OVERSEAS DEVELOPMENT ADMINISTRATION
MINISTRY OF AGRICULTURE, GOVERNMENT OF SOMALIA

# HYDROMETRY PROJECT - SOMALIA

Third Progress Report
Phase 3
March - September 1989



**Sir M. MacDonald & Partners Limited**
Demeter House, Station Road, Cambridge CB1 2RS
United Kingdom

in association with

**Institute of Hydrology**
Wallingford, Oxon OX10 8BB

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## SUMMARY


This report describes work on the Somalia Hydrometry Project between March and September 1989. Field and office work continued satisfactorily during the first half of this period, but thereafter fieldwork was very severely restricted by the general situation prevailing in Somalia.

Daily water level data has been received regularly from most of the gauging stations; this has been processed manually and also entered onto the database. A bulletin about the river flows has been produced every ten days and published in cooperation with the Food Early Warning Project. Data from the automatic water level recorders at Bardheere and Lugh Ganana was collected up until July and the recorders have been operating successfully. The recorder at Beled Weyn has been restarted but since then it has not been possible to visit the site to collect the data. Similarly, no data has been received from the newly appointed observer at Jamamme.

During the period a total of 23 discharge measurements have been taken - at eleven different stations on the two rivers and in the canals at Sabuun and Mogambo. Most of these have shown reasonable agreement with the existing rating curves. Damaged or missing staff gauges were replaced at Bulo Burti and in the Jowhar supply canal at Sabuun.

The flow routing model of the Shebelli was completed and was used extensively in checking the historic data already entered to the computer against the original records.

Numerous requests for data have been received by the Hydrology Section and appropriate advice and information has been given to various local and international organisations. Close cooperation has been maintained with the National Water Centre and the FEWS project. The latter link will be expanded when rainfall estimates become available from the FEWS satellite project; this should improve river flow forecasts.

Throughout the period specific items of work have been treated as training exercises for the counterpart staff. Two unsupervised field trips were carried out. The staff have generally made good progress in both office and fieldwork, though the recent shortage of opportunities for fieldwork is regretted. It is hoped that one of the staff members will be attending a UNESCO course for Hydrology Technicians in Zimbabwe early in 1990, and that another will undertake a period of training at a UK university in 1990/91.

The work to be carried out in the next six months will be influenced by the prevailing situation; for the time being work in the office will predominate (including the analysis of water samples to estimate sediment load), but when it is once again possible to undertake field trips to the more distant stations the emphasis will obviously shift somewhat in order to catch up on the backlog of fieldwork. A computer model of the Jubba will be developed and will be used for further checking the historic data; this and the Shebelli model will then be used to infill missing data.

It is hoped that the project will continue through most of 1990, but if this continuation beyond the original period is not possible then the work will be brought to a conclusion at about the end of March with the publication of the Final Report and the revised Data Book.

## CONTENTS

# 1 INTRODUCTION

This Progress Report describes work on the Somalia Hydrometry Project during the period from March to September 1989. In order that it can be read without the need for immediate reference to the previous reports, much of the Introduction and some other general sections and points from the previous Progress Reports have been repeated here. The report comprises a brief summary of progress during the period together with appendices covering fieldwork and computer modelling in greater detail. This is the fourth report produced during Phase 3 of the project and follows the Inception Report and the first two Progress Reports. This is currently scheduled to be the last report prior to the Final Report which will be produced at the conclusion of Phase 3. The Final Report will be accompanied by the publication of a revised Data Book so that the most up-to-date estimates of historic river flows will be available to assist in the future development of water use in Somalia. It is noted in Section 4 that the Project may be extended further into 1990: if that should be so it is expected that a further Progress Report will be produced in April 1990.

The project aims to assist the Government of Somalia in the day-to-day management of the Jubba and Shebelli rivers, and to improve the reliability of the hydrometric database for both current and historic data. The locations of the gauging stations are shown in Figure 1. The work is the responsibility of the Hydrology Section of the Directorate of Irrigation and Land Use in the Ministry of Agriculture (MOA). The scheduled two year duration of Phase 3 follows work by the Consultants over a period of about two and a half years between 1983 and 1986.

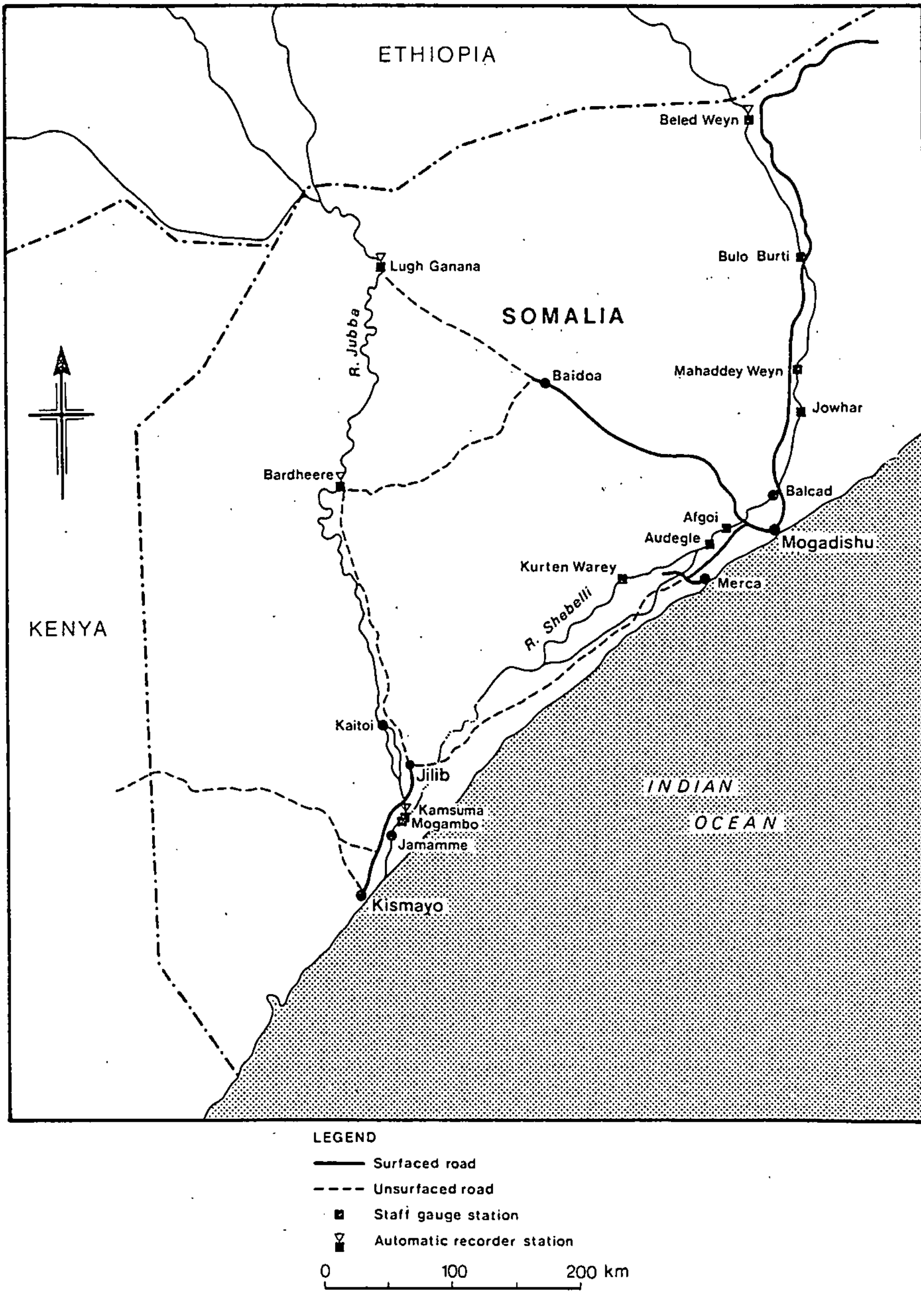
Appendix A summarizes the computer modelling work carried out by Dr K J Sene, the Programmer/hydrologist, during his visit to Somalia. This will be written up in full at the time of the Final Report. Appendix B contains the reports on fieldwork.

# 2 STAFFING

## 2.1 Expatriate Staff

Five expatriate staff members (three from Mott MacDonald Consultants - previously Sir M MacDonald and Partners - and two from the Institute of Hydrology) were scheduled to work on the project in Somalia; four of them have made inputs during this period. One staff member, the Programmer/hydrologist, has also worked on the project in the UK during this period, and there has been intermittent Head Office backup when required.

Figure 1
# Location Map



## 2.2 Staff Movements

The Field Hydrologist (Mr P F Ede, MM) was resident throughout the period except for a period of home leave; he left Somalia on June 11th and arrived back on July 26th following a brief period working in the Consultant's Head Office. The Programmer/hydrologist (Dr K J Sene, IH) worked in Somalia from March 12th until May 17th. One week of this time was spent working for the National Water Centre under a separate agreement; the remaining time was devoted to the Hydrometry Project. Mr T E Evans (Consultant Hydrologist, MM) visited the Project from May 5th to 12th and also had discussions with BDDEA in Nairobi. Mr P H W Bray, Project Coordinator (MM), visited Somalia in April and worked briefly on the project.

Dr Sene's visit was primarily for computer modelling work which is described in Appendix A; however, he also participated in most fieldwork and in particular provided essential assistance at Lugh when the counterpart staff were unable to travel. Mr Evans's visit was of a supervisory nature and was used for extensive discussions about the progress of the project and the priorities for the remaining time. His programme included field visits to a number of sites on both the Jubba and Shebelli rivers (see field trip reports in Appendix B).

## 2.3 Local Staff

The main members of the local staff have been as follows:

| | |
|---|---|
| Ali Yusuf Wayrax | |
| Ibrahim Abdullahi Sheikh Ahmed | |
| Marian Sharif Ahmed | (on a course in USA from late June) |
| Ahmed Nur Garash | (driver) |

The driver has been employed by the Project; the remaining staff are employed by the Ministry of Agriculture to work in the Hydrology Section. The work of the Section comes under the overall direction of the Director of Irrigation and Land Use; until the end of August this position was filled by Mohamoud Mohamed Ali, but following a rearrangement of responsibilities within the MOA this work was taken over by Omar Haji Dualeh.

In connection with the project one Technical Cooperation (TC) award is available from British Council funds to enable one of the local staff to receive postgraduate training at a UK university. The Director, supported by the resident hydrologist, recommended that Ibrahim should be considered for this scholarship. Unfortunately this did not prove to be possible for the 1989/90 academic year, partly because of difficulty in raising Ibrahim's English ability to the required level. There are, however, still two possibilities for overseas training. It is hoped that at least one member of the Section will be able to attend a three month course for Hydrology Technicians which is being run under the auspices of UNESCO in Zimbabwe early in 1990. In addition a British Council scholarship will be available for 1990/91 (ie after the conclusion of the Project), subject to a suitable candidate being available. Experience gained through either of these opportunities should assist the work of the Hydrology Section, particularly after the end of the project.

### 2.4 Supervision

The British Development Division in East Africa (BDDEA) has maintained a close interest in the progress of the project. Mr B Jackson, Engineering Advisor, visited Somalia in March to discuss the progress of this and other projects. In addition, both the Hydrologist and the Consultant Hydrologist visited BDDEA on the way to or from the UK. The British Embassy in Mogadishu has continued to provide support and communication with BDDEA in Nairobi.

## 3 WORK UNDERTAKEN

### 3.1 General

The regular office work of the Hydrology Section continued throughout the period; a full programme of fieldwork was undertaken until June, but thereafter it was not possible to make visits to the more distant stations because of the uncertain situation prevailing in Somalia from mid-July. When the Hydrologist returned from leave, the Director of Irrigation and Land Use advised against travelling to the Jubba valley because the safety of staff and particularly the Land Rover could not be guaranteed. It soon became clear that travel to the upper part of the Shebelli would also be inadvisable. During this time the British Embassy advised that trips outside Mogadishu should only be undertaken if safe accommodation could be guaranteed and if senior Somali staff were also able to travel.

The break in fieldwork has obviously not helped the progress of the project. However, provided that the situation improves in the coming months this should not prove to be too serious in the long term. The enforced extra time in the office in Mogadishu has enabled the Hydrologist to make major progress in the important job of checking the historic data records.

## 3.2 Fieldwork

### 3.2.1 Introduction

The primary work of the Field Hydrologist has consisted of a regular programme of field visits to the gauging stations operated by the Hydrology Section on the Jubba and Shebelli rivers. This work is planned to achieve the following main points:

(a) Early identification of any problems with staff gauges, observers etc;
(b) Regular collection of data from the observers and where appropriate from the automatic recorders;
(c) Discharge measurements in order to identify any change in the established stage/discharge rating;
(d) Water quality monitoring;
(e) Training in fieldwork for Hydrology Section staff.

The Terms of Reference for the project envisaged a programme of fieldwork such that all stations would be visited once a month. In practice the target has been for slightly less frequent visits in order not to impede the programme of office work. During this period other factors have also restricted the programme - in the month of Ramadan (April/May) the local staff were unable to travel (except for the driver who provided invaluable assistance on a field trip to measure the Gu flood at Lugh), and later work was limited by the general situation in Somalia which has already been referred to. However, in the periods both before and after Ramadan all stations were visited and much valuable work was carried out. This included the replacement of staff gauges at Bulo Burti and in the supply canal for the Jowhar Offstream Reservoir; this work was completed just before the Gu flood so that the new gauges were very soon in use by the observers.

Availability of reliable transport is critical to the success of the Section's work because most of the gauging stations are very remote from Mogadishu and the journeys include sections of very rough road. The Land Rover provided by ODA under Phase 3 has performed well to date, with no major mechanical breakdowns; some trouble was encountered with a string of punctures and then the complete failure of two tyres, but following the purchase of new tyres the vehicle has run well, covering about 17000 km during the period. For some time there was a severe fuel shortage in Somalia, but stocks built up previously were sufficient to allow work to proceed without problems.

Two field trips (one minor and one major) were undertaken by the counterpart staff on their own during the Hydrologist's absence on leave. Such trips are important because they provide a good opportunity for the staff to demonstrate their understanding of hydrological procedures learnt on previous trips. These trips were not wholly successful, but this was partly due to circumstances quite outside the control of the staff.

### 3.2.2 Data Collection

The return of observer data to Mogadishu has generally been good, although somewhat sporadic from July onwards in the absence of regular field visits. A number of the observers have brought data to the office on visits to Mogadishu, but unfortunately no recent data has been received from the stations in the lower Jubba area. Infrequent receipt of data makes the task of quality control more difficult and if there has been a problem such as a faulty bridge dipper there may be a gap in the data. For flood warning purposes adequate data is being received from the upstream stations at Lugh Ganana and Beled Weyn, but more frequent returns of data from other stations would be helpful in case of errors in observation or data transmission.

The automatic water level recorders at Lugh and Bardheere on the Jubba have operated well, with complete data being collected up to early July. They should continue to operate unattended for up to nine months so the current break in fieldwork should not affect this data. The recorder at Beled Weyn was reactivated in late May; however, because it can only record for medium and high flows the staff gauge record will continue to be essential.

In order to further improve the availability of data for the lower Jubba it was decided to restart measurements at Jamamme which was a primary station from 1963 until 1985; an observer was appointed and he was provided with a bridge dipper. Unfortunately, the restrictions on fieldwork mean that so far no data has actually been received. The station was discontinued in 1985 because of the difficulty of obtaining regular and reliable data. It has always been found to be difficult to fix staff gauges in the channel at this point and to find a good observer living close enough to make regular readings (see Stage 2 Report). Bridge dip data from the new observer will be examined to see whether a worthwhile improvement has been achieved, and the possibility of reinstalling gauges will be considered in the next low flow season.

### 3.2.3 Discharge Measurements

The regular measurement of river discharge at each station is important in order to check the validity of the existing rating curve, and if necessary to derive a new equation. During this period a total of 23 measurements have been made; these are listed in Table 1. Most measurements have been reasonably close to the rating curves. Existing rating equations have been examined, and in some cases revised - this will be reported in detail in the Final Report.

## TABLE 1

### Discharge Measurements Carried Out During the Period

| Date | Station | Gauge height[a] (m) | Velocity (m/s) | Area ($m^2$) | Discharges Measured ($m^3/s$) | Discharges Equation ($m^3/s$) | % error |
|---|---|---|---|---|---|---|---|
| 1/3/89 | Kamsuma[b] | 0.65 | 0.03 | 71.5 | 1.95 | - | |
| 8/3/89 | Bardheere | 0.22 | 0.26 | 37.6 | 9.7 | 17.9 | -45 |
| 9/3/89 | Lugh | 1.11 | 0.25 | 28.5 | 7.2 | 13.6 | -47 |
| 15/3/89 | K Waarey | 0.50 | 0.31 | 4.1 | 1.27 | - | |
| 22/3/89 | Mogambo | 6.59 | 0.32 | 6.1 | 1.94 | - | |
| 26/3/89 | Audegle | 2.53 | 0.40 | 23.8 | 9.5 | 18.5 | -49 |
| 3/4/89 | Bulo Burti | 2.86 | 0.90 | 78.7 | 70.8 | 66.1 | +7 |
| 1/5/89 | Lugh | 4.72 | 1.04 | 753.7 | 782.1 | 825.2 | -5 |
| 2/5/89 | Lugh | 4.995 | 1.10 | 795.6 | 874.6 | 932.7 | -6 |
| 9/5/89 | Afgoi | 5.31 | 0.59 | 150.2 | 89.1 | 101.2 | -12 |
| 11/5/89 | Kamsuma | 6.30 | 1.03 | 498.4 | 513.1 | 507.6 | +1 |
| 11/5/89 | Mog canal | - | 0.48 | 76.2 | 36.6 | - | |
| 11/5/89 | Jamamme | 6.765 | 1.00 | 418.1 | 418.7 | 467.9 | -11 |
| 28/5/89 | Afgoi | 5.475 | 0.62 | 150.3 | 93.7 | 105.6 | -11 |
| 30/5/89 | Mahaddey | 5.345 | 0.85 | 160.6 | 137.0 | 167.3 | -18 |
| 30/5/89 | Bulo Burti | 4.21 | 1.25 | 127.2 | 158.5 | 135.2 | +17 |
| 31/5/89 | Beled Weyn | 2.12 | 1.24 | 99.2 | 123.4 | 118.9 | +4 |
| 1/6/89 | Sabuun canal | 1.03 | 0.62 | 22.9 | 14.3 | 25.3 | -43 |
| 7/6/89 | Kamsuma | 3.21 | 0.71 | 247.2 | 176.4 | 159.5 | +11 |
| 7/6/89 | Kamsuma | 3.19 | 0.61 | 228.1 | 152.5 | 157.7 | -3 |
| 18/6/89[c] | Afgoi | 3.025 | 0.55 | 64.1 | 35.5 | 43.0 | -17 |
| 7/7/89[c] | Lugh | 2.15 | | Equipment Faulty | | | |
| 26/9/89 | Mahaddey | 3.915 | 0.65 | 113.9 | 73.8 | 87.8 | -16 |

Notes: [a] Mean gauge height during measurement period.

[b] This measurement was used to derive the rating curve for Kamsuma so it is inappropriate to compare the measured discharge to that from the equation.

[c] Discharge measurement carried out by counterpart staff without supervision.

### 3.2.4 Water Quality Measurement

A number of water samples have been taken at stations on both rivers. There are still no adequate facilities available for regular analysis; in the absence of space to set up a laboratory it has been decided that part of the office will have to be used. This is an extremely unsatisfactory situation because of the very limited space and because there is no water supply, sink etc, but it is hoped that some results will be better than nothing. Results will obviously be more approximate than would be the case if proper laboratory facilities were available.

### 3.2.5 Field Trip Reports

Reports have been written on all fieldwork undertaken on a monthly basis. These have provided an ongoing record of work carried out and have also enabled the section to keep the Director of Irrigation and Land Use fully informed of progress. These reports, which expand on the points outlined above, are reproduced in Appendix B.

## 3.3 Office Work

Office work has been centred on the computer, primarily the use of the HYDATA package for the entry and checking of data. Training has also been given in the use of Lotus spreadsheets, primarily for the calculation of discharges from current meter measurements and for producing the river flow bulletins.

All the data entered to the computer throughout the Project has been carefully checked against original record cards/sheets (where available), and critically examined. During Phase 1 a number of periods of data were rejected because of obvious data fabrication by the observers; some further such periods have been identified during the checking process. In a few cases some additional original data sheets have come to light, thus making the record more complete than had been previously thought.

