MINUTES IS AN INTEGER MULTIPLE OF THE LOGGING RATE.

For example, if the logging rate has been set to 10 minutes, recording will start on the fall of the hour, or 10 minutes past the hour, 20 minutes past the hour, 30 minutes past, ...
This feature facilitates the synchronization of several loggers.

Note that the start time stored in memory is not the time at which the *START * command was used, but the time of the first log.

VI. SERIAL INTERFACE.

6.1 Interface specification.

The serial interface is a half duplex asynchronous port, with the following characteristics :

Bit Rate : 300 ,1200 ,or 9600 per second.
Start Bit: 1.
Stop Bit : 1.
Data Bits: 8.
Parity : None.
Code : 7-bit ASCII. (MSB is set to zero)

6.2 Port configuration.

The serial output is available at the 9-way D-type socket, situated underneath the instrument cover.
It is configured as follows :

9-way socket pin No.		Function.	Direction.
1	(see Note 1)	OUTPUT (Initiates output, active low)	Device to logger.
2		GRND	-
3	(see Note 2)	CLEAR TO SEND	Device to logger.
4		TRANSMIT DATA	Logger to device
5	(see Note 1)	LOGGER 5 volts.	-

Note 1.
These signals are not EIA levels.Under no circumstances should these signals be connected to an EIA level of the associated data terminal or computer.
OUTPUT may be connected to GRND only to initiate the output routine.
The 5V supply from the logger(Pin 5) may be looped back to CTS in nil handshake applications.

Note 2.
Pin 2,3,4 are compatible with EIA-RS232 standard levels to and from the associated data terminal or computer.
Pin 2 is a signal ground to which EIA signals to and from the logger are referenced.
Pin 4 is the serial output signal from the logger.
Pin 3 is an input originating in the associated data terminal, indicating that transmission on pin 4 may proceed, when brought to the positive EIA level.This input is internally pulled low and will prevent transmission if disconnected.

6.3 Data cable.

Most data terminals are connected via a 25 way D type socket. A data cable terminated by a 25 way D type plug is thus provided.

As shipped , the data cable is configured as shown below :

```
9-way D male. <----DATA CABLE-----------> 25-way D male.

1-Connected to pin 2 of 9 way plug

2---------------------------------------7  GRND
               black

3---------------------------------------20 DATA TERMINAL READY
               green

4---------------------------------------3  RECEIVE DATA
               red

5 Not connected.
```

6.4 Example of connection to CRT terminals.

For those terminals not requiring any handshake,pin 3 and 7 only (of the 25 way plug) should be connected to the terminal.
In this case configure the cable as follows :

a/9 way plug.
- leave pin 1 & 2 connected, as shipped.
- disconnect and isolate the green wire from pin 3, and connect pin 3 to pin 5. This disables the handshake feature.

b/25 way plug.
- only the black and red wires should be connected to the 9 way plug.
- ensure that the data terminal RECEIVE DATA signal is on pin 3. (This signal may be connected to pin 2 on some terminals ; in this case , disconnect the red wire from pin 3 and connect to pin 2 on the 25 way plug)
- further connections may be required to enable communication. On some terminals such as Hazeltine 1000 or equivalent ,link pin 4,5,6,8 & 20 together. Refer to the terminal user's handbook for these extra connections.

6.5 Example of connection to lineprinters.

When interfacing to buffered lineprinters, such as Anadex DP8000 or Epson MX80, the CTS input should be used to interrupt transmission when the printer is not ready to accept data.

For the aforementioned printers,this status is available at the printer connector pin 11 (REVERSE RTS) and 20 (DATA TERMINAL READY). The polarity of this signal can be set by internal jumpers and should be set so that DTR, or Reverse RTS, is at the positive EIA level when the printer is ready to receive data.

The data cable supplied, as shipped, will suit the above printers.

6.6 Interface to desk-top computers.

Desk top computers equipped with RS232 interface may be used to collect data from the logger. Because of the relatively small store of a standard Tinylog, it is convenient to retain the data in central RAM until the transfer is complete,before permanent storage onto disk.
A full store would correspond to approximately 20k bytes of desk-top's RAM , which is well within the capability of modern microcomputers.(COMMODORE 8032, APPLE II, HP 85, ...)

A programme is required on the desk top to perform the transfer. This may be written in high-level language or machine-code.
For further assistance on this software,contact Technolog.

VII. ASPECTS OF LOGGER HARDWARE.

7.1 Switch debouncing.

To avoid erroneous action, the front-panel key-switches are debounced and scanned once per second.
It is essential to keep the desired key depressed until a change has taken place on the display, indicating that the correct function of the key has been executed.

7.2 Current consumption.

The logger supply current averages 500 to 600 microamps with the shaft-encoder connected.
If the logger utilizes an Ever Ready standard PP6 type disposable battery (type 6F50), this will correspond to approximately 40 days of field-use, at an ambient temperature of 20 deg. centigrade.
The user should be aware that the battery capacity will be reduced considerably as the ambient temperature falls below zero. For example , the battery capacity is reduced to 50 % of its nominal value at zero degrees. To avoid loss of data, the recording period should be reduced to say 3 weeks during cold weather conditions. Alternatively, Lithium -Thionyl-Chloride type LS622 may be used. These batteries will operate satisfactorily down to -40 deg., without significant reduction to their capacity,and will provide a field life of 2 months. LS622 primary batteries are available from Technolog.

7.3 Shaft encoder interface.

The shaft encoder interface comprises a four-digit up-down counter, and a power-strobed supply to the encoder. The interface has been designed primarily for use with either Honher type 2782/100 or Ferranti PYD 241 incremental encoders.

Due to the switching of the encoder supply for battery saving, the interface will operate satisfactorily for a peak rate of change of water level not exceeding 0.4 meter/second.

The up/down counter will follow changes in water levels of up to 5.000 meters in either direction, from the position at which the logger was last initialized/adjusted.(Refer to para. 2.2.b/). Note that greater ranges may be accomodated if required,by addition of software.

The interface hardware has a resolution and accuracy of 1 millimeter. Displayed levels are in meters ,with three decimals. Full resolution is used for serial output of data.

7.4 Shaft Encoder connections.

The shaft encoder should be connected as shown below :

LEMO FE 0304 pin No.	Encoder cable	
1	Blue/Black	:Supply neg.
4	Red	:Supply pos.
2	Yellow	
3	White/Green	

The above apply to both Ferranti and Honher encoders.

February 1983.
Rev. July 1984.

Technolog Limited
Technolog House,
Mill Road, Cromford,
Matlock,Derbyshire.
DE4 3RQ.

Measurement, Control & Computing Systems, Design & Consultancy.

Technolog Limited, Technolog House,
Mill Road, Cromford, DE4 3RQ Derbyshire, England
Telephone: (062 982) 3611 Telex 635091 ALBION. G. TECHNO
& 3821

LITHIUM BATTERY REPLACEMENT PROCEDURE

A. Remove Tinylog Recorder lid.

B. Remove internal battery or disconnect external power.

C. Remove two self tapping screws supporting microprocessor board, sited either side of the optional battery compartment.

D. The microprocessor board and front panel may now be lifted as one assembly.

E. The ribbon cable connecting the processor board to the interface board will allow the front panel assembly to be inverted revealing the lithium battery mounted underneath the processor board.

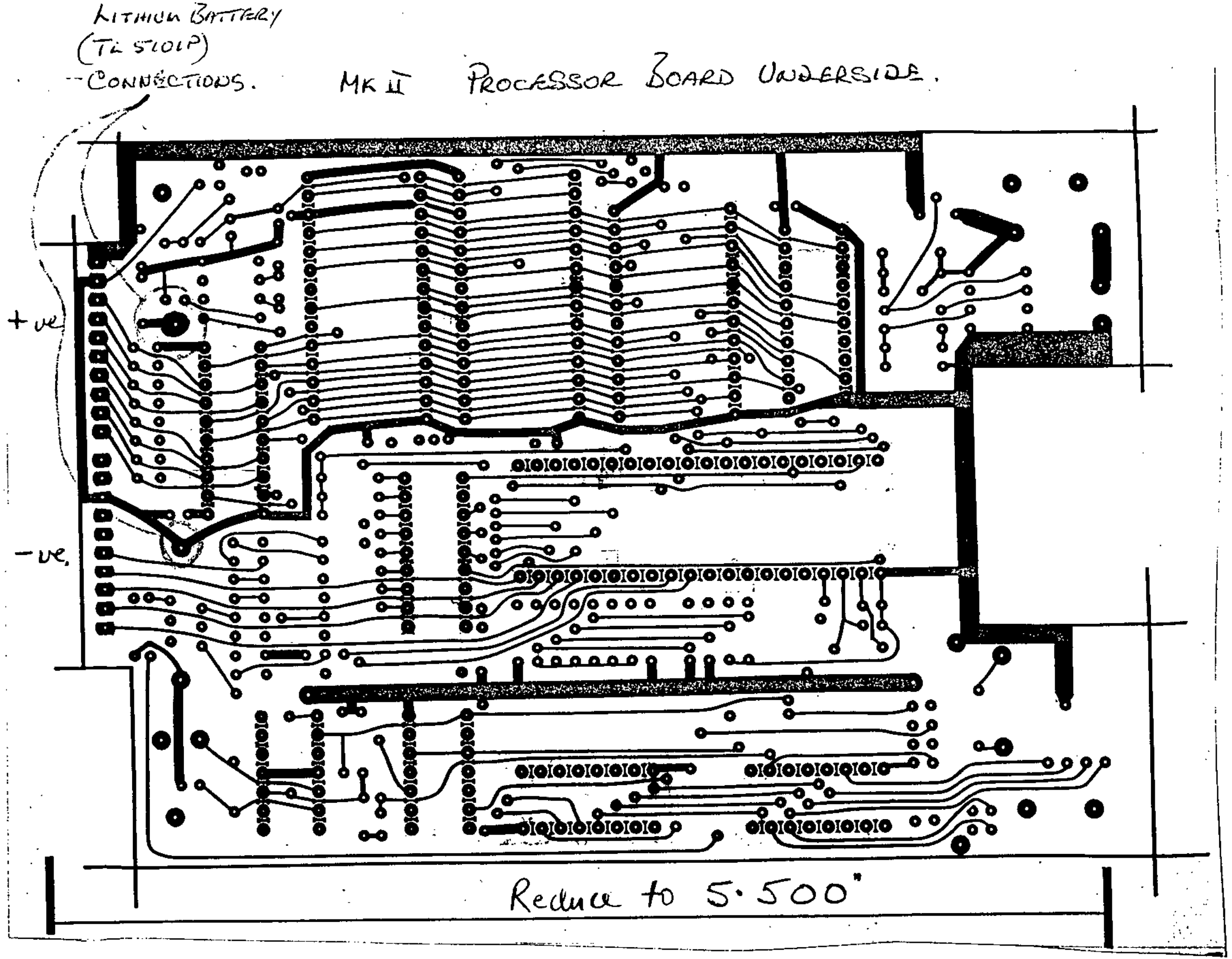
F. The lithium battery (TADIRAN TL 5101P) may now be unsoldered. If the processor board has been varnished some gentle cleaning may be necessary before installing new battery. Note battery polarity before running.

G. Prepare new battery by cutting leads to correct length, e.g. as per removed battery.

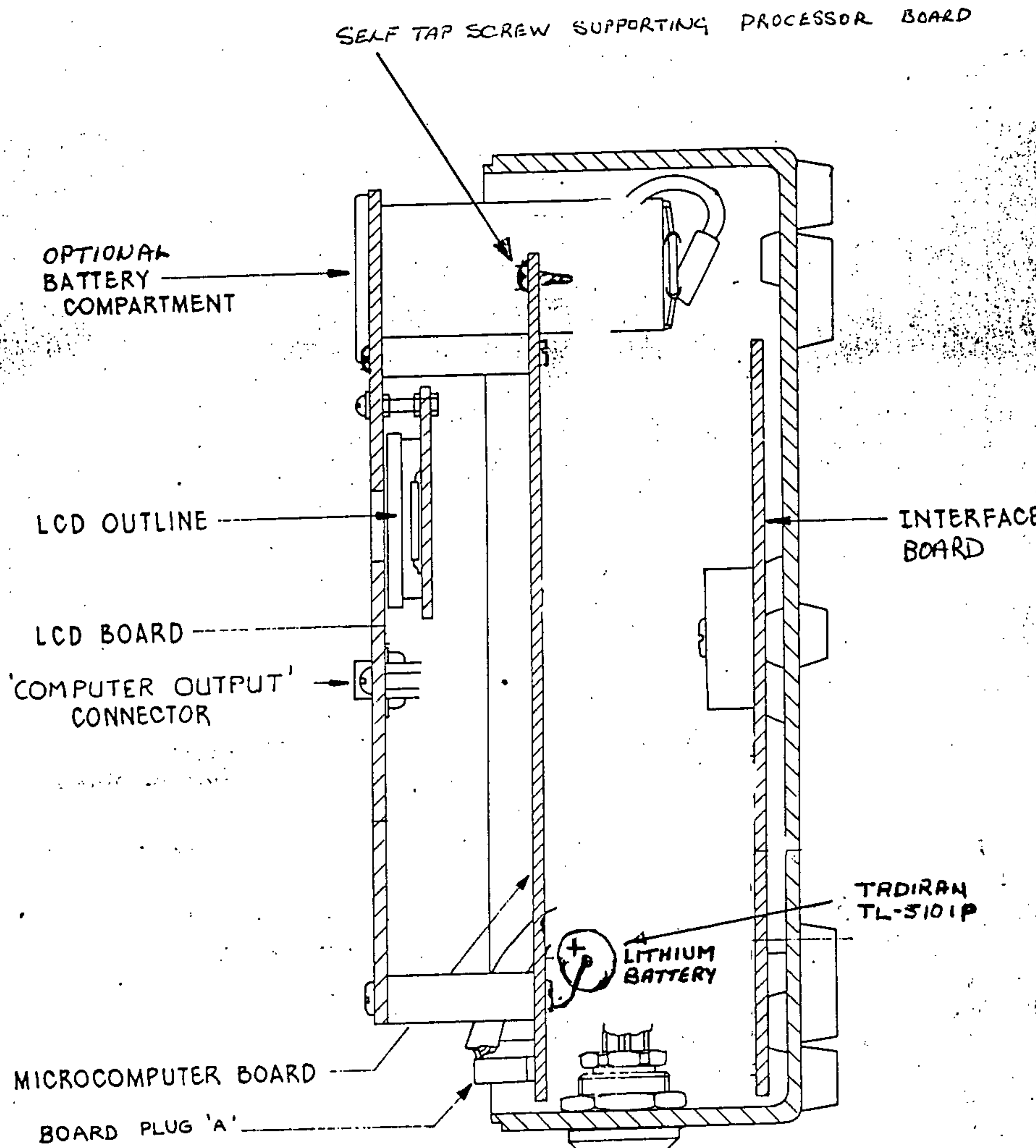
H. If a digital voltmeter is available with a current range of 0 to 200 micro-amps, the lithium battery current could be checked prior to soldering in. This should be approximately 30 micro-amps when the logger is unpowered.

I. Replace the front panel/processor board assembly making sure that the new lithium battery does not foul with the shaft encoder socket in the bottom half of the logger housing.

MK II PROCESSOR BOARD UNDERSIDE.



Reduce to 5.500"


SELF TAP SCREW SUPPORTING PROCESSOR BOARD
OPTIONAL BATTERY COMPARTMENT
LCD OUTLINE
LCD BOARD
'COMPUTER OUTPUT' CONNECTOR
INTERFACE BOARD
TADIRAN TL-5101P
LITHIUM BATTERY
MICROCOMPUTER BOARD
BOARD PLUG 'A'

APPENDIX II.4

TINYLOG SERIES MODEL TLR-32/64 SOLID-STATE DATA RETRIEVER USER'S HANDBOOK

TECHNOLOG LIMITED, TECHNOLOG HOUSE,
MILL ROAD, CROMFORD, DE4 3RQ,
DERBYSHIRE, ENGLAND,
TELEPHONE (062 982) 3611

```
***********************************
*        TINYLOG  SERIES          *
*        MODEL TLR-32/64          *
*   SOLID-STATE DATA RETRIEVER    *
***********************************
```

USER'S HANDBOOK

Your retriever identification code is ....

To ensure maximum reliability, please return your retriever to Technolog for fitting of a new lithium cell by ....

I. GENERAL.

1.1 Internal structure.

The retriever is a low-power microcomputer contained within a sealed enclosure to IP.55 standards.
Its internal structure is similar to that of any microcomputer system and includes :-

- a central processing unit.
- a read/write memory for data storage.
- a CMOS EPROM containing the retriever programme.
- a digital interface compatible with the EIA/RS232 standard for communication with other computer equipment.

1.2 Mechanical description.

The retriever is enclosed in a Noryl case with a hinged transparent top cover (Makrolon) giving access to the keypad during its operation. The cover, which is normally closed,provides protection of the front-panel display/keypad whilst leaving the display visible.

The lower half of the case supports the electronic circuit boards,and the front panel. The upper half of the enclosure can be removed to give access to the battery.

The instrument uses a 9V primary battery and a Lithium-Thionyl Chloride primary cell. The Lithium cell provides memory backup to ensure no data is lost during changing, or failure, of the 9V battery.

The 9V battery used is a PP3 type which is located in a front panel mounted enclosure.

The connector for the data logger input is situated near the base of the instrument. This is a LEMO 4-way, size 0, E series sealed socket (manufacturer's part no. RAE 0304N.) A blanking plug, attached by a chain, is provided, to avoid ingress of moisture and dust during transport, or whenever the instrument is not connected to a logger.

The connector for computer/printer output is a 9-way 'D' type socket located on the front panel.

1.3 Functional Description.

The instrument has been preprogrammed to perform the following functions :-

a) Service the user's requests, received by the keypad, to carry out the functions:-

   - Read and store data from another instrument.
   - Display the number of dumps present in the store.
   - Display the amount of unused store.
   - Display the stored data.
   - Erase the stored data.
   - Switch off the display to conserve power.

b) Output the stored data to the serial port.

II. COMMAND DESCRIPTION.

2.1 Command selection.

The front panel keys are, from left to right: FUNCTION, SELECT, and INCREMENT.
The FUNCTION key is used to display the following commands :-

*READ
*CONTENT
*INSPECT
*ERASE
*OFF

Depress the FUNCTION key repeatedly until the desired command is displayed, then press the SELECT key to select the command.
To proceed with a selected command, refer to the appropriate command description given below.
To exit a command, and return to the selection of commands above, simply press the FUNCTION key at any time.

2.2 *READ command.

The *READ command is used to read data from another instrument and store it in the retriever's store.

The data that the retriever will accept is printable ASCII data (i.e. data that is suitable for sending to a printer or VDU.)
All Technolog data loggers produce an output in this form, unless otherwise specified.

NOTE: THIS RETRIEVER IS NOT SUITABLE FOR USE WITH ANY DATA LOGGERS THAT PRODUCE ONLY A BINARY OUTPUT.

To dump data into the retriever from a logger, follow the procedure outlined below:-

1. Before selecting the *READ command, plug the cable provided into the LEMO 4-way socket, and plug the 'D'-type 9-way plug at the other end into the data logger from which data is to be retrieved.
   The message 'OUTPUT' will be displayed on the data logger.
   The data logger is now ready to produce its normal ASCII output.

2. Selecting the *READ command on the retriever will be acknowledged by the message 'START OUTPUT ON LOGGER' which will scroll from right to left across the display.
   Press the 'SELECT' key on the data logger to start its output routine.
   The retriever should now display 'INPUT' while data is being transferred from the logger to the retriever.
   (See section 4.3 for details of how long a data transfer will take.)

3. When all the data has been transferred, the message 'END' will appear on both the logger and the retriever. If either 'FULL' or 'ERROR' is displayed on the retriever then refer to notes 1 or 2 respectively.

4. The lead connecting the two devices may now be disconnected. Refer to the manual of the specific data logger being used for details of how to exit from the OUTPUT routine.
   Note: On some data loggers a special facility is provided called 'RESTART', which allows the user to exit the OUTPUT routine, clear the logger's store, and start logging again automatically. This should be used in applications where continuous logging is required.

5. Pressing any key on the retriever will return to the main selection of commands. It is suggested, at this point, that the user confirms that data has been dumped succesfully by using the *CONTENT and/or *INSPECT commands.

Note 1.

If the retriever fills its store during reading data from a logger, then the message 'FULL' will be displayed, and the data read so far will be ignored. The retriever will then wait for the output from the logger to stop.
The user should press a key on the retriever to acknowledge the 'FULL' message. The retriever will then either return to the main selection of commands, or display 'WAIT' first if the output from the logger has not finished.
(See the last paragraph of note 2.)

Note 2.

If the retriever detects an error in the data being received from the logger, then the message 'ERROR' will be displayed, and the data read so far will be ignored. The retriever will then wait for the output from the logger to stop.
The user should press a key on the retriever upon acknowledging the 'ERROR' message. The retriever will then either return to the main selection of commands, or display 'WAIT' first if the output from the logger has not finshed.

An error will be due to one of the following:-

i) An over-run or framing error in the serial data received. This may be due to the baud-rates of the logger and retriever not being the same (see note 3.)
ii) A non-ASCII character has been received (i.e. Most Significant Bit = 1, see note 4.) This is either due to using a logger that produces a binary dump, or a faulty connection between the logger and retriever.
iii) More than 80 characters have been received without a line terminator, i.e. Carriage Return. This is most probably due to using a logger that produces a binary dump.

On some loggers it is possible to terminate the OUTPUT routine by just removing the 'D'-type connector (refer to the logger manual.)
This may be done when 'ERROR' (or 'FULL') is displayed to avoid an unecessary wait.

Note 3.

The *READ command normally works at 9600 Baud. The majority of data loggers output data at 9600 Baud by default (i.e. without specifying a particular baud rate.)
If the logger does not output at 9600 Baud by default then the baud rate of the logger should be changed to 9600 Baud. If this is not convenient (e.g. baud rate is switch selectable, and is mostly used at a different baud rate,) then the baud rate of the retriever may be changed.
On certain loggers a high speed 76K Baud rate is provided which may be manually selected on the logger and retriever to speed up data transfer.

The baud rate may be altered on the retriever by following the procedure below:-

Key	Display	Comment
	START OU..	Scrolling message produced after selecting *READ.
INCREMENT	SET RATE	The baud rate may now be changed.
INCREMENT	300 BAUD	
INCREMENT	1200BAUD	
INCREMENT	9600BAUD	
INCREMENT	76K BAUD	
INCREMENT	300 BAUD	
SELECT	START OU..	300 Baud was chosen as the new rate. The initial message is now scrolled across the display again.

Note 4.

As characters are received from the logger, each one is dealt with as follows:-

i) Characters 32 to 127 are accepted as normal.
ii) Character 13 (Carriage Return) is taken as end of line terminator.
iii) Characters 0 to 31 (control codes,) excluding 13, are ignored. Certain loggers output Carriage Return and Line Feed at the end of each line. In this case the Line Feeds will be ignored. If Line Feeds are required on the output from the retriever, then this may be set as an option in the OUTPUT command.
iv) Characters 128 to 254 are taken to be illegal and will generate an error condition.
v) Character 255 is ignored.

2.3 *CONTENT command.

To proceed with *CONTENT, press the SELECT or INCREMENT keys repeatedly and the following information will be displayed:

Display	Comment
XX DUMPS	Number of dumps of data present in the retriever's store.
STORE XXK LEFT	Unused store in kilobytes.
XX DUMPS	
etc.	

Note 1.

The amount of unused memory displayed is rounded down, so, for example, 01K would be displayed if there was 1K left, or 1.9K left.

Note 2.

After reading data from a logger the number of dumps should have increased by 1. The store left should have gone down by approximately the amount of store used in the logger.

2.4 *INSPECT command.

The role of the *INSPECT command is to display any stored data.

Since the retriever only deals with the data that would be printed out by a logger, it doesn't display data as it would be displayed on the logger (by using the DATA command, if implemented.)
The data displayed is what would normally be printed out by the logger and so will contain all the text describing the logger, program, model number, etc.
This data is designed to be printed on an 80-column printer and so the text on each line is scrolled across the 8-character LCD, using the small LCD as a window onto each line of text.
Lines which contain only readings are displayed as they would be on the logger, i.e. readings are displayed consecutively, and not scrolled across the display. This also allows the auto-increment facility, normally implemented in the logger DATA command, to be used to step through readings.

It is suggested that the user does a dump from a logger into the retriever, and also prints out the data. The user may then experiment with the *INSPECT command by comparing what is displayed with the printout.

Example.

Dump number 2 in the retriever contains the following printout from a TLI-05 level recorder.

```
<cr>
<cr>
TINYLOG TLI-05 LEVEL RECORDER
LOGGER I.D. = 275
LOGGING INTERVAL = 01 MIN.
<cr>
----------------------------------------------------------------------
STARTED  10/15 15-40
 00.001 00.003 00.005 00.007 00.009 00.011 00.013 00.015 00.017
 00.019 00.021 00.023 00.025 00.027 00.029 00.031 00.033 00.035
etc.
```

Key	Display	Comment
	*INSPECT	
SELECT	DUMP 01	The user is requested to select the dump to be inspected.
INCREMENT	DUMP 02	
SELECT	TINYLOG	Dump no. 2 is selected. The display shows the first 8 characters of the first non-blank line of text.
SELECT	INYLOG T	Pressing the SELECT key causes the 'window' to move on by one character.
SELECT	NYLOG TL	
SELECT	YLOG TLI	
INCREMENT	YLOG TLI	Pressing INCREMENT, and releasing the key within 1/4 of a second, will cause the 'window' to move across the line automatically.
	....	
SELECT	ER	Pressing SELECT will cause the 'window' to stop moving. SELECT should be held down until the user is certain that the movement of the display has stopped.
SELECT	R	
SELECT	LOGGER I	When the last non-space character is displayed in the left-most position of the display, moving the 'window' any further will step to the next line.
INCREMENT	LOGGING	Pressing INCREMENT, and holding it down for more than 1/4 of a second, will cause the 'window' to move to the next line straight away.
INCREMENT	--------	
INCREMENT	STARTED	
INCREMENT	00.001	
SELECT	00.003	When readings are displayed, pressing SELECT will step to the next reading.
INCREMENT	00.003	When readings are displayed, pressing INCREMENT will start a slow auto-increment of consecutive readings. Holding the INCREMENT key down will engage a faster auto-increment.
	....	
SELECT	00.035	Pressing SELECT will stop the auto-incrementing.
etc.......................		
	END	When the end of the dump is reached the message 'END' will be displayed.

Note 1.

Blank lines in the printout (i.e. lines with either no characters on them, or just spaces) are not displayed to avoid any confusion.

Note 2.

Loggers which output two or more different types of measurement on the same line (e.g. TLI-010 or TLI-011) will produce a confusing display if the auto-increment mode is engaged while displaying readings.

Note 3.

Certain ASCII characters are not displayed (e.g. '&'), or are displayed differently (e.g. ':' becomes '='.)
All lower-case letters are converted to upper-case for displaying.

2.5 *ERASE command.

The role of the *ERASE command is to delete stored data, and make the whole of the store available for further dumps from loggers.

To avoid accidental loss of data, a code has to be entered to enable this facility. The reset code is a 2-digit number formed by the first 2 digits of the retriever identification code (see top left hand corner of front panel.)

Upon selecting the *ERASE command the display will show 'CODE 00' where the second digit is blinking. To set the code to the desired value, follow the procedure below:

i) The digit of the displayed number that is blinking may be incremented to its desired value by pressing the INCREMENT key as many times as is necessary. When the blinking digit is equal to 9, pressing the INCREMENT key will change this digit to 0, then 1, etc

ii) Use the SELECT key to change the blinking digit, and proceed as in part (i) to set it to its correct value.

iii) When the number that is displayed is the desired value, press FUNCTION to enter the displayed number.
The position of the blinking digit at the time of entry is irrelevant.

If the entered code was correct then the display will show '*READ' and the store will now be empty.
If the entered code was incorrect then the display will show 'BAD CODE' and the store will remain unaltered. The user should then press any key to return to the main selection of commands.

2.6 *OFF command.

The role of the *OFF command is to reduce power consumed by the retriever when it is not in use.

Selecting the *OFF command will result in the display being switched off. Pressing any key will cause the display to power on again and display '*READ'.

If the display is switched off after each use of the retriever then current is reduced to 25uA from 275uA.

III. SERIAL OUTPUT.

This command is not initiated on the keypad, but by inserting the data cable provided into the front panel 9-way 'D' type socket. This is acknowledged by the message 'OUTPUT'.

At this stage the retriever is prepared to start serial transmission of data, but will only commence when the SELECT key is pressed.

The data transmitted is suitable for printing on a lineprinter, or storing by a computer for future processing. Each dump printed out will be separated from the next by 4 blank lines.

On completion of the output, the message 'END' is displayed. The user may proceed with another serial output by pressing the SELECT key again. The message 'OUTPUT' will be displayed again.
The user may do this as many times as is required.

Baud rate and line termination selection.

When the data cable is first plugged in, the baud rate is set to 9600 Baud, and the end of line termination is one Carriage Return only.
A different baud rate and/or line termination may be selected by the user, prior to transmission, by following the sequence below:

Key	Display	Comment
	OUTPUT	Data cable plugged in: logger ready to output data.
INCREMENT	CR	Indicates that current line termination is CR only.
INCREMENT	CR + LF	Other option is CR + Line Feed.
SELECT	SET RATE	Pressing SELECT selects the option. New baud rate may now be selected.
INCREMENT	300 BAUD	300 Baud ?
INCREMENT	1200BAUD	1200 Baud ?
INCREMENT	9600BAUD	9600 Baud ?
INCREMENT	76K BAUD	76800 Baud ?
INCREMENT	300 BAUD	
SELECT	OUTPUT	New baud rate of 300 Baud is selected, and retriever starts outputting.

If several outputs are done consecutively then the previously selected line termination and baud rate will remain until manually changed by the user, or until the data cable is removed.

Exiting the OUTPUT command.

The OUTPUT command may be exited at any time (even during transmission) simply by removing the data cable. The retriever will then revert back to normal operation and display '*READ'.

IV. ASPECTS OF RETRIEVER HARDWARE AND SOFTWARE.

4.1 Battery replacement.

The retriever contains a 9 volt primary battery and a lithium cell. The lithium cell is fitted during manufacture and will last 4-5 years. The cell is not rechargeable, and its life is not affected by the retriever usage. The retriever should be returned for the fitting of a new cell by the date shown at the start of the manual.
The 9 volt primary battery (PP3, e.g. EVER READY 6F22, or DURACELL MALLORY MN1604) will last for so many dumps of data (see 4.3 Current consumption.) The figures given are for a 350mAh PP3 battery (EVER READY 6F22) at an average temperature of 20 degrees centigrade.
If a longer life is required then alkaline or mercury batteries such as DURACELL MALLORY MN1604 or TR146X will extend the standard life by a factor of about 1.5.

Note.

In cold environments (below zero degrees centigrade) battery capacity will be considerably reduced. For example, at 0 degrees centigrade the battery capacity is reduced to about 50% of its nominal value. The estimated battery life should therefore be reduced accordingly.
Alternatively, Lithium-Thionyl Chloride type LS622 (700mAh capacity) may be used. These batteries will operate satisfactorily down to -40 degrees centigrade without significant reduction to their capacity.

After replacing the battery it will be necessary to press a key to re-activate the retriever.

4.2 Battery voltage detector.

The retriever contains a voltage detector circuit which monitors the PP3 primary battery. When the battery voltage falls to approximately 6.8 volts this circuit inhibits operation of the retriever. The retriever will then be disabled until the voltage rises above about 8.1 volts.
This circuit has two main uses:-
i) The microcomputer is unlikely to go out of control ('crash') and corrupt data due to a flat battery.
ii) If a nearly flat battery is placed in the retriever, the retriever will not try to work off it.

4.3 Current consumption.

The table below shows the currents taken from the 9V battery by various parts of the retriever:-

Microcomputer board, microcomputer not running.	25uA
" " " running.	15mA
Additional current if display on.	250uA

When the retriever is reading data from a logger, or outputting its data, then the microcomputer board will be continuously running. This will reduce the charge in the battery by 15mAh per hour.
So, for example, if each dump of data to the retriever takes typically 2 minutes, this will require 15mAh x (2mins / 60mins) = 0.5mAh charge. With a standard PP3 battery (350mAh capacity, or 250mAh capacity to allow a safety margin) approximately 500 dumps could be made.

Note 1.

There is a constant 25uA drain on the battery which will reduce its capacity by 18mAh per month. This may need to be taken into account if batteries are to be used for very long periods, i.e. months.

Note 2.

The time taken to transfer data from a logger to the retriever depends upon the baud rate used, and the format of the numbers sent.

Example: Transmitting approximately 8000 readings from a TLI-05 level recorder, at 9600 Baud. The numbers are sent in the form XX.XXX with a space between each number, i.e. 7 characters are transmitted for each reading.

Total number of characters sent is 8000 x 7 = 56000
(This assumes the text sent in the header is negligible compared with the numeric data.)
Number of characters transmitted per second is 960.
(i.e. 1/10th of baud rate.)
Therefore, time taken is 56000 / 960 = 58 seconds.

If the fastest baud rate of 76k Baud is employed then the time taken will be only marginally faster than using the 9600 Baud rate. This is because the time taken to process the characters becomes very significant at these speeds.

4.4 Data compression and storage.

In the example above, 8000 readings (each taking typically 1 byte of store in the logger, hence 8K total) caused 56000 characters to be sent to the retriever. If the retriever were to store these characters directly in its memory then 56K of store would be needed. Obviously this is very wasteful compared with the 8K of store used by the logger to retain the same data.

To avoid this problem the retriever uses a data compression algorithm on the ASCII characters as they are received from the logger. This algorithm simply looks at each line of characters and decides whether the line contains only readings, or whether there is any additional text. If the line contains any text then the whole line is stored in memory as it is received. If the line contains only readings then each of the readings is converted to 1 or 2 bytes and then stored in memory. This reduces the amount of data to about the same as in the logger. However, since there is quite a lot of text in the header at the beginning of each dump, it is unlikely that less store will be used in the retriever than in the logger.

This technique is most efficient when there is a high percentage of readings compared with text in the output from the logger.
In general, the amount of store used in the retriever will be similar to the amount used in the logger, to within +/- 1K.

V. SERIAL INTERFACE.

5.1. Interface specification.

The serial interface is a half duplex asynchronous port, with the following characteristics :

Bit Rate : 300, 1200, 9600, or 76800 per second
Start Bit: 1.
Stop Bit : 1.
Data Bits: 8.
Parity : None.
Code : 7-bit ASCII data (MSB = 0)

5.2 Port configuration.

The serial output is available at the 9-way D-type socket, situated underneath the instrument cover.
It is configured as follows :

9-way socket pin No.		Function.	Direction.
1	(see Note 1)	OUTPUT (Initiates output, active low)	Device to logger.
2		GRND	-
3	(see Note 2)	CLEAR TO SEND	Device to logger.
4		TRANSMIT DATA	Logger to device
5	(see Note 1)	LOGGER 5 volts.	-

Note 1.

These signals are not EIA levels. Under no circumstances should these signals be connected to an EIA level of the associated data terminal or computer.
OUTPUT may be connected to GRND only, to initiate the output routine.
The 5V supply from the logger (Pin 5) is only at 5V when OUTPUT has been grounded. Current should not be drawn from this terminal unless OUTPUT has been grounded, as this may cause damage to the internal primary lithium cell.
The 5V supply may be used as a fixed positive EIA level which can be connected to handshake lines on the computer to indicate no handshake.

Note 2.

Pin 2,3,4 are compatible with EIA-RS232 standard levels to and from the associated data terminal or computer.
Pin 2 is a signal ground to which EIA signals to and from the logger are referenced.
Pin 4 is the serial output signal from the logger.
Pin 3 is an input originating in the associated data terminal, indicating that transmission on pin 4 may proceed, when brought to the positive EIA level. This input is internally pulled low and will prevent transmission if disconnected.

5.3 Retriever - Computer/Printer cable.

Most data terminals are connected via a 25 way 'D' type socket.
A data cable terminated by a 25 way 'D' type plug is thus provided.

It is configured as follows:-

```
9-way 'D' male.                                   25-way 'D' male.
    pin no.                                           pin no.
    -------                                           -------
      1     (Output sense,
             wired to pin 2.)
      2     (Ground)--------------------------        7    (Ground)
                                Black
      3     (Clear To Send)-----<-------------       20    (Data Terminal Ready)
                                Green
      4     (Transmit)----------->------------        3    (Receive)
                                 Red
      5     (5 Volts)
```

5.4 Example of connection to lineprinters.

When interfacing to buffered lineprinters, such as Anadex DP8000, or Epson MX80, the CTS input should be used to interrupt transmission when the printer is not ready to accept data.

For the above printers, this status is available at the printer connector pin 11 (Reverse RTS) and pin 20 (Data Terminal Ready) respectively. The polarity of the signal can be set by internal jumpers and should be set so that DTR, or Reverse RTS, is at the positive EIA level when the printer is ready to receive data.

5.5 Interface to desk-top computers.

Desk top computers equipped with RS232 interface may be used to collect data from the retriever. Data may be transferred completely to the desk-top's RAM and then transferred onto cassette or disk for permanent storage. Alternatively, data may be transferred in small blocks to the desk-top computer which would then store these small blocks of data onto cassette ir disk as they are received.

For every kilobyte of data stored in the retriever, this will produce about 8-9 kilobytes of ASCII data. This may either be stored directly or processed to extract the numeric information.

A programme is required on the desk top to perform the transfer.
This may be written in a high-level language or machine-code.
For further assistance on this software, contact Technolog.

5.6 Retriever - Logger cable.

The connection to the logger is made from the LEMO 4-way socket located near the base of the retriever. The cable provided is terminated with a LEMO 4-way plug (part no. FE 0304N x.x) at the retriever end, and a 9-way male 'D' type connector at the logger end.

It is configured as follows:-

```
LEMO 4-way plug.                                 9-way 'D' plug.
  pin no.                                            pin no.
  -------                                            -------
    1   (Ground)--------------------------     1 and 2 (Output Sense, and
                          Black                         Ground respectively)
    2   (DTR)---------------->-------------      3      (Clear To Send)
                           Red
    3   (Receive)-----------<-------------      4      (Transmit)
                          Green
    4   (Unused)
```

Note: DTR stands for Data Terminal Ready.

May 1984.

Technolog Limited
Victoria Chambers,
115 Dale Road,
Matlock,Derbyshire.
DE4 3LW.

APPENDIX II.5

TRANSFER OF DATA FROM THE RETRIEVER TO THE COMPUTER DATABASE

TRANSFER OF DATA FROM THE RETRIEVER TO THE COMPUTER DATABASE

These notes describe the system of transferring data from the electronic data retriever to the computer database. It is assumed that you have just returned from a field trip and have copied data from one or more loggers onto the data retriever.

The process of transferring the data from the retriever to the database involves three main stages :

(1) Running the program READLOG which reads all data stored on the retriever and stores it on a computer disc.

(2) Running the program LOGGER which transfers data from the computer disc onto the main computer database.

(3) Using the database facilities to check and compare logger data with observer data and save the data if required.

These stages are described later in detail.

Data from the retriever comes in hourly intervals and is not stored compactly. This would soon fill up the computer hard disc (where all the programs and main database files are stored). For this reason the hourly logger data is stored on removable floppy discs. When one floppy disc is full a new one may be started.

TRANSFER OF DATA STAGE 1 - RETRIEVER TO FLOPPY DISC

(1) Enter into the retreiver log book the current date in the form :

24/10/85 (day,month,year)

The date should be 8 characters long so 2nd January 1986 would be :

02/01/85

This is important as it forms the basis of the file name under which the data will be stored on the floppy disc. It will make it easy at a later date to find the data again if required.

(2) Make the complete file name by adding the two characters B: to the front of the date and the four characters .DAT to the end of the date. So in our first example above the file name would be :

B:24/10/85.DAT

Enter your file name in the retriever log book.

(3) Find the floppy disc labelled ELECTRONIC LOGGER RIVER LEVEL DATA and insert it in the floppy disc slot on the left of the computer. The side of the disc with the labels should face the centre of the computer. The arrow on the disc label points straight into the machine.

(4) Make sure that the 'T' switch is pointing to 'LOGGER'

(5) Plug the cable labelled 'RETRIEVER' into the retriever. The display on the retriever should say 'OUTPUT'.

(6) Make sure that you have left the normal database programs on the computer and the screen has the symbols A> and is waiting for you to type.

(7) Type READLOG followed by [RETURN].

(8) When requested enter the output file name you have worked out in step (2) above and press [RETURN].

(9) Press the 'SELECT' key on the retriever.

(10) The data will then be transferred from the logger to the floppy disc. As the data are being transfered they are listed line by line to the screen so you can see what is happenning.

(11) When transfer of data is complete, a message to this effect is

displayed on the computer screen.

(12) Disconnect the retriever from the computer.

(13) Note the fact that data has been transferred by noting the disc number in the appropriate column in the retriever log book.

(14) Now enter into the retriever log book the numbers of all the stations you from which you have collected data. The station numbers are the normal ones for computer use. Station 10, for example is Beled Weyn. Along side the station number list the years for which you know the data comes from. It is possible that data may be stored on the retriever for one or two years. For example :

Station Number	Years
10	1985 1986
2	1986

This means that there is data from two loggers on the retriever (stations 10 and 2) and that there is data from both 1985 and 1986 for station 10 but from station 2 there is only 1986 data.

(15) Return the 'T' switch to 'PLOTTER' position

(16) The floppy disc may be left in the computer if you are going to transfer data immediately from this disc to the database. Otherwise remove the floppy disc and store safely and cleanly.

TRANSFER OF DATA STAGE 2 - FLOPPY DISC TO DATABASE

(1) If the floppy disc containing the data has not been left in the computer from step (16) above, find it and insert it into the computer as described in step (3) above.

(2) From the retriever log book you will see how many station years of data need to be transferred from the floppy disc to the to database. In the example in (14) above there are three station years. Only one station year can be transferred at a time from the floppy disc.

(3) Make sure that you are outside the database system and that the screen says A> and is waiting for you to type.

(4) Type the command LOGGER followed by [RETURN].

(5) When the program asks for the datafile name answer with the file name as written down in the retriever log book. In our example this would be :

B:24/10/85.DAT

(6) The program will then ask :

Enter station number for data abstraction >

In our example we would enter 10 for Beled Weyn.

(7) The program will tell us what logger number it thinks is at our station. This should normally be correct unless a logger has been replaced for some reason. If it is correct then just enter [RETURN]. Otherwise reply with the new logger number.

(8) The program will then search the datafile on floppy disc line by line until it finds data from the correct logger. When it has done this the program will pause and display the start month and day of the logger data. You must then enter the year for which this starts. In our example this would be 1985.

(9) The data will then be read in line by line until the end of the dump. Finally the screen will say how many readings have been read, when they start and when they end. Enter these three items in the retriever log book.

(10) You are now presented with a choice of 6 things to do :

(1) Finish

(2) List data to screen

(All or part of the data may be listed)

(3) Transfer to database

(If data spans more than one year a choice of year to transfer is offered. A password and current date must be supplied.)

(4) Delete selected readings.

(Readings may be deleted according to order number or over a range of stages.)

(5) Add constant to selected readings.

(A constant may be applied to all readings or readings over a specified range according to order number)

(6) Plot data on screen.

(All data or a specified range of data may be plotted according to order number. The y axis scale may be changed from the default 0.0 - 5.0 metre range.)

(11) The normal procedure would be to plot the data first as an overall check on its validity. Any sudden jumps or excessive oscillations should show up on the plot.

(12) Any bad data may be deleted or a constant added if the logger system was not correctly set against the staff gauge.

(13) Once satisfied, select option 3 to transfer data to database. You must supply your password and the current date when asked. The program will then take the readings at 6:00, 12:00 and 18:00 hours automatically and store them temporarily. The database system is then called and you simply have to wait while it selects all the options and enters the data. The normal qualility are applied to the data as if it were entered by hand; ie checks against station maximum and minimum and for excessive jumps in readings.

TRANSFER OF DATA STAGE 3 - CHECKING AND SAVING

(1) When the data transfer is complete the screen will update and you are in the staff gauge data editor just as if you had enter the numbers yourself. The data is not yet saved and appears on the 'Edit' line. Therefore if observer data has already been entered it may be directly compared with your current edits or logger data. This is easily done by plotting the data on the screen, remembering to select the plotting option to plot data edits as well as the current file contents.

(2) If you wish to save the logger data use the save option.

(3) Convert all stages to flows using the convert option and then the ALL command in the editor.

(4) Save the flows

(5) Note in the retriever log book that the data has been transferred to the database and make any comment you need.

(6) Leave the database system and repeat from the beginning of Stage 2 for the remaining station years. In our example the next station year for abstraction would be station 10, year 1986. The last to be transferred would be station 2 , year 1986.

(7) Store floppy disc in a clean, safe place.

(8) Erase the contents of the retriever by following the instructions on page 8, section 2.5 of the SOLID-STATE DATA RETRIEVER USER'S HANDBOOK.

C S Green

24th October 1985

APPENDIX II.6

RIVER SHEBELLI MODEL

River Shebelli

Model

River Shebelli Model

Jeremy Meigh

Institute of Hydrology
Wallingford
Oxfordshire
United Kingdom

March 1986

Preface

This report describe the development and running of a model of the River Shebelli in Somalia. The model was developed for the Somali Ministry of Agriculture as part of the ODA funded project 'Hydrometry for Somalia' and has been installed on the project computer in the offices of the Ministry of Agriculture in Mogadishu.

The model has two modes of operation. Firstly it may be used to check existing downstream data and infill missing data by making a prediction from an upstream station. The second mode is for real time use in predicting downstream flows in a 'flow forecasting mode'.

The model is a simple regression based model relating downstream to upstream flows with a fixed time lag between each reach. The model reads input data directly from the database installed on the Ministry of Agriculture computer ('Institute of Hydrology Hydrological Database - Version 3.0, June 1986).

The FORTRAN source code for the model is available in Mogadishu on the floppy disc containing the model. The statistical analysis undertaken to develop the model was accomplished using the statistical package MINITAB which is also available on the project computer in Mogadishu. Should the need arise, it is therefore possible to repeat the regression analysis and modify the model in Mogadishu.

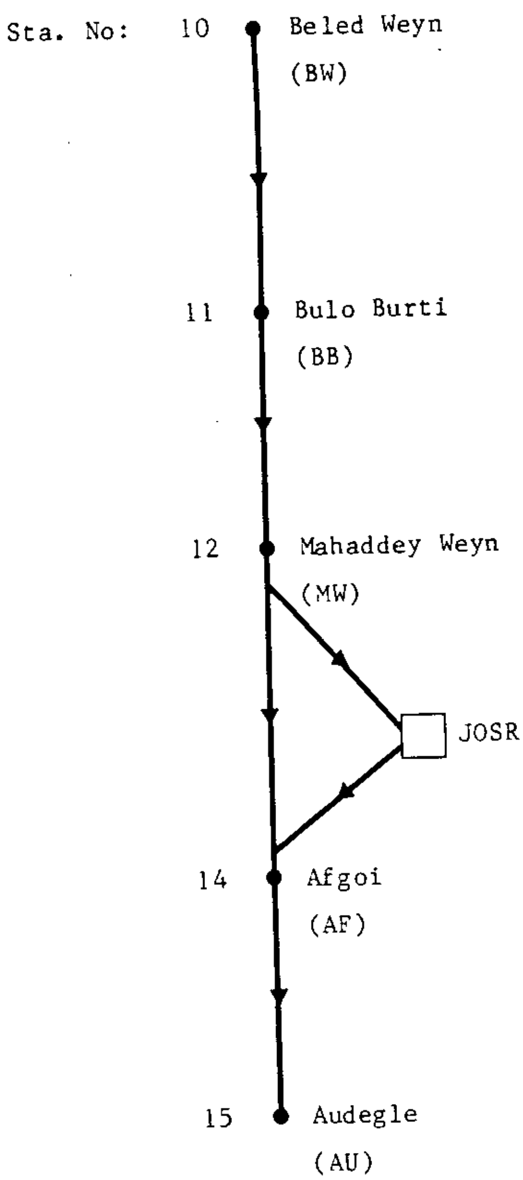
RIVER SHEBELLI MODEL

RIVER SHEBELLI MODEL

1. CONSTRUCTION OF THE MODEL

1.1 Checking the data

The model was constructed by carrying out linear regressions between daily flows for each reach of the river. All the available data for the period 1963-85 was used, except for the reach MW-AF, for which 1963-79 was used, as the Jowhar Offstream Storage Reservoir (JOSR) may affect flows after 1980. Since some of the data is of suspect quality, it was examined thoroughly before doing the regressions. The data for both upstream and downstream stations of a reach were plotted together on the same plot. This was done for each reach and for each year. From the plots a number of periods were identified, during which which flows are likely to be in error. These periods, which are listed in Table 1, were removed from the data set before carrying out the regressions. Although many periods of bad data were identified, some may still remain. This is most likely to be so at Beled Weyn as there is no upstream data to provide a check. At the three lower stations MW, AF and AU flows reach a maximum value and stay at or near these values for long periods. These periods were also removed from the data set when undertaking the regressions. (Table 1 also gives the maximum flows used in the regressions for each year for these three stations).



SCHEMATIC DIAGRAM OF THE RIVER

TABLE 1

PERIODS OMITTED FROM REGRESSIONS &
MAXIMUM VALUES USED IN REGRESSIONS

YEAR	BW	BB	MW Max Value (m^3/s)	MW	AF Max Value (m^3/s)	AF	AU Max Value (m^3/s)	AU
1963	-	-	127	-	86	1 Jul-1 Aug	66	-
1964	-	1 Feb-14 Apr	127	-	87	-	67	-
1965	-	-	130	-	83	31 Oct-31 Dec	67	13 Sep
1966	-	5-31 Dec	135	-	80	-	67	1 Jul- 8 Aug
1967	-	1 Jan-3 Feb	133	-	83	-	-	-
1968	-	17 Mar	132	-	87	-	67	-
1969	-	-	135	-	88	-	-	-
1970	-	-	135	9 Aug-19 Nov	90	-	-	-
1971	-	26 Jun-31 Aug	-	-	90	22 Sept	79	-
1972	-	-	-	-	90	-	-	-
1973	-	-	-	-	90	-	-	-
1974	-	15-31 Aug	-	-	-	-	-	-
1975	-	-	-	-	90	-	-	-
1976	-	13 Jul-12 Aug	134	-	87	-	78	-
1977	-	13 Apr-30 Jun 1 Oct-31 Dec	147	-	90	-	77	-
1978	-	1-31 Jan 1 Jul-29 Sep	-	1-28 Feb 1 Apr-31 May 1 Jul-31 Dec	90	1 Jan-28 Feb	88	1-31 Jan 1 Apr-30 Jul
1979	-	1 Apr-31 Jul 1 Sep-30 Sep 1 Nov-30 Nov	-	1 Jan-31 Aug	97	-	-	-
1980	-	-	-	-	-	-	-	-
1981	-	-	156	-	73	-	72	-
1982	-	-	-	-	80	-	82	-
1983	-	1-31 Jan 1-30 Mar 1-30 Apr 1-30 Jul	148	-	85	-	82	-
1984	-	-	-	-	80	-	78	-
1985	1 Aug-15 Oct	3 Apr-3 May 14 May-14 Oct	160	-	70	-	69	-

(this information is stored in files SDAT10.DAT to SDAT15.DAT - see appendix)

1.2 The regressions

With the remaining data the following procedure was adopted. Firstly, the downstream station was regressed on the upstream station; then the upstream data was lagged by one day with respect to the downstream and the regression repeated; the upstream was lagged by a further day and the regression repeated again, and so on. Examination of the regression plots and correlation coefficients at the various lags enabled the mean lag to be determined. The mean lag was defined as the lag which gave the best correlation between the two stations. Some of the regression equations gave the d/s flow a positive value when the u/s was zero. In these cases the regressions were recalculated with the line fixed to go through the zero point. For the reaches BW-BB and MW-AF it was apparent that a better relationship could be obtained by using a number of straight line segments. This was done by fitting the lines by eye. The resulting equations are given in Table 2 and the regression plots for the best lags are given in Figures 1-4. Besides the model equations, Table 2 also gives the regression equations obtained initially and their correlation coefficients. The correlation coefficients are all better than 0.95. Where the lines are split into segments the fit would be better than shown, but the coefficients cannot be easily calculated.

For the first three reaches equally good results were obtained in each case with lags of 2 days and of 3 days. The values shown were chosen because a number of runs using one year of data at a time indicated these to be best. The lags chosen are thought to be reasonable mean values but actual lags might be expected to vary with the state of flow. The sum of the lags used here is 8 days. As a further check on the lags, the lowest station, AU, was correlated with the highest, BW, and 8 days was found to give the best correlation.

At MW, AF and AU the flows tend to reach maximum values and these vary somewhat from year to year, and sometimes within a year. For each station the available data was examined and mean maximum values were obtained. For AF a maximum flow of 96 m^3/s was used. However, at the other two stations there seemed to be a point after which the maximum value was consistently different. Thus, at MW a value of 138 m^3/s was used up to the end of 1979 and 163 m^3/s was used thereafter. At AU 74 m^3/s was used up to the end of 1970 and 87 m^3/s thereafter.

TABLE 2

REGRESSION EQUATION

REACH	INITIAL REGRESSIONS	MODEL EQUATIONS
BW → BB	BB = 0.792 BW + 12.14	BB = BW for BB 128
lag = 2 days	r = 0.955	BB = 0.690 BW + 39.7 for 128 BB 246
	N = 4751	BB = 0.395 BW + 128.0 for BB 246
BB → MW	MW = 0.886 BB + 7.19	MW = 0.968 BB
lag = 2 days	r = 0.965	Max. flow: MW = 138 upto 31.12.1979
	N = 3269	MW = 163 from 1. 1.1980
MW → AF	AF = 0.827 MW - 0.60	AF = 1.022 MW - 5.31 for AF 46.3
lag = 3 days	r = 0.971	AF = 0.728 MW + 9.53 for AF 46.3
	N = 2580	Max. flow: AF = 96
AF → AU	AU = 0.960 AF + 2.02	AU = AF
lag = 1 day	r = 0.969	Max. flow: AU = 74 upto 31.12.1970
	N = 2569	AU = 87 from 1. 1.1971

where,

BW, BB, MW, AF, AU are flows in m^3/s at the corresponding stations.

r = correlation coefficient

N = number of data points used in the regression.