The data validation procedure was greatly assisted by the Shebelli model produced by the Programmer/hydrologist. His work is summarized in Appendix A. Periods of doubtful data were identified; where possible these and missing data will be infilled using the model so that the record for each station is as complete and accurate as possible. Data infilled by this method (or otherwise estimated) is flagged as such on the flow data printouts which will be included in the Data Book.

### 3.4 Liaison With Other Organisations

The close links established with the Food Early Warning System (FEWS) project and the National Water Centre (NWC) have been maintained. Data received via the MOA radio network set up by FEWS has been made available to the Hydrology Section and in return summary tables and analysis are produced every ten days for the regular bulletin on rainfall, river flows and crop conditions. The NWC computer contains a complete back-up system for HYDATA and the Hydrology Section's database; periodically the revised database has been copied to the NWC computer so that they can use up-to-date data. Cooperation between the Hydrometry Project and NWC was reinforced by the time which the Programmer/hydrologist spent working for NWC during his visit.

Many requests have been received for data regarding one or both rivers; advice has been given as freely as possible because the provision of validated data sets is one of the major objectives of the project. Information has been given to a number of local organisations and to Consultants and other international organisations studying particular projects related to either of the rivers. The Gu floods on both rivers were above average (though not exceptional) and warnings were made available to interested parties. There was extensive flooding in the lower Shebelli, caused by exceptional rainfall as well as river flooding.

## 4 FUTURE PROSPECTS

This report covers a period of seven months rather than the scheduled six; the report was delayed in the hope that the situation in Somalia would have become clearer so that the prospects for the remainder of the Project could be assessed more readily. However, the outlook is still somewhat uncertain. In the immediate future field trips seem likely to be limited to the nearer stations on the Shebelli which can be reached in day trips; visits to Beled Weyn or to anywhere on the Jubba are still considered inadvisable. It is not always easy to obtain reliable and up-to-date information from these areas, but recent reports have been somewhat more optimistic so it is hoped that visits may be resumed in the not-too-distant future.

With the end of the Project approaching it is important to look forward to the prospects for the Hydrology Section after the ODA support has finished. For some time there have been plans for a major project to be funded by the United States Agency for International Development (USAID). The Shebelli Water Management Project would provide substantial support for the Directorate of Irrigation and Land Use, and because river flow data is fundamental to water management it is understood that the project would largely take over the current work of the Hydrology Section with respect to the Shebelli - and there would probably be knock-on benefits for data collection and analysis from the Jubba. In discussions with the Director of Irrigation and Land Use during the visit by the Consultant Hydrologist it was agreed that a major priority for the concluding period of the Hydrometry Project would be to facilitate a smooth transfer to the USAID project.

Unfortunately there now appears to be some doubt surrounding the Shebelli Project and some delay in its start-up is inevitable. In these circumstances it is considered desirable that the Hydrometry Project should be continued beyond the scheduled finish at the end of March 1990. Fortunately the Project budget will not have been fully spent by that time so it has been proposed that work should be continued for a few months longer. This is currently being discussed by the Consultants and ODA and a decision is anticipated shortly.

The plans for the next six months depend in part on the prevailing situation in Somalia. In the present circumstances office work will continue to have priority, but as soon as conditions allow visits to the Jubba and to the distant stations on the Shebelli fieldwork will obviously take over. As well as resuming the regular programme of field visits there may be a backlog of maintenance work to be carried out. In connection with fieldwork, basic sediment analysis of river water samples will be carried out. The use of one corner of the office for this (in the absence of a laboratory) should allow some meaningful results to be obtained, but if this is not so then other avenues for sample analysis will have to be investigated.

The FEWS satellite project is due to get underway in January 1990; this will involve the installation of equipment to receive satellite imagery which will be used to provide estimates of rainfall over the whole of the region, including the entire Jubba and Shebelli catchments in Ethiopia as well as Somalia. As soon as data becomes available it will be looked at to investigate its value for river flow prediction. It is anticipated that use of the satellite data will lead to useful warnings of floods at Lugh and Beled Weyn and therefore more advanced warning of possible problems further downstream. If the project continues beyond March 1990 it is planned that analysis of the satellite data will form a major part of the work in the continuation period, but if it finishes in March then only a brief study will be possible.

In the office the emphasis of the existing computer modelling work will shift from the Shebelli to the Jubba. The work already done for the Shebelli will provide a basis for the Jubba model. When this is complete it will be used to assist in the final checking and validating of the original data (as has now largely been done for the Shebelli). Finally, the models will be used to infill missing values prior to the publication of the revised Data Book which is expected to become the definitive record of river flows in Somalia up to 1990.

# APPENDIX A

## DEVELOPMENT OF THE SHEBELLI MODEL

This appendix outlines the work undertaken by Dr K J Sene, primarily during his visit to Somalia between March and May 1989. A detailed operation manual will be presented in conjunction with the Final Report.

The IH Programmer/Hydrologist made a 10 week visit to Somalia from 11 March to 17 May 1989. The main purpose of this visit was to continue development of a computer model of the River Shebelli and to set up the model so that it could be used to infill periods of missing flow data on the hydrological database maintained at the Ministry of Agriculture (MOA) in Mogadishu. Assistance was also given on some of the field trips carried out during this period. This report describes the computer modelling work performed during the visit; the fieldwork is described elsewhere in the Field Trip Reports.

**Background**

Work on the Shebelli model was first started in 1986 during the second phase of the Somalia Hydrometry Project. The basis of the model was to use simple regressions to relate downstream flows to upstream flows assuming a fixed time lag between adjacent gauging stations. The lag times were constrained to be equal to a whole number of days. A preliminary version of the code was installed in Mogadishu during 1986 (Reference 1). Two modes of operation were available:

(a) Infilling mode - in which missing or 'doubtful' flow data could be estimated using data from upstream gauging stations.

(b) Forecasting mode - in which river flows could be forecast from river level information received in Mogadishu by radio from upstream stations such as Beled Weyn.

The model was found to give promising results and it was decided as part of Phase 3 of the project, its development should be continued and that it should be adapted for use on the River Jubba. The form of the revised model was agreed during a visit to Somalia by IH staff in July 1988.

**Modifications**

The improvements to the model were started by the IH Programmer/Hydrologist in 1988 and were largely completed during his second visit from March to May 1989. The main changes were:

(a) Provision of a menu-driven user interface, replacing the previous 'question and answer' type of input. This change was made to make the model easier and quicker to use and to make it compatible with the data input system used in the MOA hydrological database.

(b) Addition of a set of routines to derive the regressions between gauging stations. Previously, these were obtained in a more cumbersome way using a commercially available statistical package.

(c) Generalisation of the model so that it could be used for the River Jubba.

(d) Generalisation of the model so that fractional lags (ie not whole days) could be handled.

(e) Generalisation of the model so that flows at an upstream station could be estimated from flows at a downstream station, and so that the regressions need not apply to neighbouring stations. These changes were required to increase the number of periods for which data could be infilled, and were not intended for use with the forecasting mode of operation.

(f) Restructuring of the model so that the regressions are defined in a datafile outside the main code. This allows the regressions to be modified more easily and new regressions to be added when required.

The revised model was installed on the MOA computer in May 1989 and was demonstrated to MOA staff. Figures 1 and 2 show examples of the output from the model in infilling and forecasting modes.

**Calibrating the Model**

During the visit, a start was made on calibrating the model for use in infilling data for the River Shebelli. This involved defining the regression equations and lag times between stations and the bank full flows at each station.

Before calculating the regressions, it was necessary to reject all periods in which the data were of doubtful accuracy. It was also necessary to exclude periods in which local runoff events or overbank flows occurred, since, in its present form, the model includes no representation of these effects (Figures 3 and 4 show examples of these types of event). To help identify these periods, comparison and correlation plots were produced for each available year of data for each pair of neighbouring stations. Examples of these plots are shown in Figures 5 and 6 for the year 1964 for the stations Beled Weyn and Bulo Burti. Reference was also made to the work on the original Shebelli model (Reference 1), in which some of the more obvious errors had been identified using an earlier (1986) version of the database.

The periods of doubtful data identified during this work are shown in Table 1. The reasons for rejecting data included:

- obvious major errors;
- lack of correlation with neighbouring stations;
- events appearing at a downstream station before an upstream station (ie apparent negative lag times).

In many of these cases, the data were subsequently corrected after referring to the original record sheets; typical errors included mistaking benchmark heights, or confusion between dip readings and staff gauge readings. The remaining periods will be infilled wherever possible using the computer model.

Once the periods for rejecting data had been identified, the regressions were calculated using the revised computer model. In the original version of the model, it was only necessary to define four regressions, covering the five gauging stations on the River Shebelli (Beled Weyn, Bulo Burti, Mahaddey, Weyn, Afgoi and Audegle). In the new version of the model, regressions can be defined between any two stations on the river, regardless of whether they are neighbouring stations or whether first station is upstream or downstream of the second. For preliminary work, regressions were only calculated for neighbouring stations (downstream on upstream, and vice versa in some cases). To increase the opportunities for infilling periods of missing data, it was decided to incorporate three more stations into the model. The extra stations were Balcad (operated until 1979) and the stations at the inlet and the outlet of the Jowhar Offstream Reservoir (operated since 1980).

The model allows regressions to be specified in 1, 2 or 3 parts but 1 part regressions were found to be suitable in most cases. For each pair of stations, the regressions were calculated for a range of assumed lag times and the lag which gave the smallest error of fit was identified. Figures 7 and 8 show some examples of the output from the correlation routines in the model. The data are for the stations Balcad and Afgoi for the period 1963 to 1979. From Figure 8, the optimum lag time appears to be in the range 1 to 1.5 days, and further analysis suggested a value of 1.4 days.

Table 2 summarises the optimum lag times and corresponding regressions which were calculated for the selected pairs of stations, together with (where applicable) the assumed bank full flows. These values were entered into the calibration datafile for the model, thereby allowing the model to be used for forecasting and data infilling on the River Shebelli. Note that these values are provisional, and will be checked immediately before starting to infill the Shebelli data.

As a check on the output from the model, lag times were also estimated directly from the data. This was done by identifying a variety of specific events in the database, such as local runoff peaks or sudden changes in flow, and estimating the time for each of these events to travel between neighbouring stations on the river. More than 100 events were selected. Table 3 compares the resulting lag times with the lag times given by the smallest error of fit. The two estimates were generally very close. An interesting feature of the observed lags was that, in all cases, the observed lag times seemed to be almost independent of the flow. Figure 9 shows a typical example for the reach Beled Weyn-Afgoi. This is a useful result since it provides a belated justification for use of a simple regression model for the River Shebelli, instead of a more complex hydraulic routing model.

**Future Developments**

In its present form, the computer model is suitable for use on both the Rivers Jubba and Shebelli, and has been calibrated for on the Shebelli. Some further developments are planned, however, in which specific versions will be produced for each river. For the Shebelli, the separate version will incorporate a submodel of the Jowhar Offstream Reservoir, based on the study described in Reference 2. It may also be possible to include a simple model of bank storage in the upper reaches of the Shebelli. This would allow the model to be used for infilling flow data during flood events. For the Jubba, some changes may be required to account for local runoff in the upper reach between Lugh Ganana Bardheere and for variable lag times (ie dependent on flow).

Work is currently in progress on these changes and on calibrating the model for use on the Jubba. The Jubba calibrations are being performed in the same way as for the Shebelli data. The results from the Jubba model will be compared with previous modelling work on the Jubba, such as that described in Reference 3. The final calibrations for the Jubba will be performed in Somalia using the latest version of the database. The regressions for the Shebelli will also be checked at this time. The calibrated models will be used to infill the database wherever possible and their suitability for flow forecasting will also be evaluated. The end result of this work will be a computer model for each river and a validated database for the period 1963 to 1989, with as much as possible of the doubtful data infilled. The documentation remains to be finalised but will probably include:

- an operating manual for the programs;
- descriptions of the hydrology of the Rivers Jubba and Shebelli;
- a guide to the final, validated database.

## REFERENCES


1. River Shebelli Model. Appendix II.6 in 'Hydrometry Project - Somalia, Mission Report, Stage 2', February-June 1986.

2. Jowhar Offstream Reservoir, Preliminary Review of data 1980-1985, Appendix A in 'Hydrometry Project - Somalia, First Progress Report, Phase 3', March-August 1988.

3. Hydrology of the Jubba River, Agrar und Hydrotechnik GMBH, 1985.

## TABLE 1

**Period of Doubtful Data Idenfitied for the River Shebelli**

**BELED WEYN**

| | | | | |
|---|---|---|---|---|
| 1963 | 26/8 | - | 30/8 | Doubtful data (low flows cf BB, MW) |
| 1966 | 1/8 | - | 13/8 | Doubtful data (high flows cf BB, MW) |
| 1972 | 20/5 | | | Doubtful data (flow peak not appearing at BB) |
| 1977 | 1/1 | - | 20/3 | Doubtful data (non zero flows at AU, AF) |
| 1985 | 1/8 | - | 7/8 | Doubtful data (lag negative cf BB, MW) |
| 1986 | 21/10 | - | 26/10 | Doubtful data (excessive lag for flow peak cf BB, MW) |
| 1986 | 1/11 | - | 31/12 | Doubtful data (not correlated with BB, MW) |

**BULO BURTI**

| | | | | |
|---|---|---|---|---|
| 1964 | 1/2 | - | 14/4 | Doubtful data (flow high and constant cf BW, MW) |
| 1965 | 22/10 | - | 13/11 | Doubtful data (flows low cf BW) |
| 1966 | 1/10 | - | 5/10 | Doubtful data (not correlated with BBW) |
| 1966 | 5/12 | - | 31/12 | Doubtful data (flows high cf BW, MW) |
| 1967 | 1/1 | - | 3/2 | Doubtful data (flows high cf BW, MW) |
| 1967 | 14/8 | - | 26/8 | Doubtful data (excessive lag cf BW, MW) |
| 1967 | 23/11 | - | 31/12 | Doubtful data (excessive lag cf BW) |
| 1976 | 29/6 | - | 31/8 | Doubtful data (excessive lag cf BW, MW) |
| 1977 | 13/4 | - | 30/6 | Doubtful data (high flows cf BW, BA, AF) |
| 1977 | 1/10 | - | 31/12 | Doubtful data/flood event |
| 1978 | 1/1 | - | 31/1 | Doubtful data (stepwise recession) |
| 1978 | 1/7 | - | 29/9 | Doubtful data (stepwise increase, negative lag cg BW) |
| 1979 | 1/4 | - | 15/4 | Doubtful data (high flows cf BW) |
| 1979 | 1/9 | - | 30/9 | Doubtful data (uncorrelated with BW, BA) |
| 1982 | 21/6 | - | 31/12 | Doubtful data (poorly correlated with BW, MW, AF) |
| 1983 | 1/1 | - | 31/1 | Doubtful data (uncorrelated with BW, MW) |
| 1983 | 1/3 | - | 30/4 | Doubtful data (uncorrelated with BW, MW) |
| 1983 | 1/7 | - | 30/7 | Doubtful data (uncorrelated with BW, MW) |
| 1985 | 14/5 | - | 11/6 | Doubtful data (uncorrelated with BW, MW) |
| 1987 | 1/9 | - | 31/12 | Doubtful data (poorly correlated with BW, MW) |
| 1988 | 1/1 | - | 21/4 | Doubtful data (high flows and uncorrelated cf BW, MW) |
| 1988 | 8/11 | - | 11/11 | Doubtful data (lag too small cf BW, large cf MW) |

**MAHADDEY WEYN**

| | | | | |
|---|---|---|---|---|
| 1966 | 12/11 | - | 5/12 | Doubtful data (decrease in rate of recession cf BW, AF) |
| 1970 | 2/3 | - | 6/5 | Doubtful data (poorly correlated cf BW, AF) |
| 1970 | 28/7 | - | 28/8 | Doubtful data (poorly correlated cf BW, AF) |
| 1971 | 23/5 | - | 31/7 | Doubtful data (variable lag cf BW, BA) |
| 1975 | 1/1 | - | 30/3 | Doubtful data (uncorrelated cf BW, AF) |
| 1975 | 1/5 | - | 31/5 | Doubtful data (uncorrelated cf BW, AF) |
| 1976 | 1/7 | - | 30/11 | Doubtful data (change in slope on correlation plots) |
| 1977 | 1/3 | - | 13/4 | Doubtful data (uncorrelated cf AF, AU) |
| 1977 | 28/5 | - | 31/12 | Doubtful data (poorly correlated with BW, AF) |
| 1978 | 1/2 | - | 28/2 | Doubtful data (poorly correlated with BW, AF) |
| 1978 | 1/4 | - | 31/5 | Doubtful data (poorly correlated with BW, AF) |
| 1978 | 1/7 | - | 31/12 | Doubtful data (poorly correlated with BW, AF) |
| 1979 | 1/1 | - | 31/8 | Doubtful data (poorly correlated with BW, BA, AF) |

## TABLE 1

### Period of Doubtful Data Idenfitied for the River Shebelli (cont)

**BALCAD**

| | | | | |
|---|---|---|---|---|
| 1966 | 15/3 | - | 31/12 | Doubtful data (uncorrelated with MW, AF) |
| 1967 | 20/7 | - | 28/8 | Doubtful data (excessive lag cf MW, AF) |
| 1969 | 18/6 | - | 21/8 | Doubtful data (poorly correlated with MW, AF) |
| 1971 | 1/6 | - | 30/9 | Doubtful data (flows low, uncorrelated cf MW, AF) |

**AFGOI**

| | | | | |
|---|---|---|---|---|
| 1977 | 27/3 | - | 25/4 | Doubtful data (AU/AF comparison unsatisfactory) |
| 1978 | 1/1 | - | 28/2 | Doubtful data (poorly correlated with BA, AU) |
| 1978 | 1/4 | - | 31/12 | Doubtful data (poorly correlated with BA, AU) |
| 1979 | 8/1 | - | 31/3 | Doubtful data (poorly correlated with BW, BA) |
| 1979 | 10/10 | - | 31/12 | Doubtful data (poorly correlated with BW, BA) |
| 1980 | 5/1 | - | 4/2 | Doubtful data (flow constant for long period) |
| 1983 | 26/2 | - | 23/4 | Doubtful data (AU/AF comparison unsatisfactory) |
| 1984 | 1/1 | - | 26/5 | Doubtful data (AU/AF comparison unsatisfactory) |
| 1984 | 13/7 | - | 2/8 | Doubtful data (AU/AF comparison unsatisfactory) |

**AUDEGLE**

| | | | | |
|---|---|---|---|---|
| 1966 | 31/5 | - | 3/8 | Doubtful data (poorly correlated with MW, AF) |
| 1966 | 19/10 | - | 3/11 | Doubtful data (poorly correlated with MW, AF) |
| 1966 | 22/11 | - | 12/12 | Doubtful data (poorly correlated with MW, AF) |
| 1977 | 27/3 | - | 25/4 | Doubtful data (AU/AF comparison unsatisfactory) |
| 1978 | 1/1 | - | 31/1 | Doubtful data (poorly correlated with Ba, AF) |
| 1978 | 1/4 | - | 30/7 | Doubtful data (poorly correlated with BA, AF) |
| 1978 | 1/11 | - | 31/12 | Doubtful data (poorly correlated with BA, AF) |
| 1979 | 22/2 | - | 30/4 | Doubtful data (poorly correlated with BA, AF) |
| 1980 | 24/8 | - | 30/4 | Doubtful data (unlikely local runoff peak) |
| 1980 | 3/11 | - | 5/11 | Doubtful data (unlikely local runoff peak) |
| 1983 | 26/2 | - | 23/4 | Doubtful data (AU/AF comparison unsatisfactory) |
| 1984 | 1/1 | - | 26/5 | Doubtful data (AU/AF comparison unsatisfactory) |
| 1984 | 13/7 | - | 2/8 | Doubtful data (AU/AF comparison unsatisfactory) |
| 1986 | 1/1 | - | 31/12 | Doubtful data (frequent periods with constant flow) |
| 1987 | 1/1 | - | 31/12 | Doubtful data (frequent periods with constant flow) |
| 1988 | 1/1 | - | 1/8 | Doubtful data (frequent periods with constant flow) |

## TABLE 2

**Preliminary Regressions, Lag Times and Bank Full Flows for the River Shebelli Model**

| Reach | Lag (days) | Bank full flow at first station (Cumecs) | Regressions Q = Flow (results in cumecs) | |
|---|---|---|---|---|
| BW-BB | 2.0 | No limit | BB = 0.984 BW | Q < 80 |
| | | | BB = 0.810 BW + 14.9 | Q > 80 |
| BB-MW | 2.4 | No limit | MW = 1.087 B | |
| MW-BA | | 140 (until 1979) | BA = 1.033 MW - 3.89 | Q < 40 |
| | | 164 (after 1979) | BA = 0.834 MW - 3.97 | Q > 40 |
| BA-AF | | 95 | AF = 1.017 BA | |
| MW-AF | 2.8 | 140 (until 1979)<br>164 (after 1979) | AF = 1.002 MW - 4.46 | |
| AF-AU | 1.1 | 95 | AU = 1.011 AF | |
| AU-AF | 1.1 | 81 | AF = 0.979 AU | |
| SA-MW | 0 | | SA = MW | |

BW = Beled Weyn
BB = Bulo Burti
MW = Mahaddey Weyn
BA = Balcad (until 1979)
SA = Sabuun (inlet to JOSR : since 1980)
AF = Afgoi
AU = Audegle

## TABLE 3

**River Shebelli Comparison of Average Lag Times Estimated from Actual Events and From Regression Analysis (all Values in Days)**

| Reach | Average Observed lag time | Lag Time for best fit | Lag time in original model |
|---|---|---|---|
| BW-BB | 2.0 | 1.6 | 2 |
| BB-MW | 2.3 | 2.4 | 2 |
| MW-BA | 1.9 | 1.6 | |
| BA-AF | 1.4 | 1.3 | |
| MW-AF | 2.9 | 2.8 | 3 |
| AF-AU | 1.2 | 1.1 | 1 |
| From Beled Weyn | | | |
| BW-BB | 2.0 | | 2 |
| BW-MW | 4.3 | | 4 |
| BW-AF | 7.2 | | 7 |
| BW-AU | 8.5 | | 8 |

| | | |
|---|---|---|
| BW | = | Beled Weyn |
| BB | = | Bulo Burti |
| MW | = | Mahaddey Weyn |
| BA | = | Balcad (until 1979) |
| AF | = | Afgoi |
| AU | = | Audegle |

Note: These estimates were obtained directly drom the data, so in some cases the lag over a section does not quite euqal the sum of the lags over its component reaches. For example, for the section BW-AF, the lag (7.2 days) is less than the sum of the lags BW-BB, BB-MW, MW-BA, BA-AF (7.6 days).