BB vs BW 1963 - 1985

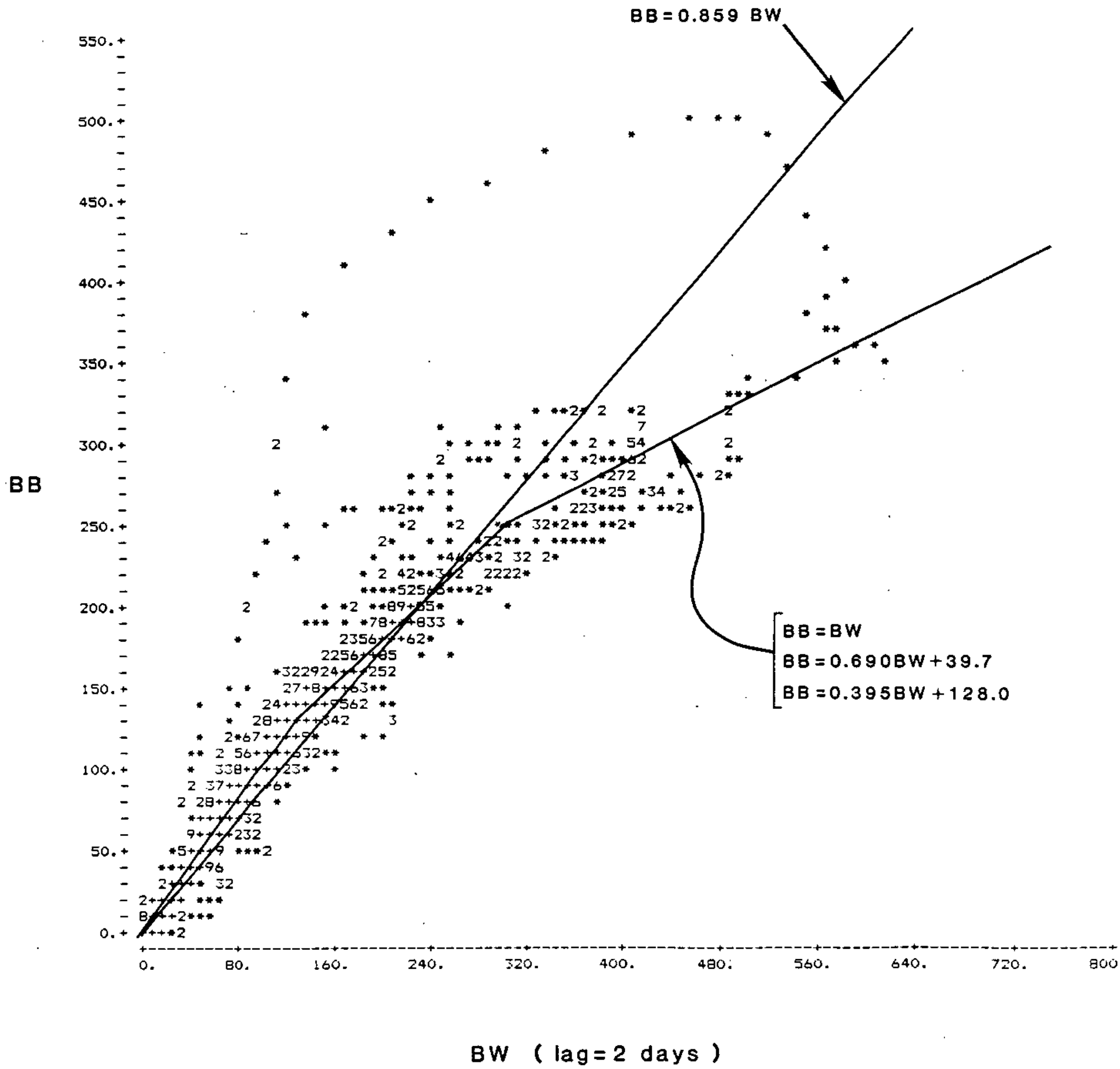


Figure 1

MW vs BB 1963 - 1985

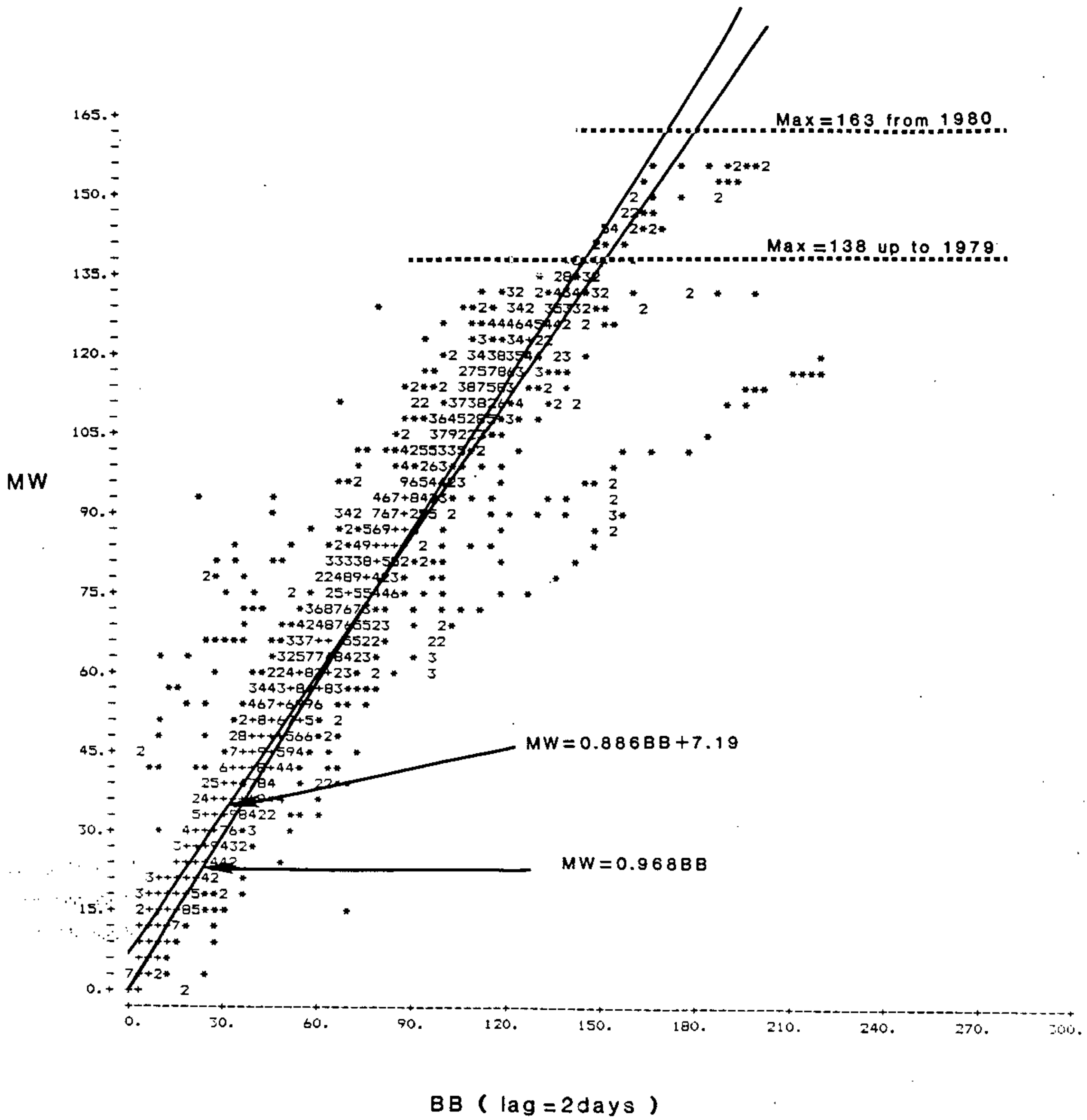


Figure 2

AF vs MW 1963 - 1979

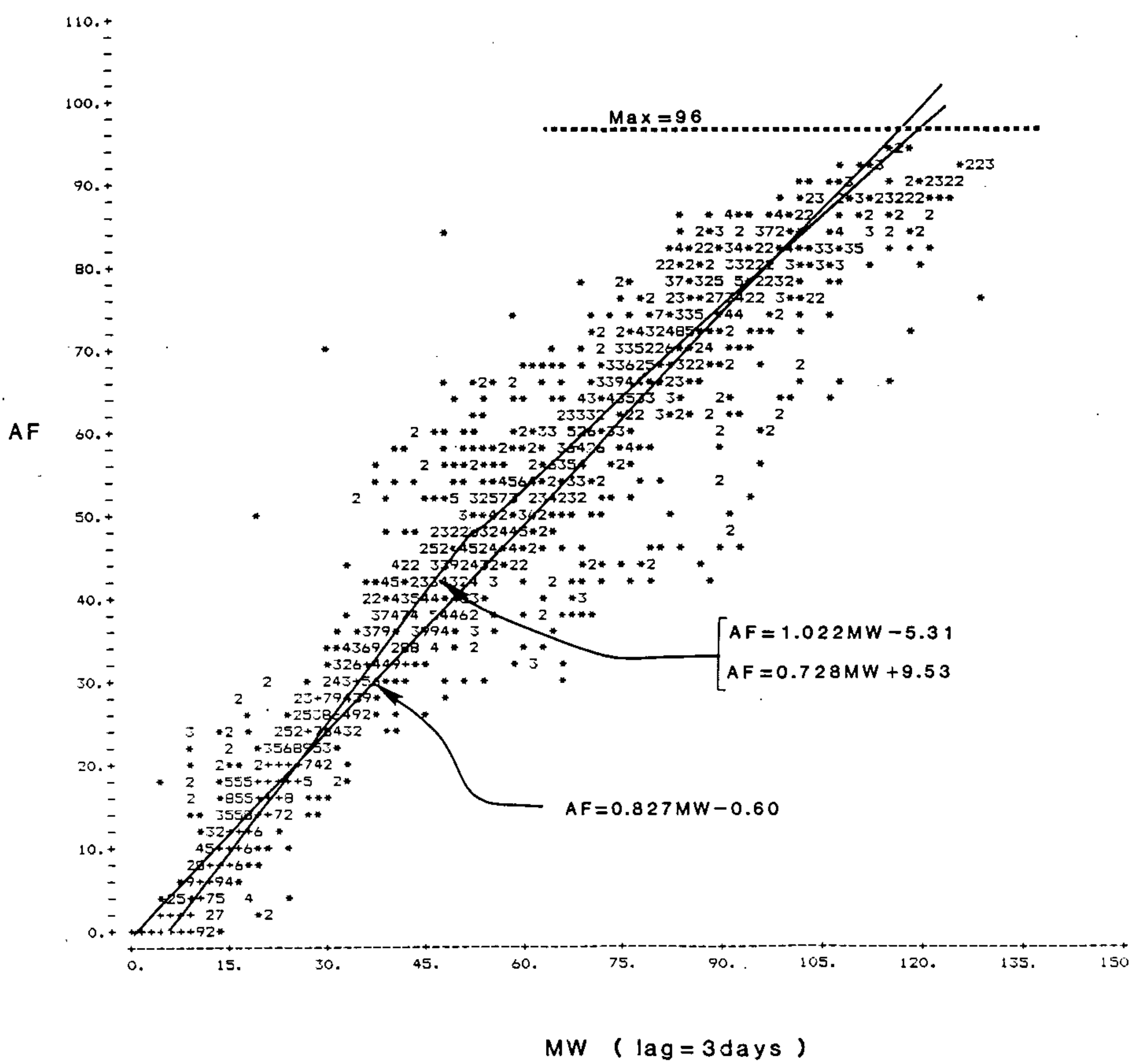


Figure 3

AU vs AF 1963 - 1985

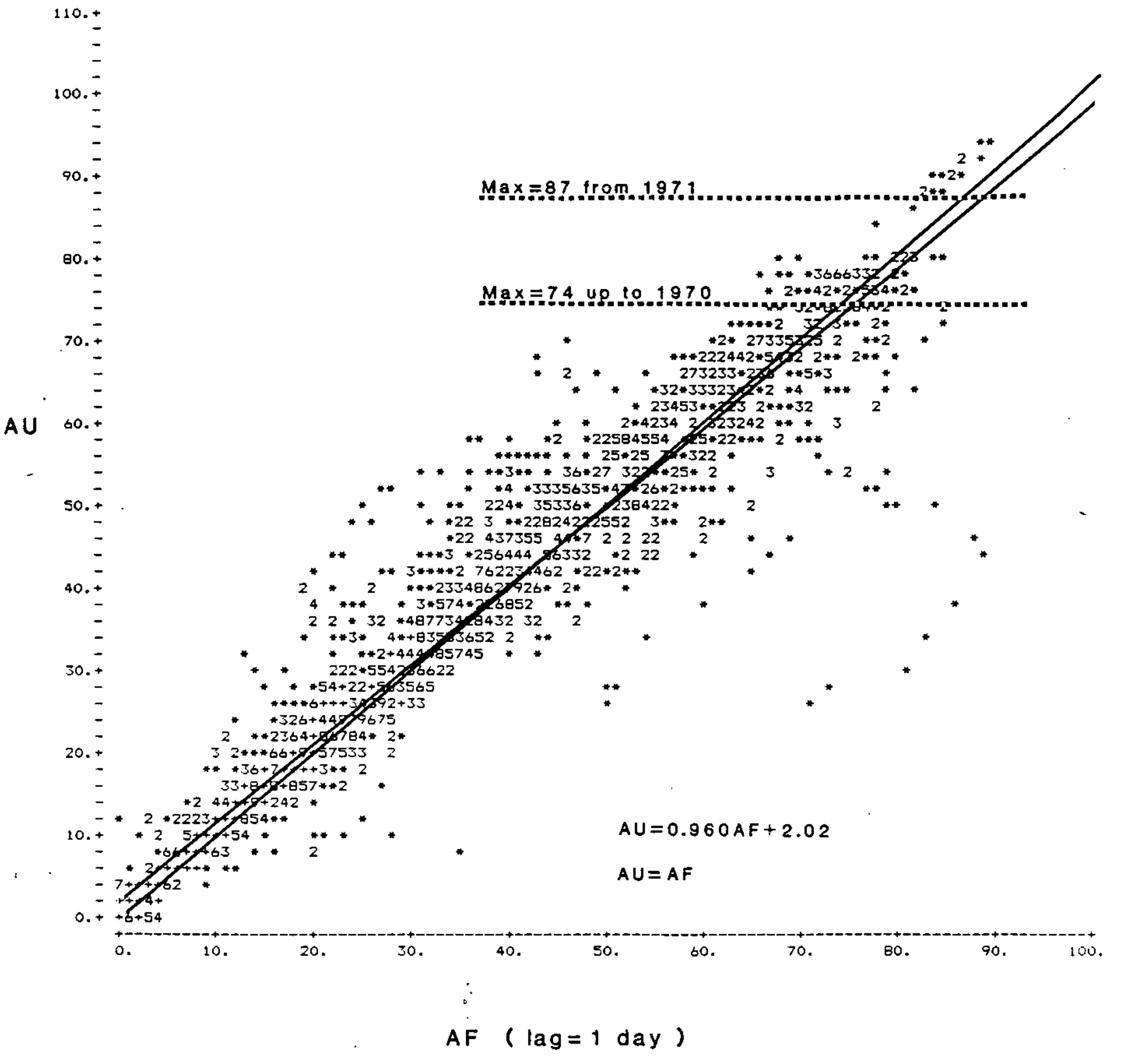


Figure 4

Although the model is simple it gives reasonably good results. The main inadequacy is the lack of variability in the lag. Also, in the first reach, BW - BB, the model is unable to satisfactorily predict the large floods of 1981. It appears that during this flood considerable bankside storage occurred, and the stored water only returned to the river after a period of 2-3 weeks. This large flood is represented in Figure 1, by the loop of points far from the regression line. The performance for smaller floods in this reach was satisfactory.

2. PROGRAMS FOR THE REGRESSIONS

2.1 Program to obtain the data : SFIND

The program obtains data from the hydrological database (HDB) for a pair of stations and outputs it to a file which is suitable to be read by MINITAB so that the regressions may be carried out.

The program asks the operator to enter the numbers of the two stations of interest, and the period for which data is to be obtained. This can be one year, or a number of years between 1963 and 1985. SFIND then reads the appropriate files of SDAT10.DAT to SDAT15.DAT, which indicate the periods of suspect data and the maximum flows to be used in the regressions (for SDAT files see Table 1 and Appendix). The requested years of data are read from the HDB files. Data in the HDB files which are flagged as missing or estimated are stored as missing values. Similarly, any periods which are marked as suspect data in the SDAT files, or any values above the station maximum, are also treated as missing values. The flow values for the pair of stations are written to a file. One day's flow is written on each line with the u/s flow in the first column and the d/s flow in the second column. To save space in the file, missing values (written as -99.99) are omitted after the first six in succession. (Six values are retained to allow regressions with a lag of up to 6 days. If it is wished to use a lag of more than 6 days the program must be amended.)

The output file from this program can be read into MINITAB and the regressions performed. Examples of the use of the program and of MINITAB follows.

2.2 Use of SFIND and MINITAB

SFIND is contained on a floppy disc. To run it the disc should have the files: SFIND.CMD, SDAT10.DAT, SDAT11.DAT, SDAT12.DAT, SDAT14.DAT, SDAT15.DAT. Run the program from A:, not B:, eg as follows:

```
A>B:SFIND

Enter numbers of u/s and d/s stations > 10,11

Enter first and last years to be read > 1963,1964
```

```
Dates of data to be rejected read from B:SDAT10.DAT

Dates of data to be rejected read from B:SDAT11.DAT
FILE HDB05    TYPE  5 BLOCKSIZE 367 SAMPLE   0 LASTWORD WRITTEN  *

 2 years data written to SHEB.DAT, from 1963 to 1964
  547 days data written;   184 days omitted
STOP
```

Note: Line '*' is a database message which may be ignored

The output file from SFIND can be read into MINITAB and the regressions carried out by the following sequence of commands (stored in SCOM.DAT):-

```
 1.  DIME 3000  <-------------  set to column length of SHEB.DAT
 2.  READ 'A:SHEB.DAT' C1 C2
 3.  WIDTH 100 60  ]<---------  set large size plot and brief
 4.  BRIEF 2       ]            output from REGR command
 5.  RECODE -99.99 C1 '*' C1 ]<-set -99.99 to MINITAB missing value
 6.  RECODE -99.99 C2 '*' C2 ]  character
 7.  STORE
 8.  LAG 1 C1 C1
 9.  PLOT C2 C1             <-  lag u/s flows by 1 day, do regression and
10.  CORR C2 C1                 plot, and regression through zero point.
11.  REGR C2 1 C1               These sequences are stored and repeated 3
12.  NOCO                       times.
13.  REGR C2 1 C1
14.  CONS
15.  END
16.  EXEC 3 <-------------------
17.  STOP                       If lag is to be greater than 6, change line
                                119 in SFIND to insert more missing values
                                in SHEB.DAT.
```

Notes (1) The sequence of commands can be run by using the MINITAB command INUNIT 4

(2) MINITAB must be run from B:

3. THE MODEL PROGRAM

3.1 The model : SHEBELLI

This is the program for the model of the river. It obtains the flow data from the HDB in a similar way to SFIND, and uses the regression equations given in Table 2 to predict flows. There are two modes of operation:-

(1) Infilling historic data.
(2) Forecasting flows.

Infilling mode

In the infilling data mode, the program operates on one complete year of data. The year of data at the station, for which the prediction is required, and at the station immediately upstream are read from the HDB. Each flow value in the HDB is flagged as either good, missing or estimated, and this information is also obtained. The appropriate SDAT files are read, to find the periods which are suspect data. The results is that each flow value obtained by the program has a flag associated with it which can have one of four values.

1. missing value,
2. good data,
3. estimated data,
4. suspect or bad data.

Note: These are different to the flags used in the HDB

When flows at the upstream station have flags of 2 or 3, the model equations are used to predict flows at the downstream station. These predicted flows are given a flag of 3. If no prediction can be made a missing value is assigned to the predicted flows. Thus predicted flows are flagged either:-

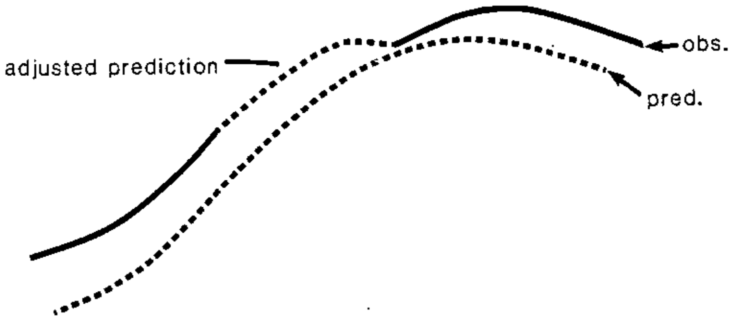
1	missing value, or	(when u/s flag = 1 or 4)
3	estimated value	(when u/s flag = 2 or 3)

After this a number of options are possible:-

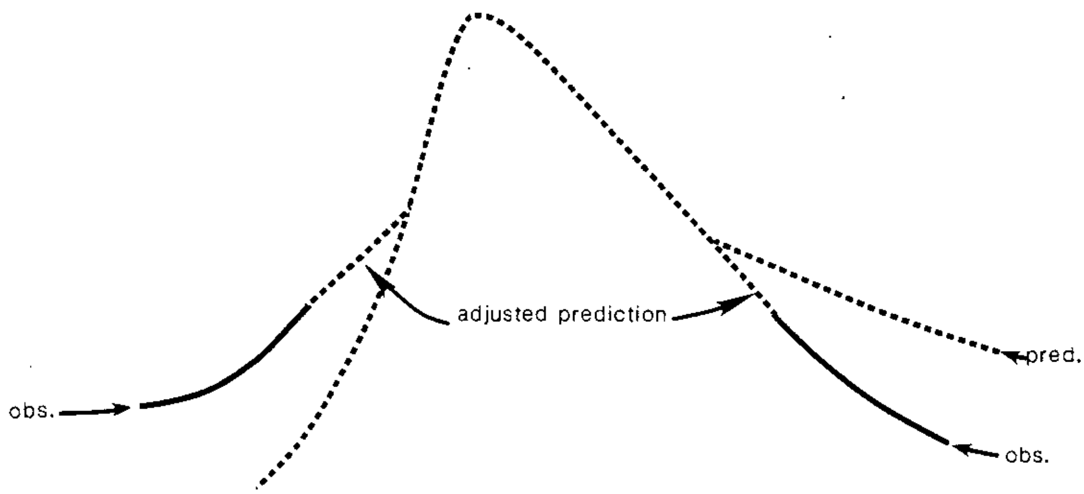
(a) Go back to try another station, year or mode of operation.

(b) Adjust predicted flows to remove discontinuities. When calculating the predictions, the program finds the differences between observed and predicted flows at each point where there is a gap in the observed flows. (ie where the flag of observed flow changes from 2 or 3 to 1 or 4, or vice versa, and the predicted flow has flag 3). This option allows the discontinuities to be removed, so that observed and predicted flows are matched at these points. There are two possible methods of making the adjustments:

(1) by shifting all predicted values in the gap, eg:



or (2) by removing the difference in equal steps over 3 values, eg:



(c) Plot observed and predicted flows. It is possible to do any of the plots on the screen or on the paper plotter. The observed flows are plotted as are all of the predicted flows. However, if desired, the prediction can be shown only at gaps (or places where data is bad) in the observed flows, so that the effect of infilling the data can be seen. If the predictions have been adjusted as in (b), these adjusted flows can also be plotted (adjusted flows are shown only in gaps in the observed flows).

(d) Write flows to file or transfer to HDB. The predictions can be written to the file DATAIN.DAT. This is the default file for reading data into the HDB. Predicted values are only written for observed flows which are missing or bad: thus, when the data is copied into the HDB the editor only contains predicted values at points where the observed data needs to be infilled. This entire operation can also be executed automatically: the program transfers control to HDB and issues the HDB commands to DATAIN.DAT which are required to copy the predicted flows into the HDB editor. Adjusted or unadjusted predictions can be copied.

It is envisaged that the model will be used in the following way for infilling historic records. For each year work will start at the upstream station. Data at BW will be used to infill BB, the operator deciding on whether the periods marked as bad data are indeed so, and whether any other periods should be replaced. The operator will also choose the most approriate method of adjusting the flows if this is thought to be necessary. When BB flows have been infilled, and the additional data copied into the database, the infilled BB data can then be used to infill MW and so on down to AF and AU.

Forecasting mode

In the forecasting mode, the program reads a year's data, but only works on a three month period. The date from which the forecast is to be made is in the second month of this period. The forecasting date can be the current date, or a past date to check the forecasts against observed data. If the forecasting date is in January the previous year's data is read, and it is in December the following year's data is ready so that the correct three month period is obtained. The SDAT files are read and the data is flagged in the same way as in infilling mode. Data is obtained for the station, for which the forecast is to be made, and for all upstream stations. Initially forecasts are made using the data from each upstream station independently. For example, if a forecast is required at AF, the data from BW is first used to predict flows at BB, this prediction is used to predict flows at MW and the prediction at MW gives a forecast at AF. Then, starting from BB a second forecast at AF is obtained, and finally a forecast is obtained directly by staring at MW. These separate predictions are combined to give a single final or combined forecast. The nearer stations data is used preferentially in doing this, only going to the next station when no data is available at the nearer station. Provided upto date information is available at each station, the furthest upstream station would only be used for the last two days of the forecast. This is because the cumulative lag time of upstream stations is the furthest ahead that a forecast can be made.

Having made the forecast a number of options are available:-

(a) Go back to try another station, forecasting date or mode of operation.

(b) Adjust predicted flows. Provided that observed flows are available and that they finish at the forecasting date or in the 7 days before, the combined forecast can be matched to the last observed flow value. There are two methods of making the adjustments, as in the infilling mode

(c) Plot observed and predicted flows. The plot shows 18 days on either side of the forecasting date. It shows observed flows, and the separate forecasts, combined forecast or adjusted combined forecast.

(d) Write the flows to the screen, printer or to a file (SFOR.DAT) for later examination. The combined forecast is written, and this can be unadjusted or adjusted as explained in (b).

3.2 Running Shebelli

The program is on the same floppy disc as SFIND, and should also be run from A:. The necessary files are, as before, SHEBELLI.CMD and SDAT10.DAT to SDAT15.DAT.

The program asks a series of questions which require the operator to enter one of a specified set of integer replies to decide the next operation. In addition to the specified replies, there are two further replies which have the following meaning:

98 returns operation to the beginning of the program and
99 which stops the program.

Examples of runs of the program in the two operating modes follow:-

Example of Shebelli in infilling historic records mode

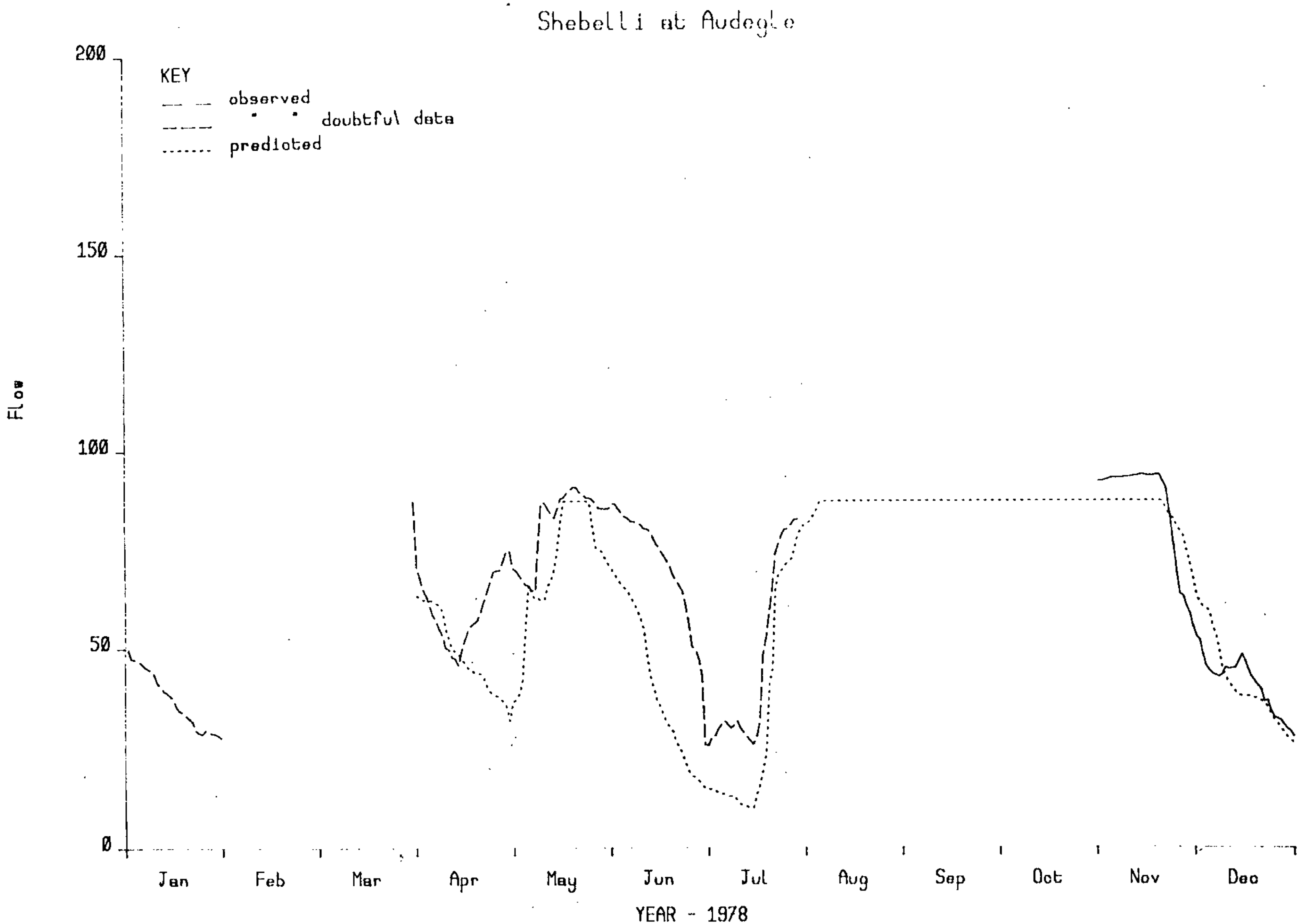
```
A>B:SHEBELLI


                    RIVER SHEBELLI MODEL
                    ====================

Enter your password  > HYDRO
```
← Not checked, only required for entry to HDB (option 6 in main menu below)

```
Enter today's date (eg. 25,2,1986)  > 28,2,1986

Enter: 1 to infill historic records
       2 to forecast flows
 > 1

Enter station number to be modelled > 15

Station number 15 - Audegle

Enter year to be modelled > 1978
```
← Possible range: 1963 - 1986

```
Dates of bad data read from B:SDAT15.DAT

Dates of bad data read from B:SDAT14.DAT
FILE HDB05    TYPE  5 BLOCKSIZE 367 SAMPLE   0 LASTWORD WRITTEN

Flows for 1978 for station 15 and u/s station 14 read, and
 days of bad data flagged


Predicted flows calculated for 1978 for station 15

Discontinuities between observed and predicted flows:
     End of obs. flows                          Start of obs. flows
     -----------------                          -------------------
     -                          -       Day 305   Diff.(Qpr - Qobs)



   INFILLING DATA  -  MAIN MENU

Enter: 1 to plot flows on the screen
       2 for paper plot
       3 to try another station, year or mode of operation
       4 to write flows to file
       5 to remove discontinuities between model & observed
       6 to enter HDB and copy flows
       7 to STOP
  > 2


Enter: 1 to show all predicted flows
       2 to show predictions only in gaps in observed flows
  > 1


Plotting ....
```
see Figure 5

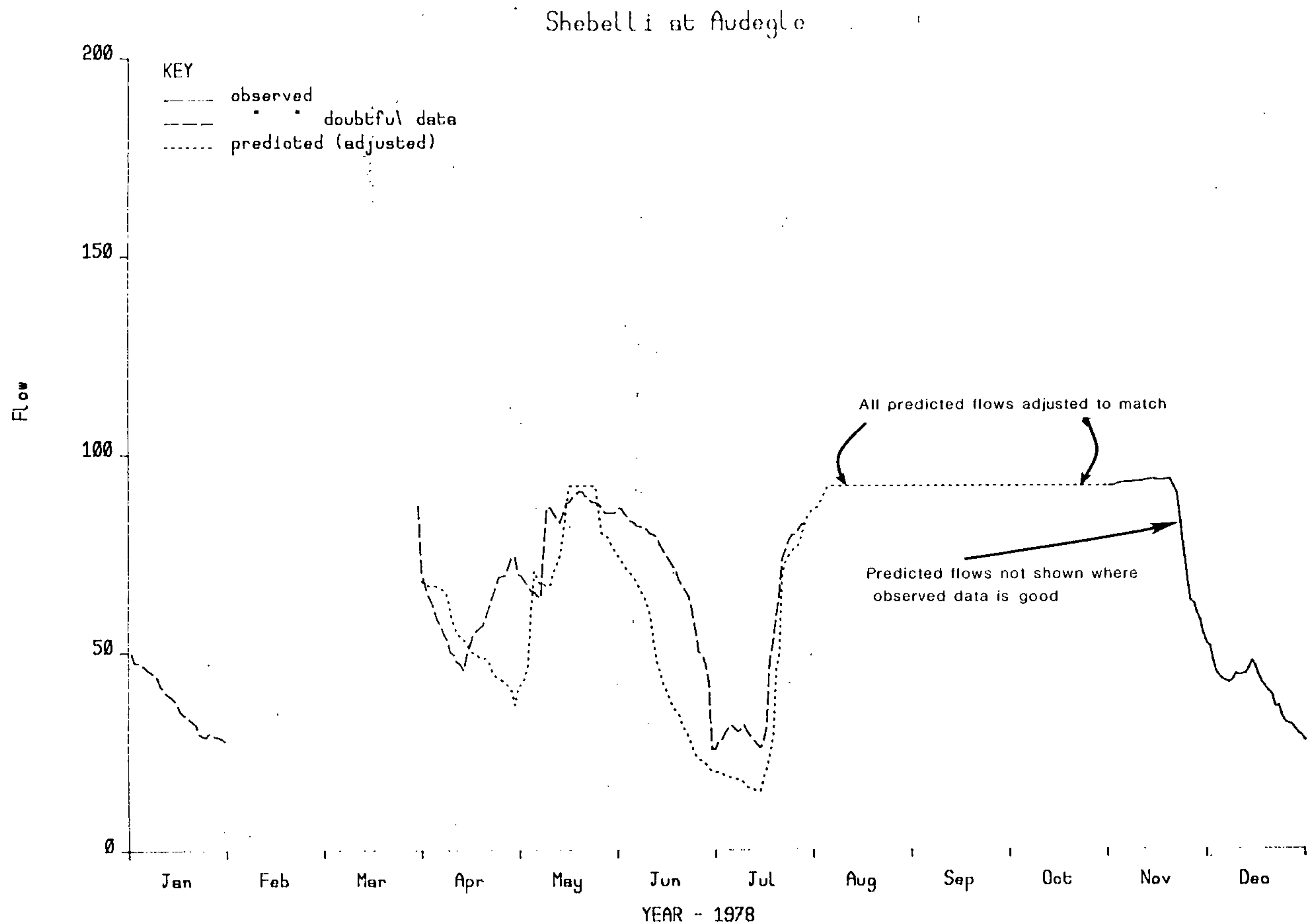
Paper plots are in one colour only- use pen NO. 1

```
   INFILLING DATA  -  MAIN MENU

Enter: 1 to plot flows on the screen
       2 for paper plot
       3 to try another station, year or mode of operation
       4 to write flows to file
       5 to remove discontinuities between model & observed
       6 to enter HDB and copy flows
       7 to STOP
 > 5


For each (single or pair of) discontinuities, enter either:
  1 to shift all flows in gap, or;
  2 to remove discontinuity over 3 values.

     End of obs. flows                          Start of obs. flows
     -----------------                          -------------------
     -                       -             Day 305   Diff.(Qpr - Qobs)
Enter 1 or 2  > 1


Discontinuities removed


Enter: 1 for screen plot of adjusted flows
       2 for paper plot of adjusted flows
       3 to write adjusted flows to file
       4 to return to MAIN MENU
 > 2


Plotting .... see Figure 6


Enter: 1 for screen plot of adjusted flows
       2 for paper plot of adjusted flows
       3 to write adjusted flows to file
       4 to return to MAIN MENU
 > 4




   INFILLING DATA  -  MAIN MENU

Enter: 1 to plot flows on the screen
       2 for paper plot
       3 to try another station, year or mode of operation
       4 to write flows to file
       5 to remove discontinuities between model & observed
       6 to enter HDB and copy flows
       7 to STOP
 > 7

STOP
```



Infilling data

Figure 5



Infilling data

Figure 6

Example of Shebelli in forecasting mode

```
A>B:SHEBELLI


                    RIVER SHEBELLI MODEL
                    ====================

Enter your password  > HYDRO

Enter today's date (eg. 25,2,1986)  > 4,3,1986

Enter: 1 to infill historic records
       2 to forecast flows
 > 2

Enter station number to be modelled > 15

Station number 15 - Audegle


Forecast from today's date (yes/no) ?  > N

Enter date for forecasting (eg. 25,2,1986)  > 4,11,1985
```

range : 1963 - 1990

```
Dates of bad data read from B:SDAT10.DAT
FILE HDB05    TYPE  5 BLOCKSIZE 367 SAMPLE    0 LASTWORD WRITTEN
Flows for 1985, station 10 read & flagged
Dates of bad data read from B:SDAT11.DAT
Flows for 1985, station 11 read & flagged
Dates of bad data read from B:SDAT12.DAT
Flows for 1985, station 12 read & flagged
Dates of bad data read from B:SDAT14.DAT
Flows for 1985, station 14 read & flagged
Dates of bad data read from B:SDAT15.DAT
Flows for 1985, station 15 read & flagged


--------------------------------------------------------------
Predicted flows for station 15     Forecasting day:  4 Nov 1985
--------------------------------------------------------------

Prediction made from station 10 is available up to: 12 Nov 1985

Prediction made from station 11 - no data available

Prediction made from station 12 is available up to:  8 Nov 1985

Prediction made from station 14 is available up to: 27 Oct 1985

            Combined prediction is available up to: 12 Nov 1985
```

Data is examined over a 3 month period.

Forecasting date is in the second month.

```
   FORECASTING  -  MAIN MENU

Enter: 1 to plot flows on screen
       2 for paper plot
       3 to try another station, date or mode of operation
       4 to write flows
       5 to remove discontinuity between predicted & observed
       6 to STOP
 > 2


Enter: 1 to plot combined prediction
       2 to plot adjusted combined prediction
       3 to plot prediction from each upstream station separately
 > 3

Plotting ....
```

see Figure 7

```
   FORECASTING  -  MAIN MENU

Enter: 1 to plot flows on screen
       2 for paper plot
       3 to try another station, date or mode of operation
       4 to write flows
       5 to remove discontinuity between predicted & observed
       6 to STOP
 > 2


Enter: 1 to plot combined prediction
       2 to plot adjusted combined prediction
       3 to plot prediction from each upstream station separately
 > 1

Plotting ....
```

see Figure 8

```
   FORECASTING  -  MAIN MENU

Enter: 1 to plot flows on screen
       2 for paper plot
       3 to try another station, date or mode of operation
       4 to write flows
       5 to remove discontinuity between predicted & observed
       6 to STOP
 > 5

Adjustments can be made to predicted flows if observed flows end on the
forecasting date, or in the 7 days before it

Difference (Qpr - Qobs) is   4.36 at 7 days before forecasting date

Enter: 1 to shift all flows after this, or;
       2 to remove discontinuity over 3 values
 > 2

Discontinuity removed


   FORECASTING  -  MAIN MENU

Enter: 1 to plot flows on screen
       2 for paper plot
       3 to try another station, date or mode of operation
       4 to write flows
       5 to remove discontinuity between predicted & observed
       6 to STOP
 > 2

Enter: 1 to plot combined prediction
       2 to plot adjusted combined prediction
       3 to plot prediction from each upstream station separately
 > 2

Plotting ....
```

see Figure 9

```
   FORECASTING  -  MAIN MENU

Enter: 1 to plot flows on screen
       2 for paper plot
       3 to try another station, date or mode of operation
       4 to write flows
       5 to remove discontinuity between predicted & observed
       6 to STOP
 > 4
```

```
Enter: 1 to write flows to the screen
       2 to print flows
       3 to write flows to file
 > 1


Enter: 1 to write unadjusted flows
       2 to write adjusted flows
 > 1


    RIVER SHEBELLI

Observed and predicted flows for station 15 - Audegle
    Forecasting day:  4 Nov 1985

                                FLOW
                          observed    predicted
     1 Oct 1985           71.19, 2        m
     2 Oct 1985           71.61, 2      75.88
     3 Oct 1985           71.65, 2      75.13
     4 Oct 1985           71.65, 2      75.05
     5 Oct 1985           71.65, 2      74.59
     6 Oct 1985           71.65, 2      74.56
     7 Oct 1985           71.65, 2      74.56
     8 Oct 1985           71.65, 2      74.64
     9 Oct 1985           71.65, 2      75.77
    10 Oct 1985           71.61, 2      75.77
    11 Oct 1985           71.11, 2      74.64
    12 Oct 1985           70.35, 2      74.53
    13 Oct 1985           69.44, 2      73.31
    14 Oct 1985           68.56, 2      71.84
    15 Oct 1985           67.94, 2      69.45
    16 Oct 1985           66.98, 2      66.99
    17 Oct 1985           64.86, 2      65.33
    18 Oct 1985           61.53, 2      61.76
    19 Oct 1985           59.47, 2      56.99
    20 Oct 1985           57.68, 2      54.45
    21 Oct 1985           57.39, 2      52.92
    22 Oct 1985           59.52, 2      54.65
    23 Oct 1985           62.46, 2      58.15
    24 Oct 1985           64.17, 2      61.65
    25 Oct 1985           64.22, 2      61.88
    26 Oct 1985           62.31, 2      61.57
    27 Oct 1985           61.93, 2      57.25
    28 Oct 1985           61.06, 2      65.42
    29 Oct 1985             m           76.45
    30 Oct 1985             m           66.47
    31 Oct 1985             m           54.41
     1 Nov 1985           59.95, 2      50.16
     2 Nov 1985           58.75, 2      54.53
     3 Nov 1985           55.94, 2      43.68
---> 4 Nov 1985           55.10, 2      36.58<---
     5 Nov 1985           54.61, 2        m
     6 Nov 1985           54.16, 2      39.70
     7 Nov 1985           52.85, 2      37.24
     8 Nov 1985           50.65, 2      36.68
     9 Nov 1985           48.94, 2      48.44
    10 Nov 1985           47.83, 2      47.65
    11 Nov 1985           46.43, 2      40.79
    12 Nov 1985           45.51, 2      29.90
```

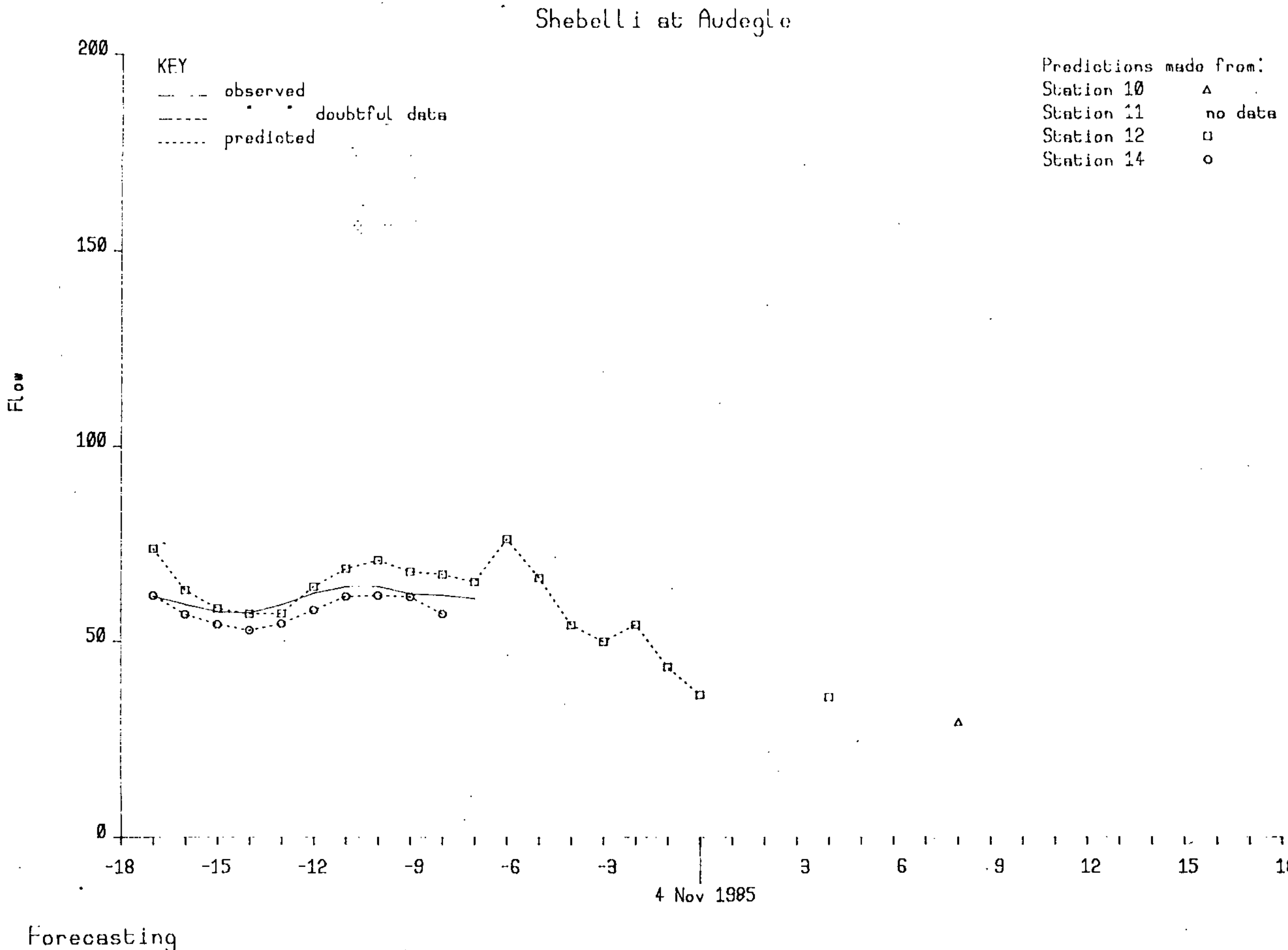
These flags are the same as those decribed in the text:

2 = good data
3 = estimated data
m = missing value

Arrow indicates forecasting date

Listing stops when there are no more predicted flows

```
   FORECASTING  -  MAIN MENU

Enter: 1 to plot flows on screen
       2 for paper plot
       3 to try another station, date or mode of operation
       4 to write flows
       5 to remove discontinuity between predicted & observed
       6 to STOP
 > 6

STOP
```



Shebelli at Audegle
KEY
observed
doubtful data
predicted
Predictions made from:
Station 10
Station 11 no data
Station 12
Station 14
Flow
200
150
100
50
0
-18
-15
-12
-9
-6
-3
3
6
9
12
15
18
4 Nov 1985
Forecasting

Figure 7

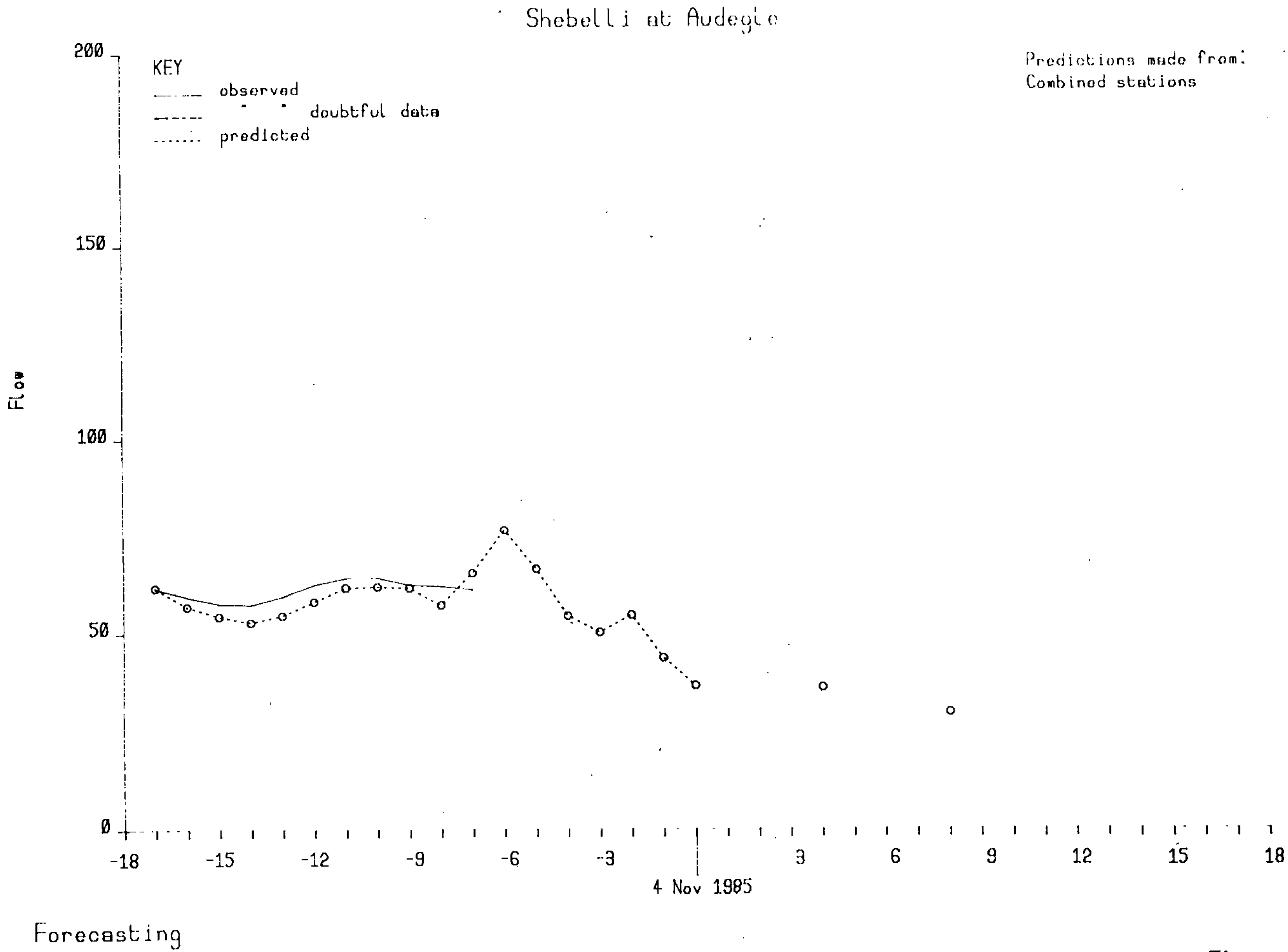
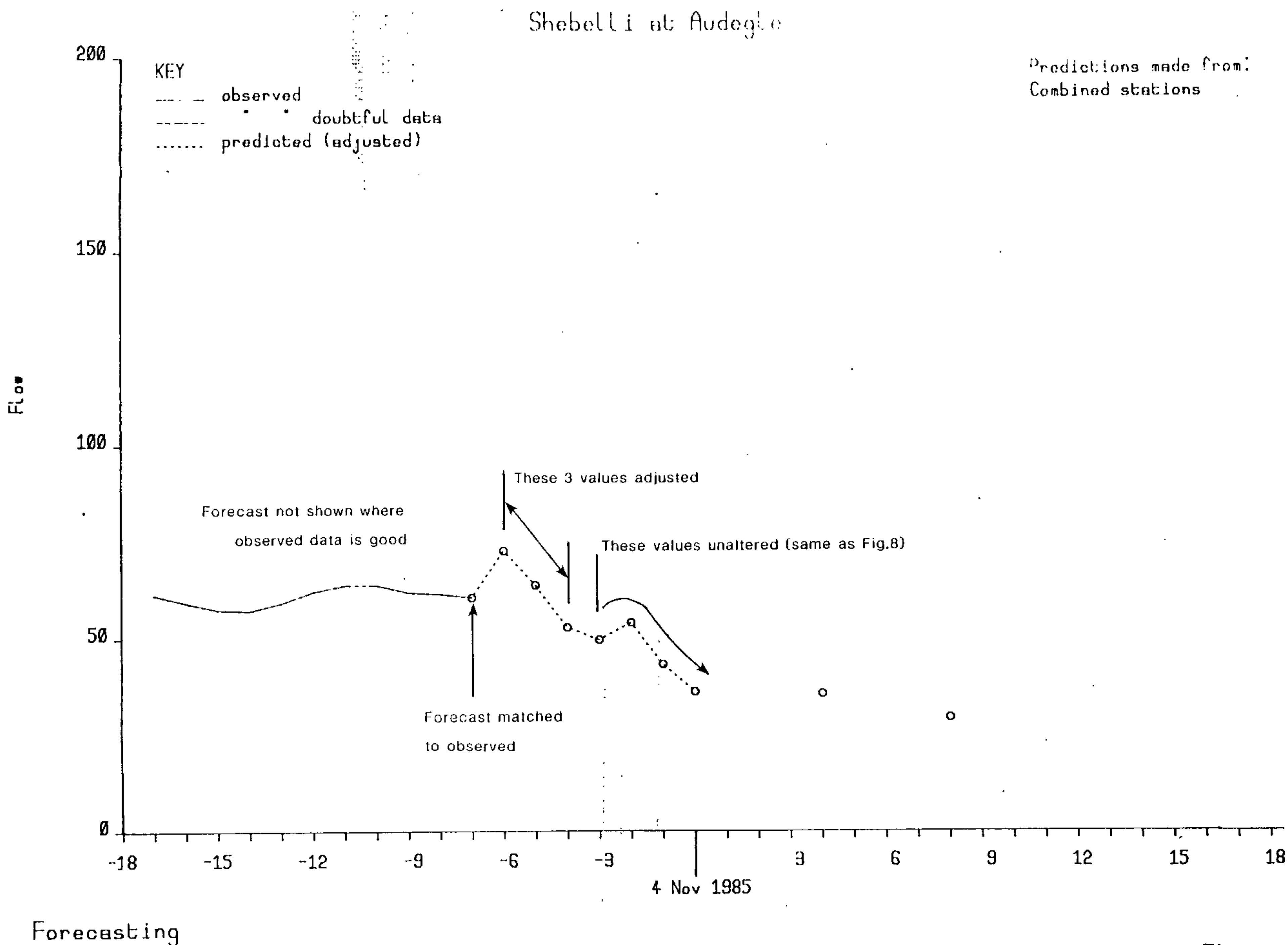

Shebelli at Audegle
KEY
observed
doubtful data
predicted
Predictions made from:
Combined stations
Flow
200
150
100
50
0
-18
-15
-12
-9
-6
-3
3
6
9
12
15
18
4 Nov 1985
Forecasting

Figure 8



Shebelli at Audegle
KEY
observed
doubtful data
predicted (adjusted)
Predictions made from:
Combined stations
Flow
200
150
100
50
0
These 3 values adjusted
Forecast not shown where
observed data is good
These values unaltered (same as Fig.8)
Forecast matched
to observed
-18
-15
-12
-9
-6
-3
3
6
9
12
15
18
4 Nov 1985
Forecasting

Figure 9

APPENDIX SDAT FILES

Data Files: SDAT10.DAT
SDAT11.DAT
SDAT12.DAT
SDAT14.DAT
SDAT15.DAT

These contain the information given in Table 1 for stations 10, 11, 12, 14 and 15 respectively.

The files are required by both programs SFIND and SHEBELLI.

Format : I4, F5.0, 17I3

Column 1	(I4)	Year
Column 2	(F5.0)	Maximum flow value to be used in regressions for that station in that year (used in SFIND only). If this is set to zero, no maximum value is applied.
Column 3	(I3)	No. of values to be read from the remaining columns 4 to 19. Must be : 0, 4, 8, 12, or 16. If set to zero, columns 4 to 19 are not read.
Column 4-19	(16I3)	Gives dates between which data is to be omitted. In SFIND this period will be omitted from the regressions, and in SHEBELLI it will not be used to model the downstream flow. Example: If column 3 = 4, and columns 4-7 are: 1 1 12 2 then the period 1 January to 12 February, inclusive, is to be omitted.

The files should contain 28 rows, giving data for the period 1963 to 1990 inclusively.

APPENDIX III

INVENTORY OF PROJECT EQUIPMENT

MMP

Sir M. MacDonald & Partners Limited

Consulting Engineers

Head Office

Demeter House
Station Road
Cambridge CB1 2RS
England

Telephone: 0223 66455
Cables: Screetan, Cambridge
Telex: 817260

Directors

W McCREADY MEng FICE FIWES
G L ACKERS MA FICE MIWES FIPHE FCIArb
J I M DEMPSTER OBE BSc FICE
G M FENTON FICE FIWES MASCE
R B FOX MSc FCA (Secretary)
M H KHAN BE MSc MIE MASCE
J F ROBSON OBE MA FICE MASCE
R F STONER BSc FICE

Please reply to:

PO Box 996
Mogadishu
Somali Democratic Republic

Telephone 80307
Telex: 745 CROCESUD MOG
(for MacDonalds)

Date: 3 June 1986 Our Ref: 1302/1/1/159 Your Ref:

Mr Mahamoud Mohamed Ali
Director, Land and Water Resources
Ministry of Agriculture
Mogadishu

Dear Mr Ali

Re: Handover of Hydrometry Project Equipment

My departure on 4th June will effectively bring to an end Stage 2 of the Somalia Hydrometry Project. I would therefore like to take this opportunity to formally handover the equipment procured with ODA funds for Stages 1 & 2 of the project as listed in the attached inventory.

After having taken note of the points raised below, would you please be kind enough to acknowledge receipt of the project equipment by signing and dating the enclosed copy of this letter, initialling the bottom of each page of the copy of the equipment inventory and returning the whole to me before my departure.

With reference to the inventory, I would like to draw your attention to the following points:

(i) Following your request, and until further notice, we are prepared to keep the project Land Rover and associated items listed in section (i) Vehicle, at our Mogadishu office. We will not allow them to be used by anybody without having recieved prior written authorisation from yourself.

It is understood that all normal precautions will be taken to ensure their safe-keeping but that Sir M Macdonald and Partners Limited cannot be held responsible for any loss or damage sustained by the equipment whilst in their custody.

(2) The Braystoke current meter Nr.75-807 and its associated equipment is currently at the MMP site office at Mogambo. Its immediate return to Mogadishu has been requested and it will be handed over to you by the Resident Representative as soon as it arrives.

Two replacement impellers for the Braystoke current meters have been ordered and will be handed over to you when delivery is received.

(3) The drill mentioned in section (ii) Hydrology Field Equipment, has recently been stolen. A replacement has been ordered and will similarly be handed over when delivery is received.

(4) Four automatic water level stations have been installed. All the spare electronic logging equipment is in the Hydrology Section office except one float and two counterweights which were lost because of operational failures at the Beled Weyn station and one faulty electronic recorder which was returned to the UK for repair with Dr Green on 16th April.

(5) Most of the consumable building material and hardware mentioned in section (iii) Hydrometric Station Equipment, was used in the construction of the said stations. All that remains is at the Ministry, notably, 24m of UVPC pipe and 6 connectors together with 3 sacks of cement destined for the reinsatallation of the upper staff gauge at Bulo Burti.

(6) The ampmeter mentioned in section (iv) Computer System Hardware, was removed from the right-hand drawer in the Hydrology Section computer room sometime between the end of the October-November 1985 mission of the IH hydrologist and my arrival at the beginning of February 1986. It has not, as yet, been returned.

(7) As agreed, for security reasons back-up floppy disk copies of all programs and data on the Hydrology Section's microcomputer will be left both in the Hydrology Section's office and at Sir M MacDonald & Partners Limited Mogadishu office.

We certify that all the equipment is in good condition after making due allowance for fair wear and tear commensurate with its proper use during the project.

Yours sincerely

Keith Stallard

Keith Stallard
Project Hydrologist

SIR M MACDONALD AND PARTNERS LTD. MOGADISHU OFFICE

D H...
Acting Resident Representative

~~we Receive~~
The Ministry of Agriculture acknowledge receipt of all the equipment listed in the attached inventory.

K/S MS. Ahmed Hey
Noor

AGRICULTURE

4/6/86

c.c. MMP Head Office, UK
Institute of Hydrology, UK

Enc. Copy of letter (for signature)
Project equipment inventory and copy

The Tinylog data retriever failed at the end of the project and was taken back to UK by Mr K Stallard for repair.

Keith Stallard

Equipment Procured within the Framework of Stages 1 & 2 of the ODA Somalia Hydrometry Project

(i) Vehicle

1 x Long wheelbase Landrover, chassis Nr.2AA191266, engine Nr.36407797B with 5 wheels, 6 tyres, roofrack and basic tools. Current registration Nr.43161
4 x 200 litre fuel drum
- Assorted ropes for roofrack

(ii) Hydrology Field Equipment

2 x Braystoke BFM.001 current meter with wading and suspension accessories and spare parts. Serial numbers 75-806 & 75-807
1 x Valeport SK100 suspension derrick Nr.1078
1 x Valeport SK78 gauging reel Nr.1065
1 x Current meter suspension cable
1 x OTT 25m winch cable
4 x Kalamos 30m water level dipper with medium probe
1 x Pocket dipmeter
1 x Briggs & Stratton 3hp 4-cycle petrol driven water pump Nr.M2410
2 x Chest wader
2 x Welded metal ladder
1 x Chair for suspension from bridges
1 x Tajima 100 metre nylon coated steel surveyor's tape
1 x Two speed percussion drill
- Assorted metal and masonary drill bits & punch
2 x Eclipse No.40PG hacksaw
- Miscellaneous tools
1 x 5m retractable builders metal tape measure
1 x Plastic jerrycan

(iii) Hydrometric Station Equipment

40 x 1mx100mm gauge board
6 x Tinylog TLI-05 solid-state level record
6 x Connectors & cables for level recorders
1 x Tinylog TLR-32/64 solid-state data retriever
1 x Data cable for connecting retriever to logger
1 x Data cable for connecting retriever to computer
6 x Feranti type 24R1/S29 shaft encoders & pulley wheels
7 x 80mm float
8 x 0.25kg counterweight and cable
5 x Aluminium recorder box
1 x RS sealed lead acid battery charger Nr.591-411

(iii) Hydrometric Station Equipment (contd.)

8 x 12 volts 5.7AH lead acid battery
30 x UPVC 2mx250mm dia pipe lengths & connectors
48m assorted angle aluminium
2 x 4m steel joist
2 x 400mm int. dia. concrete pipe sections
- Miscellaneous consumable building materials; angle iron, cement, sand, aggregate, etc
- Miscellaneous consumable hardware; nuts, bolts, washers, threaded bars, nails, wooden planks, paint, brushes, etc.

(iv) Computer System Hardware

1 x Comart Communicator CP500 microcomputer Nr.J4335
1 x Cifer 2841 computer video display unit Nr.21899
1 x Cifer 2841 Y keyboard Nr.21899
1 x Epson MX-100 III matrix-dot printer Nr.833215
1 x Gould Colorwriter 6120 pen plotter, model 6120-3111-06 Nr.N5B00383
1 x Inmac T-switch, model 1863, Nr.63-03124
1 x Galatrek voltage stabilizer, type WH060 Nr.722760
1 x Mains distribution board and extension lead
- Mains and connection cables for microcomputer system
1 x Floppy disk storage box
1 x FD-05 disk drive head cleaning kit
5 x Dust cover for computer & peripherals
- Miscellaneous computer consumables floppy disks, printer ribbons and paper, plotter pens & paper, filters, etc
1 x Set of precision screwdrivers
1 x Ampmeter

(v) Computer System Software

- CP/M 86 microcomputer monitor control program & documentation (Digital Research)
- PROFOR Fortran compiler & documentation
- PROLINK Object module to command file link-editor
- WordStar 3.3 word processing program & documentation (copyright: MicroPro International Corporation)
- MINITAB statistical package & documentation
- HDB (compiled command files); surface water Hydrological Data Base (copyright: Institute of Hydrology, UK)
- READLOG (Fortran source code & command file); transfers water level data from retriever to computer disk
- LOGGER (Fortran source code & command file); transfers water level data from computer disk onto Hydrological Data Base
- GAGCAL (FORTRAN source code & command file); discharge measurement calculations
- XYPLOT (command file); plotting program

(vi) General Office Equipment

2 x Desk calculator
2 x Hydrology text book
- Duplicate office keys and key rings
- Miscellaneous office consumables; boxes and guide cards, weekly stage data cards, stationary

APPENDIX IV

NOTES ASSOCIATED WITH THE VISITS OF OTHER PROJECT HYDROLOGISTS

APPENDIX IV.1

SUPPLEMENTARY NOTES ON GAUGING STATION HISTORIES AND ANALYSIS WORK INCLUDING RATING DEVELOPMENT, MAY 1985

Note: This appendix was compiled from notes prepared in May 1985 by R.J.E. Hawnt, Project Hydrologist from November 1983 to May 1985. It should be read in conjunction with the Final Report - Stage 1.

CONTENTS

LIST OF ABBREVIATIONS

BDP	Bardheere Dam Project
BM	Benchmark
CON	CONstant command in hydrological database program
DM	Discharge measurement
d/s	Downstream
EGH	Equivalent gauge height
ELC	Electroconsult (an Italian engineering consultancy)
FAO	United Nations, Food and Agriculture Organisation
GH	Gauge height
GZ	Gauge zero
IH	Institute of Hydrology, UK
Jowhar OSR	Jowhar Offstream Storage Reservoir
JSP	Jubba Sugar Project
LB	Left bank
LLPD	Government department during UN administration
m	metres
m AMSL	Metres above mean sea level
MB	Bridge mark for bridge dip
MJVD	Ministry of Jubba Valley Development
MMP	Sir M. MacDonald & Partners
MOA	Ministry of Agriculture
MP	Measuring point
MSL	Mean sea level
RB	Right bank
RL	Reduced level
RSJ	Rolled steel joist
S/D	Stage/discharge
SG	Staff gauge
SNAI	Societa Nazionale Agricola Industriale
TBM	Temporary bench mark
u/s	Upstream
VDU	Visual display unit
w/l	Water level

SECTION 1

APPROACH TO STATION HISTORIES AND DATA PROCESSING

These notes provide general information on data available and methods used to analyse records.

See final report on Stage I of the project (February, 1985) for full details of the work carried out.

1.1 Summary of General Approach to Data Processing - Stage I

The complete record of SG readings was examined for every station in preparation for data entry onto the Comart computer. Original observer records were used whenever possible after checking. If not available, then processed summaries of mean daily GHs were accepted if they were available.

All discharge measurements at every station taken by current-meter velocity area methods were compiled together on a listing for each station. Calculations of discharges were checked at random and occasionally recalculated by computer - suspect DMs were checked for meter calibration, GH (GZ used), etc. DM points were plotted on linear and log/log graph paper initially and also entered onto computer. Screen graphics aided the derivation and the best-fit curve through the scatter of points was obtained using regression techniques.

See IH manual 'Computer System and Hydrological Database' for full details of the computer system used for data processing and analysis.

Rating curves and DM plots were examined for shifts with respect to time and if a rating shift was suspected then the data set was split at a suitable point and the two sets analysed separately. A unique rating for the whole stage record was preferred but, if more than one rating was necessary, different rating equations were applied to different periods.

After inspection and checking of the SG records and entry onto computer archive files, the complete record of GHs was adjusted to a common GZ base then converted to discharges using the appropriate stage-discharge rating curve.

Printouts of all the stage and flow records stored on computer were produced as monthly and annual discharge summaries in standard printout formats.

1.2 Stage 2 Procedures for Further Checking

Further software will be developed in 1985/86 to include screen displays of hydrographs. This will aid further checking and validation of data on the computer. Obvious typing errors on the keyboard when entering data will be picked up from these displays. Further checks should also be made to ensure that the data on the computer matches the data from the original records. This is best done by comparing printouts or screen listings of data with the handwritten data record. Since direct comparison of data is difficult due to SG overlaps and changes in GZ during the record period, routines should be developed to allow simulation on screen of actual observer record sheets. Any errors can therefore be spotted easily and the record validated much more quickly. Methods should also be devised for cross-correlating station records for adjacent stations, so that further validation is facilitated. The same methods could then be used for filling periods of missing data.

1.3 Station Histories

The history of changes in SG, GZ and MP datums on wells and bridges and on BMs has been compiled into a standard log format (see Annex 1).

This was partly compiled from the initial log system started by FAO-Lockwood and partly from other odd pieces of data found on files and from the SG record sheets themselves. It is now up-to-date and includes changes and checks made in 1983/84.

Any changes in SGs, the addition of new stands, the replacement of gauge-plates, the movement of SG zeros or datum points should be registered on the station log.

1.4 Stage-Discharge Rating Development

Notes are included on this file on the individual rating derivation for each station, detailing precisely how the resulting equation(s) were derived. Comments are also included on suspect DMs and on how good the derived rating is and whether it can be improved by deriving multi-segmented curves. This is only practically possible after changes in the software, which at present caters only for single segment curve development.

1.5 Other Notes

Notes are also included on file on special analyses carried out or items of particular interest. For instance, collating the stage record for Jamaame required a great deal of effort to determine the GZ applicable to different periods of the record, before a common GZ could be applied to the complete data set.

A simple regression analysis was used to correlate Jamaame and the new Mogambo record. The Jamaame records are very unreliable and the Mogambo record can be used as a substitute to fill in missing data.

1.6 General Procedures for all Stations - Rating Derivation

Every station was subjected to a rigorous system of data checks before an acceptable rating equation was derived.

All known DMs were extracted from the files and various lists that had been compiled over the years. If possible, only DMs which had original data sheets available that could still be checked were included. The only DMs excluded from the analysis were:

(a) very suspect readings;

(b) DMs taken during the project in 1983/84 (or just before by IH visitors in 1983).

The latter were regarded as checks on the 'current' rating.

GHs were examined and a common GZ applied to the entire period. Generally the latest GZ used by Gemmell in 1980/81 was accepted, the only exception being Jamamme station, where Gemmell neglected the fact that, prior to 1980, a lower gauge stand existed which had been washed away. Some of the GHs recorded during measurements were calculated using dippings from well or bridge datum points (MP or MB). Where an error in GH was suspected the stage record of the station for that day was checked.

All DM measurements were plotted on both natural and log-log graph paper. Any obvious outliers were again checked for GH errors or errors in computation by recalculation using a specially developed computer program on the Comart machine. Any outlying measurements still remaining were included in the derivation process unless good reasons could be found for their exclusion, e.g. a faulty meter suspected or the application of an incorrect calibration, the right one of which could not be determined.

Computerised derivation methods were used to assess first whether there had been a rating shift over the years by selecting different data sets from particular periods, e.g. 1960, 1970, 1980/81 and testing (qualitatively) for changes in curve fits; and, secondly, for selecting the optimum coefficients in the power law equation:

$$Q \quad = \quad a(C + H)^b$$

for the number of ratings selected for each station's record.

The computer program developed for deriving the best-fit solution only allowed a single set of coefficients to be used; but some ratings were clearly not best represented by a single line and would have benefited from a multi-segmented (two or three part) rating curve with different coefficients for each segment. Many ratings that had good fits through the middle range of flows had a few points at the extremes of flows which lay off the best-fit curve. If it was not possible to force the curve through, say, the highest discharge point, the only way to do this would be to use multi-segmented curves.

When the multi-segment curve derivation program has been developed for the second stage of the project all ratings should be reassessed to determine whether multi-segment ratings are appropriate to each station.

SECTION 2

HYDROMETRIC NETWORK AND STATION HISTORIES

2.1 Existing and Proposed Network of Hydrometric Stations

RIVER FLOW GAUGING STATION NETWORK

A. River Jubba

	Current	Records start
Operated by MOA: Hydrology section	Lugh Ganana*	1951
	Bardheere*	1963
	Jamamme	1963
	Mogambo	1984
	Kamsuma*	1985
Operated by others	Mareere JSP	
	Fanoole (MOA)	
	Redundant	
	Kaitoi	
	Maleida	
Proposed stations in 1986 at	Buaale (Middle Juba)	
	Goobe Weyn (Lower Juba)	

B. River Shebelli

	Current	Records start
	Beled Weyn*	1951
	Bulo Burti	1963
	Mahaddey Weyn	1963
	Jowhar OSR (Sabuun)	1979
	Afgoi	1963
	Audegle	1963
	Redundant	Record Period
	Jowhar	?
	Balaad	1963-1980
Proposed stations in 1986 at:	Kurten Warey	

Note: * Indicates station with new automatic water level recorder installed in 1985.

EXISTING RECORDING FACILITIES - 1984

Station	Minimum GH recordable (bottom of lowest inlet pipe)	Maximum GH recordable (MP datum point)
Lugh Ganana	1.34	8.92
Bardheere	-0.52	5.54
Beled Weyn	-0.56	6.61
Bulo Burti	1.47	8.92
Jamamme	0.20	8.00

PROPOSED RECORDING FACILITIES - 1985
(updated to show progress of installation work 1985/86)

Station		Minimum GH to be recorded bottom of stilling pipe staged installation 1, 2, 3 etc.			Maximum GH to be recorded (top of pipe)
		1	2	3	
Lugh Ganana	Date	5/85	8/7/85	1/3/86	
	Level	Float not installed	3.8	0.4	9.6
Bardheere	Date	5/85	5/7/85	19/3/86	
	Level	2.7	0.7	-0.3	8.7
Kamsuma	Date	22/7/85	3/4/86		
	Level	4.1	-0.3		10.1
Beled Weyn	Date	5/85	8/8/85		
	Level	3.0	1.8		6.5
Kurten Warey	Date				
	Level				

2.2 Jubba River at Lugh Ganana

Staff Gauge Zeros

The most recent SG zero of 141.42 m AMSL established by B.A.P. Gemmell in 1980 has been accepted as the GZ datum for the whole of the record 1951 to 1984 and onwards to which all readings have been related for storage on the computer database. Gauge height data shown on printouts are therefore not as originally recorded by observers if a different GZ was in use at a particular time. When a different GZ was in use the values have been recorded on the SG log (see Annex 1) and also on the 'comment' line of the printouts of daily gauge-height data.

There is great confusion about how the GZs have changed since records began in 1951. No clear, unambiguous records of GZs and datums have been maintained and the attached log is at best an interpretation of the records, based on observers/office notes on data return sheets and on an old staff gauge record log, a copy of which is contained in Gemmell's 1982 report pp2(F)-2(G) of the Jubba Appendix.