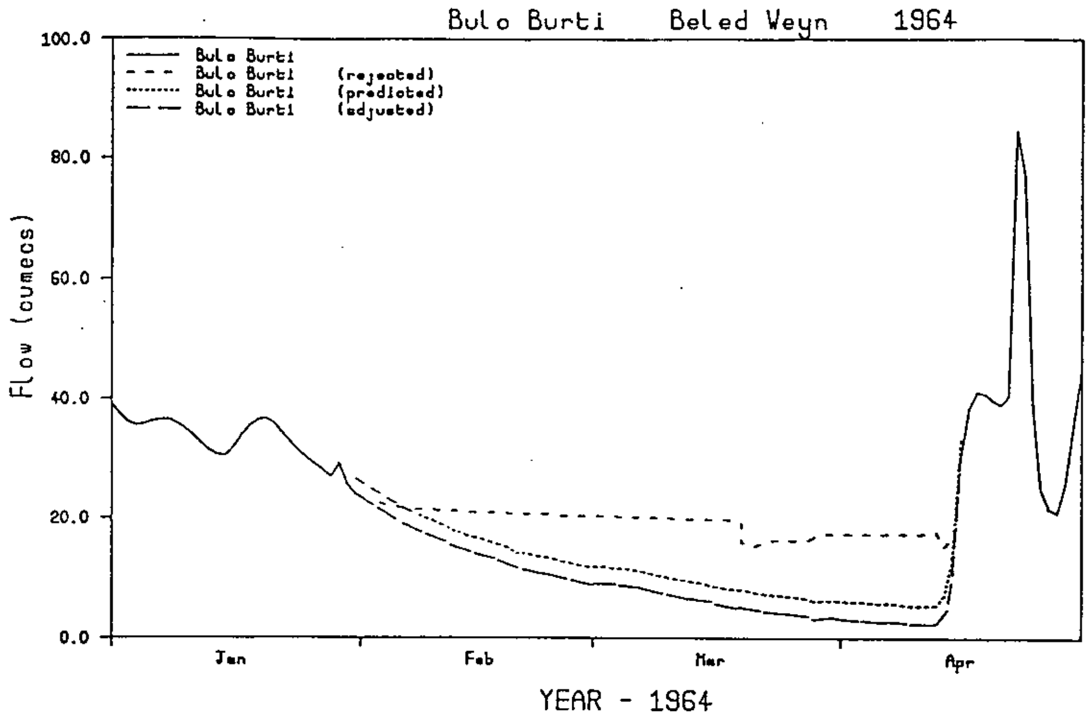



**Figure 1** - Example of an infilling exercise for a period of doubtful data for Bulo Burti in 1964. The 'adjusted' prediction has been adjusted by the program to blend smoothly with the observed flow.

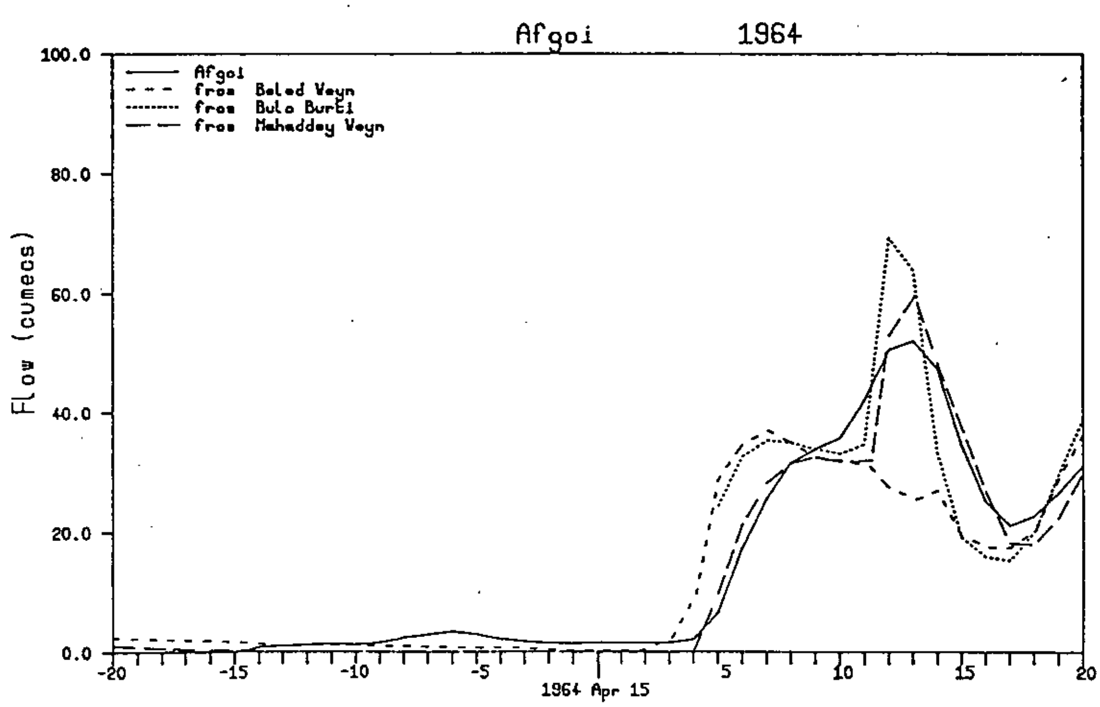



**Figure 2** Example of a flow forecast for Afgoi on 15 April 1964, at the start of the Gu flood. The plot compares the observed flow with the forecasts obtained from flow data for Beled Weyn, Bulo Burti and Mahaddey Weyn.

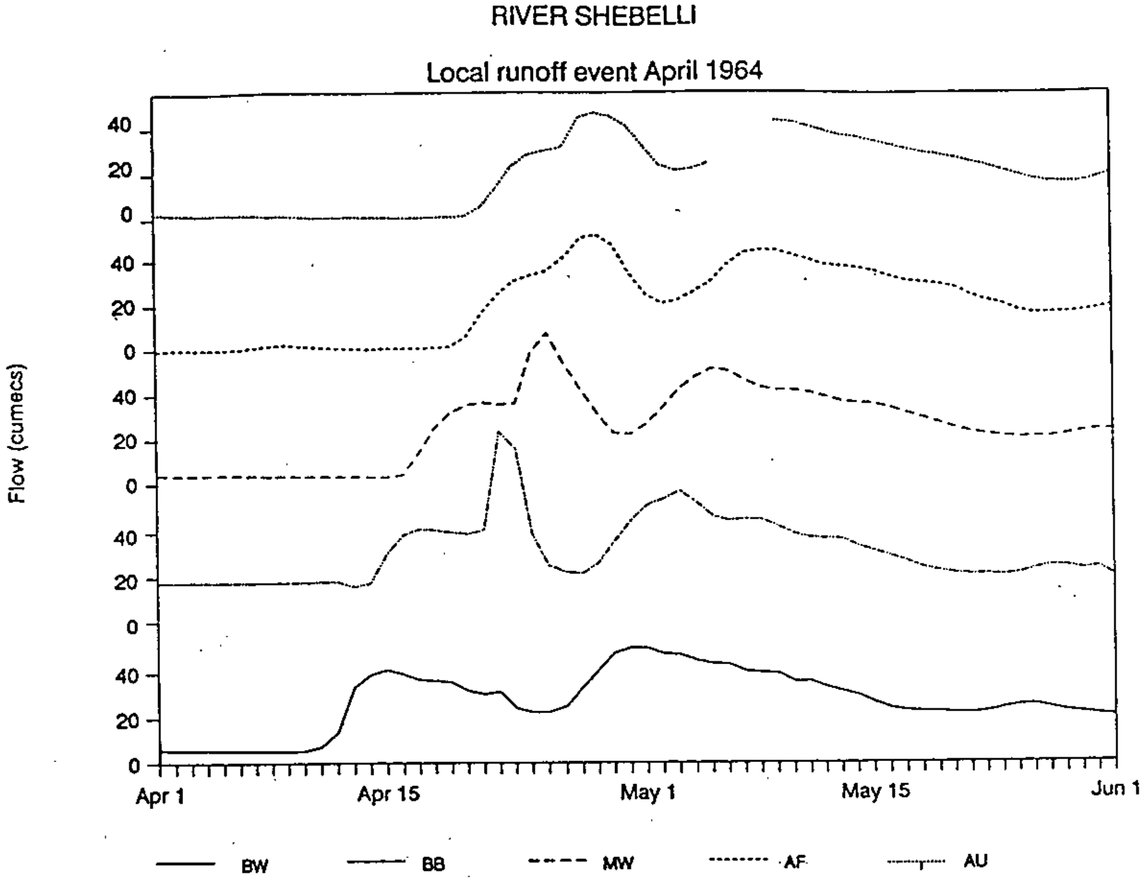



**Figure 3** - An example of a local runoff event due to rainfall occurring in the reach Beled Weyn-Bulo Burti. Approximately 39 mm of rainfall was recorded in Beled Weyn on 20 April 164, two days before the start of this event was observed at Bulo Burti.

BW = Beled Weyn, BB = Bulo Burti, MW = Mahaddey Weyn, AF = Afgoi, AU = Audegle

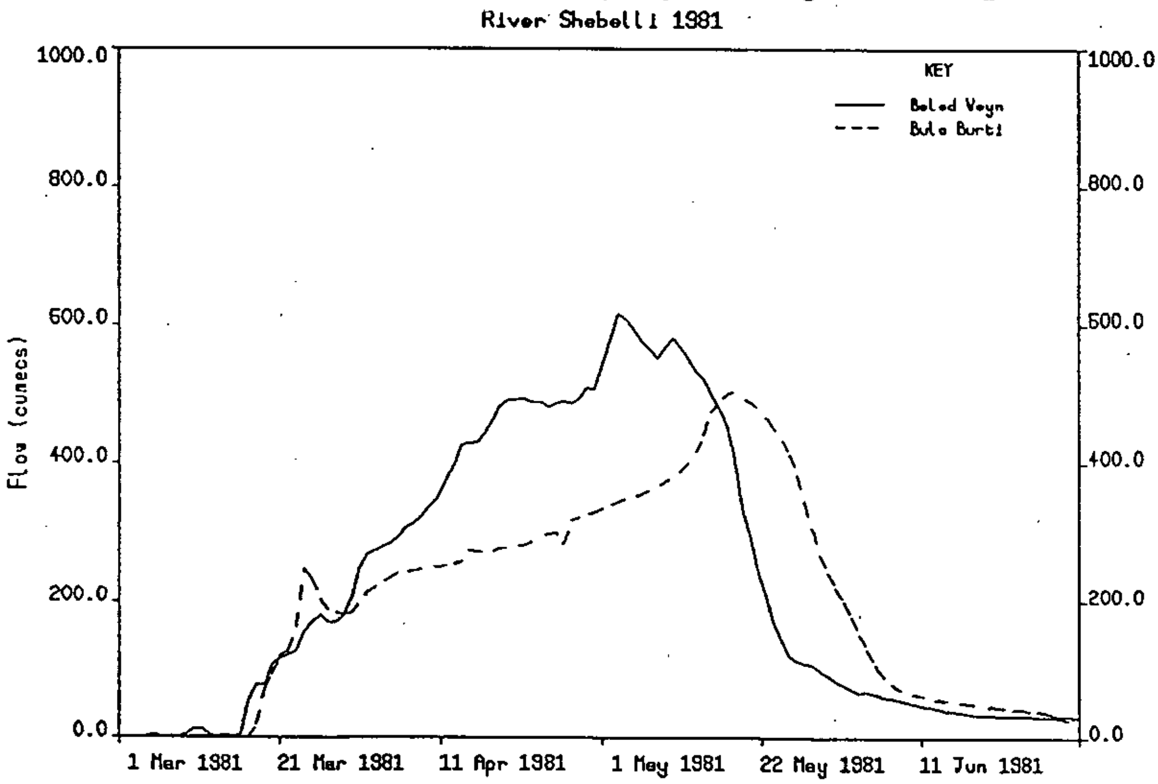
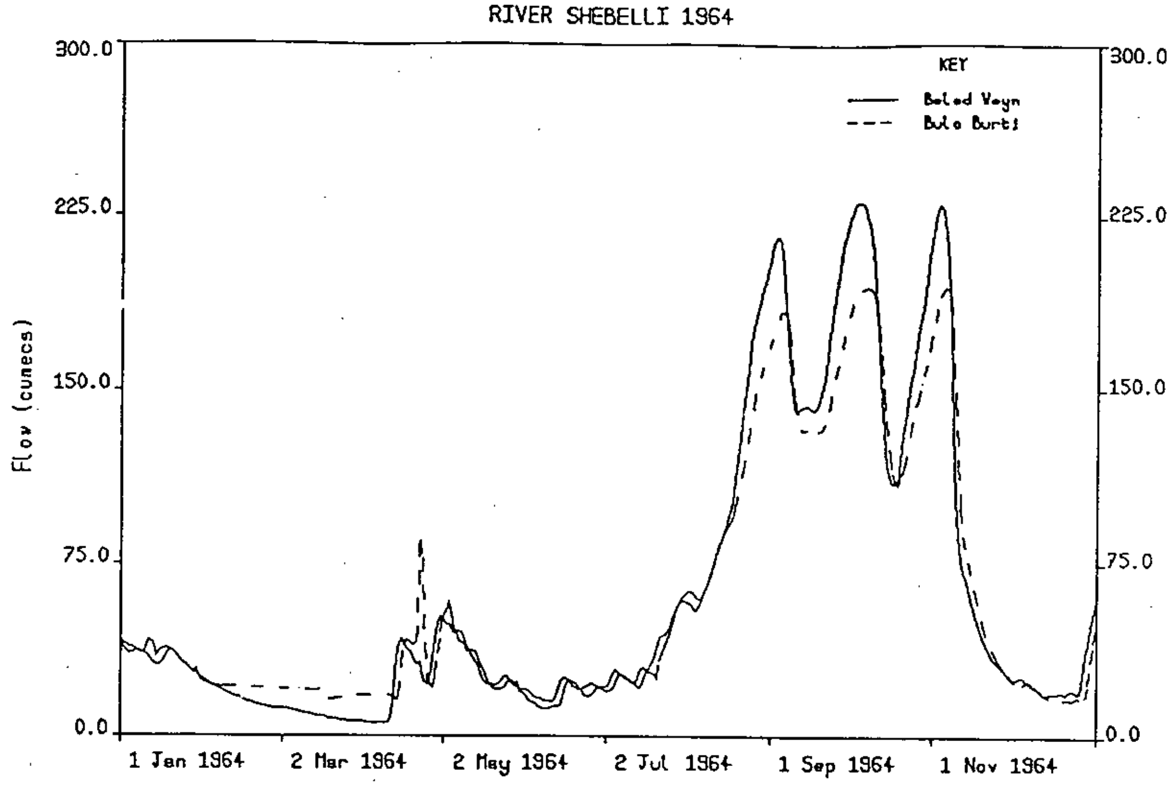



**Figure 4** - An example of a flood event in the reach Beled Weyn-Bulo Burti. The long lag time between the two stations is due to the return of water which went 'out of bank' during the initial flood. It may be possible to include this effect in the computer model.



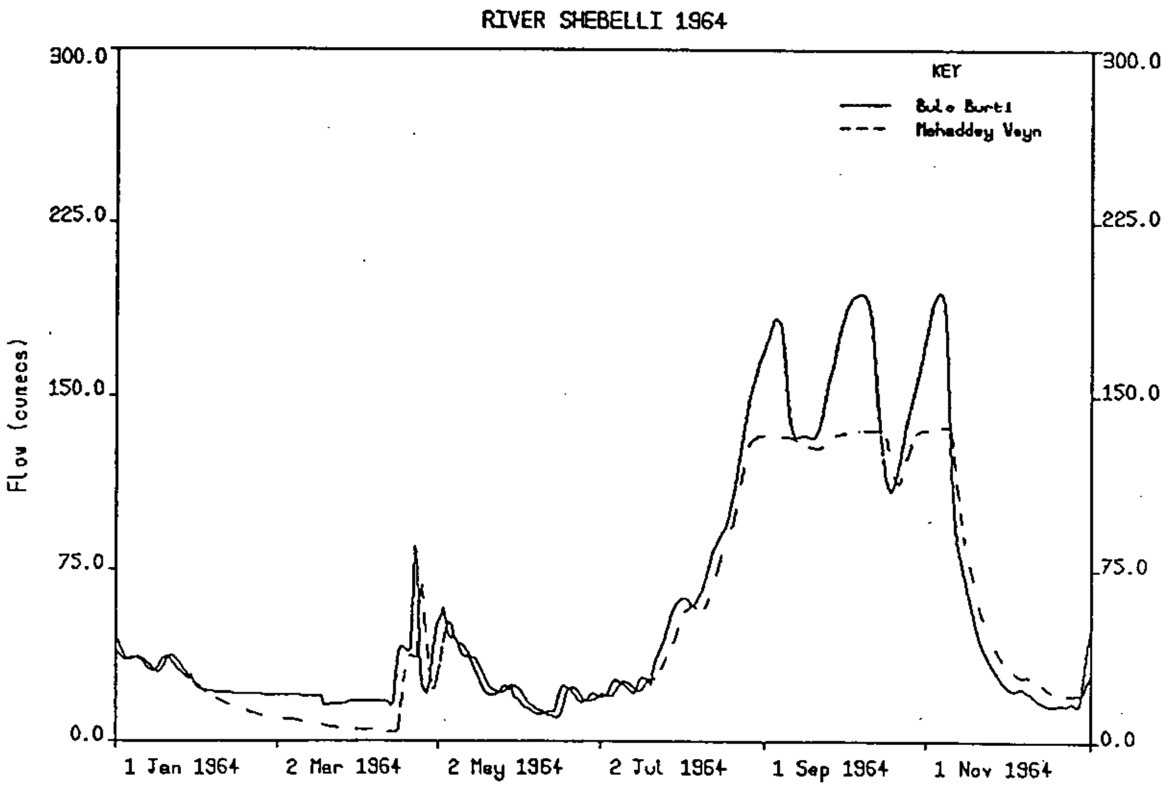




**Figure 5** - Comparison plots for the stations Beled Weyn, Mahaddey Weyn and Bulo Burti for 1964. The plots indicate a period of doubtful data for Bulo Burti between February and April, and a possible local runoff event during April in the reach Beled Weyn-Beled Burti. The predicted flow for the period of doubtful data is shown in Figure 1.