There is very little information about the 1951-1963 record, but odd notes indicate that a GZ of 141.59 m AMSL was used. This is the corrected value, after a benchmark error of 0.25 m has been taken account of.

The post-1963 period, marking the start of the FAO-Lockwood study started with the use of dippings (or perhaps data extracted from recorder charts) from the recorder stilling well MP. SG readings resumed in May 1964. Two different stands appear to have been used from this time: an 'old' SG assumed to be in the 2 to 6 m range with a '0' at 141.45 m AMSL and a 1 to 2 m plate with '0' in fact 1.0 m at 142.67. These values were surveyed on 9th September, 1964, and 27th March, 1965, but are assumed to have been applied from May 1964.

Russian SGs were briefly in use during 1965 situated 175 m upstream of the FAO gauges, but in 1966 the FAO gauges were used again.

The lower range gauges 0 to 2 m appear to have always been two separate stands 0 to 1 m and 1 to 2 m. These were probably never set in concrete but driven in with a hammer as water levels became low enough. This is why the GZ never seems to match up with the 2 to 6 m stand GZ. These lower range stands are always susceptible to damage and frequently become dislodged or completely swept away. Hence the GZ of these plates frequently changes: 142.67 in 1964/65 to 141.61 in 1967 to 141.64 in 1975 (assumed date of installation).

Although the same 2 to 6 m range stand has been in use since initial installation in 1964, the actual graduated plates may have been replaced several times. Hence the reason for the change in the GZ from 141.45 to 141.42 in 1972, if care was not taken to maintain the GZ when drilling new fixing holes.

The overlap between gauges in 1963 of 0.22 m has coincidently recurred from around 1975 when it is assumed that the lower stands were again reinstalled and surveyed. This appears to have remained in position up to the present day; Gemmell reset one of them in 1980.

Since 1984 (March) the new SGs have eliminated the 0.22 m overlap. The 0 to 2 m range gauge is now attached to one of the bridge pillars and new plates have been fitted to the original 2 to 4 m stand.

When the lower range gauges have been replaced in the past, some have never been levelled in but have still been read by the observer. These have generally been installed on an 'ad hoc' basis as soon as the water levels approach the zero of the lowest stand remaining, then a new gauge has been hammered in. Frequently these do not last until the next season. The only way to utilise these records is to assume that a recession was in progress and that the sudden jump in readings from say 0.02 to 0.91 does not indicate a rise in water level by 0.89 m but rather that a new SG has been installed and that there is now an overlap of a maximum of 0.11 m and probably a little less. Recession analysis could determine more precisely what the overlap and hence new GZ of the gauge would be.

Recorder Stilling-well Data

Some information is available on the MP used when taking dippings in the well. This appears to have changed since the well was built in 1963 from 150.29 to 150.33 in 1964/65 (probably by the addition of covering wooden boards to protect the well), to 150.31 in 1972 and to 150.34 in 1980. The reason for these changes is not entirely clear. However, the well data have not been used unless no other data were available.

The wells become blocked very quickly by sediment deposition inside the well and inlet pipes and there has never been a log of maintenance kept. It is certain that maintenance by pumping out has not been regular and therefore much of the well data (some of it may be derived from recorder charts) are of little value, being subjected to considerable lag in response between river and well when blocked by silt.

Notes on Rating Curve Development

A list of 111 discharge measurements (DMs) was compiled for detailed inspection prior to derivation of the rating curve. This comprised 31 DMs in the period 1963-1972 during the FAO/pre-Russian period. These measurements have been checked by previous experts and initially only a cursory inspection was considered necessary. However, further analysis later revealed suspected errors in GHs, since well dips/recorder data were used when the stilling-well was blocked.

A further 60 DMs were extracted from the files in the period October 1972 to June 1977. These were in the 'Russian period' and represent approximately one third of all the gaugings carried out. The selection was made because the computerized method of derivation used during the first stage of this project only allowed a maximum of 166 DMs to be stored on the database (see computer manual). In addition, if all the DMs had been used, undue bias would have resulted during the derivation toward one 5 year period. The selection criteria used for this period is outlined below. All the DMs during this period were subjected to a rigorous checking procedure, since it became clear that they had previously been largely unchecked. Sixteen of this group taken with one meter during the period August 1973 to April 1974 were discarded, since the wrong calibration equation had been applied to the revolution readings during computations. This only became apparent when the data were plotted and a clear systematic error was displayed by the curve plotted through these points. The correct calibration equation was not known, and so those measurements were excluded from the analysis. Of the remaining 44 DMs, 25% had significant errors in computation - sometimes a factor of 2 and occasionally a factor of 10 due to placing the decimal point in the wrong position.

The DMs taken by Gemmell's team in 1980/81 were to a high standard, and when plotted they displayed remarkably little scatter as a group on their own. Some errors in computation were noted, however, when clearly marked flow reversals in some verticals were not properly computed. Any DMs that required recalculation were carried out using a program developed for the Comart machine.

The list was taken as a single group initially and some tests were made to check for rating shifts by separating the data in period sets: one for the 1960s, one for the 1970s and one for the 1980s. No clear shift in rating could be discerned from the scatter plot and so the complete data set was taken as one.

The best-fit coefficients of the rating equation were derived by computer methods, but a single equation does not adequately fit the points in the extremes of the curve, particularly at the highest flows. A two or three segment curve would be more appropriate, but this is not easy to obtain using the existing derivation program. Further development in the second stage of the project should provide a much improved rating to fit the entire range of DMs.

Exclusions from List for Derivation

Where possible no DMs were exluded from the rating analysis just because they happened to be outliers. Those not included are marked on the printout listing with a '?'. In 1963/64 several were excluded due to doubts about the GH, because it was calculated using an MP well dipping, probably when blocked by silt. The only other excluded was Nr 25 when at virtually the same GH, the calculated discharge differed by 25% from the DM taken the day before. No explanation could be found for this obvious outlier and thus it was excluded.

Selection Criteria for Sample of DMs Carried Out in Russian Period at Lugh Ganana

Previous studies report a large scatter of DMs perhaps due to rating shifts but much of it may be due to errors in measurements, GHs computations, etc.

In 1972 to 1977, 180 to 200 DMs were taken by Fanoole project staff under Russian supervision. Quick checks revealed many errors. Rather than check every single one, a sample of one third of the group was selected to cover the period. This also helped reduce the total number of gaugings available for analysis by computer methods, since the maximum that the programs for archiving/ editing/ displaying DMs allowed was 166. But a total of about 260 gaugings were available. By taking a sample of available DMs in the mid-seventies there is a reasonable distribution of readings with time as follows:

1963-1969	-	22
1970-1976	-	44 (excludes bad DM in selection)
1977-1982	-	44

Method of Selection

The period October 1972 to June 1977 was a period of 57 months, therefore to obtain about one third of the total requires approximately one per month.

So:

(i) Select first DM in month, if not one in a particular month, choose one at end of previous month.

(ii) If obviously suspicious, ignore it and take one adjacent to it.

(iii) Select also minimum flow DM and maximum flow DM for each year and all readings of GH above 3.5 m.

(iv) Discard DMs with rapidly changing stage.

(v) Check computation, rating applied and GH.

Work Programme for 1985/86

1. Install new recording facilities.

   (a) Fix stilling pipes to bridge pillar in stages.

   - May 1985 - fix instrument box to bridge deck and as much of range as possible, given the high stages during the Gu flood. Work down in 2 m pipe lengths from deck level. Motorised winch required to lower man on safety chair. Additional safety harness would be useful. Set up recorder and note minimum level at which float stops.

- June/July 1985 - fix as many of remaining pipe sections as allowed by falling stage before arrival of Der flood.

- Finish fixing lowest sections in February/March 1986. Aim for minimum recordable level to be a little below present GZ.

(b) Evaluate recorders by comparing and examining data from July 1985 onwards.

2. Provide new water level dipper instrument to observer so that MB readings are recorded on weekly cards.

3. Further check gaugings during Der/Gu floods and during minimum flow period February/March 1986 by wading.

4. Check levelling, especially of new recorder datum point.

2.3 Jubba River at Bardheere

Staff Gauge Records

This station was, until recently, very remote in terms of time and travel from Mogadishu (distance/road conditions). It is also not a very hospitable place and hence little attention has been paid to this station in the past. There is now however, a good road from Baidoa to Bardheere, accessible year round.

In view of the siting of the station in relation to the Bardheere Dam proposals, it must now assume new importance with a increased attention paid to the rating and record quality.

The lack of attention to this station has resulted in very poor records. The rating is derived from relatively few points and the lack of gauging work at this site is probably partly due to the fact that no bridge crossing existed until 1978.

Staff Gauge Zeros

An SG was first installed by FAO-Lockwood with GZ at 89.2 m AMSL in April 1964; from May 1963 until then, dippings had been taken from the recorder stilling well installation. In 1965 another system (GZ at 89.02 m AMSL), presumably installed by the Russians for the Fanoole studies, was in operation producing duplicate records for a time in 1965. In May 1967 a new SG system was used and there is virtually no information about SG zero changes between 1967 and 1980 available on files in Mogadishu. Therefore the assumption has been made that the same SGs (GZ at 89.01 m AMSL) were in use throughout the period up to 1977 when the gauges were all washed away except the 4 m to 6 m stand. New gauges were installed by Gemmell in 1980/81 but these were washed away in 1981. The GZ adopted by Gemmell in 1980 was retained for new SG plates which were fitted to the bridge in March 1984, by this project in conjunction with Ministry of Jubba Valley Development project hydrologist, Klaus Jacobi. This was set at 88.980 m AMSL.

However, the GZ should really be some 0.5 m lower to avoid negative readings. To overcome this, dippings should be made from the bridge MB.

Recorder Stilling-well Data

The recording system with large diameter stilling well and small diameter (4 in.) inlet pipes (2 Nr) was installed in 1963 before the SGs. The MP datum appears to have been unchanged since that time and was at 94.57 m AMSL. Unfortunately, however, there is no information or log available on maintenance (pumping not carried out) and it is most probable that it has not been regularly pumped out and kept unblocked. Therefore any records of water levels taken from the MP must be regarded as suspect.

Gauging Section

The bridge built in 1978 has recently been used for gauging purposes and prior to that a ferry at the same site. But the section is on a bend and suffers from poor velocity distribution at all river stages. On the left bank, flow reversals are a major problem; and, hence, the resulting plot of DMs shows considerable scatter.

The proposal to install a cableway system by the Bardheere Dam Project should be an improvement since it will be sited some way downstream of the bridge and the effects of the bend.

It should possible to obtain much more accurate gaugings using this cableway.

Notes on the Rating Curve Development

A list of 45 DMs was compiled from old records in the 1960's. Of these 17 were taken during the FAO period 1963 to 1965; only 6 were taken from 1965 to 1979. The remaining 22 were taken during Gemmell's 1980/81 project.

All the GHs were checked to ensure that they were consistent with a GZ of 88.98 m AMSL.

Four of the group of DMs were considered so dubious in quality that they were excluded from the rating derivation. These were initially spotted as outliers on the stage-discharge graph plot and were further investigated. One of these DMs, Nr 27, was excluded because of doubts about the GH recorded; the other three, numbers 5, 35, and 36, were excluded because of very low velocities recorded. Nr 5 was taken using an Ott meter Nr 12497 which consistently gave low velocity readings during 1963 and was responsible for a number of other outliers at other stations. Nr 35 and 36 were both taken by meter Nr 30192 in June 1981 and it is suspected that this too was damaged and not functioning properly at this time.

Many of the DMs recorded in 1980/81 by Gemmell and/or the 'Hydro team' suffered from flow reversals which were not properly taken account of. Significant error resulted because of this and many of these DMs were recalculated using a computer program.

The complete list of DMs does not adequately cover the highest flows. The maximum recorded DM is 478 m^3/s in September 1981 which was at a GH of 3.35 m. This is well short of bankfull stage. Unfortunately, Gemmell did not manage to gauge the May 1981 flood, when the peak level was recorded/estimated as 6.0 m or 1 331 m^3/s. The plot of DMs on natural and log-log paper shows considerable scatter, and due to the relatively small number of points is considered to be rather unsatisfactory.

However, no real improvement can be expected until further gaugings are carried out in the future using the new cableway (if it is ever installed) - see note below.

Work Carried Out During This Project - 1983/84

1. New SGs installed.

2. New MB datum point established above new SGs on walkway (upstream side).

3. Recorder well pumped out twice, but recorder missing at last visit December 1984, presumably thrown into well - not recovered. No useful information recovered from any of the charts, therefore.

4. Current meter gaugings carried out by:

   (a) wading at low flow gauging section upstream of bridge;

   (b) winch suspension from bridge.

Proposed for 1985/86 by this Project

1. Installation of new stilling pipe system with solid-state data-logger and shaft encoder sensor.

2. Provision of water-level dipping instrument so that regular readings can be taken from the bridge and recorded on weekly data cards.

3. Further current meter gaugings during Der and Gu floods and during minimum flow period February/March 1986.

Proposed for 1985 by Bardheere Dam Project

BDP has planned to install a new station at this site consisting of new staff gauges, a permanent cableway for current meter gauging work, and an automatic water-level recorder using the bubbler method. An Electroconsult (ELC) hydrologist came to Somalia in March/April 1985 to supervise construction, but was unable to get any action from the contractors 'Astaldi'. He departed having completed one gauging.

Situation Update by MMP Hydrologist, Peter Ede, August 1985

BDP installed the cableway in July 1985. Their (ELC) hydrologist, Jasper Tomlinson, discussed possible co-operation with this project and with MJVD. Klaus Jacobi of MJVD now has Tomlinson's key to the hut at Bardheere. The team (2 people) there will be doing gaugings approximately every week for which they are to be paid 400/- each per head. These could be paid for by ourselves or MJVD and the money reclaimed from BDP (after taking copies).

Checks of the relative SG levels at bridge and cableway should also be made.

Proposed Work Programme for 1985/86

1. Install new recording facilities

   (a) Fix instrument box in May 1985 at level of walkway on upstream face on same pier as SGs, and install as many of top 2 m pipe sections as water level allows. Set up recorder and note minimum level before float rests on bottom support.

   (b) June/July 1985: fix as many of lower pipe sections as possible before arrival of Der flood.

   (c) Finish fixing lowest sections in February/March 1986. Miminum recordable level should be at least 0.5 m below existing GZ since levels have dropped below GZ in the past.

   (d) Evaluate recorders.

2. Check levelling - establish new MP recorder datum point.

3. Provide new w/l dipper instrument to observer so that MB readings can be recorded on weekly cards.

4. Further check gaugings throughout flow range.

2.4 Jubba River at Kamsuma, Mogambo and Jamamme

Staff Gauge Record at Jamamme

Initial inspection of the data available on monthly record sheets indicated that three separate periods of record existed, each with a different GZ applied. Unfortunately there was no apparent link between these records, since no log existed which showed the tie-up between GZs. The lack of continuity was apparently due to the use of different benchmarks which did not appear to be tied to each other.

The staff gauges created in 1963 by FAO Lockwood were washed away in the late sixties or early seventies. Russian experts reinstalled the gauges and tried to relate GZ to MSL using existing benchmarks. However the benchmarks used seemed to be different from those used by FAO with different datums assigned to them. But a few odd scraps of paper available indicated that, in fact, the same benchmark had been used (originally known as M4) by both FAO and Russian teams; the only difference being that they assigned different MSL values to it. The original TBM established by Lockwood was the top of a concrete pillar on the bridge deck and marked M4. This is situated on the left bank on the upstream edge of the bridge. This was given a value of 12.12 m AMSL (revised from 12.81 m) on 10th September, 1964. The benchmark used to establish the TBM was known as 294A with a datum of 10.74 m AMSL; this was on the other side of the bridge from M4 (at deck level).

The Russians surveyed their new staff gauges on 20th August, 1972, and from sketches available the TBM used was, in fact, M4 although they had indicated that it was BM Nr 294B. The value given to 294B is 10.495 m AMSL, which is well below deck level. However, the evidence available shows the BM datum point used to be at the top of the concrete pillar - in other words the same position as M4. The Russians used two different BM systems with different values for this TBM.

By the Canadian (FAO-Lockwood) system the value of BM Nr 294B was 10.495 m AMSL, but by the Fanoole system the value was 12.267 m AMSL. The table below relates the various values ascribed to the important datums at the station. It is based on the translation of an original Russian note dated 26th August, 1972. The Canadian system is adopted for this project as the 'correct' system, but in reality it is suspected that it too is not accurate. If this system was correct then the mean bed level at the Arara Bridge location would probably be below mean sea level, which would imply that the section is tidal. There is no evidence whatsoever either physically, e.g. tide marks, or from inspection of staff gauge data and particularly the rating curve, that there is any tidal influence at this site. Nevertheless the Canadian system can be accepted until another benchmark is established at the bridge.

Datum point	Russian Fanoole system	Canadian system	
		Incorrect	Correct
BM 294B or TBM-M4	12.267	10.495	12.12
Concrete deck at base of M4 pillar	11.197	9.425	11.05
MB point Nr centre of bridge	11.235	9.463	11.09
GZs Nr 1 gauge	5.464	3.692	5.32
Nr 2 gauge	3.434	1.662	3.29
Nr 3 gauge	1.68	(-0.09)	1.54
Nr 4 gauge	0.33	(-1.44) (replaced as 0.00)	0.19

The gauge zero for the entire range of 0.19 is very close to Lockwood's GZ of 0.18 established in 1963 which may or may not be coincidence.

The third period of record, seemingly unrelated to the Lockwood and Russian staff GZs reduced level is the Gemmell 1980/81 period in which the designated GZ of the range is at a relative level of 90.48 m related to a TBM of 100.00 reduced level newly established by Gemmell.

However, the datums can be tied to the M4 TBM again using the MP point on the well which was used throughout the period 1963 to 1981. Using this the various datums of GZs for 1980/81 can be converted to AMSL values (Canadian) as follows, the SG numbers now reversed to follow the normal numbering system.

Datum	RL	m AMSL	Russian Gauges 1972 (for comparison)
Gemmell's TBM	100.00	11.03	-
MP	96.97	8.00	-
MB	100.06	11.09	11.09
1	-	-	-
2	90.48	1.51	1.54
3	92.23	3.26	3.29
4	94.14	5.17	5.32

This strongly indicates that the gauges, or at least the stands, used in 1980/81 were most probably the same as installed in 1972 by the Russians. The 3 cm difference between SGs Nr 2 and 3 may be due to levelling error or perhaps plates refitted inaccurately. The bigger difference between Nr 4 GZ must be due to replacement of the SG stand at some time after 1972.

Unfortunately in 1984 the gauges used by Gemmell were almost entirely destroyed or covered by silt, and it was impossible to check the levels again. However, check levelling was carried out to confirm the assumption regarding M4 above, so that the Gemmell's TBM could be linked with the Lockwood TBM. The results are given below.

	RL (according to Gemmell)	m AMSL (Canadian) on 31.10.84
Gemmell's TBM	100.00	11.02
Lockwood's M4-TBM	-	12.12 (assumed)
MB	100.06	11.04

Datum point description	Level m AMSL calculated by tying to MP or M4	Check levelling on 31.10.84 tied to M4
MP	8.00	-
TBM (M4)	12.12	12.120
Floor by M4	11.05	11.005
TBM (Gemmell)	11.03	11.016
MB (Lockwood at 28 m mark)	11.05	-
MB (Russian ? location)	11.09	-
MB (Gemmell u/s face near centre)	11.09	-
MB (Hawnt u/s face near centre)	-	11.037

The reason for the errors is not clear. The assumed location of M4 concrete post/pillar may have been incorrect. There are several in the same position and since the white painted M4 mark could not be located, two different posts were used (both of which, in fact, had the same level).

The 'old' MBs were not surveyed at the time.

A further survey should be carried out and double checked. The MP point should be included in the survey and the Lockwood MB at 28 m mark included also. The approximate position of Gemmell's MB can be located (see his report). The MB location established for this project is the painted MB on a cross girder and the point is the concrete deck edge near the centre of the bridge on the upstream face.

For the time being, in the absence of staff gauges, the current MB is the only source of water level data; and, until surveyed again the value of 11.04 m AMSL should be used. Any errors detected by future survey work can be corrected later. In any case the maximum errors seemingly possible would be 5 cm which is relatively minor compared with the overall accuracy obtainable using the staff gauge/rated channel system, although significant.

DM Analysis and Rating Development

Having sorted out the problem of benchmark/GZ confusion, all SG data from SGs and MB readings for the continuous record and DM analysis were related to a common GZ of 0.0 m AMSL.

A list of 49 gaugings was compiled: 20 of which were for the period 1963 to 1965, 15 from the period 1969 - early seventies and 14 from the 1980/81 period. None were excluded from the analysis.

The plot of stage versus discharge showed remarkably little scatter. This reflects the almost ideal approach conditions, the absence of interference from bridge pillars and clearly a very stable channel that has remained little changed since 1963.

The resulting best-fit line is the most highly correlated of any of the stations. Little improvement would be obtained if a multi-segmented curve were fitted through the data points. The DMs cover the complete range of the station and the highest measurements appear to indicate that bankfull stage for the reach has been attained. The sudden flattening of the curve suggests that overspill is occurring upstream at a GH of about 6.9 m.

Jamamme Record 1983/84

The observer for this station is based at the town of Jamamme, which is a distance of 10 km from the Arara Bridge site of the gauging station. Consequently the continuity and reliability of data returns are traditionally poor. The cost of bus fares to the bridge is prohibitive (as is the distance to cycle) and therefore much of the data are synthesized.

In 1984, the problem continued. No usable staff gauges remain and so a water-level dipper instrument was supplied to the observer. Unfortunately the type purchased for the project was a 'pocket type' with graduations on electric cable at 1 m intervals only. This is rather unsatisfactory even for experienced technicians. A length of tape was supplied to the observer so that he could 'interpolate' between metre markings. However, the resulting returns showed that he was not using this properly!

Another dipper with centimetre graduations was dispatched to him in December 1984 via a third party, but unfortunately this never arrived.

Anticipating the poor returns from this obvserver, the MMP staff at Mogambo were asked, in October 1984, to start taking readings three times per day as per normal practice; they had previously taken 'occasional levels' using a dumpy level. Consequently there is an excellent record in the Lower Jubba from October 1984 onwards and some data in the first 9 months of the year. Due to the proximity of Mogambo to Arara Bridge, the two sets of stage data can be correlated. This was initially done using the very poor data from the observer at Jamamme from June 1984 up to November 1984. The correlation exercise should be repeated as soon as a good continuous record is obtained from Jamamme. The record for Jamamme for 1984/85 can then be synthesized from Mogambo data.

The new dipper should be delivered to the Jamamme observer (or his replacement) as soon as possible and further attempts made to retrain him. This has not been possible due to other committments as at May 1985.

It is not considered feasible to reinstall SGs at this site due to difficulties in construction in the very steep channel sides; there are no suitable bridge abutments or pillars to which SG plates could be attached.

A program FSOURCE. CORR was written to generate individual Jamamme synthesized readings from observed Mogambo data, and this is available on hard disk in USER 1.

Proposed Work Programme for 1985/86

1a. Install new waterlevel recording facility at Kamsuma, to downstream face of bridge. Second pillar from left bank at distance mark 64 to 68 m from the right bank. Finish work in February/March 1986 if not fully completed in lowest range during June/July 1985.

1b. Also install SGs to be provided by Klaus Jacobi of Agrar and Hydrotechnik, attached to Ministry of Jubba Valley Development, after first determining acceptable level for GZ. New SG plates should be attached to same brackets as used for stilling pipes.

2. Set up BM and fully survey MB and new MP datum points at all three sites. If possible tie BMs at each site to each other - if not use TBM and assign an approximate datum in m AMSL and use it as a relative level. Particularly check levelling at Jamamme to confirm assumptions made about tying old GZs together - use MP well datum as common datum.

3. Find new observer at Jamamme and consider appointing one at Kamsuma. Observer at Mogambo Irrigation Project, employed by MMP is not an official observer, but he is sending in good record cards. He is being paid a special allowance of 15/- per day by the project for continuing his good work.

4. Supply new water level dippers to observers at Jamamme and Kamsuma.

5. Correlate, by computer analysis, the records of all these sites and recreate an acceptable record for Jamamme for 1984 and 1985.

6. Check gaugings at Kamsuma and Jamamme.

2.5 Shebelli River at Beled Weyn

Staff Gauge Record

There is some confusion as to the periods over which different GZs should apply.

Since April 1964 two GZs are quoted on record sheets:

(1) The FAO gauge with GZ at 176.16 m AMSL.

(2) The LLPD gauge with GZ at 176.11 m AMSL.

Little information, as usual, is available on the installation and use of these gauges so an interpretation of the data on monthly sheets is the best that can be achieved.

Throughout the first stage of the project up to December 1984, it was assumed that the following system applied between April 1964 and sometime around 1979/80.

Location	Name	Range	GZ
Downstream of bridge	FAO gauge	0-2 m	176.16
Attached to downstream face of bridge	LLPD	2-6 m	176.11

However, further examination of reports suggests that the original FAO gauges were upstream of the bridge just by the recorder hut. It is these that probably had a GZ of 176.16. These appear to have been in use from 1964 to May 1966 but may then have become unusable because of siltation. They comprised 3 Nr 2 m gauge stands. The plates attached to the downstream face of the bridge today are assumed to be the LLPD ones used from 1966 onwards. Whether they are the same as used by the Italians prior to 1964 is debatable, since it has been suggested that these were sited on the other side of the bridge.

At some point in time the lower plates of the bridge SGs became silted up and the existing 0 to 2 m range stand was added a few metres downstream of the bridge.

It seems that this came to be adopted also as an FAO gauge and covered only the 0 to 2 m range.

The Lockwood nomograms, however, indicate the GZ to be at 176.15 m, which ties in with the GZ originally written as 183.22 m before correction by -7.07 m. Anyway this 1 cm error is negligible and insignificant; 5 cm is significant.

Diagrams dated 19th August, 1969, show the GZ at 176.11 m AMSL.

A note dated 28th December, 1971 on the programme of work for 1972 states that one task should be 'the lower new staff-gauges would be readjusted and reinstalled as there is some error in it.' It is not clear whether this refers to the original FAO gauges upstream of the bridge or perhaps the 'new' one downstream of the bridge. But this has been assumed to be the case.

The report 'Inspection of gauging stations in the Shebelli and Jubba valleys' dated February 1975 by T. Jonoh-Clausen (FAO Associate Expert) confirms (by his own levelling) that the 5 cm overlap at 2 m between the two stands, still exists. He also states that the FAO stands upstream were not being used.

However, in February 1980 when Gemmell surveyed the gauges the overlap had been reduced to 1 cm and he definitely identifies the 0 to 2 m gauge as being downstream of the bridge. It is not possible to say on present evidence when the transition from GZ of 176.16 m to 176.12 m occurred for the lower range. But for convenience, it has been selected as 1st January, 1980: 1979 shows some confusing readings which indicate it may have occurred during that year.

The archived record was based on the assumption of continuity of GZs from 1964 to 1979 and therefore some of the data from April 1964 to May 1966 need editing mainly above 2.0 m by adding 0.05 m to each reading. This has already been marked on the computer printouts.

The adjustments made to GH should also be carried through to the DM archive list and the analysis repeated. This can be combined with a re-analysis required to test whether a multi-segment rating curve would produce a better fit to the DM points than the single segment curve already developed.

Reprocessing of all the SG records to mean daily flow, monthly and annual summary statistics will also be required.

Rating Development/DM Analysis

The list of DMs compiled from records available comprised 80 measurements. Of these, 22 were from the 1963/65 FAO study period. Nineteen were from the period 1967 to 1974 and 39 were taken by Gemmell in 1980/81. There is therefore heavy bias for two periods of two years.

All GHs have been adjusted to a common GZ of 176.11 m AMSL.

Checking and plotting revealed 4 DMs which were suspect. These are Nr 1 and 2 on the list, which were excluded from the list because of unusually low mean velocity, calculated for each measurement. The results of Nr 2 were noted by the observer to be suspect and a faulty meter was given as the cause. The measurement the previous month with the same meter is assumed to have been affected also.

DMs Nr 70 and 71 were also excluded for different reasons, Nr 70 because of the note of an observed reservoir state i.e. it was backed up. This was presumably due to the flooding which had at that time only just passed its peak. A natural bypass channel was probably responsible for diverting much of the flow away from the station section. The nominal rating for the section therefore broke down due to unusual water slope conditions. This DM could not therefore be included in the analysis. DM Nr 71 was also excluded because of excessively high velocities and since the meter used was not noted on the DM sheet, it is suspected that the wrong calibration was used on the assumption that a different meter was used, or perhaps, as Gemmell suggests, the measurement was 'cooked'.

The rating, established using the computer derivation techniques for a single segment curve, was not a good fit. In the mid-range around 100 m^3/s discharge level, a distinct kink is displayed presumably due to some peculiarity in the channel morphology. At the highest levels discharge measurements are lower than expected for the given rating. This may be due to bypassing or the filling of flood plain storage above the bankfull stage. Gemmell tried to rate an existing flood relief bypass canal, but this has not been incorporated into the rating since, at this level, many other inaccuracies arise from temporary bypassing and flood plain storage. The use of extrapolation of the best-fit curve is as good a method as any for estimating the true flow when bankfull levels are exceeded. Perhaps the best approach is to accept that the measuring ability of the station is up to a maximum stage of about 5.3 m. Above that discharge records should be regarded as estimates. A fuller investigation of the bypassing problem should be considered.

Work Programme for 1985/86

1. Install new recording facilities.

   (a) May, 1985 - attach instrument box to top of abutment wall upstream of bridge on right bank, and fix top 2 m pipe sections as allowed by stage.

(b) June/July 1985 - return to fix lower pipe sections.

(c) February/March 1986 - check all existing sections and fix lowest section/bracket if required.

(d) Evaluate recorders.

2. Establish new MP recorder datum by checking levelling.

3. Dig away silt from staff-gauges.

4. Provide new w/l dipper instrument to observer so that MB readings can be recorded on weekly cards.

5. Further check gaugings throughout flow range.

2.6 Shebelli River at Bulo Burti

Staff Gauge Record

From May 1963 readings were taken from the MP well or MB bridge datum points. SG readings commenced on 19th March, 1964, with a corrected GZ at 134.98 m AMSL. The position of this gauge is not clear. Diagrams available that were drawn in conjunction with the Water Control and Management of the Shebelli river clearly state that they were attached to the bridge (downstream face), but this may have been a typing error, since the actual location of the SGs is marked on the right bank downstream of the bridge in approximately the same location as present day gauges. Another available sketch (found later) clearly marks the gauges in the same location and this appears to be an original sketch from the Lockwood era. Nevertheless there seems to be no doubt about the GZ: the only question is whether these early SG readings should be corrected, if they were sited at the bridge, to allow for the water slope to the present gauges. The initial assumption was that the SGs were at the bridge and all data was entered into computer archives with this assumption, with a 0.03 m water-slope correction incorporated into CON value used. All MB data used should anyway have this correction applied. If, after further research, it is found that the SGs were always well downstream of the bridge, then SG data in the period from March 1964 to November 1967 should be corrected again. From December 1967 to March 1971 only MB data are available. The Shebelli study reports that the SGs were washed away well before 1969. However, there seem to be no data about the GZ of the new SGs when they were installed in 1971 and it may not have been properly surveyed until 1980. Due to the lack of reliable information about the GZs overlaps, etc. relating to the SG, the MB data which are reasonably continuous were used right up to 1980 for entering data into the archive.

Closer analysis of the SG data may reveal that they were the same gauges that Gemmell levelled in 1980 and comparison of the records derived from SG and those derived from MB readings now on archive may show that the SG data are the more accurate. MB readings are susceptible to errors due to 'wind' effects and shortenings of tape measures, which are not reported.

The adjusted GZ established by Gemmell (lowered by 1.0 m) at 133.39 m AMSL was accepted as the common GZ for the record.

Analysis of Discharge Measurements

A list of 61 DMs was compiled from all sources available for the rating analysis, 23 were from the FAO period 1963/65; 6 from the late 1960's/early 1970's and 31 taken by Gemmell's team in 1980/81.

Normal checking procedures were carried out and GHs adjusted to the common (most recent) GZ. Of the outliers on the stage/discharge plot only one was excluded from the analysis - Nr 22. This measurement was taken with Ott meter Nr 12497 and gave very low velocity readings. This is the same meter that was faulty in 1963 and it is suspected that it was not repaired at that time, but shelved and accidently used again in 1965.