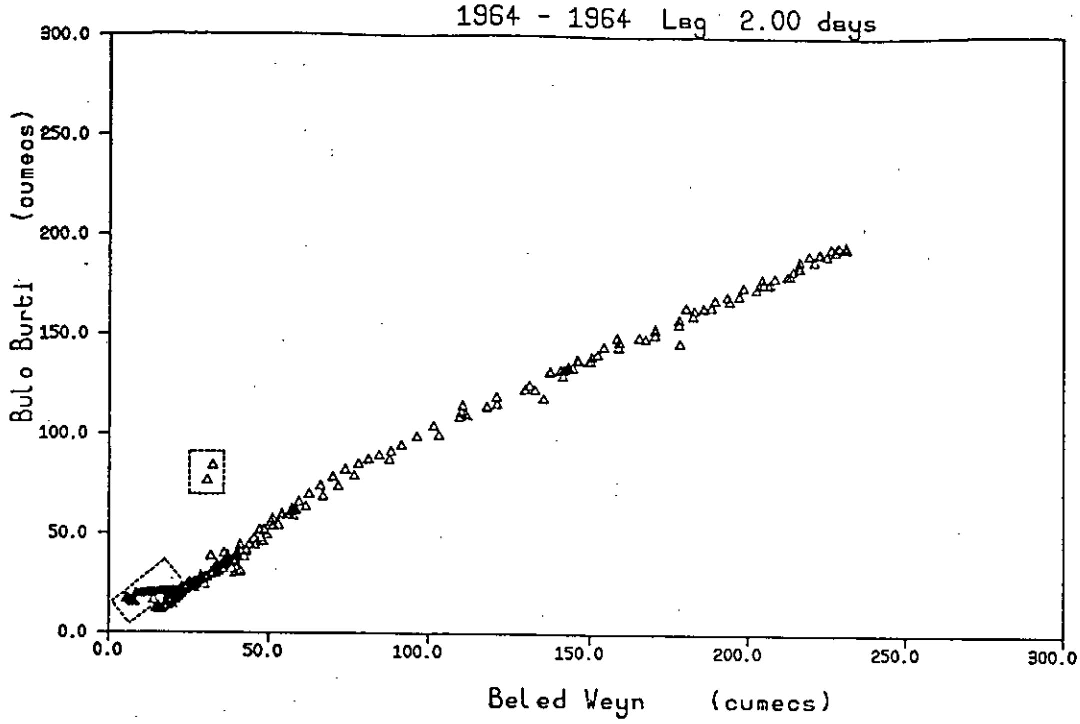



**Figure 6** - A correlation plot between the stations Bulo Burti and Beled Weyn for 1964. The datapoints within dotted lines correspond to the local runoff event and to the period of doubtful data shown in Figure 5. These periods were excluded when developing the regression between the two stations.

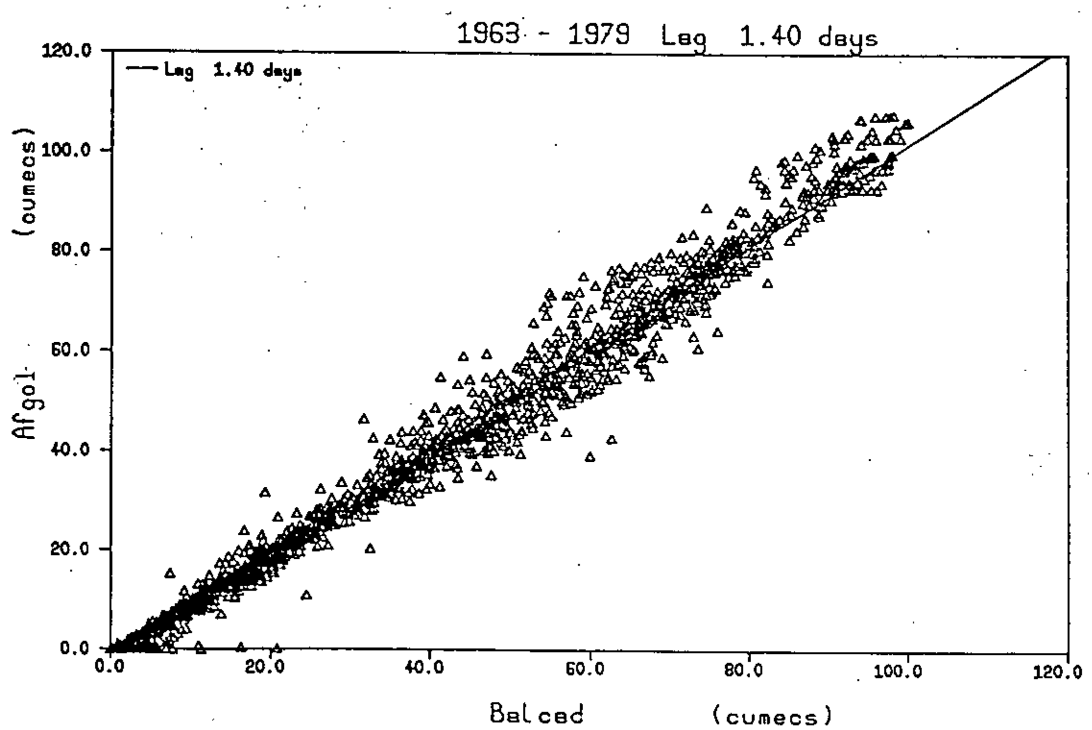



**Figure 7** - Correlation plot for the stations Afgoi and Balcad assuming a lag of 1.4 days. The plot also shows the best fit (1 part) regression for this lag time.

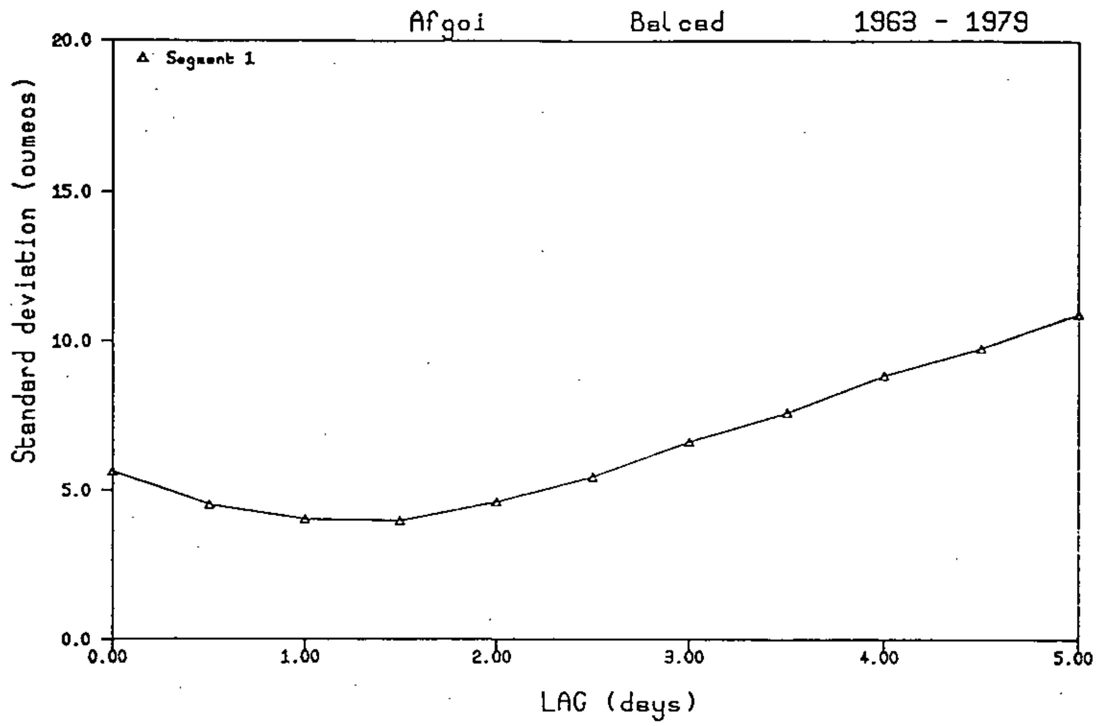



**Figure 8** - Effect of lag time on the error of fit (standard deviation) for the stations Afgoi and Balcad, using a 1 part regression. The minimum error of fit occurs for lags between 1 and 1.5 days.

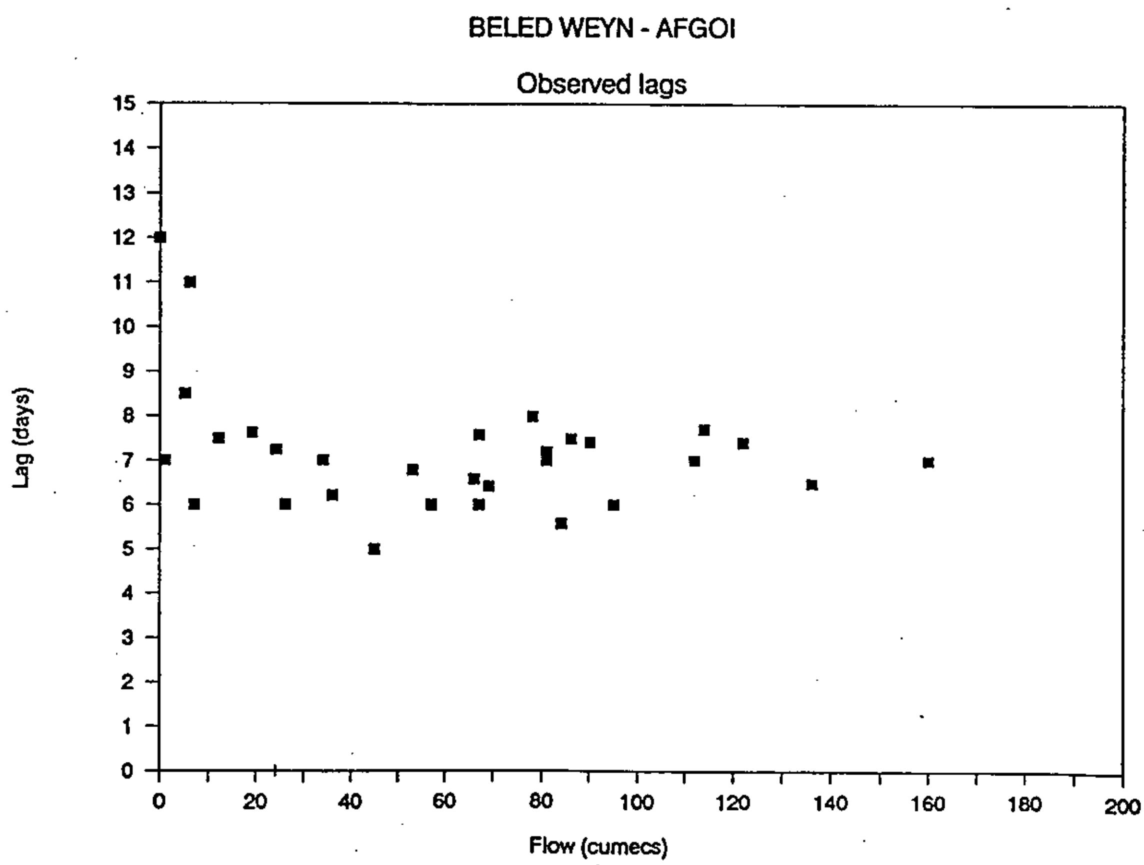



**Figure 9** - Observed lag times for the reach Beled Weyn to Afgoi. The flow values are the average of the flows at Beled Weyn and Afgoi during each event.

# APPENDIX B

## FIELD TRIP REPORTS

This appendix contains copies of the field trip reports produced during this period, brought together in a single document. The discharge measurement calculations are included at the end of the appendix rather than after each particular report.

## CONTENTS

## B1 Fieldwork Undertaken During March 1989

| | |
|---|---|
| 28th Feb-2nd March | Kurten Waarey, Kamsuma, Jilib and Mogambo |
| 7th - 9th March | Bardheere and Lugh |
| 15th March | Kurten Waarey and Audegle |
| 21st - 23rd March | Kamsuma, Jilib and Mogambo |
| 26th March | Audegle |

Participants:

| | 28-2 | 7-9 | 15 | 21-23 | 26 |
|---|---|---|---|---|---|
| Peter Ede | y | y | y | y | y |
| Kevin Sene | | | y | y | y |
| Ibrahim | y | | y | y | y |
| Ali | y | y | | y | |
| Marian | | y | y | | |
| Ahmed | y | y | y | y | y |

### Lower Jubba Field Trip 28th February - 2nd March 1989

### Kurten Waarey, River Shebelli

This first visit to Kurten Waarey for over three months was made to collect data and to pay the observer. Data was collected up to mid-December when the level dropped below the staff gauge. The observer was absent (attending a funeral), but his allowance was paid to Ahmed at the MOA office and arrangements were made for a further visit in mid-March. The sides of the river channel below the barrage (particularly on the right bank) have been severely eroded and further major floods could lead to a threat to the structure.

It was clear that it should be relatively straightforward to undertake a discharge measurement by wading in the region of the staff gauges, but in view of the long journey to Mogambo it was not attempted on this occasion. A level and staff will be needed to measure the water level.

**Jilib**

The river at Jilib had virtually stopped flowing when we visited on March 1st and the level was below the bottom SG (this had apparently been so for only a few days). 1988/89 data was collected, together with some historic data for Kaitoi which was kindly lent by the Chief Executive at the Fanoole Project, Dr. Abdullahi Sheikh Ali. He requested that we make contact with the Fanoole office in Mogadishu so that arrangements can be made for water level reports from Lugh and Bardheere to be transmitted to Fanoole.

**Kamsuma**

On February 28th it was so windy that it was not possible to obtain an accurate dip reading. When the discharge measurement was made on March 1st it was again windy, but the river level was found by strapping the dipper to the suspension cable. It was 9.31 m, corresponding to a gauge height of 0.65 m. Virtually no movement in the water could be discerned by eye, and the results of the DM confirmed this. Towards the right bank the velocities were extremely low and the direction of flow varied - upstream, downstream and sideways. Towards the left bank the flow was definitely in a downstream direction, but the highest velocity recorded was only about 0.1 m/s. The overall results were as follows:

| | |
|---|---|
| Bridge Dip | 9.31 m |
| Equivalent GH | 0.65 m |
| Discharge | 1.95 cumecs |
| Mean velocity | 0.03 m/s |

This measurement is very valuable in identifying the approximate zero flow level of the river at this section. Together with the other measurements made during the project (which include one at close to bank-full level) this should lead to a satisfactory rating equation. However, it must be said that the bridge suspension method of measuring discharge is subject to substantial errors when the water depths are large and the velocities very slow. It would be better to do a DM by wading, subject to the identification of a suitable section where the water is much shallower and preferably flowing only in a narrow channel.

**Mogambo**

The irrigation period for the rice crop had finished so the pumps were not operational. There was therefore little incentive for the staff to clear the silt near the lower gauges. The water level was measured by levelling and found to be about 6.72 m. This may be taken to be close to, though not quite as low as, the zero flow level for the site. The 7.50 to 9.00 m SG had been knocked slightly skew during dredging operations. Levelling established that the base of this gauge was very close to the required level; the top is obviously slightly in error, but this amounts to no more than 2-3 cm which is not significant in terms of the overall accuracy of SG readings.

Just downstream of the offtake to the flood relief canal the river was noticeably flowing in a narrow channel. By an approximate Pooh Sticks method the discharge was guesstimated to be around 2-3 cumecs, though the margin of error could certainly be as high as 50 %.

**Afgoi and Audegle**

Observations on the return journey on March 2nd were as follows:

| | | SG | Bridge Dip |
|---|---|---|---|
| Audegle | 1500 | 2.90 | 4.47 |
| Afgoi | 1650 | 2.13 | 5.28 |

**Upper Jubba Field Trip 7th-9th March 1989**

**Bardheere**

The river levels on March 7th and 8th were as follows:

| | 7th/1700 | 8th/0800 |
|---|---|---|
| Staff Gauge | 0.23 m ? | 0.22 m ? |
| Bridge Dip | 7.74 m | 7.75 m |
| Automatic recorder | 0.236 m | 0.233 m |

The staff gauge is extremely difficult to read at these levels because of the angle of sight from the bridge, together with the fact that the 0-1 m SG is set back further than the remainder. The data was copied from the recorder to the portable retriever, but the level was not adjusted because of the difficulty in identifying the true level. The dip reading of 7.75 corresponds to a SG value of 0.24 m.

The observer identified the site where Jasper Tomlinson (hydrologist with the Bardheere Dam Project) had done a wading measurement in 1985, but because of the very large width of the river at that point a section somewhat closer to the bridge was chosen, such that the maximum depth was slightly below the top of the chest waders! At this point (some 400 m upstream of the bridge) the river was still too wide for the available tape measure so local people had to be recruited to act as markers and other assistants. None of the team had previously participated in such an extensive wading measurement so it was something of a learning experience. The results were as follows:

| | | |
|---|---|---|
| River level (approx) | 0.22 m | (this was the observer's value) |
| Discharge | 9.7 cumecs | |
| Mean velocity | 0.26 m/s | |

This is about 46 % below the rated value but is in keeping with other measurements during the current recession period. It must be accepted that the bed level varies substantially from one year to the next, and therefore the rating equation is not particularly accurate at very low levels.

**Lugh**

On March 8th at 1700 the readings were as follows:

| | |
|---|---|
| Staff Gauge | 1.12 m (difficult to read) |
| Recorder | 1.118 m |
| Bridge dip | 8.49 m (EGH = 1.10) |

The SG level appeared to have dropped slightly by the following morning and the observer's value of 1.11 m was accepted for the discharge measurement. The recorder level had dropped by only 1 mm. The SG is in a good position for viewing, but cannot be reached for cleaning - the numbers have been obscured by mud. The 2-3 m SG on the bank was cleaned and repainted in readiness for the higher levels later in the year.

The recorder data was copied to the retriever, but as at Bardheere it was felt that there was no need to adjust the set level. The clock was a few minutes slow, but as at Bardheere this was not corrected.

A suitable section for a wading measurement was identified some 300 m upstream of the bridge and the measurement made on March 9th. This proved to be easier than at Bardheere, partly because of the experience gained there and partly because the section was much narrower - about 50 m. The results were as follows:

| | |
|---|---|
| River level | 1.11 m |
| Discharge | 7.2 cumecs |
| Mean velocity | 0.25 m/s |

This is also about 46 % below the rated value, and similar comments to those above for Bardheere apply.

**Kurten Waarey 15th March 1989**

The observer was paid his allowance to 31/12/88, and he subsequently assisted with the discharge measurement which was undertaken by wading at a section a few metres upstream of the staff gauges. The section was narrow and not very deep so this was a very quick exercise. The results were as follows:

| | |
|---|---|
| River level | 0.50 m |
| Discharge | 1.27 cumecs |
| Mean velocity | 0.31 m/s |

Because of the shallow water readings were only taken at 0.6 x depth which may have introduced errors as there was a considerable layer of mud at the bottom.

The opportunity was also taken to try the sediment sampler for the first time. This is lowered and raised by hand on the wading rods. A number of samples were taken, all of which looked remarkably clear. There is currently no laboratory facility available, but some analysis will be done in due course.

**Audegle 15th March 1989**

The main purpose of visiting Audegle on the return journey was to assess whether there would be any chance of doing a discharge measurement in the near future. The water appeared to be too deep for wading (and the villagers were avidly searching for a crocodile which had just killed a goat!), but it seems that a measurement might be possible at the new bridge. It has previously been reported that this bridge is totally unsuitable for gauging; it is certainly impossible to use the gauging derrick and winch, but the current meter and sinker weight could possibly be lowered on a handline between the girders.

The river level readings at Audegle at 1640 were 2.50 m (SG) and 4.88 m (Dip), both approximate values because of debris and wind respectively. At Afgoi at 1800 the SG reading was 1.81 m, and the dip about 5.63 m.