Rating Development

The initial intention, as always, was to derive a single rating curve for the entire period of record. Firstly, the different groups of data FAO, late 1960's/1970's and 1980/81 periods were assigned different letters and the result was that the 1980/81 data showed a distinct shift from the early periods' plot of points. The transition point was conveniently chosen as 1st January, 1976, since there was a gap in the record from January to May. On reflection a better transition point would be January/February 1978. It is most likely that the channel morphology changes that have caused the shift in rating would have been due to excessive scour/fill during the 1977 peak flood around November/December which was the highest recorded flow at the station since records began. The transition point should be chosen when there is a short gap in the record. Otherwise an unacceptable jump will be evident in hydrograph plots. In 1978 the transition point could be at any time between February to July, probably 1st July, 1978, is best.

The result of the analysis was that one rating was applied to the period 1963 to 1975 inclusive, another for 1976 on.

Further checks and tests should be made to determine whether multi-segment ratings should be derived for either or both of the separate period ratings.

Work Programme for 1985/86

1. Rehabilitate SGs - particularly lowest plates 0 to 2 m range in February/March 1986.

2. Continue MB readings and check slope of water surface between bridge and SG site, at all stages so that a function can be incorporated into processing software to automatically correct for these errors.

3. Investigate possibility of establishing new water level recorder at this site, perhaps using bridge and/or RSJ concreted in riverbed.

4. Further check gaugings - inspecting rating curve for further shifts.

2.7 Shebelli River at Mahaddey Weyn and the Jowhar Offstream Storage Reservoir

Staff Gauge Record

This station has been fortunate in that a common GZ has been used throughout its years of record from 1962. Prior to this it is known that there are records in store of the SNAI offices at Jowhar. Unsuccessful attempts have been made to recover these. Another try would be worthwhile in view of the fact that it could extend the record on the Shebelli at this section by 20 or 30 years. Mr. Bray (MMP) has more information on this and apparently Mostyn Morgan (MMP) is the ultimate source of knowledge about this data.

The FAO staff gauge record started in 1964 and for most of the time either this or the bridge dip readings and most usually both have been available. The bridge dip data are the most continuous and reliable, getting over possible problems of overlapping SG plates when records of replacement are scarce. So unless otherwise specified the MB data has been used in the archive. Only recent data since 1980 have been derived from SG readings since for some reason the MB was not identified by Gemmell. However, it was easily located on the bridge (arrow cut in concrete edge on upstream face) and check levelling produced a level of 112.09 m AMSL, very close to the one quoted originally (1 cm difference). This gives confidence that the same MB point has been in use for many years.

When the SGs have been used recently and concurrently the 7 cm overlap of plates at 4.0 m must be corrected for using the CON command during data entry.

Unfortunately, during the project the 0 to 2 m range SG has always been missing. The opportunity to replace it in March 1985 was unfortunately missed. This should be done as a priority next year. A dipper has recently been supplied to the reader so that MB readings can be restarted.

The observer is always difficult to find and the main contact for this station has been Hajir, the Ministry of Agriculture Jowhar OSR Engineer based in Jowhar. He is very helpful and collects and forwards data cards. He also conscientiously maintains the SG records for Sabuun and Jowhar OSR. These would be extremely useful for long-term archiving, especially catchment modelling and flow routing. I have suggested including all the data on the archive. The Sabuun main channel data would be particularly useful for correlating with Mahaddey Weyn.

The records 1978 to 1983 are now kept at MOA (against Hajir's wishes) but 1984 current data are at Jowhar.

Discharge Measurement Analysis

A list of 55 DMs was compiled from original records: 23 in the early sixties, 6 in the late sixties/early seventies and 25 in 1980/81. Only one reading (Nr 51) was excluded from the analysis. This produced a very low velocity and it is assumed that a faulty meter was in use at the time; this was noted at several other sites around the same period.

Rating Derivation

Plotting and inspection of curves suggested a definite shift in rating, particularly at low flows. This is assumed to have occurred following construction of the Sabuun gated barrage in 1978. The effect would be far more noticeable at low flows than at higher flows provided that the gates on the main channel are not operated, which normally they are not. Diversion of river flood water down to the reservoir will only affect the channel rating, although the effect seems to be small. (Assuming measurements have been taken at Mahaddey Weyn, both when the reservoir is being filled and when it is not - this can be checked.)

So two ratings were derived - one from 1962 to December 1980 and one from 1st January, 1981, onwards. Further gaugings should be performed to check the effect of Sabuun/reservoir operations. Generally however the rating at this station is considered to be a good one - the approach is excellent with no interference from bridge piers, etc.

Work Programme for 1985/86

1. Install new gauge plates in 0 to 2 m range in February/March 1986.

2. Correct overlap (7 cm) at 4.0 m by refitting 4 to 6 m plates.

3. Supply dipper to observer for commencing MB readings. Done May 1985 but observer not personally instructed how to use instrument and where to take data from.

4. Check on correlation between Mahaddey Weyn and Sabuun.

5. Check effect of Sabuun operations on Mahaddey Weyn rating curve.

2.8 Shebelli River at Afgoi

Staff Gauge Record

The original GZ was given as 77.40 m AMSL. There is no record of any changes in this datum until Gemmell levelled the gauge plates in 1980. Apparently the plates were not firmly attached and some slippage had occurred. The GZ was then set at 77.42 m AMSL. This is a small error considering the condition of the old bridge structure to which the SG is attached.

The MB on the old bridge has also been fairly consistent at 84.89 m AMSL, sometimes being quoted 1 cm higher, but this may be due to levelling error, bridge movements, etc.

It can safely be assumed that effectively the same GZ has been in operation since 1963.

Discharge Measurement Analysis

Being closest to Mogadishu of all the stations there have been many opportunities in the past to carry out gaugings even as a training exercise, yet only 42 DMs were available for derivation of the rating curve up to the beginning of 1982. Of these, FAO carried out 19 and Gemmell 13, leaving only 10 carried out in the intervening years.

The distribution is therefore reasonable in time but with bias to the beginning and end of the period as is true of all the stations.

None of the available DMs were excluded from the rating.

The plot of DM points on both natural and log-log paper shows little scatter about the rating curve. The range covered is good. There is some scatter around the 4.0 m GH which is unexplained but presumably due to channel hydraulics downstream or perhaps hydraulic disturbance around the bridge support pillars.

Rating Derivation

There is no shift of rating discernible with time so a unique rating was derived for the entire period of rating. The derived rating is considered to be satisfactory with little improvement possible from multi-segment analysis.

Work Programme for 1985/86

1. Liaise with Maurizzio Nazzari at the Faculty of Agriculture, Mogadishu University based near Lafoole. He is the technician in charge of the automatic recorder located at the old bridge. He collects all data for salinity research studies. I have suggested installing one of our own recorders in the instrument box but this would mean replacing his almost new weekly chart recorder. I have offered him any data that we produce, summary GHs or flows.

   We have worked well together on installing the Beled Weyn recorder recently - he is also keen on that site and he will no doubt require data from it when analysed.

2. No plans for this station. An MB is established on the old bridge and by the new recorder but experience has shown that if the observer is given a dipper he simply ensures that the SG reading and MB reading always add up to 7.50 which used to be the GH of the MB originally. So the instrument was taken away.

3. Plates could be painted white for clarity.

2.9 Shebelli River at Audegle

Staff Gauge Record

The record starts in December 1982. The GZ of the station has been changed on several occasions although only by adding or subtracting 1 m. Some at least of the original gauge plates are still believed to be in their original positions. A new set of gauges on new stands was installed upstream of the bridge in 1980 by Gemmell using the same GZ. However this has led to confusion about the range.

The history of GZ changes started in December 1962 when the original set was given a value of 94.07 m (RL) with the MB as 100.58 m (RL) (EGH of 6.51 m). The BM established in 1963 gave a GZ of 70.25 m AMSL and MB at 76.76 m AMSL.

In March 1963 the GZ was raised to 71.25 m for some reason which caused confusion when converting for earlier data, since, in June 1963, stages fell below the revised GZ resulting in negative GHs. However, the use of the higher GZ was maintained apparently up until 1980 when Gemmell re-adopted the original

GZ and relevelled it as 70.05 m AMSL with the MB as 76.59 m AMSL (EGH of 6.54 m). This discrepancy between the EGHs of the MB in use in 1963 and 1980 is small considering the collapsed state of the old bridge with wooden deck (warped). It is assumed that approximately the same MB has been in use throughout the record.

A new bridge was constructed in 1984 about 200 m downstream of the old one and it will be necessary to consider resiting the station at this point for several reasons. This is the obvious point of gauging, under the bridge using a boat (or permanent cableway); the bridge can be used for MB measurements; the old bridge is too far upstream to allow reliable slope corrections to be made if a combination of MB from new bridge and old SGs were to be used. One site or the other should be used, not both.

All stage readings, either from SG or MB data, have been adjusted assuming a common GZ of 70.05 m AMSL.

Since 1984 1 m errors have had to be accounted for, following confusion by the observer as to the correct GZ. He has since been provided with a sketch so that he should not now make the same mistake. He is incidently the most conscientious of any of the observers and should be encouraged. The only way to check for gross 1 m errors by observers is to use stage correlation methods for adjacent station (e.g. Afgoi is used to check Audegle).

Analysis of Discharge Measurements

The list of gaugings used in the rating derivation comprised 36 DMs up to 1982. Fourteen from the FAO early sixties, 8 from the late sixties/early seventies and 14 from 1980/81. The paucity of data indicates the problems of getting a reliable measurement from the disintegrating old bridge structure at the site. Now it is positively dangerous to work from; and, as the new bridge is totally unsuitable, the only method available is by boat which can be extremely dangerous with inexperienced people together in a small boat. It was tried once but not twice.

Many of the DMs were checked if they appeared to be outliers from a curve but none was excluded from the analysis. Some corrections have been made to GHs. Nr 32 was changed to fit in with GH record. Nr 36 had the wrong date assigned to it.

Rating Derivation

Initial analysis and plots showed that a unique curve for the whole period would not be appropriate since a definite shift in rating has occurred in time. The 1980/81 measurements show higher stages for the same flow as compared with 1962 to the seventies (1971). The change has presumably occurred due to changes of the control regime in the river between Jenaale and Audegle. It could be associated with the control of the Jenaale barrage - the reason is speculation at this stage.

A transition point was chosen where the actual change in rating use would not be noticed by a jump in computed flows. Conveniently there is a gap in records between 1971 and 1976 and so 1st January, 1976, was selected as the transitional point. All DMs from 1963 to 1975 were analysed as a separate group from those in the 1980/81 group with the intention of deriving separate ratings for those periods.

Rating A, 1963 to 1975 was derived from 22 measurements and shows very little scatter, the best fit computer derivation is considered acceptable. Rating B, 1976 onwards was derived from 14 DMs. There are rather too few gaugings for an acceptable rating especially in the higher flow ranges. The computer-derived best-fit curve fits the majority of low flow DMs but not the less numerous high flow DMs. An alternative solution was selected from the VDU log plot but is not considered satisfactory. There are too few measurements available to allow much confidence to be placed in the final rating 'B' used to convert post-1976 records.

Some concentration of gauging effort is required at this station to firm up on the rating: a cableway installation would provide the obvious solution in view of the problems associated with gauging from small boats or dangerous bridges.

Further Work Required 1985/86

1. Rehabilitation of staff gauges and changing site to new bridge. Installation of new gauge stands in March 1986.

2. Establish new MB on new bridge.

3. Consider installation of permanent cableway for facilitating a concentrated effort on flood gaugings.

ANNEX 1

STATION LOGS

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Jubba | Location: Lugh Ganana | Database Nr 1

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. No information b. In or before 1951	1. 141.59 m AMSL (91.67 RL)	BM Nr :) BM level :) MB location :) No information MB level :) MP location :) MP level :)
a. Before 1.5.63	No evidence of staff gauge records	BM Nr : 243-B Cross cut in concrete of ferry anchor block on right bank by recorder house (100.00 m RL assumed initially) BM level : 149.917 MB location : MB level : MP location : Top of concrete well casing MP level : 150.29 (100.37 RL)
a. Before 1.5.64 b. 11.6.64 and 9.9.64	1. 142.67 m AMSL (1-2) 2. 143.45 m AMSL (2-6) (Based on assumption that the same gauges were in use in 1964 and 1965)	BM Nr : As above BM level : MB location : MB level : MP location : Probably top of wooden boards of well cover MP level : 150.73 (?)

Note: All levels corrected from original values up to 9.9.64 when level of BM AMSL was reduced by 0.25 m.

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Jubba | Location: Lugh Ganana | Database Nr 1

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. Before 10.3.65 b. 27.3.65 (?)	1. 142.34 m AMSL (0-1) 2. 143.18 m AMSL (1-2) 3. 143.99 m AMSL (2-3) 4. 145.03 m AMSL (3-4) Russian SGs 175 m upstream of FAO SGs. Only used during 1965 with FAO gauges still in operation.	BM Nr :) BM level :) MB location :) Assumed as above MB level :) MP location :) MP level :)
a. circa 6.6.67	1. 141.61 m AMSL (0-2) 2. 143.45 m AMSL (2-6)	BM Nr :) BM level :) MB location :) Assumed as above MB level :) MP location :) MP level :)
a. 14.10.72 (?) b. 14.10.72	1. 141.61 m AMSL (0-2) 2. 143.42 m AMSL (2-6) Possibly new plates fitted in 2-6 m range	BM Nr :) BM level :) Assumed as above MB location :) MB level :) MP location : Not indicated; assumed to be top of concrete ring MP level : 150.31 m AMSL

Note: The following temporary gauges were installed below 2m:

a. 12.1.65 to 27.3.65 GZ 140.69 m AMSL
b. 8.1.70 to 18.2.70 GZ 141.98 m AMSL
c. 19.2.70 to 21.3.70 GZ 141.50 m AMSL

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Jubba | Location: Lugh Ganana | Database Nr 1

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. circa 12.75 b. checked by Gemmell 18.3.80	1. 141.64 m AMSL (0-1) 2. 142.64 m AMSL (1-2) 3. 143.42 m AMSL (2-6)	BM Nr : 243(B) (as above) BM level : 149.917 m AMSL MB location : Bridge deck on downstream face at 16.0 m mark MB level : 150.98 m AMSL MP location : Top of wooden boards over well MP level : 150.34 m AMSL
a. 28.3.84 b. 28.3.84	1. 141.42 m AMSL (0-2) 2. 143.42 m AMSL (2-6) New 0-2 m plates attached on hardwood support to bridge pier. New 2-6 m plates on original support	BM Nr : BM level : MB location : Mark painted on downstream face 32 m from left bank at concrete bridge deck level MB level : 151.01 m AMSL MP location : MP level :

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Jubba | Location: Bardheere | Database Nr 2

Dates	Staff gauge zeroes	Datum points	
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point	
a. 5.63 b. 4.6.63	No staff gauges	BM Nr :	RL datum on concrete anchor block with ring bolt
		BM level :	100.00 m assumed (94.04 m AMSL)
		MB location :	No bridge
		MB level :	
		MP location :	Top of concrete well tile (?)
		MP level :	(100.47 RL, 94.51 m AMSL)
a. 4.64 (?) b. 29.2.64 and 9.9.64 when values corrected	1. 89.22 m AMSL (Assumed to be as below)	BM Nr :	182-B; BM 182-A used originally. (102.988 m AMSL, concrete column monument with light, at junction by filling station)
		BM level :	94.04 (94.47 to 9.9.64)
		MB location :	No bridge
		MB level :	
		MP location :	Top of well
		MP level :	94.57 (95.00 to 9.9.64)
a. 10.3.65 (?) b. 27.3.65 and/ or 5.5.65	1. 89.23 m AMSL 2. 90.23 m AMSL 3. 91.04 m AMSL 4. 92.04 m AMSL 5. 93.18 m AMSL	BM Nr :) BM level :) MB location :) MB level :) MP location :) MP level :)	As above

Note: Level correction of -0.43 m on 9.9.64

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Jubba | Location: Bardheere | Database Nr 2

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. 5.67 b. 9.6.67	1. 89.01 m AMSL (0-2) 2. 90.92 m AMSL (2-4) 3. 92.95 m AMSL (4-5) No information on gauge location. Assumed to be new upstream gauges	BM Nr :) BM level :) MB location :) MB level :) As above MP location :) MP level :)
a. 30.4.80 b. 25.2.81	1. 88.98 m AMSL (0-2) 2. 90.98 m AMSL (2-4) 3. 92.98 m AMSL (4-6)	BM Nr : As above BM level : MB location : On bridge (constructed 1978) Painted on downstream face of girder close to left bank MB level : 96.79 MP location : Top of floorboards MP level : 94.57
a. 26.3.84 b. 26.3.84	1. 88.98 m AMSL (0-7) New 7 m plates fitted to existing GZ	BM Nr : BM level : MB location : Top of metal triangular beam on catwalk on upstream face near new SGs MB level : 96.97 MP location : as above MP level : 94.57

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Jubba — Location: Jamamme (Arara Bridge) — Database Nr 3

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. 18.6.63 b. 18.6.63 to 9.10.63	1. 0.18 m AMSL (0-1) 2. 1.28 m AMSL (1-2) 3. 2.21 m AMSL (2-3) 4. 3.19 m AMSL (3-4) 5. 4.17 m AMSL (4-5) 6. 5.13 m AMSL (5-6) 7. 6.13 m AMSL (6-7) (also noted as 6.42 m)	BM Nr : 294 A - bridge deck, downstream right bank abutment BM level : 10.64 (also BM M4 - see below) MB location : At mark 28 m, upstream face MB level : 11.05 MP location : 'V' cut in top ring of concrete well tile MP level : 8.00
a. 4.72 (?) b. 26.8.72	1. 0.00 m AMSL (0-2) 2. 1.54 m AMSL (2-4) 3. 3.29 m AMSL (4-6) 4. 5.32 m AMSL (6-8)	BM Nr : 249 B - assumed to be same as M4 - top of concrete post on upstream left bank BM level : 12.12 MB location : Not specified MB level : 11.09 MP location : MP level :
a. Assumed 1972 24.3.80	1. 1.51 m AMSL (2-4) 2. 3.26 m AMSL (4-6) 3. 5.17 m AMSL (6-8) Stand replaced 11.11.80 3. 5.26 m AMSL (6-8)	BM Nr : Gemmell's TBM 1980. Mark painted on downstream b. left bank abutment deck near joint between bridge and abutment BM level : 11.03 m AMSL (100.00 RL) MB location : Upstream bridge deck, near centre of bridge MB level : 11.09 MP location : Top of well rings MP level : 8.00

Note: All levels refer to FAO MSL datum (not Russian), after correction for MSL error of -0.69 m. The various benchmarks and gauge zeroes are discussed in detail in Section 2.4.

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Jubba | Location: Jamamme (Arara Bridge) | Database Nr 3

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed.	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. b. 12.6.84 and 31.10.84	Staff gauges abandoned	BM Nr : M4; TBM (1980) BM level : 12.12; 11.02 MB location : As above - locating arrow on cross beam MB level : 11.04 MP location : Abandoned MP level :

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Shebelli | Location: Belet Weyn | Database Nr 10

Dates	Staff gauge zeroes	Datum points	
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point	
a. 1951 (?) b.	1. 176.13 m AMSL (183.20) assumed range 0-6 m	BM Nr :	Not known
		BM level :	
		MB location :	Not used (?)
		MB level :	
		MP location :	Not built
		MP level :	
a. 1963 (?) b.	No staff gauges	BM Nr :	Not known
		BM level :	
		MB location :	Not specified. MB first used on 20.4.63, but no datum given
		MB level :	
		MP location :	Not specified
		MP level :	182.62 m AMSL from 23.4.63 to 19.5.63 182.75 m AMSL from 20.5.63
a. 13.4.64 b. 8.64	1. 176.15 m AMSL (183.22) Assumed to refer to set next to recorder site	BM Nr :	139-A
		BM level :	182.69 - In May 1965 MP indicated as 182.77 m AMSL. The 2 cm difference has been ignored
		MB location :	Not specified
		MB level :	
		MP location :	Not specified
		MP level :	182.75 m AMSL

Note: Values in parentheses are for datums before MSL adjustment (-6.07 m)

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Shebelli | Location: Belet Weyn | Database Nr 10

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. Before 13.4.64(?) b. 18.2.66 and 23.5.66 Checked 14.5.67	1 176.16 m AMSL (FAO) 2. 176.11 m AMSL (LLPP) These gauges assumed to have been in position since 13.4.64	BM Nr : ? BM level : MB location : Not specified. MB level : 182.75 m AMSL. Some confusion about MB datum 182.73 and 182.77 also quoted MP location : Not specified MP level : 182.75 m AMSL
a. b. 27.2.80	1. 176.12 m AMSL (FAO) 2. 176.11 m AMSL (LLPP) (overlap ignored in processing)	BM Nr : ? - BM is a cross carved into outside corner ledge of upstream right bank bridge abutment BM level : 182.692 MB location : Not specified MB level : 182.80 m AMSL MP location : Top of floorboards MP level : 182.72 m AMSL
a. b. 14.12.83	as above	BM Nr : BM level : MB location : Top of metal handrail on downstream face of bridge (3rd upright from right bank) MB level : 183.69 m AMSL (GH = 7.58) MP location : Top of floorboards MP level : 182.71 m AMSL

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Shebelli | Location: Bulo Burti | Database Nr 11

Dates	Staff gauge zeroes	Datum points		
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point		
a. Assumed by 3.71	1. 134.39 m AMSL (0-2)	BM Nr :	114A	114B
b. 29.2.80	2. 136.24 (2-4)	BM level :	142.64	142.493
	3. Not known	MB location :	Bottom of girder	Road kerb
	4.	MB level :	141.22	142.62
		MP location :	Not in use	
		MP level :		
a. 8.3.80	1. No staff gauge	BM Nr :	As above	
b.	2. 134.39 m AMSL (1-3)	BM level :		
	3. 136.39 (3-5)	MB location :	Metal angle iron, edge of downstream sidewalk	
	4. 138.39 (5-7)	MB level :	142.63	
		MP location :	Top of concrete rings	
		MP level :	142.31	
a.	As above	BM Nr :	As above	
b. 14.12.83 and 20.12.83 and 7.3.84		BM level :		
		MB location :	Top of handrail, downstream face, centre of bridge	
		MB level :	143.535 (GH = 10.14)	
	2-4 plates refitted 7.3.84	MP location :		
		MP level :		

Note: Information prior to 1971 unclear. See Section 2.6 for further details.

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Shebelli | Location: Mahaddey Weyn | Database Nr 12

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. By 11.62 b.	1. 2. 3. 4.	BM Nr : BM level : MB location : Not indicated MB level : 112.90 (27.4.63 to 9.5.63); 112.08 (from 9.5.63) MP location : MP level :
a. 10.64 b. 20.10.65 and 14.2.66	1. 104.57 m AMSL range not indicated - assumed to be 0-6. Location 10 m downstream of bridge on left bank	BM Nr : BM 83-A - cross cut into concrete of south-east bridge abutment BM level : 112.065 (later given as 112.079) MB location : Not indicated MB level : 112.08 MP location : MP level :
a. ? same gauges b. 16.2.80	1. 104.57 m AMSL (0-2) 2. 106.57 m AMSL (2-4) 3. 108.50 m AMSL (4-6)	BM Nr : BM 83-A (?) - cross cut into approach sidewalk to bridge, left bank upstream BM level : 112.079 MB location : Not used MB level : MP location : MP level :

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Shebelli | Location: Mahaddey Weyn | Database Nr 12

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. Same gauges b. 6.12.83 and 1.3.84	1. No plate (0-2) 2. 106.57 m AMSL (2-4) 3. 108.50 m AMSL (4-6) 2-4 m plate refitted on 1.3.84	BM Nr : as above BM level : 112.079 MB location : notch cut in concrete ledge just below bridge deck, between two pillars near centre of upstream face MB level : 112.09 MP location : MP level :

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Shebelli | Location: Afgoi | Database Nr 14

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. 5.63 b.	1. 77.40 m AMSL (0-6) Gauges fixed to one of the trestle support pillars	BM Nr : 15A. White painted cross on top of south bridge abutment (downstream, left bank) BM level : 84.910 MB location : (?) MB level : 84.90 MP location : - MP level : -
a. 27.4.80 b. 7.2.80	1. 77.42 m AMSL (0-6) New gauges fitted to existing GZ	BM Nr : 15A 15B BM 15B may account for 2 cm change in datum. (Left bank, upstream, mark on road surface) BM level : 84.91 84.93 MB location : Upstream edge of old bridge overlooking gauges MB level : 84.89 MP location : - MP level : -
a. b. 12.12.83 and 25.6.84	1. As above 6 m level checked at 83.43 m AMSL	BM Nr : 15A BM level : MB location : As above MB level : 84.89 New MB established. Bottom edge of window on recorder stilling pipe 85.41.

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Shebelli | Location: Audegle | Database Nr 15

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. 12.62 b. (?)	1. 70.25 m AMSL (0-6) Downstream face of bridge, attached to pillar	BM Nr : 307-A (?). Top centre of south-east corner post of bridge, left bank downstream side BM level : 77.22 MB location : Not indicated, but assumed to be floorboards of bridge deck on downstream side. MB level : 76.76 MP location : - MP level : -
a. 21.3.64 b. (?)	1. 71.25 m AMSL (0-5) Same gauges, range reduced	BM Nr :) BM level :) MB location :) MB level :) As above MP location :) MP level :)
a. by 7.71 b.	1. 70.25 m AMSL	BM Nr :) BM level :) MB location :) As above MB level :) MP location :) MP level :)

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Shebelli | Location: Audegle | Database Nr 15

Dates	Staff gauge zeroes	Datum points
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point
a. By 1.76 b.	1. 71.25 m AMSL 2. 3. 4.	BM Nr :) BM level :) Assumed as above MB location :) MB level : MB of 77.22 indicated on some sheets but ignored MP location : MP level :
a. b.13.2.80	1. 70.05 m AMSL (0-2) 2. 72.05 m AMSL (2-6) Note: 1. Near downstream bridge pillar 2. Attached to downstream pillar	BM Nr : - (Blue painted mark on concrete slab, left bank downstream abutment) BM level : 76.43 MB location : - Boards on downstream deck of bridge near centre overlooking gauges MB level : 76.59 MP location : MP level :
a. 19.3.81 b.	1. 71.05 m AMSL (1-3) 2. 73.05 m AMSL (3-5) New gauges 20 m upstream	BM Nr : BM level : MB location : MB level : MP location : MP level :

Hydrology Section - Flow Gauging Station Staff Gauge Log

River: Shebelli | Location: Audegle | Database Nr 15

Dates	Staff gauge zeroes	Datum points	
a. Installed and operational b. Surveyed	SG Nr with GZ level as m AMSL or RL and range e.g. 1. 56.09 m AMSL (0-2) 2. 58.02 m AMSL (2-6)	BM - Benchmark Nr and level m AMSL MB - Bridge dip point MP - Well dip point	
a. b. 6.3.84	Old gauges: 6 m level at 76.07 New gauges: 4 m level at 74.09	BM Nr : BM level : MB location : MB level : MP location : MP level :	 Check levelling gave MB at 6.61 GH but only approximate because of state of bridge boards

ANNEX 2

RECORD FILES KEPT IN HYDROLOGY SECTION OFFICE

1. Pre-ODA Hydrometry Project, 1983

(a) By station name index:

1. Monthly SG readings from observers, 1963-1984.
2. Mean daily water level/gauge height, computed to 1983.
3. Mean daily discharges, computed to 1983.
4. Annual gauge height/discharge sheets, incomplete 1950s to 1960s.
5. Annual gauge height and discharge sheets, typed 1951 to 1977 prepared by Technital, 1977.
6. Discharge measurements.
7. Station files including history notes marked 1980.

(b) Whole network:

1. Mean monthly discharge computed up to 1982.
2. Minimum monthly discharge computed up to 1982.
3. Maximum monthly discharge computed up to 1982.

2. System Starting in 1984 - ODA Hydrometry Project

Designed for computerised data processing using:

COMART COMMUNICATOR hard-disk computer with CIPHER VDU and keyboard unit, Epson MX100 printer.

1. Weekly observers record cards for SG readings and MB bridge dippings.

2. Graphical plots
   - Annual Hydrographs 1980 onwards
   - Stage - Discharge - natural linear scales
   - Stage - Discharge - log-log scales

3. Computer printout files:

   (a) Monthly GH and discharge sheets.
   (b) Annual discharge summary sheets.
   (c) Complete lists of all known discharge measurements.
   (d) Computed stage-discharge tables.
   (e) System summary.

   (a) and (b) are stored by station name index.
   (c), (d) and (e) are kept in separate files for the whole network.

4. Station details of stage-gauges, GZs, datums and BMs.

APPENDIX IV.2

VISIT OF THE MMP HYDROLOGIST
JUNE - AUGUST 1985

SOMALIA HYDROMETRY PROJECT - PHASE II

Visit of MMP Hydrologist June - August, 1985

1. Introduction

This visit was specifically arranged to permit additional work to be carried out on the installation of the automatic water level recorders. The progress of this work is summarised below. It was hoped that the entering and checking of data for the computer database could also be continued. However, owing to delays in the shipment of the computer (which had been returned to England for service and upgrade), and difficulties with the office electricity supply, the computer was not re-installed until less than 36 hours before the hydrologist's return to the UK, and for much of that time there was a power cut in Mogadishu.

The prospects for undertaking other office work were seriously undermined by the staffing situation in the Hydrology section of the Ministry of Agriculture. The two experienced staff members both left the Ministry during this period (to universities in Somalia and the USA), leaving only the junior technician. During the time between field trips considerable effort was expended on training in basic data handling procedures, but little immediate benefit resulted.

2. Installation of Automatic Water Level Recorders

2.1 Bardheere, Jubba River

Existing position :	Recorder installed in May 1985, together with three pipe sections. Data recorded hourly, but only useful for water levels in the range 2.7 to 8.7 m.
July 1985 :	Water level about 1.7 m. Data for May 21st - July 4th was transferred to the retriever (and subsequently to the computer in Mogadishu), but was only useful up to May 31st when the water level dropped below the bottom of the pipe.
	An additional 2 m pipe section was fixed and the recorder re-initialised to record levels in the range 0.7 to 8.7 m. In many years this would be sufficient for a full data record to be achieved.
Future work :	In early 1986 it may be possible to install a further 2 m pipe section. However, the trash rack which protects the bridge pier ends at a GH of about 0.9 m so that a more elaborate fixing structure will be required.

2.2 Lugh Ganana, Jubba River

Existing position :	Recorder box installed in May, 1985, together with two pipe sections temporarily fixed to the pillar adjacent to the bridge. The float was not installed and the recorder was therefore not operational.

July 1985	:	Water level about 3 m. Existing pipes firmly fixed and additional 2 m section fitted. The relatively high water level prevented the fixing of a fourth section. Recorder and float installed such that water levels in the range 3.8 to 9.8 m will be recorded.
Future work	:	In early 1986, one or two further pipe sections (depending on the water level during the low flow period) may be added using the same fixing method.

2.3 Kamsuma, Jubba River

Existing position	:	Basic design and location suggested by RJE Hawnt (MMP), but no work undertaken.
July 1985	:	Recorder box installed at centre of bridge on downstream face. Three pipe sections fixed - top two to concrete of bridge and the third to the pillar under the bridge. The fourth pipe could not be fitted because of the strong current. 4 to 8 m gauge plates (provided by K. Jacobi of MJVD) were fixed to the structure supporting the pipe. The float was installed and the recorder initialised, but the data will only be useful when the river level is above about 4.2 m (at installation, level 3.2 m).
Future work	:	In 1986 the fourth and (probably) fifth pipe sections may be installed. Fixing should be slightly less difficult because the pillar will be more accessible. The remaining gauge plates may also be fitted. A request has been made to the Director of Land and Water Resources for the Ministry of Agriculture to arrange for an observer to be employed to record the staff gauge readings.

2.4 Kurten Warey, Shebelli River

A brief visit indicated that the proposed position for fixing the recorder and pipe to the barrage was totally unsuitable. Because of the importance of this site, further discussions should take place with a view to installing the recorder in this area early in 1986. However, because of the absence of any bridge or other structure to which the pipe may be fitted, the amount of work and expense involved would be substantially greater than that for the other installations.

2.5 Beled Weyn, Shebelli River

Existing position : Recorder installed in May 1985, together with two pipe sections. Levels exceeding approximately 3 m recorded.