**Lower Jubba Field Trip 21st-23rd March 1989**

**Kamsuma, Mogambo and Jilib**

The main purpose of this visit concerned the observer at Kamsuma. It was found that the man appointed on a trial basis on the previous trip was not suited to the task. A close friend of Ahmed (the driver) offered to try to find someone suitable and in the meantime to make observations himself. Bridge dip readings taken during the trip were:

9.31 m on 21/3 at 1640
9.45 m on 22/3 at 1340
9.37 m on 23/3 at 0830

Because of a minor car accident in Jilib there was insufficient time to attempt a discharge measurement at Kamsuma. In any case it would be necessary to find a site suitable for wading, and no such place was immediately apparent. A gauging was therefore carried out just downstream of the Mogambo offtake where the channel was quite narrow but not too deep. The river level at the pump station (which was not operating) was almost six metres below that seen in early November. The gauges had been completely cleared of silt since the previous visit. The results of the gauging were as follows:

| | |
|---|---|
| SG (start) | 6.60 m |
| SG (finish) | 6.58 m |
| Discharge | 1.94 cumecs |
| Mean velocity | 0.32 m/s |

This discharge is almost identical to that measured at Kamsuma on March 1st; since the level at Kamsuma then was the same as that observed the day before this measurement (and travel time could be as much as 24 hours at low levels) this may be taken as confirmation of that result. The conductivity was measured at 950 microsiemens and sediment samples were taken at five verticals spaced across the channel.

Other SG readings were 6.79 m at 1700 on 21/3 and 6.55 m at 0800 on 23/3. The variation in level at Kamsuma and Mogambo is due to releases from Fanoole.

Data previously borrowed from the Fanoole project at Jilib was returned. The river level there was again below the bottom staff gauge.

**Afgoi and Audegle**

River Shebelli observations on route were as follows:

| | | | SG | Bridge Dip |
|---|---|---|---|---|
| Afgoi | 21/3 | 0910 | 1.65 | 5.76 |
| Audegle | 21/3 | 1010 | 2.10 | 5.27 |
| Audegle | 23/3 | 1500 | 2.65 | 4.71 |
| Afgoi | 23/3 | 1600 | 1.79 | - |

**Audegle 26th March 1989**

Following the exploratory visit on March 15th a discharge measurement was made by using the current meter and 10 kg weight on a handline. Depths were measured by means of a tape measure attached to the cable - the position on the tape next to the girder being noted and the depth found by subtraction. The results were as follows:

| | |
|---|---|
| SG (start/finish) | 2.54 / 2.52 m |
| Bridge dip | 4.74 / 4.76 m |
| Discharge | 9.5 cumecs |
| Mean velocity | 0.40 m/s |

This discharge is substantially below the rated value - as was expected because of the debris at the old bridge which raises the water level in the vicinity of the staff gauges. The rated flow for a level of 2.53 m would be 18.5 cumecs, so the result is about 48 % lower. An alternative (and probably more useful) method of assessing the difference is to determine the level implied by the rating equation for the observed discharge; this is 2.00 m which suggests that the effect of the bridge debris is to raise the level by about 50 cm. If further gaugings can be made it should be possible to determine an appropriate shift to apply to the zero correction in the equation. However, since the old bridge has a much less significant effect at high river levels it may not be sufficient to shift the curve over the whole range.

**Afgoi**

The readings at Afgoi at 0850 were 1.44 m on the staff gauge and a bridge dip of 5.97 m.

Peter Ede
10th April 1989

## B2 Fieldwork Undertaken During April 1989

| | |
|---|---|
| 2nd - 5th April | Beled Weyn, Bulo Burti, Mahaddey Weyn and Jowhar |
| 11th April | Jowhar |

Participants:

| | 2-5 | 11 |
|---|---|---|
| Peter Ede | y | y |
| Kevin Sene | y | y |
| Ibrahim | | y |
| Ali | y | |
| Said | y | |
| Ahmed | y | y |

### Introduction

The programme of fieldwork was restricted this month because of Ramadan which began on April 8th and continued until early May.

### Upper Shebelli Field Trip 2nd-5th April 1989

This trip was planned to fix replacement staff gauges at Beled Weyn and Bulo Burti. There was some doubt about the prospects for the former because the river has stayed relatively high during the jilaal period this year, and news of a sudden rise in the river on March 31st meant that there was no chance at all. The reported level would probably have prevented work at Bulo Burti as well, but it transpired that the Beled Weyn observer had made a mistake in reading the gauge so that the river was less high than expected.

### Bulo Burti

The new 5-7 m staff gauges (already fixed to the stand) were fixed on April 3rd. Local labourers were recruited for this job - amazingly one of them recalled having fixed one of the lower gauge stands for Peter Bray and Mostyn Morgan of MMP in 1968! He did an excellent job again. The river only occasionally rises above 5 m, but the presence of these new gauges should result in improved data for flood peaks because the observer's bridge dip readings have tended to be less reliable than those from the SG.

A discharge measurement was undertaken on April 3rd. Problems with the distance counter meant that water depths had to be measured by an improvised technique using a tape measure and pieces of tape fixed to the cable; the results should be as good as those using the counter, but this procedure is one which might not be readily adopted by the counterpart staff. The results were good - discharge about 7 % above the rating:

| | |
|---|---|
| Mean SG level | 2.86 m |
| Mean bridge dip | 7.25 m |
| Discharge | 70.8 cumecs |
| Mean velocity | 0.90 m/s |

Some SG readings during the visit were as follows:

| | |
|---|---|
| 2nd April at 1750 | 3.00 m |
| 3rd April at 0740 | 2.94 m |
| 3rd April at 1400 | 2.88 m |
| 3rd April at 1750 | 2.84 m |
| 4th April at 0800 | 2.86 m |
| 4th April at 1700 | 3.10 m |
| 5th April at 0745 | 3.52 m |

**Beled Weyn**

On April 4th the river level was steady at 2.10 m during our visit from 1020 to 1430. This was much too high to attempt installation of the new 0-2 m SG (and might well have been so even before the arrival of the flood on March 31st) so it was left at the MOA office for a subsequent visit. The absence of the 1-2 m gauge is not too serious because there was previously an overlap between that and the upper gauge which starts at about 1.3 m. It had been hoped to restart the automatic recorder, but there was no sign of the cable and the water was too high to gain access to the base of the pipe to look for the float and counterweight.

The observer could not be found, but it was clear from his notes in the office that data sent over the radio in recent days was 1 m too high. Since he has been reading the staff gauge for very many years it is surprising that such a mistake should have occurred (there are in any case metre marks on the main SG). A message was sent to the Director in Mogadishu to explain this error, and within a few minutes he was speaking on the radio to Mr Hajir at Jowhar to tell him that the flood would be less severe than previously expected.

Because of the faulty equipment no discharge measurement was undertaken, but the derrick was used to take sediment samples using the larger sampler designed for bridge suspension. With very high water velocities it proved to be difficult to wind the cable down and up quickly enough to avoid overfilling the sample bottle. Five samples were taken at points spaced across the section. The samples were extremely murky compared to those taken in low flow conditions at Kurten Waarey and Mogambo.

**Mahaddey Weyn**

On April 2nd the river level was still low, but an investigation of possible sites upstream of the bridge for a discharge measurement by wading indicated that the depth was still too great. At the bridge itself the water was too shallow over most of the width for an accurate result to be obtained by using the bridge derrick. Some useful work was done by clearing debris from the 0- 2 m SG; however, the top part of the gauge is broken and should be replaced if river levels are sufficiently low next year. It would be better to use the old stand under the bridge towards the right bank. A lot of debris round this stand was cleared so that there should be a more even flow pattern, and hopefully closer agreement with the rating equation.

By April 5th the level had risen substantially, though it appeared to have dropped slightly since an overnight peak. No discharge measurement was made because of the faulty distance counter. River level readings on the two visits were as follows:

| | Staff gauge | Bridge dip |
|---|---|---|
| 2nd April at 1400 | 1.47 m | 6.04 m |
| 5th April at 0945 | 3.56 m | |

**Jowhar**

Mr. Hajir and Mr. Chino were absent on April 2nd, but we left a message and when we returned on April 5th we collected data left by Mr. Hajir and met Mr. Chino. He told us that the inlet canal gauge at Sabuun had collapsed and that a replacement was therefore urgently needed before the river rose to a level at which the canal gates would be opened. We had in any case planned to have a tour of the reservoir sites, but this information gave increased importance to our visit.

At Sabuun the old gauge was found to be in the nearby building. The wooden stand had simply rotted away, but the gauge plates were in reasonable condition. It was agreed that we would try to make a replacement metal stand similar to those just done for Bulo Burti and Beled Weyn and that we would endeavour to return the following week to fix it. The local staff at the barrage said they would arrange for labourers to be available if we brought cement and sand.

We continued round the reservoir and saw the outlet canal which had recently been blocked off near the river so that dredging can be undertaken. Readings were taken at several gauges as follows:

| | | |
|---|---|---|
| River at Sabuun u/s LB | (gauge E) | 3.35 m |
| River at Sabuun d/s RB | (gauge B) | 2.76 m approx. |
| Inlet canal | (no gauge) | almost dry |
| Reservoir level | (gauge H) | 2.84 m |

**Jowhar 11th April 1989**

A day trip was made to fix the replacement staff gauge at the head of the JOSR inlet canal at Sabuun. The original gauge covered the range 0-3 m, but since the full supply level is around 1.7 m the new gauge only covers 0-2 m. The new gauge was fixed towards the left bank of the canal, opposite to the position of the previous one because access to the canal bed was easier.

A temporary bench mark was set up by levelling from the bench mark BXJ/1 which has a reduced level of 109.997 m. The gauge stand was then set in concrete and the final gauge zero measured as 103.501 m. This is 6 mm lower than the original GZ, but such a difference is totally insignificant.

The river levels at about 1120 were as follows:

| | |
|---|---|
| Upstream (left bank, gauge E) | 3.73 m |
| Downstream (right bank, gauge B) | 2.98 m approx. |

The level in the canal (with one gate very slightly open) was found by levelling to be 0.02 m. Some clearing of silt would be needed for the water to reach the new staff gauge and this was considered inadvisable while the concrete was setting.

During a visit by Peter Ede and Kevin Sene to **Bur Hakaba** on April 21st some impromptu measurements were made in the spate channel which passes under the main road on the Mogadishu side of Bur Hakaba. On all previous visits within the memory of the present project team (both local and expatriate) this channel has always been completely dry, but as a result of heavy rainfall the previous day it was flowing at a substantial rate.

A bridge dip measurement of 6.26 m was made from the bottom (wooden) rung of the railings. This will be compared to the dip to the channel bed on a future visit when there is no water. The water had already receded from its overnight peak - by measuring the dip to the clear flood marks on the banks this drop was estimated to be 1.7 m. The water surface width was about 29 m, and the width at high water about 40 m. The surface velocity was estimated by the Pooh sticks method to be about 1.4 m/s (measuring the time to pass under the bridge which is about 12 m wide).

Until the channel is dry and the depth to the bed can be measured it is not possible to estimate the discharge because the depth of the water is not known. However, it is possible to estimate the difference in discharge between the peak and the observed situation.

| | |
|---|---|
| Mean width of additional section | 34.5 m |
| Depth of additional section | 1.7 m |
| Additional cross-sectional area | 59 $m^2$ |
| Estimated average velocity of additional section | 1.3 m/s |
| Approximate additional discharge | 76 cumecs |

The most uncertain part of the above calculation is the velocity; it is reasonable to expect that the mid-stream velocity would increase with the increased depth of the river, but this would be counteracted by lesser velocities near the bank. The adopted figure of 1.3 m/s is a purely subjective guess.

This reduction in discharge is of the same order of magnitude as the normal peak discharge in the Shebelli at Afgoi or Audegle, so it may confidently be stated that the total peak flow would have comfortably exceeded the bank-full discharge in the Shebelli anywhere downstream of Balcad - and possibly even that in the region of Jowhar.

Peter Ede
6th May 1989

## B3 Fieldwork Undertaken During May 1989

| | |
|---|---|
| 1st-2nd May | Lugh Ganana |
| 9th May | Afgoi |
| 10th-13th May | Audegle, Kamsuma, Jilib, Mogambo and Jamamme |
| 28th May | Afgoi |
| 30th May - 1st June | Beled Weyn, Bulo Burti, Mahaddey Weyn and Jowhar |

Participants:

| | 1-2 | 9 | 10-12 | 30-1 |
|---|---|---|---|---|
| Peter Ede | y | y | y | y |
| Kevin Sene | y | | | |
| Terry Evans | | y | y | |
| Ibrahim | | y | y | y |
| Ali | | | y | |
| Marian | | | | y |
| Ahmed | y | y | y | y |

**Lugh Ganana - 1st and 2nd May 1989**

Because of the sudden rise in the river at Lugh reported on April 29th a visit was made by the expatriate hydrologists (ably assisted by the driver) to try to obtain a high discharge measurement; the counterparts had previously indicated their unwillingness to travel during Ramadan. The road was significantly worse and the journey longer following exceptional rains in the area.

On arrival shortly after 4.30 on May 1st the SG reading was 4.70 m, already 50 cm below that reported for the previous morning. The drop was not unexpected because the difference between April 29th and 30th had been only 1 cm which suggested that the peak had been passed. The discharge was measured forthwith, the work being completed by torchlight at about 7 pm. At some verticals the flow was severely affected by debris around the upstream bridge pillars and it was sometimes difficult to be certain of the direction of flow.

The level rose towards the end of the measurement and was up to 5.00 m the following morning. Examination of the record on the automatic recorder showed a declining rate of increase indicating a probable peak shortly afterwards so that a second measurement should be done at once rather than waiting until later in the day. This subsidiary peak duly materialised with the level dropping back by

1 cm by the end of the measurement at about 10 am. The problems caused by the debris were similar to or slightly worse than those experienced the previous evening. On other measurements at Lugh the flow pattern has been affected by the bridge pillars, but the result has been verticals with low velocities. Generally the flow direction has been clear, but even if this was not so the effect on the final result would be small because of the low velocity; on these two measurements, however, an incorrect assumption about the flow direction would make a significant difference to the calculated discharge.

At the disturbed verticals best estimates were made regarding the direction of flow - in several places surface velocities were taken to be negative, but where the velocity near the bed was high it appeared to be positive. This observation accords with the likely effect of debris near the surface which would act like an undershot sluice gate - i.e. very fast flow near the bed but turbulence near the surface. As a result of the difficulty in interpreting some of the readings the calculated discharges below must be treated with caution.

| | 1/5 | 2/5 |
|---|---|---|
| SG (start) | 4.70 m | 5.00 m |
| SG (finish) | 4.76 m | 4.99 m |
| Mean GH | 4.72*m | 4.995 m |
| Area | 754 $m^2$ | 796 $m^2$ |
| Mean velocity | 1.04 m/s | 1.10 m/s |
| Discharge | 782.1 $m^3/s$ | 874.6 $m^3/s$ |

Note: *Sharp rise in level near end of measurement so effective mean taken as 4.72 m.

These discharges are a little lower than the rating equation derived during phase 1 of the project, as has been the case with all measurements made since January 1982. A slight change in the rating equation is likely to be appropriate, probably just a shift in the zero flow level with the gradient of the rating curve remaining unchanged.

**Afgoi 9th May 1989**

With the river at its highest level of the year so far a discharge measurement was carried out. Results were as follows:

| | |
|---|---|
| SG reading | 5.31 m |
| Mean velocity | 0.59 m/s |
| Discharge | 89.1 $m^3/s$ |

The discharge is below the rated value. There is a considerable amount of scatter in the measurements for gauge heights above about 4 m, and this measurement lies well within the bounds of earlier measurements. However, as all recent measurements have been on the same side of the curve an adjustment in the rating curve for recent years may be made.

**Lower Jubba Field Trip 10th-12th May 1989**

**Audegle**

The Shebelli at Audegle was at the highest level observed there by the Hydrometry team - 5.69 m. The bridge dip was 1.50 m. The old bridge was seen to be having a negligible effect on the water level at the staff gauges.

The road from Afgoi was very poor after recent rain and that to Janaale had been breached by floodwater at the same point as last September. The Land Rover just got through, but this route will be impracticable until major repairs have been effected.

**Kamsuma**

A discharge measurement was undertaken on May 11th. This was at the highest level seen since the station was rehabilitated, and resulted in the second highest discharge ever measured here. Results were as follows:

| | |
|---|---|
| Bridge dip | 3.66 m |
| EGH | 6.30 m |
| Discharge | 513.1 $m^3/s$ |
| Mean velocity | 1.03 m/s |

Other bridge dip readings were 3.67 m at 1730 on May 10th and 3.66 m at 0840 on May 12th.

**Mogambo**

The staff gauge reading was 12.57 m at each of three observations on May 11th/12th. With irrigation not in process the gates were closed and the upstream level was somewhat lower at just over 12 m.

A discharge measurement was carried out in the flood relief canal where it passes under the main road. The measured discharge was about 37 cumecs. This is well below the design capacity of 100 cumecs - at least partly because several gates were kept closed to reduce the risk of damage to the back of the Mogambo project area by return flood flows.

**Jamamme**

The first discharge measurement for some years was made at Arara bridge, Jamamme on May 11th. The results were as follows:

| | |
|---|---|
| Mean bridge dip | 4.275 m |
| EGH | 6.765 m |
| Mean velocity | 1.00 m/s |
| Discharge | 418.7 $m^3/s$ |

This discharge is significantly below that implied by the old rating equation which was (1984) considered to be good because of the straight approach and the absence of bridge pillars or other obstruction.

The main reason for doing this measurement was to complete three sequential measurements with the river at its bank-full level. The difference between Kamsuma and Jamamme (94 cumecs) is partly explained by the offtake at Mogambo; some of the rest is undoubtedly due to flooding in the intervening reach. Flooding problems were reported from Jamamme itself (upstream of the bridge), but the extent is not known. It is very unlikely that flooding could account for the loss of 57 cumecs so measurement error must be at least partly responsible. The most likely error is an over-estimate at Kamsuma.

**Jilib**

Data was collected from Fanoole on May 11th. The level at 0930 was 5.33 m on the staff gauge; however, the observer reads this as 1.33 m and adds a constant of 4.32 m (gauge zero correction for the third gauge stand) to get the reading of 5.65 m. This was apparently a drop of 2 cm since the reading earlier in the morning.

**Afgoi 28th May 1989**

The level had just passed its peak level, even though flows at upstream stations are still considerably higher than the bank-full discharge at Afgoi. The level dropped by 1 cm during the measurement, results of which were as follows:

| | |
|---|---|
| SG (mean) | 5.475 m |
| Bridge dip (mean) | 1.945 m |
| Mean velocity | 0.62 m/s |
| Discharge | 93.7 $m^3/s$ |

**Upper Shebelli Field Trip 30th May - 1st June 1989**

**Mahaddey Weyn**

On May 30th, the level had just started falling from its peak of 5.45 m. The velocity measurements showed some sign of the slow section observed last year (caused by debris round an old SG stand), but the clearance work done in April appeared to have had some effect. Results as follows:

| | |
|---|---|
| Mean gauge height | 5.345 m |
| Mean velocity | 0.85 m/s |
| Discharge | 137.0 $m^3/s$ |

The EC reading was 1200 microsiemens and the bridge dip at the start of the measurement was 2.16 m. On our return on June 1st at 1010 the level had dropped to 5.13 m.

**Bulo Burti**

The results of the discharge measurement on May 30th were as follows:

| | |
|---|---|
| Mean gauge height | 4.21 m |
| Mean velocity | 1.25 m/s |
| Discharge | 158.5 $m^3/s$ |

This discharge is significantly above the rated value of 135 cumecs, but it does not provide sufficient evidence to require a change in the rating equation at this stage. The level continued to fall on May 31st - 4.07 m at 0800 and 3.96 m at 1810. Data was collected from the observer - including some old sheets which had been noted as missing in the Mogadishu office.

**Beled Weyn**

A discharge measurement was carried out on May 31st:

| | |
|---|---|
| Mean gauge height | 2.13 m |
| Mean velocity | 1.24 m/s |
| Discharge | 123.4 $m^3/s$ |
| EC | 1000 microsiemens |

This discharge is very close to the rated value. The automatic recorder was set up and started at 1550 with the level 2.10 m. However, as the base of the pipe is only a short distance below this level only one or two days' useful data are expected before the float comes to rest at the base of the pipe; data should be of value again once the river rises for the Der season flood. Because of rusting of the nuts and bolts, great difficulty was experienced in opening the pipe in order to fit a new float and counterweight; eventually the recorder box was substantially removed to achieve this.

**Jowhar**

A visit was made to Sabuun on June 1st to measure the discharge in the JOSR supply canal. This was done at the first footbridge some 5 km downstream from the offtake. With a staff gauge reading of approximately 1.03 m at the offtake the flow was 14.3 cumecs. This is around 40 % below the rating equation which was derived from measurements made in 1979 and 1980. From observation of the canal bed when the gauge was replaced it would seem that the zero flow intercept in the equation may be incorrect. Further discharge measurements are required in the canal to check the rating.

In the river the 3-4 m SG on the downstream side of the barrage was missing. The level was estimated to be about 3.6 m. The upstream level was ?.55 m (on the highest gauge). EC reading was 1050 microsiemens.

Peter Ede
10th June 1989

## B4 Fieldwork Undertaken During June and July 1989

| | |
|---|---|
| 6th-8th June | Afgoi, Kamsuma, Mareere, Mogambo and Jamamme |
| 21st June | Afgoi |
| 5th-7th July | Bardheere and Lugh Ganana |

Participants:

| | 6-8 | 21 | 5-7 |
|---|---|---|---|
| Peter Ede | y | | |
| Ibrahim | y | y | y |
| Ali | | y | y |
| Ahmed | y | y | y |

**Introduction**

The amount of fieldwork undertaken during these two months was somewhat less than usual. In the absence of Peter Ede on leave from June 11th to July 26th a reduced programme was planned, involving two major trips, but only one of these was made because field allowances were not available from MOA in June. A second trip in July was not possible because of the situation in Somalia after July 14th.

**Lower Jubba Field Trip 6th-8th June 1989**

**Afgoi (River Shebelli)**

At 0900 on June 6th the water level readings were 4.65 m (SG) and 2.77 m (Dip). The observer's dipper was faulty and was replaced by a new one. On the return journey on June 8th at about 5 pm the river had dropped to a little below 4 m. The SG was obscured and the dip reading was about 3.46 m.

**Jamamme**

In order to facilitate the correlating of data from the various stations in the lower Jubba it was decided to restart measurements at Jamamme; if the results are satisfactory this will once again be treated as a primary station. We met the new Jamamme co-ordinator (Abdirahman Hassan Aweis) and proceeded with him to Arara bridge where we appointed an observer (Maxamuud Maxamed Hassan). He will make bridge dip readings; at 0810 on June 7th the dip was 7.30 m.

**Kamsuma**

At Kamsuma metre marks were painted on the upstream side of the bridge so that in future discharge measurements can be made from either side depending on the amount of debris and the resulting flow conditions. It has been found that there are considerable eddies on the downstream side and hence that the measured discharge is somewhat approximate. This flow pattern is caused by the bridge pillars and the debris which accumulates on them. At times this debris would make it extremely difficult to take measurements from the upstream face, but if the pillars are clear then the upstream side would certainly produce a more accurate result.

On June 7th two discharge measurements were made - one from each face of the bridge. Results are given below. The debris and resulting inability to measure velocities for certain places probably caused an underestimate in the flow at the upstream face, but this is unlikely to fully explain the difference. The discharge at the downstream face is therefore probably an over-estimate.

| | D/s face | U/s face |
|---|---|---|
| Mean Dip | 6.75 m | 6.77 m |
| Mean EGH | 3.21 m | 3.19 m |
| Mean Velocity | 0.71 m/s | 0.61 m/s |
| Discharge | 176.4 $m^3/s$ | 152.5 $m^3/s$ |

**Mogambo**

A considerable amount of data was collected from the Irrigation Department at the Mogambo Irrigation Project. Observed levels during this visit were as follows:

| | |
|---|---|
| 6th June at 1755 | 9.77 m |
| 7th June at 1555 | 9.65 m |
| 8th June at 0800 | 9.70 m |

**Mareere**

The Jubba Sugar Project was visited on the return journey to Mogadishu on 8th June; because of the recently opened bridge at Jilib this required only a small detour. The Agricultural Manager, Keith Ward, said that monthly data sheets had been sent to the JSP Mogadishu office but they had obviously not been sent on to the MOA or to MMP. He provided copies of data from April 1988 to April 1989 and we agreed that we would collect subsequent data on our regular field visits to the lower Jubba.

There was nobody at the Fanoole office when we called on June 8th so no data was collected for Jilib. The actual staff gauge reading was 2.41 m which should equate to an observer reading of 2.80 m (0.41 + 2.39).

**Field Trips By Counterpart Staff**

A brief report is attached on the two unsupervised trips made by the counterparts. Unfortunately these were not wholly successful. Very detailed instructions were prepared, and explained to the counterparts, with emphasis on the need to carefully record everything that was seen and done. However, virtually no notes were made and not everything could be remembered when the report was eventually written some weeks later. Details of the levels observed on the automatic recorders, and any adjustments made to them, are not available. Certain required staff gauge or bridge dip readings were also omitted. Fortunately, the recovery of data from the recorders was achieved without any repeat of the loss of data experienced on the previous unsupervised trip in January.

One problem outside the staff's control was the malfunction of the current meter equipment at Lugh which caused the abandonment of the discharge measurement there. The current meter spindle was later found to be bent to such an extent that impellor revolution was severely impaired. The faulty spindle has been discarded.

The recorders appear to have continued to function well, though with slight slippage over the period. At Bardheere the difference from the staff gauge was about 2 cm since the previous visit in early March, while at Lugh the difference was about 3 cm over about two months. At Bardheere the range of levels was very high - from the 0.235 m on the March visit to a peak of 5.471 m in early May. The recorder software only covers a range of +/- 5 m from the initially set level (i.e. to 5.235 m in this case), so the peak reading actually appeared as -4.529 m. 10.00 m had to be added to this and adjacent readings (25 hourly values in all) to obtain the true levels.

Peter Ede
14th August 1989

## Field Trip Report June/July 1989

Participants:

Ibrahim
Ali
Ahmed

### Afgoi 18th June and 24th July 1989

Arrived at 8.30 on the 18th June. The SG reading was about 3.03m. The river discharge was measured. After we took the measurement we went to the MOA office and collected data from the observer.

Results:

| | | |
|---|---|---|
| Mean Gauge | = | 3.025 m |
| Discharge | = | 35.45 cumecs |
| Area | = | 64.10 sq.m |
| Velocity | = | 0.55 m/s |

This discharge is about 18% below the rating table.

We went back to Afgoi on the 24th July. The main purpose we went there was to collect data from the observer and give him more blank cards. (N.B. no river level observation was made.)

### Upper Jubba Field Trip 5th-8th July 1989

#### Bardheere

Reached Baidoa at about 1230. After lunch we left Baidoa but before we reached Audinle we had a lot of problems about both the landrover's fuel tanks. Ahmed went back to Baidoa to call a mechanic to help us about the tanks. By the time he had done the repairs we had been stuck for 3 hours. Arrived Bardheere at 8.15 pm on 5th July.

On the 6th July at 8.30 am the SG reading was about 1.42 m and bridge dip was about 6.59 m.

The automatic water level recorder was still working. The data was copied to the data retriever and the recorder was reset. We collected data from the observer.

**Lugh Ganana**

Arrived at Lugh Ganana at 4.30 pm on the 6th July. The SG was 2.15 m. Cards and monthly sheets were collected from the observer. A discharge measurement was taken starting from the left bank at the bridge. During the measurement the propeller revolution stopped working; we tried to fix it, but unfortunately we did not succeed. Because of this we couldn't complete the measurement. The data from the recorder was copied to the retriever and the recorder was reset.

Ibrahim Abdullahi Sheikh Ahmed
13th August 1989

## B5 Fieldwork Undertaken During August and September 1989

### Introduction

Following advice from the British Embassy and the Director of Irrigation and Land Use it was decided that it would not be possible to undertake any long distance field trips until the general situation in Somalia improves. The only fieldwork was on a day trip to Mahaddey, plus data collection from Afgoi. It is hoped that further work will be possible on the Shebelli next month, but the outlook for journeys to the Jubba remains poor. In addition to the uncertain situation prevailing in Somalia at present, field trips were logistically impracticable for a time because of the acute shortage of banknotes in the country. Project expenses on vehicle running/maintenance and other costs had to be kept to an absolute minimum, and the MOA was unable to obtain cash from the bank to fund field allowances.

### Field Trip to Mahaddey and Jowhar 26th September 1989

Participants: Peter Ede, Ibrahim, Zakia, Ahmed

Data was collected from Jowhar and a discharge measurement was carried out at Mahaddey Weyn. The results were as follows:

| | |
|---|---|
| Staff Gauge (mean) | 3.915 m |
| Mean Velocity | 0.65 m/s |
| Discharge | 73.8 $m^3/s$ |

This is once again below the rated value; this has been so quite regularly with measurements at Mahaddey and clearly some adjustment to the rating curve is required.

Peter Ede
15th October 1989

## B6 Discharge Measurements Undertaken During the Period

The following pages contain the calculation sheets for the discharge measurements carried out by the project team. A total of 23 measurements were made, bringing the total during Phase 3 to 55, and these are listed below:

| Date | River | Station |
|---|---|---|
| 1st March 1989 | Jubba | Kamsuma |
| 8th March | Jubba | Bardheere |
| 9th March | Jubba | Lugh Ganana |
| 15th March | Shebelli | Kurten Waarey |
| 22nd March | Jubba | Mogambo |
| 26th March | Shebelli | Audegle |
| 3rd April | Shebelli | Bulo Burti |
| 1st May | Jubba | Lugh Ganana |
| 2nd May | Jubba | Lugh Ganana |
| 9th May | Shebelli | Afgoi |
| 11th May | Jubba | Kamsuma |
| 11th May | - | Mogambo Flood Canal |
| 11th May | Jubba | Jamamme |
| 28th May | Shebelli | Afgoi |
| 30th May | Shebelli | Mahaddey Weyn |
| 30th May | Shebelli | Bulo Burti |
| 31st May | Shebelli | Beled Weyn |
| 1st June | - | Sabuun Canal |
| 7th June | Jubba | Kamsuma |
| 7th June | Jubba | Kamsuma |
| 18th June | Shebelli | Afgoi |
| 7th July* | Jubba | Lugh Ganana |
| 26th September | Shebelli | Mahaddey Weyn |

Note: *The measurement at Lugh Ganana on 7th July could not be completed because of faulty equipment and there is therefore no calculation sheet.

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | |
|---|---|---|---|---|
| Station: | Jubba at Kamsuma | | Start | Finish |
| Date: | 1st March 1989 | | | |
| Method: | Suspension from bridge (d/s face) with 10kg weight | Time | 1050 | 1150 |
| Origin: | Right Bank | Bridge Dip | 9.31 | 9.31 |
| Observers: | Peter Ede/Ibrahim/Ali/Ahmed | Equivalent GH | 0.65 | 0.65 |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | |

Calculations made by method of mean velocity over section between two verticals.

Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12.6 | 0.0 | - | 50 | | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | -0.015 | 0.90 | 3.4 | 3.06 | -0.046 |
| 2 | 16.0 | 1.8 | .8d | 50 | -6 | -0.043 | -0.030 | | | | | |
| | | | .2d | 50 | -2 | -0.017 | | -0.015 | 1.60 | 2.0 | 3.20 | -0.048 |
| 3 | 18.0 | 1.4 | .8d | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | .2d | 50 | 0 | 0.000 | | 0.020 | 1.40 | 2.0 | 2.80 | 0.057 |
| 4 | 20.0 | 1.4 | .8d | 50 | 2 | 0.017 | 0.040 | | | | | |
| | | | .2d | 50 | 10 | 0.063 | | 0.027 | 1.40 | 2.0 | 2.80 | 0.075 |
| 5 | 22.0 | 1.4 | .8d | 50 | 0 | 0.000 | 0.013 | | | | | |
| | | | .2d | 50 | 3 | 0.026 | | 0.007 | 1.45 | 2.0 | 2.90 | 0.019 |
| 6 | 24.0 | 1.5 | .8d | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | .2d | 50 | 0 | 0.000 | | -0.002 | 1.40 | 4.0 | 5.60 | -0.012 |
| 7 | 28.0 | 1.3 | .8d | 50 | 0 | 0.000 | -0.004 | | | | | |
| | | | .2d | 50 | -1 | -0.009 | | -0.017 | 1.65 | 4.0 | 6.60 | -0.112 |
| 8 | 32.0 | 2.0 | .8d | 50 | -4 | -0.033 | -0.030 | | | | | |
| | | | .2d | 50 | -3 | -0.026 | | 0.036 | 2.00 | 4.0 | 8.00 | 0.287 |
| 9 | 36.0 | 2.0 | .8d | 50 | 16 | 0.093 | 0.101 | | | | | |
| | | | .2d | 50 | 19 | 0.109 | | 0.100 | 1.95 | 4.0 | 7.80 | 0.780 |
| 10 | 40.0 | 1.9 | .8d | 50 | 16 | 0.093 | 0.099 | | | | | |
| | | | .2d | 50 | 18 | 0.104 | | 0.078 | 1.95 | 4.0 | 7.80 | 0.608 |
| 11 | 44.0 | 2.0 | .8d | 50 | 3 | 0.026 | 0.057 | | | | | |
| | | | .2d | 50 | 15 | 0.088 | | 0.029 | 1.35 | 4.0 | 5.40 | 0.155 |
| 12 | 48.0 | 0.7 | .6d | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | - | 50 | | 0.000 | | 0.009 | 0.85 | 4.0 | 3.40 | 0.030 |
| 13 | 52.0 | 1.0 | .6d | 50 | 2 | 0.017 | 0.017 | | | | | |
| | | | .6d | 50 | 2 | 0.017 | | 0.024 | 1.10 | 4.0 | 4.40 | 0.104 |
| 14 | 56.0 | 1.2 | .8d | 50 | 3 | 0.026 | 0.030 | | | | | |
| | | | .2d | 50 | 4 | 0.033 | | 0.015 | 1.00 | 4.0 | 4.00 | 0.059 |
| 15 | 60.0 | 0.8 | .6d | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | .6d | 50 | 0 | 0.000 | | 0.000 | 0.70 | 2.0 | 1.40 | 0.000 |
| 16 | 62.0 | 0.6 | .6d | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | - | 50 | | 0.000 | | 0.000 | 0.35 | 3.4 | 1.19 | 0.000 |
| 17 | 65.4 | 0.1 | - | 50 | | 0.000 | 0.000 | | | | | |
| | | | - | 50 | | 0.000 | | 0.000 | 0.10 | 2.6 | 0.26 | 0.000 |
| 18 | 68.0 | 0.1 | - | 50 | | 0.000 | 0.000 | | | | | |
| | | | - | 50 | | 0.000 | | | | | | |

(cont.)

(cont.)

Jubba at Kamsuma 1st March 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 68.0 | 0.1 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | - | 50 | 0 | 0.000 | | 0.000 | 0.20 | 2.0 | 0.40 | 0.000 |
| 19 | 70.0 | 0.3 | - | 50 | | 0.000 | 0.000 | | | | | |
| | | | - | 50 | | 0.000 | | 0.000 | 0.15 | 3.0 | 0.45 | 0.000 |
| 20 | 73.0 | 0.0 | - | 50 | | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 71.46 Total discharge (cumecs) = 1.95 Mean Velocity (m/s) = 0.03

Note: Where flow was sideways the number of observed revolutions was changed to zero.
Appropriate reductions were also made for diagonal flow.
Where reverse flow was indicated at 0.2 x depth it was assumed that flow was also reverse at 0.8 x depth.

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | |
|---|---|---|---|---|
| Station: | Jubba at Bardheere | | Start | Finish |
| Date: | 8th March 1989 | | | |
| Method: | Wading | Time | 0910 | 1030 |
| Origin: | Left Bank | Stage | 0.22 | 0.22 |
| Observers: | Peter Ede/Ali/Marian/Ahmed | | | |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | |

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 16.0 | 0.00 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.000 | 0.13 | 1.0 | 0.13 | 0.000 |
| 2 | 17.0 | 0.25 | 0.15 | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | 0.000 | | 0.063 | 0.35 | 1.0 | 0.35 | 0.022 |
| 3 | 18.0 | 0.44 | 0.26 | 50 | 21 | 0.120 | 0.125 | | | | | |
| | | | 0.26 | 50 | 23 | 0.131 | | 0.179 | 0.51 | 1.0 | 0.51 | 0.091 |
| 4 | 19.0 | 0.58 | 0.46 | 50 | 35 | 0.195 | 0.232 | | | | | |
| | | | 0.12 | 50 | 49 | 0.269 | | 0.257 | 0.75 | 1.5 | 1.12 | 0.288 |
| 5 | 20.5 | 0.91 | 0.73 | 50 | 43 | 0.237 | 0.283 | | | | | |
| | | | 0.18 | 50 | 60 | 0.328 | | 0.288 | 1.00 | 2.0 | 2.00 | 0.576 |
| 6 | 22.5 | 1.09 | 0.87 | 50 | 48 | 0.264 | 0.293 | | | | | |
| | | | 0.22 | 50 | 59 | 0.323 | | 0.285 | 1.10 | 2.5 | 2.75 | 0.785 |
| 7 | 25.0 | 1.11 | 0.89 | 50 | 50 | 0.275 | 0.277 | | | | | |
| | | | 0.22 | 50 | 51 | 0.280 | | 0.269 | 1.01 | 2.5 | 2.51 | 0.677 |
| 8 | 27.5 | 0.90 | 0.72 | 50 | 49 | 0.269 | 0.261 | | | | | |
| | | | 0.18 | 50 | 46 | 0.253 | | 0.240 | 0.91 | 2.5 | 2.28 | 0.546 |
| 9 | 30.0 | 0.92 | 0.74 | 50 | 36 | 0.200 | 0.219 | | | | | |
| | | | 0.18 | 50 | 43 | 0.237 | | 0.211 | 0.87 | 2.5 | 2.16 | 0.456 |
| 10 | 32.5 | 0.81 | 0.65 | 50 | 40 | 0.221 | 0.203 | | | | | |
| | | | 0.16 | 50 | 33 | 0.184 | | 0.213 | 0.70 | 2.5 | 1.75 | 0.373 |
| 11 | 35.0 | 0.59 | 0.47 | 50 | 37 | 0.205 | 0.224 | | | | | |
| | | | 0.12 | 50 | 44 | 0.243 | | 0.209 | 0.48 | 2.5 | 1.19 | 0.249 |
| 12 | 37.5 | 0.36 | 0.22 | 50 | 35 | 0.195 | 0.195 | | | | | |
| | | | 0.22 | 50 | 35 | 0.195 | | 0.235 | 0.37 | 5.5 | 2.01 | 0.471 |
| 13 | 43.0 | 0.37 | 0.22 | 50 | 54 | 0.296 | 0.275 | | | | | |
| | | | 0.22 | 50 | 46 | 0.253 | | 0.264 | 0.40 | 7.0 | 2.77 | 0.730 |
| 14 | 50.0 | 0.42 | 0.25 | 50 | 44 | 0.243 | 0.253 | | | | | |
| | | | 0.25 | 50 | 48 | 0.264 | | 0.284 | 0.41 | 10.0 | 4.10 | 1.165 |
| 15 | 60.0 | 0.40 | 0.24 | 50 | 62 | 0.339 | 0.315 | | | | | |
| | | | 0.24 | 50 | 53 | 0.291 | | 0.305 | 0.38 | 10.0 | 3.80 | 1.160 |
| 16 | 70.0 | 0.36 | 0.22 | 50 | 54 | 0.296 | 0.296 | | | | | |
| | | | 0.22 | 50 | 54 | 0.296 | | 0.287 | 0.36 | 10.0 | 3.55 | 1.018 |
| 17 | 80.0 | 0.35 | 0.21 | 50 | 49 | 0.269 | 0.277 | | | | | |
| | | | 0.21 | 50 | 52 | 0.285 | | 0.287 | 0.34 | 7.0 | 2.35 | 0.672 |
| 18 | 87.0 | 0.32 | 0.19 | 50 | 53 | 0.291 | 0.296 | | | | | |
| | | | 0.19 | 50 | 55 | 0.301 | | | | | | |

(cont.)

(cont.)