August 1985 : The wire was found to be broken and the counterweight missing. There was no evidence to explain the cause, but vandalism appears extremely unlikely. Examination of the data showed that the break occurred on June 7th so that useful data were limited to 3 weeks.

Because of a blockage by the bridge abutment (possibly part of the abutment footing) it was not possible to install a further 2 m pipe, a section of length 1.25 m was added.

The recorder was set up with a makeshift counterweight which should allow reasonable data to be recorded. Levels exceeding approximately 1.8 m will be recorded.

Future work : The replacement counterweight (from the Hydrology Office) should be fitted at the earliest opportunity. Further extension of the pipe will depend on an examination (during the low flow period in 1986) of the apparent blockage at the base of the pipe. It might be necessary to consider re-positioning the installation slightly further away from the abutment.

APPENDIX IV.3

VISIT OF THE IH HYDROLOGIST
SEPTEMBER - NOVEMBER 1985

Somalia Hydrometry Project - Visit 29/9/85 to 10/11/85

Work done during visit

(1) Installed new database programs onto Ministry of Agriculture computer.

(2) Transferred all data from the old system onto the new system.

(3) Trained new Hydrology section staff on the operation and care of computer (there is now a new head of Hydrology).

(4) Instructed staff on day to day running of the database programs including the new screen and plotter graphics programs.

(5) Re-computed all daily mean flows for all stations sccording to the new algorithm which takes into account the time of day of each stage reading.

(6) Prepartion of Land Rover for field visits, including obtaining 400 litres of fuel and fitting two new tyres.

(7) Field visits to all stations on the Shebelle (see notes on field visits).

(8) Entry of all data collected in the field onto the computer, including graphical checking and conversion to flows.

(9) Preparation for a counterpart only field visit to the Jubba (Lugh and Bardheere).

(10) Processing of the backlog of data which had accumulated in the Hydrology office.

(11) Abstraction of the following data for the 'Genale Rehabilitation Project' (TAMS) :

Daily mean flows	:	River Shebelle all stations and all years
Annual max/min stage	:	" " " " " " "
Rating tables	:	River Shebelle all stations
Jowhar OSR levels	:	1980-84 (plots)

(12) Development of a program (LOGGER) for transferring data from the electronic loggers to the database (see attached notes).

(13) Discussions with the Director of Land and Water Resources on project extension.

Work not completed

The following work was not completed because a considerable ammount of time was spent on and preparing for field visits :

(1) Completion of database software. Although the system is fully operational for day to day use, the following items have yet to be written :

(a) 3 segment rating curve development program

(b) Graphics for discharge measurements and ratings

(c) New operation manual

(d) Minor improvements which emerged from operation of the new programs whilst in Mogadishu.

(2) Modification of Rod Hawnt's program to calculate discharge measurements (GAGCAL) to incorporate the two curent meters now being used by the Bardheere Dam Project.

C S Green
19th November 1985

APPENDIX IV.4

NOTES ON BELED WEYN FIELD VISIT
14th-15th OCTOBER 1985

Notes on Beled Weyn field visit 14-15th October 1985

Participants

C S Green
Zakia
Ali
Annab
Driver Mohamoud

14/10/85 Mahaddey Weyn

The observer was not present in his house (we were told that he was at Jowhar). We were also unable to see his records as they were locked away. We left a message that we would return the following day on the way back from Beled Weyn. The staff gauge reading and the bridge dip readings that we made were:

Staff gauge ?.90 metres (2.10 metres from the top)
Bridge dip 3.58 metres

The time was approximately 11 am.

In view of the fact that this gauge could not be read properly because there were no metre numerals and also that past data is plagued with miss read metre readings, I would suggest that metre numerals be put on all staff gauges that do not have them at present.

The topmost section of staff gauge was silted up to a depth of 0.4 metres. In view of the long journey to Beled Weyn it was decided to dig gauge out on the return visit.

14/10/85 Bulo Burti

We visited the Ministry of Agriculture regional office and spoke to the local co-ordinator (the observer was not at home). The co-ordinator was able to produce the observer's monthly log book from which the following, hitherto missing, data was copied by hand :

(1) No data was recorded from 1st January to April 2nd because there was no water on the staff gauge and his water level dipper was broken.

(2) Readings for April 3rd to April 5th (2 per day)

(3) May 2nd (pm) to May 3rd (2 per day)

(4) August 24th to October 14th (2 per day)

We asked if he had posted the weekly reports (Rod Hawnt's new card system) as requested. He stated that he had and suggested that their non arrival in Mogadishu was due to the poor postal service.

We gave the regional co-ordinator the folllowing :

(1) A replacement water level dipper

(2) Enough weekly cards for 6 months

(3) A new monthly stage log book for 1986

The defective water level dipper was returned to us.

In view of the fact that many weekly cards are returned to Mogadishu without river, station name or observer's name, all cards issued on this visit had the river name and station written on in advance.

The staff gauge was read as 1.70 metres at approximately 2pm.

The top most section of the staff gauge was uprooted from its correct position and left lying on its side on the river bank. Asked when and how this happened, the co-ordinator said that it was during floods earlier in the year.

This section of the staff gauge requires re-establishing. It may be possible to re-use the old section, anchoring it to larger concrete base in the river bank and then re-levelling the stage plate. However this depends on whether the gauge remains where it is until January and also whether it can be safely lifted as it is still attached to its original concrete base.

Having left the co-orinator we asked permission from the military to make a bridge dip. Permission was refused on the grounds we needed police permission first.

<u>14/10/1985</u> <u>Beled</u> <u>Weyn</u>

After arranging accommodation there was about one hour's daylight left. This time was used to replace the temporary counter-weight installed by Peter Ede. This was done, but it was not possible to set the correct level on the recorder since the water level was below the base of the stilling well. The obstruction to the stlling well was clearly visible as a large flat topped stone. Although this was photographed a better picture of this obstruction is shown in Gemmell's report since the level of the river was much lower at the time of his picture.

The staff gauge reading at 18:00 hours was 1.30 metres.

<u>15/10/85</u> <u>Beled</u> <u>Weyn</u>

Since the retriever was not working we attemped to read data from the logger manually, stopping the display at 6:00, 12:00 and 18:00 hours each day. Originally we could not understand why the the data started on th 16th of the month (start month is not displayed) since Peter Ede's note said that he was there 7th/8th August. We assumed it was a setting error. After reading data from the logger for about an hour there was a sudden drop below zero in the readings. It then became obvious that the data we had been reading was from the original installation of the recorder and that the drop below zero was the point that the counterweight had broken.

Having wasted time in the above exercise, we decided to calculate how long the remaining store would last. The number of unused locations was 4178, enough for 174 days or 5.6 months. We came to the conclusion that it would better to not try and read the data by hand because of the time it was taking. Instead we replaced the battery and reset date, time and level. Since the stilling well was still dry it was not possible to set the level exactly. The level was set to a nominal 1.500 metres. This means that from 15/10/85 all readings from the logger will require the addition of a constant. The constant may be determined by cross checking with observer readings as soon as the float is fully afloat.

We were not sure whether there was a 'MB' point on the bridge. It was not obvious to us and the observer did not know of it. The observer also knew nothing of bridge dipping. A 'MB' point was established on the same side of the bridge as the recorder, towards the centre of the river (hacksaw mark on the top hand rail). Whether this is the best point for low flow dipping should be clearer during the visit next January when the river is lower. If it is then this point requires levelling to the local bench mark. Zakia instructed the observer in the use of the dipper.

At the regional office of the Minisry of Agriculture we obtained the following hitherto missing data:

(1) April 1st to May 31st copied by hand from the monthly log sheets.

(2) Original log sheets for the period 1/6/85 to 30/9/85

(3) Hand copy of the readings 1/10/85 to 15/10/85

Asked why we were not receiving weekly cards in Mogadishu, the observer said that the post was unreliable and that he could not trust Ministry drivers to deliver. He had also run out of cards. We gave the observer the following:

(1) Enough cards for 6 months (already labelled 'Beled Weyn')

(2) A new monthly log book for 1986

(3) A water level dipper

The observer complained that the old staff gauge was difficult to read. This is indeed so, but the gauge does not need replacing. All that is required is that on the next visit the gauge be rubbed down with a wire brush and repainted white. The raised graduations may then be painted black and the numerals red.

Staff gauge reading was 1.44 metres at 6:00 am.

15/10/85 Mahaddey Weyn

The return visit to this station also proved fruitless in the attempt to see the observer. He was again absent and his records locked away. We stopped at the bridge and dug the top staff gauge free of 0.4 metres of river mud that had accumulated from earlier high levels.

The staff reading was ?.50 metres or 2.50 metres from the top staff gauge.

Recommendations

(1) Weekly record cards issued to observers should only be handed over after the river and station name has been written on the top of each card.

(2) When data are dumped from a logger to the retriever, the store should be initialised (ie emptied). This will :

(a) Avoid any confusion over reading the same data twice

(b) Lengthen the time the logger may operate should the retriever malfunction again or a field be visit be delayed.

(3) The old staff gauge at Beled Weyn needs repainting.

(4) The top most section of the staff gauge at Bulo Burti needs re-establishing on the river bank.

(5) Metre marks should be applied to all staves which do not have them at present.

C S Green

16th October 1985

Notes on Jowhar/Mahaddey Weyn field visit 19th October 1985

Participants

C S Green
Zakia
Ali
Annab
Driver Mohamoud

19/10/85 Jowhar reservoir

We visited the outlet structure at Hawadley to obtain current storage level :

Level at Hawadley : 3.44 metres

Drove around far side of resevoir to inflow point. Water still entering the reservoir at low level (about 2/3rds the height of the energy dissipators just downstream of bridge). Unable to read the staff gauge upstream of the bridge since it was silted up.

Heavy overnight rain had made passage difficult so we travelled only a limited distance up the inflow channel. We had hoped to reach Sabuun. Instead we crossed the channel and headed for Jowhar where we hoped to find Hajir and ask for an altenative route. Due to a combination of poor conditions and bad driving the Land Rover went over the side of the embankment on which we were travelling in the sugar estate. It took 3 hours to find a tractor and free the vehicle.

At Jowhar we were unable to find Hajir and were told he had gone to Mogadishu.

19/10/85 Mahaddey Weyn

Arrived at Mahaddey Weyn at 4pm to find the observer still not present in his house. We waited for an hour in the hope that he would return. He did not. We left a supply of the weekly cards (enough for 6 months) and a new monthly stage log book for 1986 in the hands of his wife. We were again unable to gain access to his records to find the missing data since he had the key.

The river level at 4pm was 3.64 metres.

C S Green

20th October 1985

Notes on Afgoi/Audegel field visit 26th October 1985

Participants

C S Green
Zakia
Ali
Driver Mohamoud

26/10/85 Afgoi

We first visited the local office of the Ministry of Agriculture in Afgoi. It was 9am and the observer had not taken his 6am reading yet. We collected as much of the missing data as was available. This included several weekly cards which had not been sent on to Mogadishu and monthly sheets for June, July, August and September. We asked why we had not been receiving the weekly cards (the last data received at Mogadishu was on June 21st !). The observer said he had taken the earlier cards himself to the Director of Land and Water Resources. We asked if a Ministry of Agriculture driver went regularly to Mogadishu. The observer replied that there was such a driver and he went once a week. We asked if it would not be possible for this driver to take the cards with him and give them direct to the Hydrology Section. He said it would and would try to carry this request out.

We gave the observer the following :

(1) Enough weekly cards to last for nearly a year. (with Afgoi already written on)

(2) A new monthly stage log book.

(3) A water level dipper (the last spare one we had)

Ali spotted that the writting on the cards was the same as the unmarked cards in office in Mogadishu. Indeed the cards that he handed to us had neither the river or station name marked on.

We asked the observer if he had any problems and he said that the gauge was covered with debris.

We went to the river bridge at Afgoi with the observer. He was correct in that the gauge was obscured by river debris. It was onlv possible to estimate level to within about 75mm. Furthermore it was impossible, without the aid of a boat, to clear the gauge.

We estimated the river level as 3.60 metres. As with other gauges we visited without metre numerals, it would have been impossible to know what the metre reading was if we were not aware that the maximum was 6 metres. The divisions on the gauge were rusty and unclear. Re-painting of the gauge (as in Beled Weyn) should be carried out when river conditions permit. There is no obvious way to keep the gauge clear of debris.

Ali instructed the observer in the use of the water level dipper. We were using a white painted mark on the old bridge deck as the 'MB'. This mark is on the same side as the staff and fairly close to it. The observer said this was the position of bridge dip used by gauging crews. The bridge dip was 3.78 metres. The bridge dip must be considered the more reliable measure of water level because of this problem of debris around the gauge.

Zakia told the observer that the bridge dip should be recorded both on the monthly sheets (and labelled Bundo) and also on the weekly cards.

<u>26/10/85 Audegle</u>

After some time we found the observer at Audegle. He had visited the office in Mogadishu just a few days earlier when he was given :

(1) A supply of weekly cards (without Audegle written on). (But on our visit it was made clear to him the importance of doing this.)

(2) A new monthly stage log book.

(3) A new water level dipper.

We were unable to fill the large gap in data between February and mid June from his record because his annual log book started in April. The previous one, we were told, had been returned to the Mogadishu office. From records later in the year it was clear that he was unable to read water levels above 5.00 metres. From a drawing by Rod Hawnt produced by the observer, it was explained why. There were two sets of gauges, one attached to the old bridge reading up to 6 metres and the other just upstream on the river bank reading to 5 metres. The gauges on the old bridge had been washed away we were told.

Indeed when we visited the old bridge the bridge itself was in an advanced state of collapse. It was not safe (with the river a its current level) to attempt to get on the old bridge. We read the staff gauge on the bank at about 12.30pm as 4.52 metres. Again no metre numerals. If it were not for Rod's drawing the number of metres would be uncertain. It all very well to rely on the observer remembering which gauge is which, but when the river is rising fast it is easy to make a mistake. This sort of mistake is even more difficult to detect later. It is no wonder that that the old data is full of these errors. As with the the gauges at Beled Weyn and Afgoi the old metal plates are rusty and difficult to read. A re-paint is required here also, as well as an additional one metre section of staff gauge.

Since we provided the observer with the dipper a few days before he had been making bridge dips from the old bridge. He was unhappy about this on the grounds of safety. Considering the present state of the old bridge this is not surprising. In view of this and the fact that the old bridge will not last much longer, we established a new bridge dip point on the new bridge. This is marked by an arrow shaped hacksaw cut on the edge of the bridge deck, towards the centre, and on the downstream side.

The bridge dip readings the observer is taking from now till February will help establish a correlation between the two sites, provided the staff gauge readings are taken concurrently. There is some distance between the bridge, perhaps a few hundred metres, but it is difficult to say exactly since the two bridges are not inter-visible.

Some though should be given as to whether the gauges should be moved to a site near to the new bridge, since this is where the dip measurements are now taken and were all new discharge measurements will have to be made. A visit in January or February is required to assess the situation when the river is lower. The gauges would need to be installed on the bank since the new bridge has a clear span with no supports in the river.

The bridge dip reading from the new bridge was 2.77 metres.

C S Green

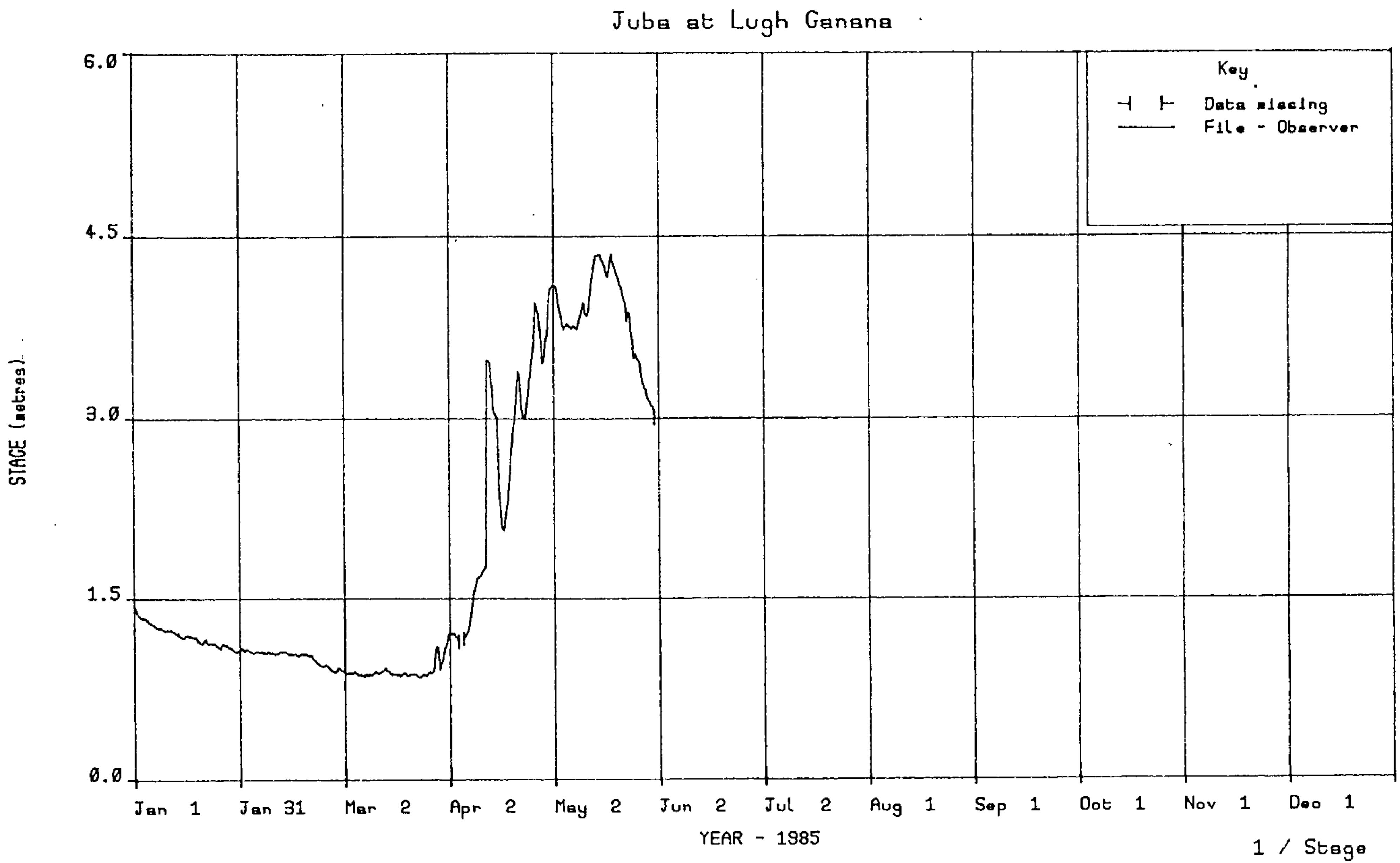
27th October 1985

APPENDIX IV.5

RETURN OF DATA 1985

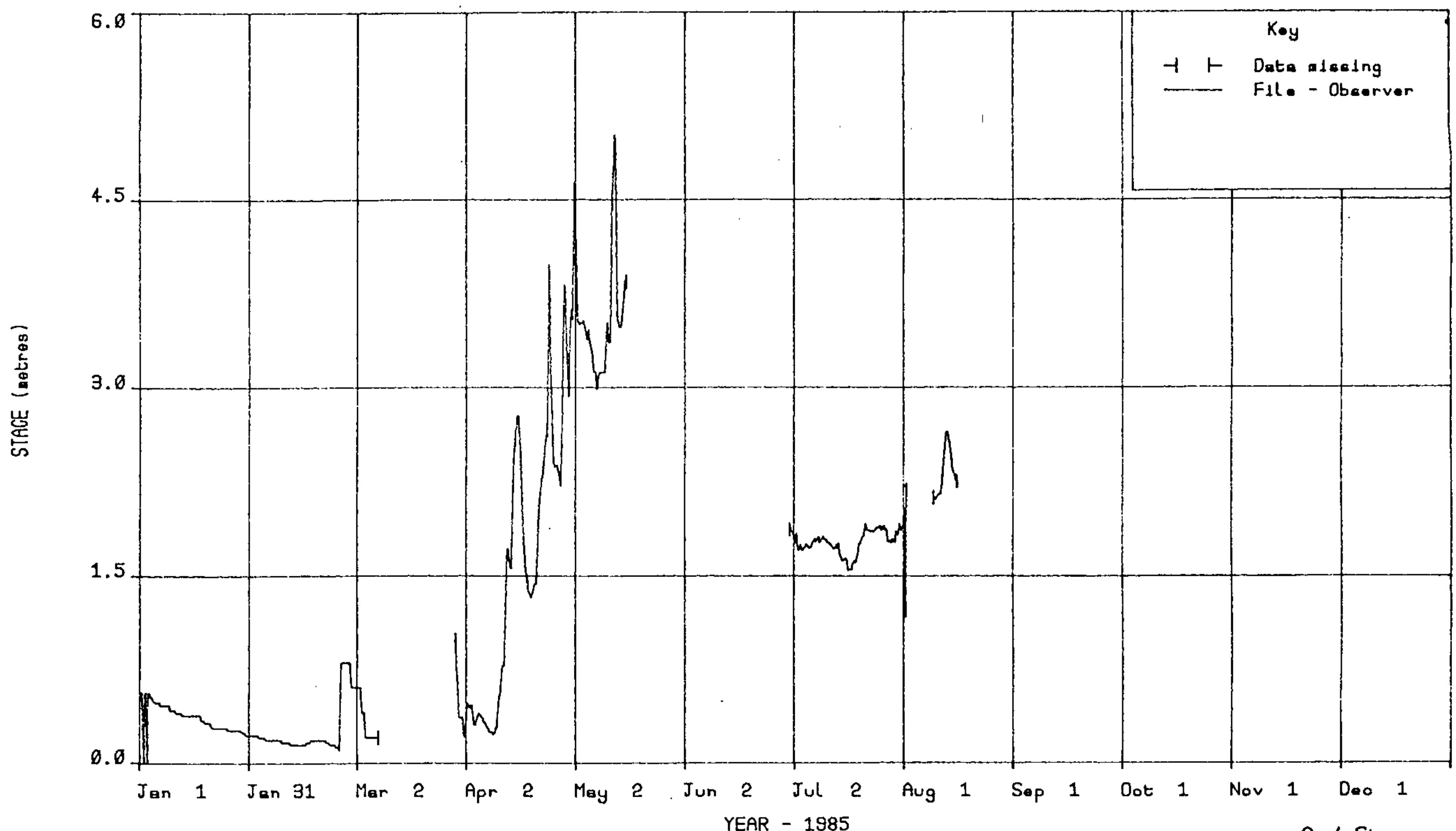
SOMALIA HYDROMETRY PROJECT - RETURN OF DATA 1985

The following plots illustrate the poor return of data from hydrometric stations as of mid October 1985. Some thought should be given as to whether the system of relying on the post is working and whether an alternative (eg a program of regular vists) would be more effective.

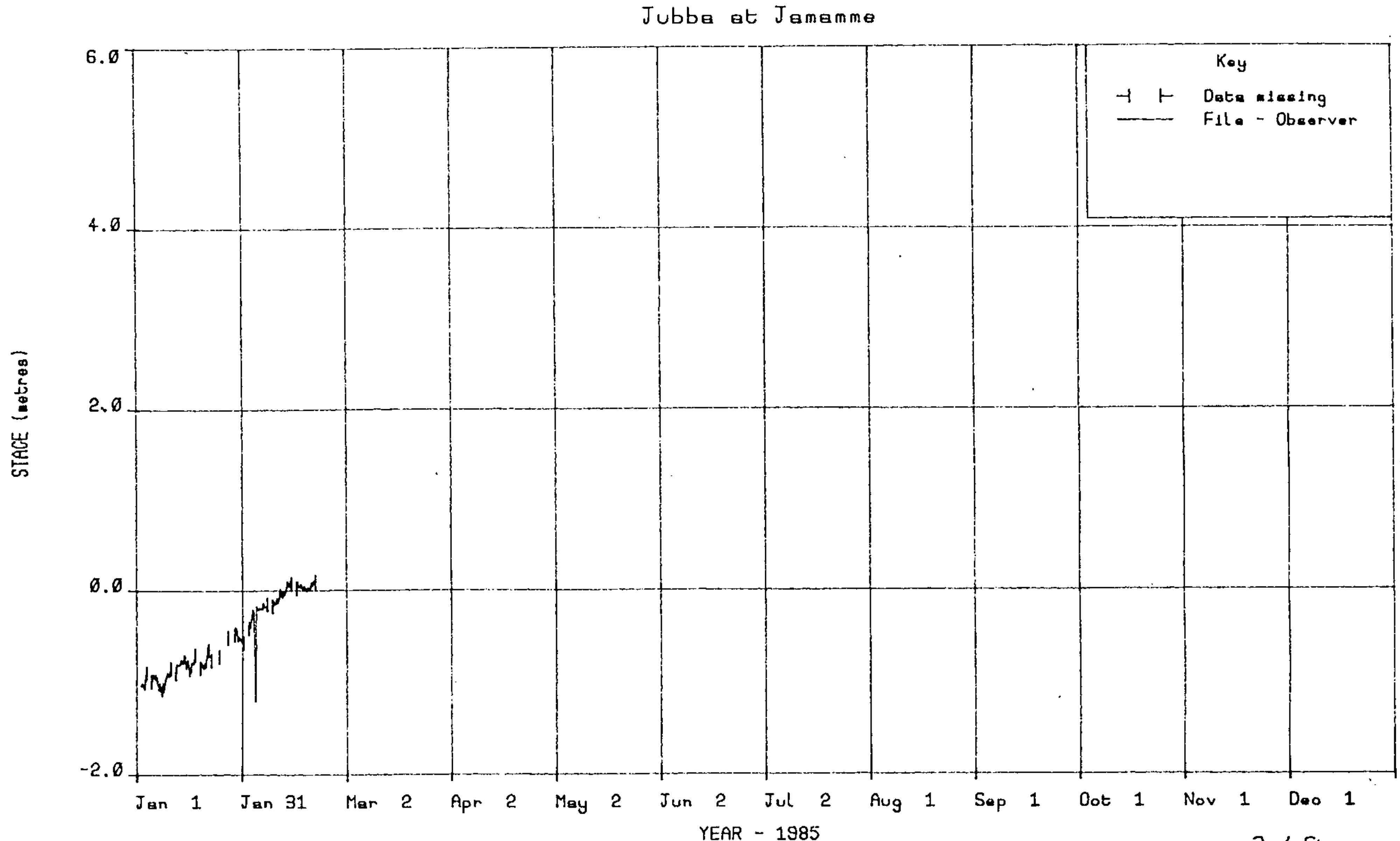


Juba at Lugh Ganana
Key
Data missing
File - Observer
STAGE (metres)
6.0
4.5
3.0
1.5
0.0
Jan 1
Jan 31
Mar 2
Apr 2
May 2
Jun 2
Jul 2
Aug 1
Sep 1
Oct 1
Nov 1
Dec 1
YEAR - 1985
1 / Stage

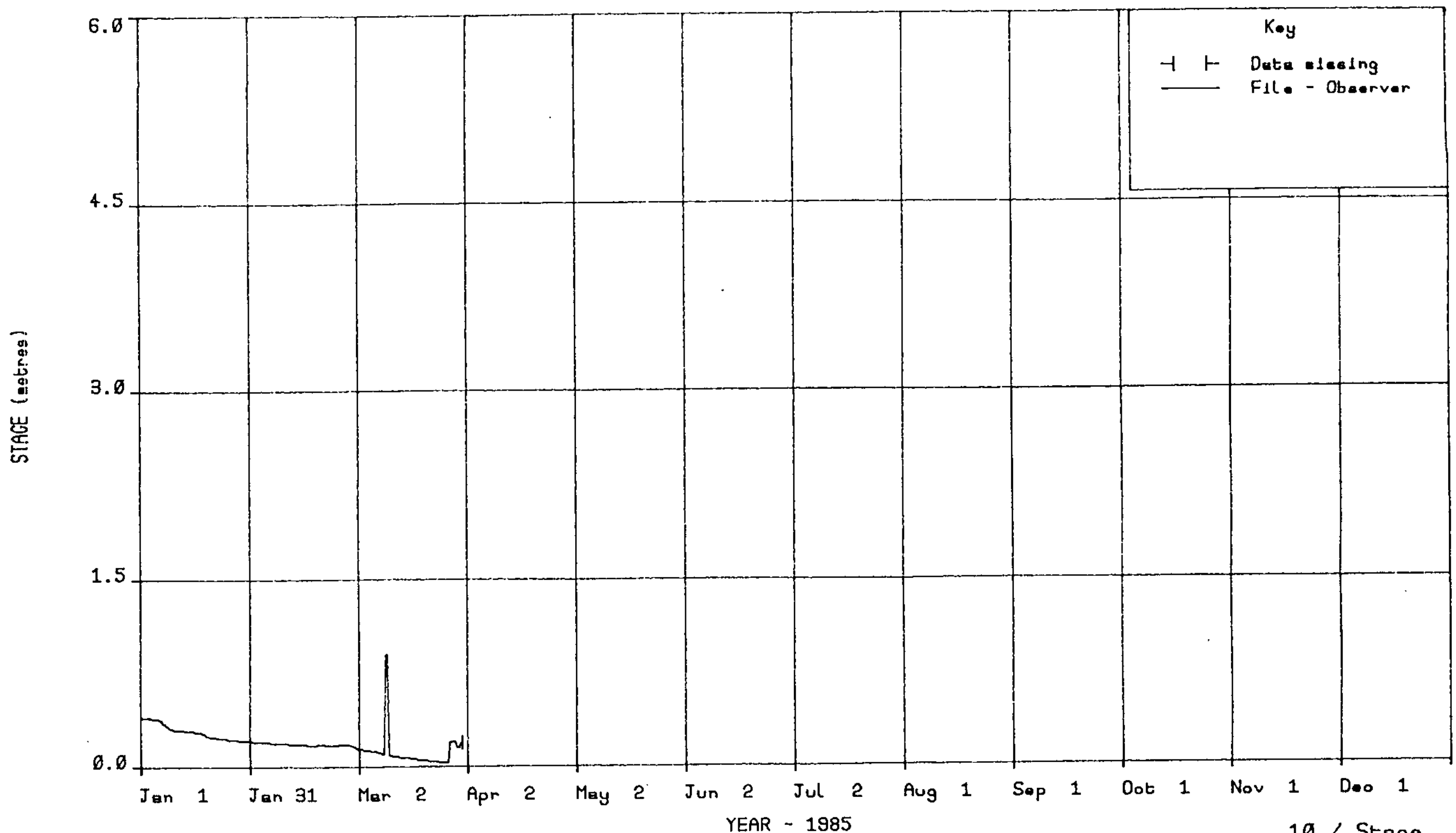
Jubba at Bardheere



2 / Stage

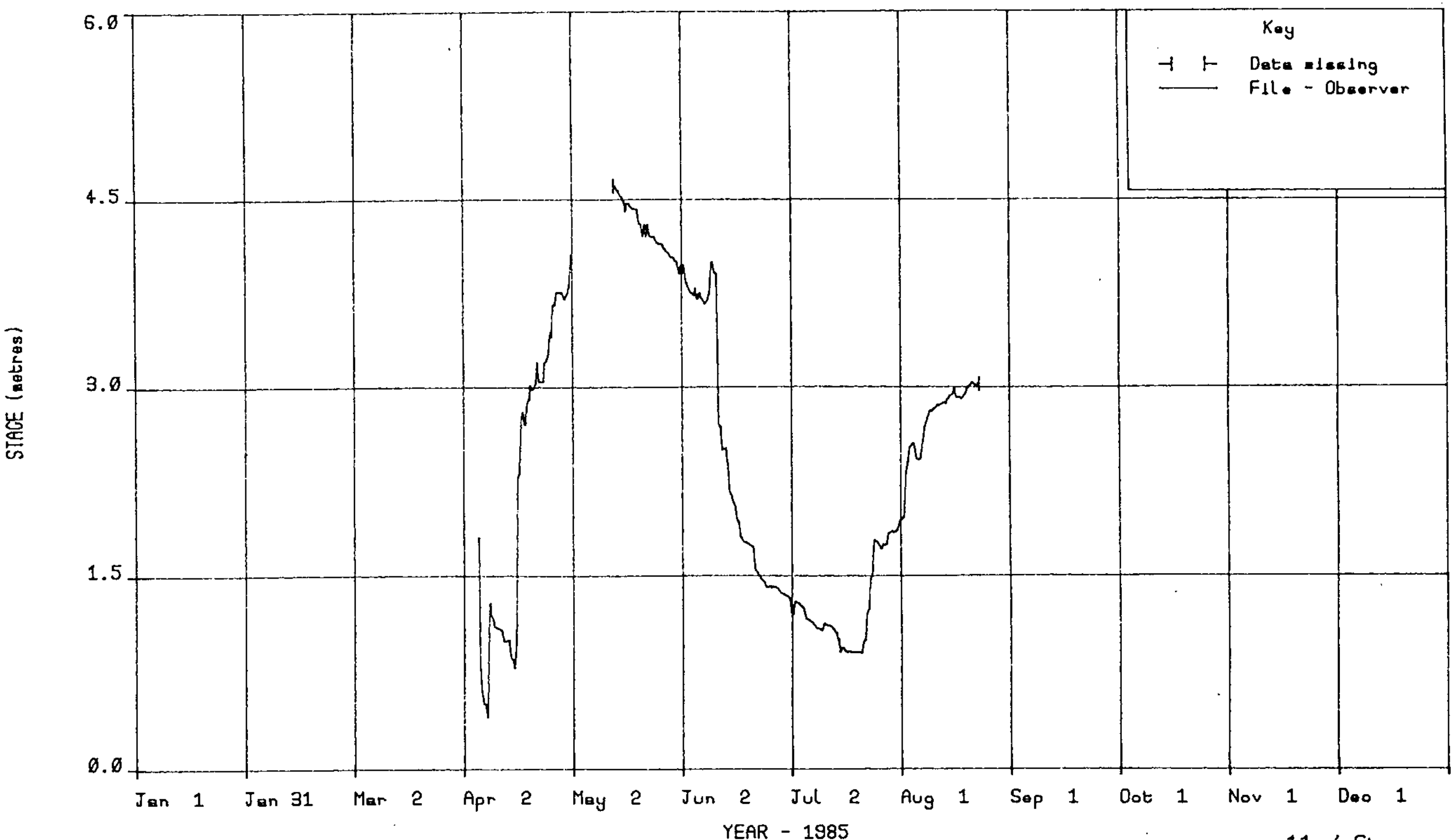

Jubba at Jamamme
Key
Data missing
File - Observer
STAGE (metres)
6.0
4.0
2.0
0.0
-2.0
Jan 1
Jan 31
Mar 2
Apr 2
May 2
Jun 2
Jul 2
Aug 1
Sep 1
Oct 1
Nov 1
Dec 1
YEAR - 1985
3 / Stage