Jubba at Bardheere 8th March 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Velocity Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 87.0 | 0.32 | 0.19 | 50 | 53 | 0.291 | 0.296 | | | | | |
| | | | 0.19 | 50 | 55 | 0.301 | | 0.241 | 0.29 | 4.0 | 1.16 | 0.280 |
| 19 | 91.0 | 0.26 | 0.16 | 50 | 33 | 0.184 | 0.187 | | | | | |
| | | | 0.16 | 50 | 34 | 0.189 | | 0.213 | 0.18 | 3.0 | 0.54 | 0.115 |
| 20 | 94.0 | 0.10 | 0.02 | 50 | 48 | 0.264 | 0.240 | | | | | |
| | | | 0.02 | 50 | 39 | 0.216 | | 0.120 | 0.05 | 10.9 | 0.55 | 0.065 |
| 21 | 104.9 | 0.00 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

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Total Area (sq.m) = 37.55 Total discharge (cumecs) = 9.74 Mean Velocity (m/s) = 0.26

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Note: for 20th vertical current meter placed as near to required position as possible

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | |
|---|---|---|---|
| Station: | Jubba at Lugh Ganana | Start | Finish |
| Date: | 9th March 1989 | | |
| Method: | Wading | 0830 | 1030 (approx) |
| Origin: | Left Bank | 1.11 | 1.11 |
| Observers: | Peter Ede/Marian/Ali | | |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-508 | | |

Calculations made by method of mean velocity over section between two verticals.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 18.5 | 0.00 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.124 | 0.21 | 1.0 | 0.21 | 0.026 |
| 2 | 19.5 | 0.42 | .8d | 50 | 46 | 0.253 | 0.248 | | | | | |
| | | | .2d | 50 | 44 | 0.243 | | 0.271 | 0.48 | 1.5 | 0.71 | 0.193 |
| 3 | 21.0 | 0.53 | .8d | 50 | 43 | 0.237 | 0.293 | | | | | |
| | | | .2d | 50 | 64 | 0.349 | | 0.289 | 0.57 | 2.0 | 1.14 | 0.330 |
| 4 | 23.0 | 0.61 | .8d | 50 | 45 | 0.248 | 0.285 | | | | | |
| | | | .2d | 50 | 59 | 0.323 | | 0.296 | 0.67 | 2.0 | 1.33 | 0.394 |
| 5 | 25.0 | 0.72 | .8d | 50 | 57 | 0.312 | 0.307 | | | | | |
| | | | .2d | 50 | 55 | 0.301 | | 0.329 | 0.76 | 2.0 | 1.51 | 0.497 |
| 6 | 27.0 | 0.79 | .8d | 50 | 61 | 0.333 | 0.352 | | | | | |
| | | | .2d | 50 | 68 | 0.371 | | 0.357 | 0.77 | 3.0 | 2.30 | 0.820 |
| 7 | 30.0 | 0.74 | .8d | 50 | 65 | 0.355 | 0.363 | | | | | |
| | | | .2d | 50 | 68 | 0.371 | | 0.349 | 0.72 | 2.5 | 1.79 | 0.625 |
| 8 | 32.5 | 0.69 | .8d | 50 | 58 | 0.317 | 0.336 | | | | | |
| | | | .2d | 50 | 65 | 0.355 | | 0.323 | 0.66 | 2.5 | 1.64 | 0.528 |
| 9 | 35.0 | 0.62 | .8d | 50 | 48 | 0.264 | 0.309 | | | | | |
| | | | .2d | 50 | 65 | 0.355 | | 0.307 | 0.60 | 2.5 | 1.50 | 0.460 |
| 10 | 37.5 | 0.58 | .8d | 50 | 50 | 0.275 | 0.304 | | | | | |
| | | | .2d | 50 | 61 | 0.333 | | 0.292 | 0.57 | 2.5 | 1.43 | 0.416 |
| 11 | 40.0 | 0.56 | .8d | 50 | 39 | 0.216 | 0.280 | | | | | |
| | | | .2d | 50 | 63 | 0.344 | | 0.247 | 0.57 | 2.5 | 1.43 | 0.352 |
| 12 | 42.5 | 0.58 | .8d | 50 | 34 | 0.189 | 0.213 | | | | | |
| | | | .2d | 50 | 43 | 0.237 | | 0.204 | 0.76 | 2.5 | 1.90 | 0.388 |
| 13 | 45.0 | 0.94 | .8d | 50 | 39 | 0.216 | 0.195 | | | | | |
| | | | .2d | 50 | 31 | 0.173 | | 0.204 | 0.93 | 2.5 | 2.33 | 0.474 |
| 14 | 47.5 | 0.92 | .8d | 50 | 40 | 0.221 | 0.213 | | | | | |
| | | | .2d | 50 | 37 | 0.205 | | 0.225 | 0.85 | 2.5 | 2.11 | 0.476 |
| 15 | 50.0 | 0.77 | .8d | 50 | 42 | 0.232 | 0.237 | | | | | |
| | | | .2d | 50 | 44 | 0.243 | | 0.221 | 0.71 | 2.5 | 1.78 | 0.393 |
| 16 | 52.5 | 0.65 | .8d | 50 | 36 | 0.200 | 0.205 | | | | | |
| | | | .2d | 50 | 38 | 0.211 | | 0.197 | 0.62 | 2.5 | 1.55 | 0.306 |
| 17 | 55.0 | 0.59 | .8d | 50 | 32 | 0.179 | 0.189 | | | | | |
| | | | .2d | 50 | 36 | 0.200 | | 0.176 | 0.55 | 2.5 | 1.36 | 0.240 |
| 18 | 57.5 | 0.50 | .8d | 50 | 32 | 0.179 | 0.163 | | | | | |
| | | | .2d | 50 | 26 | 0.147 | | | | | | |

(cont.)

(cont.)

Jubba at Lugh Ganana 9th March 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 57.5 | 0.50 | .8d | 50 | 32 | 0.179 | 0.163 | | | | | |
| | | | .2d | 50 | 26 | 0.147 | | 0.149 | 0.43 | 2.5 | 1.08 | 0.161 |
| 19 | 60.0 | 0.36 | .8d | 50 | 29 | 0.163 | 0.136 | | | | | |
| | | | .2d | 50 | 19 | 0.109 | | 0.127 | 0.30 | 3.0 | 0.90 | 0.114 |
| 20 | 63.0 | 0.24 | .8d | 50 | 17 | 0.099 | 0.117 | | | | | |
| | | | .2d | 50 | 24 | 0.136 | | 0.059 | 0.12 | 4.1 | 0.49 | 0.029 |
| 21 | 67.1 | 0.00 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 28.46 Total discharge (cumecs) = 7.22 Mean Velocity (m/s) = 0.25

# DISCHARGE MEASUREMENT BY CURRENT METER

Station: Shebelli at Kurten Waarey
Date: 15th March 1989
Method: by Wading
Origin: Left Bank
Observers: Ali (SG observer)/Peter/Kevin/Marian/Ali/Ibrahim
Meter: Braystoke BFM 001 No. 75-306 Impellor No. 8011-503

| | Start | Finish |
|---|---|---|
| Time | 12.30 | 12.40 |
| Stage | 0.50 | 0.50 |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 19.3 | 0.00 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.000 | 0.07 | 0.7 | 0.05 | 0.000 |
| 2 | 20.0 | 0.14 | .6d | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | 0.000 | | 0.147 | 0.28 | 2.0 | 0.56 | 0.082 |
| 3 | 22.0 | 0.42 | .6d | 50 | 54 | 0.296 | 0.293 | | | | | |
| | | | .6d | 50 | 53 | 0.291 | | 0.373 | 0.54 | 2.0 | 1.07 | 0.400 |
| 4 | 24.0 | 0.65 | .6d | 50 | 83 | 0.451 | 0.453 | | | | | |
| | | | .6d | 50 | 84 | 0.456 | | 0.389 | 0.65 | 2.0 | 1.30 | 0.506 |
| 5 | 26.0 | 0.65 | .6d | 50 | 66 | 0.360 | 0.325 | | | | | |
| | | | .6d | 50 | 53 | 0.291 | | 0.277 | 0.48 | 2.0 | 0.95 | 0.263 |
| 6 | 28.0 | 0.30 | .6d | 50 | 43 | 0.237 | 0.229 | | | | | |
| | | | .6d | 50 | 40 | 0.221 | | 0.115 | 0.15 | 1.0 | 0.15 | 0.017 |
| 7 | 29.0 | 0.00 | - | 50 | | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 4.08  Total discharge (cumecs) = 1.27  Mean Velocity (m/s) = 0.31

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | | |
|---|---|---|---|---|---|
| Station: | Jubba at Mogambo | | | Start | Finish |
| Date: | 22nd March 1989 | | | | |
| Method: | Wading | | Time | 1623 | 1715 |
| Origin: | Right Bank | | Stage | 6.60 | 6.58 |
| Observers: | Kevin Sene/Peter Ede/Ahmed | | | | |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | | |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Velocity Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17.5 | 0.00 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.071 | 0.30 | 0.5 | 0.15 | 0.011 |
| 2 | 18.0 | 0.60 | .8d | 50 | 0 | 0.000 | 0.143 | | | | | |
| | | | .2d | 50 | 52 | 0.285 | | 0.223 | 0.65 | 0.7 | 0.45 | 0.102 |
| 3 | 18.7 | 0.70 | .8d | 50 | 34 | 0.189 | 0.304 | | | | | |
| | | | .2d | 50 | 77 | 0.419 | | 0.372 | 0.72 | 0.7 | 0.50 | 0.186 |
| 4 | 19.4 | 0.73 | .8d | 50 | 70 | 0.381 | 0.440 | | | | | |
| | | | .2d | 50 | 92 | 0.499 | | 0.436 | 0.72 | 0.7 | 0.50 | 0.218 |
| 5 | 20.1 | 0.70 | .8d | 50 | 73 | 0.397 | 0.432 | | | | | |
| | | | .2d | 50 | 86 | 0.467 | | 0.405 | 0.73 | 0.7 | 0.51 | 0.206 |
| 6 | 20.8 | 0.75 | .8d | 50 | 59 | 0.323 | 0.379 | | | | | |
| | | | .2d | 50 | 80 | 0.435 | | 0.396 | 0.76 | 0.7 | 0.53 | 0.209 |
| 7 | 21.5 | 0.76 | .8d | 50 | 63 | 0.344 | 0.413 | | | | | |
| | | | .2d | 50 | 89 | 0.483 | | 0.405 | 0.75 | 0.7 | 0.52 | 0.213 |
| 8 | 22.2 | 0.74 | .8d | 50 | 62 | 0.339 | 0.397 | | | | | |
| | | | .2d | 50 | 84 | 0.456 | | 0.404 | 0.70 | 0.8 | 0.56 | 0.225 |
| 9 | 23.0 | 0.65 | .8d | 50 | 70 | 0.381 | 0.411 | | | | | |
| | | | .2d | 50 | 81 | 0.440 | | 0.379 | 0.64 | 0.8 | 0.51 | 0.192 |
| 10 | 23.8 | 0.62 | .8d | 50 | 56 | 0.307 | 0.347 | | | | | |
| | | | .2d | 50 | 71 | 0.387 | | 0.311 | 0.62 | 0.9 | 0.56 | 0.173 |
| 11 | 24.7 | 0.62 | .8d | 50 | 47 | 0.259 | 0.275 | | | | | |
| | | | .2d | 50 | 53 | 0.291 | | 0.223 | 0.57 | 1.1 | 0.63 | 0.140 |
| 12 | 25.8 | 0.52 | .8d | 50 | 31 | 0.173 | 0.171 | | | | | |
| | | | .2d | 50 | 30 | 0.168 | | 0.118 | 0.44 | 1.1 | 0.48 | 0.057 |
| 13 | 26.9 | 0.36 | .6d | 50 | 11 | 0.068 | 0.066 | | | | | |
| | | | .6d | 50 | 10 | 0.063 | | 0.033 | 0.18 | 1.2 | 0.22 | 0.007 |
| 14 | 28.1 | 0.00 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total Area (sq.m) | = | 6.12 | Total discharge (cumecs) = | 1.94 | Mean Velocity (m/s) | = | 0.32 |

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | |
|---|---|---|---|---|
| Station: | Shebelli at Audegle | | Start | Finish |
| Date: | 26th March 1989 | | | |
| Method: | Suspension from bridge (d/s face) with hand line and 10kg weight | Time | 10.10 | 11.25 |
| Origin: | Left Bank | Stage | 2.54 | 2.52 |
| Observers: | Peter/Kevin/Ibrahim/Ahmed | Br. dip | 4.74 | 4.76 |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | |

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.3 | 0.00 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | | | | | 0.111 | 0.32 | 2.0 | 0.63 | 0.070 |
| 2 | 3.3 | 0.63 | .6d | 50 | 38 | 0.211 | 0.221 | | | | | |
| | | | .6d | 50 | 42 | 0.232 | | 0.239 | 0.64 | 1.6 | 1.02 | 0.244 |
| 3 | 4.9 | 0.65 | .6d | 50 | 48 | 0.264 | 0.256 | | | | | |
| | | | .6d | 50 | 45 | 0.248 | | 0.283 | 0.65 | 1.4 | 0.91 | 0.257 |
| 4 | 6.3 | 0.65 | .6d | 50 | 53 | 0.291 | 0.309 | | | | | |
| | | | .6d | 50 | 60 | 0.328 | | 0.339 | 0.74 | 1.7 | 1.25 | 0.423 |
| 5 | 8.0 | 0.82 | .6d | 50 | 67 | 0.365 | 0.368 | | | | | |
| | | | .6d | 50 | 68 | 0.371 | | 0.379 | 0.90 | 1.5 | 1.35 | 0.511 |
| 6 | 9.5 | 0.98 | .6d | 50 | 72 | 0.392 | 0.389 | | | | | |
| | | | .6d | 50 | 71 | 0.387 | | 0.397 | 1.01 | 1.4 | 1.41 | 0.562 |
| 7 | 10.9 | 1.04 | .6d | 50 | 75 | 0.408 | 0.405 | | | | | |
| | | | .6d | 50 | 74 | 0.403 | | 0.412 | 1.07 | 1.5 | 1.60 | 0.658 |
| 8 | 12.4 | 1.09 | .6d | 50 | 77 | 0.419 | 0.419 | | | | | |
| | | | .6d | 50 | 77 | 0.419 | | 0.425 | 1.12 | 1.8 | 2.01 | 0.854 |
| 9 | 14.2 | 1.14 | .6d | 50 | 81 | 0.440 | 0.432 | | | | | |
| | | | .6d | 50 | 78 | 0.424 | | 0.456 | 1.13 | 1.3 | 1.47 | 0.670 |
| 10 | 15.5 | 1.12 | .6d | 50 | 88 | 0.477 | 0.480 | | | | | |
| | | | .6d | 50 | 89 | 0.483 | | 0.463 | 1.15 | 1.9 | 2.18 | 1.011 |
| 11 | 17.4 | 1.18 | .6d | 50 | 85 | 0.461 | 0.445 | | | | | |
| | | | .6d | 50 | 79 | 0.429 | | 0.445 | 1.13 | 1.1 | 1.24 | 0.551 |
| 12 | 18.5 | 1.07 | .6d | 50 | 82 | 0.445 | 0.445 | | | | | |
| | | | .6d | 50 | 82 | 0.445 | | 0.467 | 1.06 | 1.9 | 2.01 | 0.940 |
| 13 | 20.4 | 1.05 | .6d | 50 | 91 | 0.493 | 0.488 | | | | | |
| | | | .6d | 50 | 89 | 0.483 | | 0.473 | 0.98 | 1.3 | 1.27 | 0.600 |
| 14 | 21.7 | 0.90 | .6d | 50 | 84 | 0.456 | 0.459 | | | | | |
| | | | .6d | 50 | 85 | 0.461 | | 0.449 | 0.90 | 1.7 | 1.53 | 0.688 |
| 15 | 23.4 | 0.90 | .6d | 50 | 86 | 0.467 | 0.440 | | | | | |
| | | | .6d | 50 | 76 | 0.413 | | 0.437 | 0.93 | 1.4 | 1.30 | 0.566 |
| 16 | 24.8 | 0.95 | .6d | 50 | 80 | 0.435 | 0.435 | | | | | |
| | | | .6d | 50 | 80 | 0.435 | | 0.399 | 0.85 | 1.6 | 1.35 | 0.539 |
| 17 | 26.4 | 0.74 | .6d | 50 | 65 | 0.355 | 0.363 | | | | | |
| | | | .6d | 50 | 68 | 0.371 | | 0.353 | 0.59 | 1.4 | 0.82 | 0.289 |
| 18 | 27.8 | 0.43 | .6d | 50 | 61 | 0.333 | 0.344 | | | | | |
| | | | .6d | 50 | 65 | 0.355 | | 0.172 | 0.22 | 2.2 | 0.47 | 0.081 |
| 19 | 30.0 | 0.00 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 23.82 Total discharge (cumecs) = 9.52 Mean Velocity (m/s) = 0.40

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | | |
|---|---|---|---|---|---|
| Station: | Shebelli at Bulo Burti | | Start | Finish |
| Date: | 3rd April 1989 | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | Time | 15.10 | 17.20 |
| Origin: | Left Bank | Stage | 2.87 | 2.85 |
| Observers: | Peter Ede/Kevin Sene/Ali/Said | | | |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Velocity Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.9 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.064 | 0.37 | 2.7 | 0.99 | 0.063 |
| 2 | 4.6 | 0.7 | .6d | 50 | 23 | 0.131 | 0.128 | | | | | |
| | | | .6d | 50 | 22 | 0.125 | | 0.407 | 1.01 | 2.2 | 2.22 | 0.904 |
| 3 | 6.8 | 1.3 | .6d | 50 | 126 | 0.680 | 0.685 | | | | | |
| | | | .6d | 50 | 128 | 0.691 | | 0.768 | 1.45 | 1.7 | 2.46 | 1.887 |
| 4 | 8.5 | 1.6 | .8d | 50 | 136 | 0.733 | 0.851 | | | | | |
| | | | .2d | 50 | 180 | 0.968 | | 0.875 | 1.70 | 3.1 | 5.27 | 4.610 |
| 5 | 11.6 | 1.8 | .8d | 50 | 148 | 0.797 | 0.899 | | | | | |
| | | | .2d | 50 | 186 | 1.000 | | 0.936 | 2.00 | 3.0 | 6.00 | 5.617 |
| 6 | 14.6 | 2.2 | .8d | 50 | 172 | 0.925 | 0.973 | | | | | |
| | | | .2d | 50 | 190 | 1.021 | | 0.917 | 2.20 | 2.8 | 6.16 | 5.651 |
| 7 | 17.4 | 2.2 | .8d | 50 | 128 | 0.691 | 0.861 | | | | | |
| | | | .2d | 50 | 192 | 1.032 | | 0.921 | 2.40 | 1.5 | 3.60 | 3.317 |
| 8 | 18.9 | 2.6 | .8d | 50 | 171 | 0.920 | 0.981 | | | | | |
| | | | .2d | 50 | 194 | 1.043 | | 0.987 | 2.65 | 2.9 | 7.69 | 7.583 |
| 9 | 21.8 | 2.7 | .8d | 50 | 171 | 0.920 | 0.992 | | | | | |
| | | | .2d | 50 | 198 | 1.064 | | 0.977 | 2.80 | 2.6 | 7.28 | 7.116 |
| 10 | 24.4 | 2.9 | .8d | 50 | 166 | 0.893 | 0.963 | | | | | |
| | | | .2d | 50 | 192 | 1.032 | | 0.939 | 2.95 | 3.2 | 9.44 | 8.862 |
| 11 | 27.6 | 3.0 | .8d | 50 | 153 | 0.824 | 0.915 | | | | | |
| | | | .2d | 50 | 187 | 1.005 | | 0.943 | 2.85 | 1.5 | 4.28 | 4.030 |
| 12 | 29.1 | 2.7 | .8d | 50 | 170 | 0.915 | 0.971 | | | | | |
| | | | .2d | 50 | 191 | 1.027 | | 0.981 | 2.60 | 2.8 | 7.28 | 7.145 |
| 13 | 31.9 | 2.5 | .8d | 50 | 179 | 0.963 | 0.992 | | | | | |
| | | | .2d | 50 | 190 | 1.021 | | 0.972 | 2.30 | 3.2 | 7.36 | 7.155 |
| 14 | 35.1 | 2.1 | .8d | 50 | 165 | 0.888 | 0.952 | | | | | |
| | | | .2d | 50 | 189 | 1.016 | | 0.899 | 1.80 | 3.0 | 5.40 | 4.853 |
| 15 | 38.1 | 1.5 | .6d | 50 | 157 | 0.845 | 0.845 | | | | | |
| | | | .6d | 50 | 157 | 0.845 | | 0.777 | 1.30 | 1.6 | 2.08 | 1.617 |
| 16 | 39.7 | 1.1 | .6d | 50 | 140 | 0.755 | 0.709 | | | | | |
| | | | .6d | 50 | 123 | 0.664 | | 0.355 | 0.55 | 2.2 | 1.21 | 0.429 |
| 17 | 41.9 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 78.70 Total discharge (cumecs) = 70.84 Mean Velocity (m/s) = 0.90

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | Start | Finish |
|---|---|---|---|---|
| Station: | Jubba at Lugh Ganana | | | |
| Date: | 1st May 1989 | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | Time | 1655 | 1905 |
| Origin: | Left Bank | Stage | 4.70 | 4.76 |
| Observers: | Peter Ede/Kevin Sene/Ahmed | | | |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | (Note: very rapid rise near end, so effective mean = 4.72) | | |