Shebelli at Beled Weyn



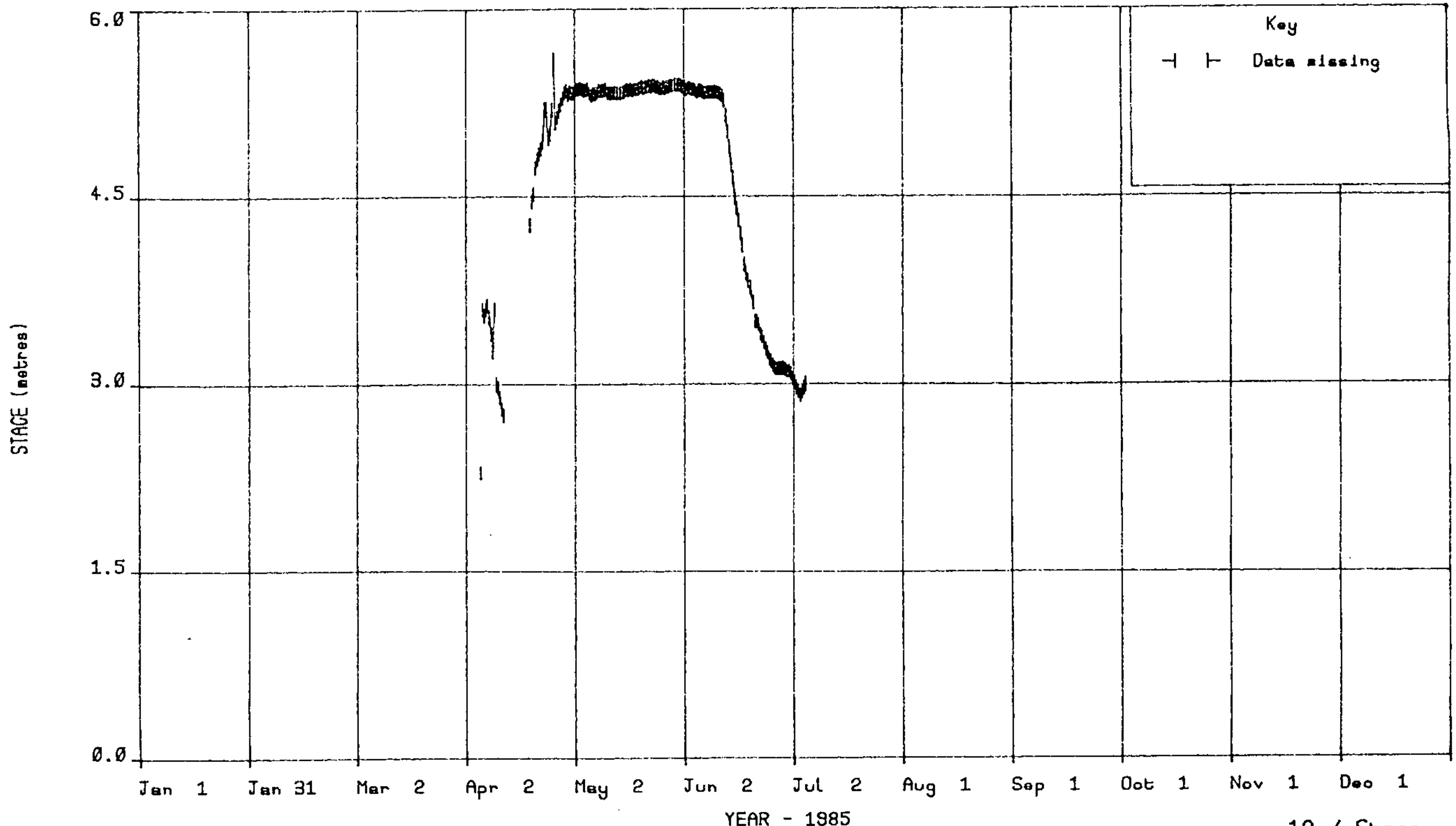
10 / Stage

Shebelli at Bulo Burti



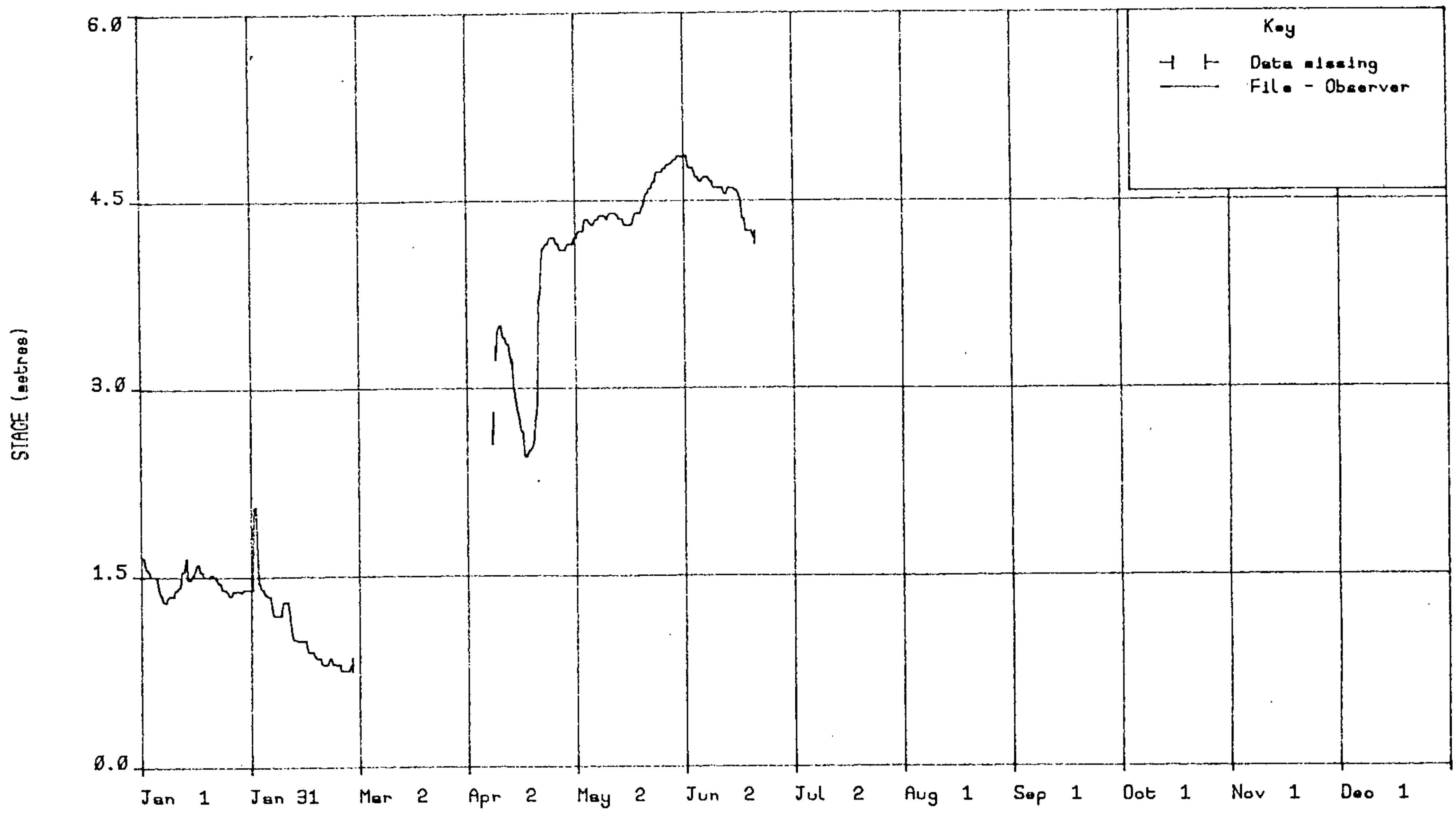
11 / Stage

Shebelli at Mahaddey Weyn



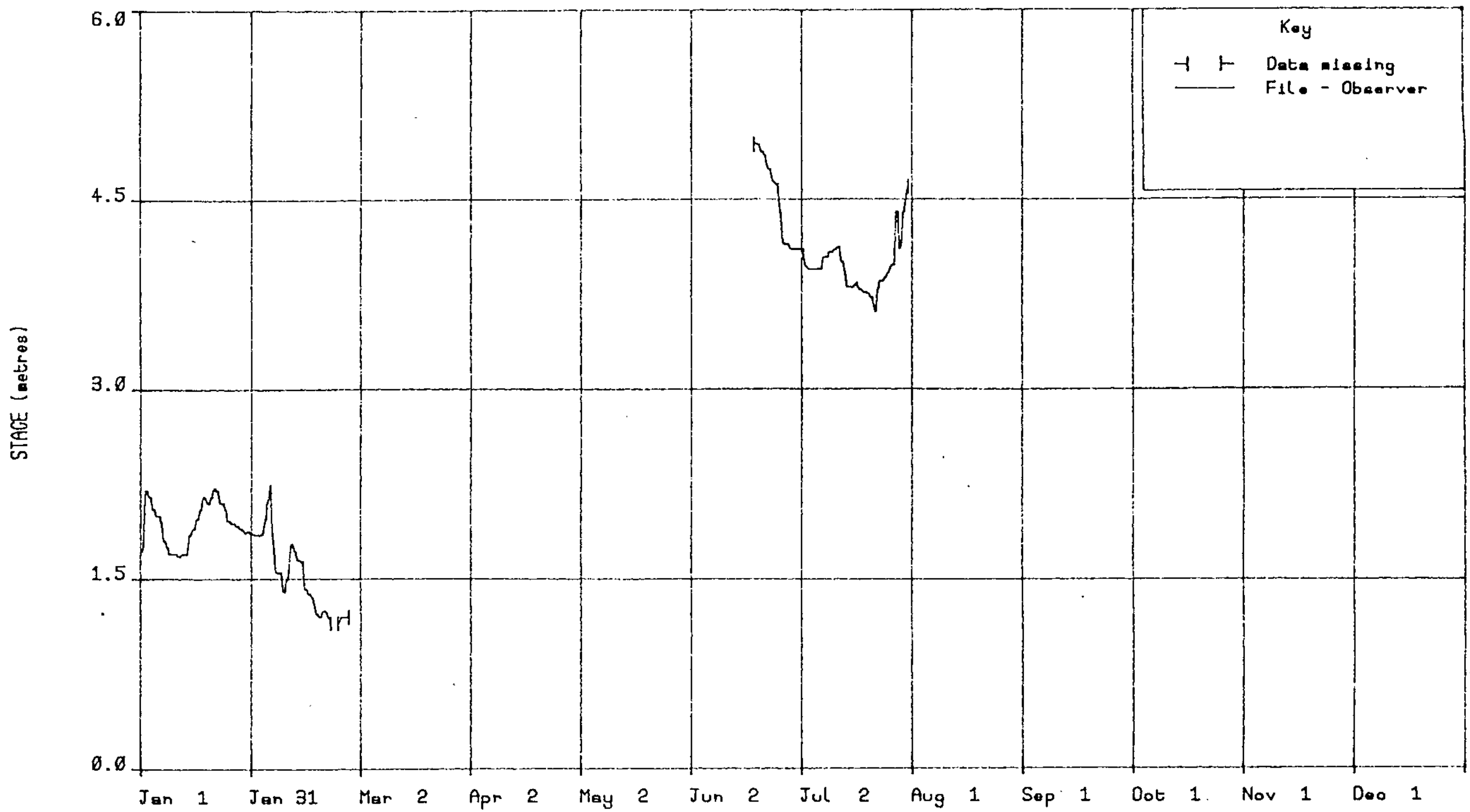
12 / Stage

Shebelli at Afgoi



14 / Stage

Shebelli at Audegle



15 / Stage

APPENDIX IV.6

BARDHEERE AND LUGH FIELD TRIP
15/11/85 and 16/11/85

Bardheere & Lugh Field Trip 15/11/85 & 16/11/85

Participants

Zakia
Anab
Ali
Driver Mohamud

15/11/86 Bardheere

We visited the Ministry of Agriculture Regional Office and spoke to the local co-ordinator. The observer was not in the office but was called by the co-ordinator and we met him there and saw his records.

We copied as much of the missing data as was available. He told us that their non arrival in Mogadishu was due to the poor postal services.

We gave the observer:

(a) Enough weekly cards for six months
(b) New monthly stage log book for 1986.

The staff gauge was read as 1.50 metres at approximately 3pm.

The problem was that the gauge was obscured by river debris which is difficult and dangerous to remove unless you have the aid of a boat.

At the same time we visited the Bardheere Dam Project's station and saw their staff gauge and flow measurement equipment.

16/11/85 Lugh-Ganane

After some time the observer turned up in the office. We did not see the Agricultural co-ordinator.

We collected the missing data from the office. We instructed the observer to write on the cards the name of the station and the river.

Staff gauge was read 1.70 metres at 2pm. There was no gauge problem at Lugh.

The observer told us that he needed envelopes to mail the weekly cards.

APPENDIX IV.7

2ND VISIT OF IH HYDROLOGIST
MARCH/APRIL 1986

HYDROMETRY PROJECT - STAGE 2

2nd visit of IH hydrologist March/April 1986

Work undertaken

On arrival the computer was found to have developed a serious error. After consultation with Wallingford, UK, the fault was diagnosed as a possible problem with the hard disc unit or one of the hard disc control boards. The hard disc system is used to store all information (programs and data) on the computer. The computer cannot operate without the hard disc system in working order.

Thankfully the fault was intermittent and none of the information on the disc appeared to be corrupted. However, the fault meant that the computer nearly always failed to start, requiring many attempts to to get going. Quite often programs failed when reading data from disc.

Much time was lost due both to this fault and trying to obtain spare parts from the UK. The parts were finally cleared from customs one day before my date of departure from Mogadishu and have just been fitted. At the moment the machine appears to be working correctly, but has not been fully tested yet.

The poor operating environment for the computer of excess heat, dust and humidity as well as unstable power supply must be partly, if not entirely, responsible for the fault. The air conditioner in the computer room is still not working because no suitable power supply has been installed.

Because of this fault and also because of the urgent need to get the field stations in operation before the Gu floods, it was considered beneficial to switch some of my time from computer to field work and make good the time on the computer during the wet season. The work undertaken, which is described below, reflects this decision :

(1) Further database programs, developed after my last visit in October and November 1985, were installed

on the Hydrology Section computer at the Ministry of Agriculture. These enhancements to the data processing system permit the processing of reservoir level data which is used for the Jowhar scheme. Programs were also installed which facilitate the development of rating curves.

(2) Hydrology section staff were trained in the use of the new programs. Rating curves were developed by the counterpart staff for the following stations :

Shebelli downstream of Sabuun
Jowhar inlet canal
Jowhar supply canal
Shebelli downstream of supply canal

In addition a curve was fitted to the reservoir storage/head relationship to enable the conversion of reservoir level to stored volume.

(3) All previously entered stage data for the five stations on the Jowhar scheme was converted to either flows or storage volume.

(4) The model of the Shebelli river which had been developed in Wallingford during February 1986 was installed on the Hydrology computer and the staff trained in the operation of the model in forecasting mode.

(5) Discussions were held with the Ministry radio operators to enable river level data to be sent to Mogadishu on a daily basis for use in the forecasting model. A book was prepared to enable radio information from Beled Weyn and the Jowhar scheme to be recorded at Mogadishu.

(6) The most important remaining item of work on the database system, the operation manual, was started using the computer's word processor. Unfortunately, because of the computer problems and field work, it is only half complete. This manual will be completed in Wallingford and then sent to Mogadishu.

(7) Eight days were spent in the field at Kamsuma in conjunction with the MMP hydrologist and counterparts on the further installation of the electronic recorder. The stilling well was extended down over four metres to the minimum value necessary. The staff gauge was similarly extended.

(8) Two days were spent in the field at Sablaale to as sist UNHCR and Euro Action Accord in the installation of staff gauges in the river and swamp. Construction of these stations has now started. It is intended that these stations will be taken over as part of the Ministry of Agriculture network in the next twelve months.

(9) One day was spent in the field to collect the 1985 Jowhar reservoir operation data from Jowhar. At the same time the requirements for transmission of data for the forecasting model were discussed. The Mahaddey Weyn station was visited in conjunction with the MMP hydrologist and counterparts. A missing gauge plate was repaired and the upper sections of staff gauges levelled in correctly.

Work remaining on the computer

(1) Entry of the 1985 Jowhar data

(2) Checking of all data using both the graphics now available and the Shebelli model in 'Infilling mode'. Rating equations should also be checked.

(3) Infilling of data on the Shebelli using the model

(4) Addition of the following stations and their data :

Kaitoi (from GTZ project)
Mareere (" " ")
Kamsuma (" " ")
Kurten Warey
Balad

(5) Production of a revised 'data book' of river flow data

C S Green

15th April 1986

APPENDIX V

HYDROLOGICAL DATABASE - SYSTEM SUMMARY AND LIST OF STATIONS AND PARAMETERS

Ministry of Agriculture - Somali Democratic Republic

System summary

Institute of Hydrology Database

Wallingford 8 Jul 1986

System Summary

FIXED PROJECT PARAMETERS

Project location	Wallingford	Project start year	1951
Serial number	4	Project end year	1990
HDB version number	3.000	Project start month	Jan
No. station types	6	Installation date	1/10/1985
Number of passwords	6		

CURRENT STATIONS

```
Overall  : Maximum [1000] Used [  48]
Stage    : Maximum [1000] Used [  16]
Rating   : Maximum [1000] Used [  16]
Flow     : Maximum [1000] Used [  15]
General  : Maximum [1000] Used [   0]
Rainfall : Maximum [1000] Used [   0]
Storage  : Maximum [1000] Used [   1]
```

List of stations & parameters

Type	Number	Name	Basin No.	Latitude	Longitude	Altitude	Area	Max value	Min value	Max change	Convert to	Rating	Store in	Source 1	Source 2
Stage	1	Jubba at Lugh Ganana	1	0: 0: 0 N	0: 0: 0 E	141.42	179000.	7.5	-1.0	3.0	Flow	1	1	Observer	Logger
Stage	2	Jubba at Bardheere	1	0: 0: 0 N	0: 0: 0 E	88.98	216730.	7.0	-1.0	2.0	Flow	2	2	Observer	Logger
Stage	3	Jubba at Jamamme	1	0: 0: 0 N	0: 0: 0 E	0.0	268800.	7.5	-2.0	1.5	Flow	3	3	Observer	
Stage	6	Jubba at Kamsuma	1	0: 0: 0 N	0: 0: 0 E	0.0	1000.0	6.0	0.0	2.0	Flow	6	6	Observer	Logger
Stage	7	Jubba at Mogambo	1	0: 0: 0 N	0: 0: 0 E	0.0	1.0	13.5	5.5	1.0	Flow	7	7	Observer	
Stage	10	Shebelli at Beled Weyn	2	0: 0: 0 N	0: 0: 0 E	176.11	211800.	7.0	-1.0	2.5	Flow	10	10	Observer	Logger
Stage	11	Shebelli at Bulo Burti	2	0: 0: 0 N	0: 0: 0 E	133.39	231000.	10.0	-1.0	2.0	Flow	11	11	Observer	
Stage	12	Shebelli at Mahaddey Weyn	2	0: 0: 0 N	0: 0: 0 E	104.57	255300.	7.0	-1.0	2.0	Flow	12	12	Observer	Radio
Stage	14	Shebelli at Afgoi	2	0: 0: 0 N	0: 0: 0 E	77.42	278000.	6.0	0.0	2.0	Flow	14	14	Observer	
Stage	15	Shebelli at Audegle	2	0: 0: 0 N	0: 0: 0 E	70.05	280000.	6.45	-2.0	2.5	Flow	15	15	Observer	
Stage	16	Shebelli at Kurten Warey	2	0: 0: 0 N	0: 0: 0 E	0.0	1.0	6.0	0.0	2.0	Flow	16	16	Observer	
Stage	101	Jowhar Reservoir Level (gauge H)	2	0: 0: 0 N	0: 0: 0 E	95.5	999.0	5.0	0.0	1.0	Storage	101	101	Observer	Radio
Stage	102	Jowhar OSR - Shebelle d/s intake	2	0: 0: 0 N	0: 0: 0 E	103.5	255400.	5.0	0.0	2.0	Flow	102	102	Observer	Radio
Stage	103	Jowhar OSR supply canal/Gauge F	2	0: 0: 0 N	0: 0: 0 E	103.5	999.0	3.0	0.0	1.0	Flow	103	103	Observer	Radio
Stage	104	Jowhar OSR outlet canal/Gauge I	2	0: 0: 0 N	0: 0: 0 E	0.0	1000.0	4.0	0.0	0.5	Flow	104	104	Observer	Radio
Stage	105	Jowhar OSR - Shebelli d/s outlet	2	0: 0: 0 N	0: 0: 0 E	0.0	264000.	6.0	0.0	2.0	Flow	105	105	Observer	Radio
Rating	1	Jubba at Lugh Ganana	1	0: 0: 0 N	0: 0: 0 E	141.42		7.5	0.0						
Rating	2	Jubba at Bardheere	1	0: 0: 0 N	0: 0: 0 E	88.98		7.0	-1.0						
Rating	3	Jubba at Jamamme	1	0: 0: 0 N	0: 0: 0 E	0.0		7.5	0.0						
Rating	6	Jubba at Kamsuma	1	0: 0: 0 N	0: 0: 0 E	0.0		6.0	0.0						
Rating	7	Jubba at Mogambo	1	0: 0: 0 N	0: 0: 0 E	0.0		13.5	5.5						
Rating	10	Shebelli at Beled Weyn	2	0: 0: 0 N	0: 0: 0 E	176.11		7.0	-1.0						
Rating	11	Shebelli at Bulo Burti	2	0: 0: 0 N	0: 0: 0 E	133.39		10.0	0.0						
Rating	12	Shebelli at Mahaddey Weyn	2	0: 0: 0 N	0: 0: 0 E	104.57		7.0	0.0						
Rating	14	Shebelli at Afgoi	2	0: 0: 0 N	0: 0: 0 E	77.42		7.0	-1.0						
Rating	15	Shebelli at Audegle	2	0: 0: 0 N	0: 0: 0 E	70.05		6.5	0.0						
Rating	16	Shebelli at Kurten Warey	2	0: 0: 0 N	0: 0: 0 E	0.0		6.0	0.0						
Rating	101	Jowhar Res. (head/storage curve)	2	0: 0: 0 N	0: 0: 0 E	95.5		5.0	0.0						
Rating	102	Jowhar OSR - Shebelle d/s intake	2	0: 0: 0 N	0: 0: 0 E	103.5		5.0	0.0						
Rating	103	Jowhar OSR supply canal/Gauge F	2	0: 0: 0 N	0: 0: 0 E	103.5		3.0	0.0						

List of stations & parameters

Type	Number	Name	Basin No.	Latitude	Longitude	Altitude	Area	Max value	Min value	Max change	Convert to	Rating	Store in	Source 1	Source 2
Rating	104	Jowhar OSR outlet canal/Gauge I	2	0: 0: 0 N	0: 0: 0 E	0.0		2.0	0.0						
Rating	105	Jowhar OSR - Shebelli d/s outlet	2	0: 0: 0 N	0: 0: 0 E	0.0		6.0	0.0						
Flow	1	Jubba at Lugh Ganana	1	0: 0: 0 N	0: 0: 0 E	141.42	179000.	2000.0	0.0	250.0				Original	Estimate
Flow	2	Jubba at Bardheere	1	0: 0: 0 N	0: 0: 0 E	88.98	216730.	2000.0	0.0	250.0				Original	Estimate
Flow	3	Jubba at Jamamme	1	0: 0: 0 N	0: 0: 0 E	0.0	268800.	1000.0	0.0	200.0				Original	Estimate
Flow	6	Jubba at Kamsuma	1	0: 0: 0 N	0: 0: 0 E	0.0	1000.0	1000.0	0.0	150.0				Original	Estimate
Flow	7	Jubba at Mogambo	0	0: 0: 0 N	0: 0: 0 E	0.0	1.0	100.0	0.0	100.0				Original	Estimate
Flow	10	Shebelli at Beled Weyn	2	0: 0: 0 N	0: 0: 0 E	176.11	211800.	800.0	0.0	200.0				Original	Estimate
Flow	11	Shebelli at Bulo Burti	2	0: 0: 0 N	0: 0: 0 E	133.39	231000.	1000.0	0.0	200.0				Original	Estimate
Flow	12	Shebelli at Mahaddey Weyn	2	0: 0: 0 N	0: 0: 0 E	104.57	255300.	500.0	0.0	100.0				Original	Estimate
Flow	14	Shebelli at Afgoi	2	0: 0: 0 N	0: 0: 0 E	0.0	278000.	150.0	0.0	100.0				Original	Estimate
Flow	15	Shebelli at Audegle	2	0: 0: 0 N	0: 0: 0 E	70.05	280000.	200.0	0.0	100.0				Original	Estimate
Flow	16	Shebelli at Kurten Warey	2	0: 0: 0 N	0: 0: 0 E	0.0	1.0	100.0	0.0	100.0				Original	Estimate
Flow	102	Jowhar OSR - Shebelle d/s intake	2	0: 0: 0 N	0: 0: 0 E	103.5	255400.	400.0	0.0	100.0				Original	Estimate
Flow	103	Jowhar OSR supply canal/Gauge F	2	0: 0: 0 N	0: 0: 0 E	103.5	999.0	50.0	0.0	10.0				Original	Estimate
Flow	104	Jowhar OSR outlet canal/Gauge I	2	0: 0: 0 N	0: 0: 0 E	0.0	999.0	50.0	0.0	10.0				Original	Estimate
Flow	105	Jowhar OSR - Shebelle d/s outlet	2	0: 0: 0 N	0: 0: 0 E	0.0	264000.	600.0	0.0	150.0				Original	Estimate
Storage	101	Jowhar Reservoir Storage	2	0: 0: 0 N	0: 0: 0 E	95.5		250.0	0.0	20.0				Original	Estimate

```
-----------------------------------------------------------------------------------------

                    File allocation & usage for Stage     stations

-----------------------------------------------------------------------------------------


                                           Y E A R

           1900-09    1910-19    1920-29    1930-39    1940-49    1950-59    1960-69    1970-79    1980-89    1990 - 2000
           0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0
Station

      1    ---------- ---------- ---------- ---------- ---------- -ddddddddd dddddddddd dddddddddd dddddddxxx x--------- -
      2    ---------- ---------- ---------- ---------- ---------- -......... ...dddddxd dddddxddxx ddxxdddxxx x--------- -
      3    ---------- ---------- ---------- ---------- ---------- -......... ...ddddxxx dxdddddddd ddxddd.... .--------- -
      6    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... .....ddxxx x--------- -
      7    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ...ddddxxx x--------- -
     10    ---------- ---------- ---------- ---------- ---------- -ddxdddddd dddddddddd dddddddddd dddddddxxx x--------- -
     11    ---------- ---------- ---------- ---------- ---------- -......... ...ddddddd dddddxdddd dddddddxxx x--------- -
     12    ---------- ---------- ---------- ---------- ---------- -......... ...ddddddd ddxxdddddd dddddddxxx x--------- -
     14    ---------- ---------- ---------- ---------- ---------- -......... ...ddddddd dddddddddd dddddddxxx x--------- -
     15    ---------- ---------- ---------- ---------- ---------- -......... ...ddddddx xdxxxxdddd dddddddxxx x--------- -

     16    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ......dxxx x--------- -
    101    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ddddddxxxx x--------- -
    102    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... dddddddxxx x--------- -
    103    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... xdddddxxxx x--------- -
    104    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ddddddxxxx x--------- -
    105    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ddddddxxxx x--------- -


Key :
        - = outside project period
        . = inside  project period
        x = space allocated - no data
        d = space allocated - data on
```

File allocation & usage for Flow stations

```
                                        Y E A R

          1900-09    1910-19    1920-29    1930-39    1940-49    1950-59    1960-69    1970-79    1980-89    1990 - 2000
          0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0
Station

     1    ---------- ---------- ---------- ---------- ---------- -ddddddddd dddddddddd dddddddddd ddddddxxxx x--------- -
     2    ---------- ---------- ---------- ---------- ---------- -......... ...dddddxd dddddxddxx ddxxddxxxx x--------- -
     3    ---------- ---------- ---------- ---------- ---------- -......... ...ddddxxx dxdddddddd ddxddd.... .--------- -
     6    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... .....xxxxx x--------- -
     7    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ...xxxxxxx x--------- -
    10    ---------- ---------- ---------- ---------- ---------- -ddxdddddd dddddddddd dddddddddd dddddddxxx x--------- -
    11    ---------- ---------- ---------- ---------- ---------- -......... ...ddddddd dddddxdddd ddddddxxxx x--------- -
    12    ---------- ---------- ---------- ---------- ---------- -......... ...ddddddd ddxxdddddd dddddddxxx x--------- -
    14    ---------- ---------- ---------- ---------- ---------- -......... ...ddddddd dddddddddd dddddddxxx x--------- -
    15    ---------- ---------- ---------- ---------- ---------- -......... ...ddddddx xdxxxxdddd dddddddxxx x--------- -

    16    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ......xxxx x--------- -
   102    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ddddddxxxx x--------- -
   103    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... xdddddxxxx x--------- -
   104    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ddddddxxxx x--------- -
   105    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ddddddxxxx x--------- -
```

Key :

- `-` = outside project period
- `.` = inside project period
- `x` = space allocated - no data
- `d` = space allocated - data on

File allocation & usage for Rating stations

Station number	Number of gaugings	Number of ratings
1	113	1
2	76	1
3	52	1
6	0	0
7	0	0
10	83	1
11	63	2
12	57	2
14	48	1
15	39	2
16	0	0
101	14	1
102	30	1
103	21	1
104	5	1
105	8	1

```
File allocation & usage for Storage  stations

                         Y E A R

        1900-09    1910-19    1920-29    1930-39    1940-49    1950-59    1960-69    1970-79    1980-89   1990 - 2000
        0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0123456789 0
Station

 101    ---------- ---------- ---------- ---------- ---------- -......... .......... .......... ddddddxxxx x--------- -


Key :
        - = outside project period
        . = inside  project period
        x = space allocated - no data
        d = space allocated - data on
```