Calculations made by method of mean velocity over section between two verticals. Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10.7 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | | | | | 0.200 | 0.90 | 3.3 | 2.97 | 0.594 |
| 2 | 14.0 | 1.8 | .8d | 50 | 74 | 0.403 | 0.400 | | | | | |
| | | | .2d | 50 | 73 | 0.397 | | 0.517 | 2.20 | 2.0 | 4.40 | 2.277 |
| 3 | 16.0 | 2.6 | .8d | 50 | 114 | 0.616 | 0.635 | | | | | |
| | | | .2d | 50 | 121 | 0.653 | | 0.505 | 3.30 | 4.0 | 13.20 | 6.671 |
| 4 | 20.0 | 4.0 | .8d | 50 | 44 | 0.243 | 0.376 | | | | | |
| | | | .2d | 50 | 94 | 0.509 | | 0.815 | 4.80 | 4.0 | 19.20 | 15.644 |
| 5 | 24.0 | 5.6 | .8d | 50 | 232 | 1.245 | 1.253 | | | | | |
| | | | .2d | 50 | 235 | 1.261 | | 1.207 | 5.65 | 4.0 | 22.60 | 27.274 |
| 6 | 28.0 | 5.7 | .8d | 50 | 154 | 0.829 | 1.160 | | | | | |
| | | | .2d | 50 | 278 | 1.491 | | 1.331 | 6.05 | 4.0 | 24.20 | 32.206 |
| 7 | 32.0 | 6.4 | .8d | 50 | 245 | 1.315 | 1.502 | | | | | |
| | | | .2d | 50 | 315 | 1.688 | | 1.100 | 6.40 | 4.0 | 25.60 | 28.163 |
| 8 | 36.0 | 6.4 | .8d | 50 | 149 | 0.803 | 0.699 | | | | | |
| | | | .2d | 50 | 110 | 0.595 | | 1.072 | 6.80 | 4.0 | 27.20 | 29.162 |
| 9 | 40.0 | 7.2 | .8d | 50 | 214 | 1.149 | 1.446 | | | | | |
| | | | .2d | 50 | 325 | 1.742 | | 1.466 | 7.45 | 4.0 | 29.80 | 43.672 |
| 10 | 44.0 | 7.7 | .8d | 50 | 222 | 1.192 | 1.486 | | | | | |
| | | | .2d | 50 | 332 | 1.779 | | 1.471 | 8.05 | 4.0 | 32.20 | 47.361 |
| 11 | 48.0 | 8.4 | .8d | 50 | 237 | 1.272 | 1.456 | | | | | |
| | | | .2d | 50 | 306 | 1.640 | | 0.781 | 8.15 | 4.0 | 32.60 | 25.475 |
| 12 | 52.0 | 7.9 | .8d | 50 | 59 | 0.323 | 0.107 | | | | | |
| | | | .2d | 50 | -19 | -0.109 | | 0.268 | 8.20 | 4.0 | 32.80 | 8.791 |
| 13 | 56.0 | 8.5 | .8d | 50 | 213 | 1.144 | 0.429 | | | | | |
| | | | .2d | 50 | -52 | -0.285 | | 0.904 | 8.60 | 4.0 | 34.40 | 31.101 |
| 14 | 60.0 | 8.7 | .8d | 50 | 205 | 1.101 | 1.379 | | | | | |
| | | | .2d | 50 | 309 | 1.656 | | 1.372 | 8.35 | 4.0 | 33.40 | 45.830 |
| 15 | 64.0 | 8.0 | .8d | 50 | 208 | 1.117 | 1.366 | | | | | |
| | | | .2d | 50 | 301 | 1.614 | | 1.348 | 7.90 | 4.0 | 31.60 | 42.602 |
| 16 | 68.0 | 7.8 | .8d | 50 | 234 | 1.256 | 1.331 | | | | | |
| | | | .2d | 50 | 262 | 1.406 | | 1.077 | 7.20 | 4.0 | 28.80 | 31.031 |
| 17 | 72.0 | 6.6 | .8d | 50 | 224 | 1.203 | 0.824 | | | | | |
| | | | .2d | 50 | 82 | 0.445 | | 1.129 | 6.80 | 4.0 | 27.20 | 30.722 |
| 18 | 76.0 | 7.0 | .8d | 50 | 230 | 1.235 | 1.435 | | | | | |
| | | | .2d | 50 | 305 | 1.635 | | | | | | |

(cont.)

(cont.)

Jubba at Lugh Ganana 1st May 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 76.0 | 7.0 | .8d | 50 | 230 | 1.235 | 1.435 | | | | | |
| | | | .2d | 50 | 305 | 1.635 | | 1.368 | 7.00 | 4.0 | 28.00 | 38.309 |
| 19 | 80.0 | 7.0 | .8d | 50 | 194 | 1.043 | 1.301 | | | | | |
| | | | .2d | 50 | 291 | 1.560 | | 1.312 | 6.85 | 4.0 | 27.40 | 35.953 |
| 20 | 84.0 | 6.7 | .8d | 50 | 209 | 1.123 | 1.323 | | | | | |
| | | | .2d | 50 | 284 | 1.523 | | 0.811 | 6.45 | 4.0 | 25.80 | 20.918 |
| 21 | 88.0 | 6.2 | .8d | 50 | 140 | 0.755 | 0.299 | | | | | |
| | | | .2d | 50 | -28 | -0.157 | | 0.772 | 6.10 | 4.0 | 24.40 | 18.839 |
| 22 | 92.0 | 6.0 | .8d | 50 | 192 | 1.032 | 1.245 | | | | | |
| | | | .2d | 50 | 272 | 1.459 | | 1.231 | 5.85 | 4.0 | 23.40 | 28.801 |
| 23 | 96.0 | 5.7 | .8d | 50 | 187 | 1.005 | 1.216 | | | | | |
| | | | .2d | 50 | 266 | 1.427 | | 1.221 | 5.90 | 4.0 | 23.60 | 28.827 |
| 24 | 100.0 | 6.1 | .8d | 50 | 218 | 1.171 | 1.227 | | | | | |
| | | | .2d | 50 | 239 | 1.283 | | 0.613 | 5.55 | 4.0 | 22.20 | 13.618 |
| 25 | 104.0 | 5.0 | .8d | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | .2d | 50 | 0 | 0.000 | | 0.635 | 5.00 | 4.0 | 20.00 | 12.695 |
| 26 | 108.0 | 5.0 | .8d | 50 | 212 | 1.139 | 1.269 | | | | | |
| | | | .2d | 50 | 261 | 1.400 | | 1.189 | 4.70 | 4.0 | 18.80 | 22.362 |
| 27 | 112.0 | 4.4 | .8d | 50 | 175 | 0.941 | 1.109 | | | | | |
| | | | .2d | 50 | 238 | 1.277 | | 1.123 | 4.40 | 4.0 | 17.60 | 19.761 |
| 28 | 116.0 | 4.4 | .8d | 50 | 189 | 1.016 | 1.136 | | | | | |
| | | | .2d | 50 | 234 | 1.256 | | 0.936 | 4.25 | 4.0 | 17.00 | 15.914 |
| 29 | 120.0 | 4.1 | .8d | 50 | 95 | 0.515 | 0.736 | | | | | |
| | | | .2d | 50 | 178 | 0.957 | | 0.925 | 4.35 | 4.0 | 17.40 | 16.103 |
| 30 | 124.0 | 4.6 | .8d | 50 | 174 | 0.936 | 1.115 | | | | | |
| | | | .2d | 50 | 241 | 1.293 | | 1.120 | 4.45 | 4.0 | 17.80 | 19.938 |
| 31 | 128.0 | 4.3 | .8d | 50 | 183 | 0.984 | 1.125 | | | | | |
| | | | .2d | 50 | 236 | 1.267 | | 1.136 | 4.50 | 4.0 | 18.00 | 20.451 |
| 32 | 132.0 | 4.7 | .8d | 50 | 198 | 1.064 | 1.147 | | | | | |
| | | | .2d | 50 | 229 | 1.229 | | 0.911 | 3.95 | 4.0 | 15.80 | 14.390 |
| 33 | 136.0 | 3.2 | .8d | 50 | 123 | 0.664 | 0.675 | | | | | |
| | | | .2d | 50 | 127 | 0.685 | | 0.573 | 2.45 | 4.0 | 9.80 | 5.619 |
| 34 | 140.0 | 1.7 | .8d | 50 | 92 | 0.499 | 0.472 | | | | | |
| | | | .2d | 50 | 82 | 0.445 | | 0.236 | 0.85 | 5.3 | 4.51 | 1.063 |
| 35 | 145.3 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 753.68 Total discharge (cumecs) = 782.14 Mean Velocity (m/s) = 1.04

Note: At verticals 12, 13 and 21 the direction of flow was not clear because of eddies caused by debris round the upstream bridge pillars. It is thought that this affects the flow primarily near the surface, with the effect similar to that of an undershot sluice gate.

The negative values for flow at 0.2 x depth represent the observers' best estimate of actual conditions.

In practice the flow may have been partially sideways and/or vertical

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | |
|---|---|---|---|---|
| Station: | Jubba at Lugh Ganana | | Start | Finish |
| Date: | 2nd May 1989 | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | Time | 0750 | 1010 |
| Origin: | Left Bank | Stage | 5.00 | 4.99 |
| Observers: | Peter Ede/Kevin Sene/Ahmed | | | |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | |

Calculations made by method of mean velocity over section between two verticals.

Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Velocity Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10.2 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | | | | | 0.192 | 0.70 | 2.8 | 1.96 | 0.376 |
| 2 | 13.0 | 1.4 | .6d | 50 | 67 | 0.365 | 0.384 | | | | | |
| | | | .6d | 50 | 74 | 0.403 | | 0.556 | 2.15 | 3.0 | 6.45 | 3.587 |
| 3 | 16.0 | 2.9 | .8d | 50 | 123 | 0.664 | 0.728 | | | | | |
| | | | .2d | 50 | 147 | 0.792 | | 0.588 | 3.65 | 4.0 | 14.60 | 8.586 |
| 4 | 20.0 | 4.4 | .8d | 50 | 47 | 0.259 | 0.448 | | | | | |
| | | | .2d | 50 | 118 | 0.637 | | 0.864 | 5.20 | 4.0 | 20.80 | 17.973 |
| 5 | 24.0 | 6.0 | .8d | 50 | 217 | 1.165 | 1.280 | | | | | |
| | | | .2d | 50 | 260 | 1.395 | | 1.252 | 6.00 | 4.0 | 24.00 | 30.052 |
| 6 | 28.0 | 6.0 | .8d | 50 | 158 | 0.851 | 1.224 | | | | | |
| | | | .2d | 50 | 298 | 1.598 | | 1.436 | 6.35 | 4.0 | 25.40 | 36.479 |
| 7 | 32.0 | 6.7 | .8d | 50 | 272 | 1.459 | 1.648 | | | | | |
| | | | .2d | 50 | 343 | 1.838 | | 1.281 | 6.60 | 4.0 | 26.40 | 33.831 |
| 8 | 36.0 | 6.5 | .8d | 50 | 183 | 0.984 | 0.915 | | | | | |
| | | | .2d | 50 | 157 | 0.845 | | 1.283 | 6.95 | 4.0 | 27.80 | 35.663 |
| 9 | 40.0 | 7.4 | .8d | 50 | 267 | 1.432 | 1.651 | | | | | |
| | | | .2d | 50 | 349 | 1.870 | | 1.615 | 7.75 | 4.0 | 31.00 | 50.061 |
| 10 | 44.0 | 8.1 | .8d | 50 | 244 | 1.309 | 1.579 | | | | | |
| | | | .2d | 50 | 345 | 1.848 | | 1.638 | 8.30 | 4.0 | 33.20 | 54.366 |
| 11 | 48.0 | 8.5 | .8d | 50 | 284 | 1.523 | 1.696 | | | | | |
| | | | .2d | 50 | 349 | 1.870 | | 0.905 | 8.55 | 4.0 | 34.20 | 30.966 |
| 12 | 52.0 | 8.6 | .8d | 50 | 80 | 0.435 | 0.115 | | | | | |
| | | | .2d | 50 | -37 | -0.205 | | 0.296 | 8.50 | 4.0 | 34.00 | 10.065 |
| 13 | 56.0 | 8.4 | .8d | 50 | 217 | 1.165 | 0.477 | | | | | |
| | | | .2d | 50 | -38 | -0.211 | | 0.979 | 8.85 | 4.0 | 35.40 | 34.649 |
| 14 | 60.0 | 9.3 | .8d | 50 | 235 | 1.261 | 1.480 | | | | | |
| | | | .2d | 50 | 317 | 1.699 | | 1.488 | 9.15 | 4.0 | 36.60 | 54.468 |
| 15 | 64.0 | 9.0 | .8d | 50 | 233 | 1.251 | 1.496 | | | | | |
| | | | .2d | 50 | 325 | 1.742 | | 1.311 | 8.60 | 4.0 | 34.40 | 45.093 |
| 16 | 68.0 | 8.2 | .8d | 50 | 269 | 1.443 | 1.125 | | | | | |
| | | | .2d | 50 | 150 | 0.808 | | 0.807 | 7.60 | 4.0 | 30.40 | 24.526 |
| 17 | 72.0 | 7.0 | .8d | 50 | 232 | 1.245 | 0.488 | | | | | |
| | | | .2d | 50 | -49 | -0.269 | | 0.984 | 7.30 | 4.0 | 29.20 | 28.736 |
| 18 | 76.0 | 7.6 | .8d | 50 | 228 | 1.224 | 1.480 | | | | | |
| | | | .2d | 50 | 324 | 1.736 | | | | | | |

(cont.)

(cont.)

Jubba at Lugh Ganana 2nd May 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 76.0 | 7.6 | .8d | 50 | 228 | 1.224 | 1.480 | | | | | |
| | | | .2d | 50 | 324 | 1.736 | | 1.438 | 7.50 | 4.0 | 30.00 | 43.125 |
| 19 | 80.0 | 7.4 | .8d | 50 | 213 | 1.144 | 1.395 | | | | | |
| | | | .2d | 50 | 307 | 1.646 | | 1.452 | 7.10 | 4.0 | 28.40 | 41.242 |
| 20 | 84.0 | 6.8 | .8d | 50 | 259 | 1.390 | 1.510 | | | | | |
| | | | .2d | 50 | 304 | 1.630 | | 0.981 | 6.40 | 4.0 | 25.60 | 25.125 |
| 21 | 88.0 | 6.0 | .8d | 50 | 188 | 1.011 | 0.453 | | | | | |
| | | | .2d | 50 | -18 | -0.104 | | 0.917 | 6.10 | 4.0 | 24.40 | 22.386 |
| 22 | 92.0 | 6.2 | .8d | 50 | 222 | 1.192 | 1.382 | | | | | |
| | | | .2d | 50 | 293 | 1.571 | | 1.337 | 6.05 | 4.0 | 24.20 | 32.367 |
| 23 | 96.0 | 5.9 | .8d | 50 | 208 | 1.117 | 1.293 | | | | | |
| | | | .2d | 50 | 274 | 1.470 | | 1.339 | 6.10 | 4.0 | 24.40 | 32.668 |
| 24 | 100.0 | 6.3 | .8d | 50 | 231 | 1.240 | 1.384 | | | | | |
| | | | .2d | 50 | 285 | 1.528 | | 0.583 | 5.75 | 4.0 | 23.00 | 13.403 |
| 25 | 104.0 | 5.2 | .8d | 50 | -31 | -0.173 | -0.219 | | | | | |
| | | | .2d | 50 | -48 | -0.264 | | 0.536 | 5.20 | 4.0 | 20.80 | 11.150 |
| 26 | 108.0 | 5.2 | .8d | 50 | 215 | 1.155 | 1.291 | | | | | |
| | | | .2d | 50 | 266 | 1.427 | | 1.279 | 4.95 | 4.0 | 19.80 | 25.321 |
| 27 | 112.0 | 4.7 | .8d | 50 | 217 | 1.165 | 1.267 | | | | | |
| | | | .2d | 50 | 255 | 1.368 | | 1.247 | 4.65 | 4.0 | 18.60 | 23.191 |
| 28 | 116.0 | 4.6 | .8d | 50 | 203 | 1.091 | 1.227 | | | | | |
| | | | .2d | 50 | 254 | 1.363 | | 1.001 | 4.45 | 4.0 | 17.80 | 17.826 |
| 29 | 120.0 | 4.3 | .8d | 50 | 113 | 0.611 | 0.776 | | | | | |
| | | | .2d | 50 | 175 | 0.941 | | 0.971 | 4.50 | 4.0 | 18.00 | 17.474 |
| 30 | 124.0 | 4.7 | .8d | 50 | 188 | 1.011 | 1.165 | | | | | |
| | | | .2d | 50 | 246 | 1.320 | | 1.163 | 4.70 | 4.0 | 18.80 | 21.861 |
| 31 | 128.0 | 4.7 | .8d | 50 | 191 | 1.027 | 1.160 | | | | | |
| | | | .2d | 50 | 241 | 1.293 | | 1.176 | 4.85 | 4.0 | 19.40 | 22.817 |
| 32 | 132.0 | 5.0 | .8d | 50 | 202 | 1.085 | 1.192 | | | | | |
| | | | .2d | 50 | 242 | 1.299 | | 0.893 | 4.15 | 4.0 | 16.60 | 14.831 |
| 33 | 136.0 | 3.3 | .8d | 50 | 115 | 0.621 | 0.595 | | | | | |
| | | | .2d | 50 | 105 | 0.568 | | 0.542 | 2.05 | 7.0 | 14.35 | 7.782 |
| 34 | 140.0 | 2.1 | .8d | 50 | 105 | 0.568 | 0.549 | | | | | |
| | | | .2d | 50 | 98 | 0.531 | | 0.516 | 1.45 | 3.0 | 4.35 | 2.245 |
| 35 | 143.0 | 0.8 | .6d | 50 | 89 | 0.483 | 0.483 | | | | | |
| | | | .6d | 50 | 89 | 0.483 | | 0.241 | 0.40 | 3.2 | 1.28 | 0.309 |
| 36 | 146.2 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 795.59 Total discharge (cumecs) = 874.60 Mean Velocity (m/s) = 1.10

Note: At verticals 12, 13, 16, 17 and 21 the direction of flow was not clear because of eddies caused by debris round the upstream bridge pillars. It is thought that this affects the flow primarily near the surface, with the effect similar to that of an undershot sluice gate.

The negative values for flow at 0.2 x depth represent the observers' best estimate of actual conditions.

In practice the flow may have been partially sideways and/or vertical

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | |
|---|---|---|---|---|
| Station: | Shebelli at Afgoi | | Start | Finish |
| Date: | 9th May 1989 | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | Time | 1020 | 1135 |
| Origin: | Left Bank | Stage | 5.31 | 5.31 |
| Observers: | Peter Ede/Terry Evans/Ibrahim/Ahmed | | | |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | |

Calculations made by method of mean velocity over section between two verticals.

Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Velocity Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.037 | 1.00 | 2.0 | 2.00 | 0.073 |
| 2 | 2.0 | 2.0 | .8d | 50 | 8 | 0.053 | 0.073 | | | | | |
| | | | .2d | 50 | 16 | 0.093 | | 0.201 | 2.25 | 2.0 | 4.50 | 0.903 |
| 3 | 4.0 | 2.5 | .8d | 50 | 78 | 0.424 | 0.328 | | | | | |
| | | | .2d | 50 | 42 | 0.232 | | 0.421 | 2.80 | 2.0 | 5.60 | 2.360 |
| 4 | 6.0 | 3.1 | .8d | 50 | 117 | 0.632 | 0.515 | | | | | |
| | | | .2d | 50 | 73 | 0.397 | | 0.601 | 3.15 | 2.0 | 6.30 | 3.789 |
| 5 | 8.0 | 3.2 | .8d | 50 | 128 | 0.691 | 0.688 | | | | | |
| | | | .2d | 50 | 127 | 0.685 | | 0.736 | 3.45 | 2.0 | 6.90 | 5.079 |
| 6 | 10.0 | 3.7 | .8d | 50 | 145 | 0.781 | 0.784 | | | | | |
| | | | .2d | 50 | 146 | 0.787 | | 0.777 | 4.00 | 2.0 | 8.00 | 6.219 |
| 7 | 12.0 | 4.3 | .8d | 50 | 129 | 0.696 | 0.771 | | | | | |
| | | | .2d | 50 | 157 | 0.845 | | 0.756 | 4.35 | 2.0 | 8.70 | 6.578 |
| 8 | 14.0 | 4.4 | .8d | 50 | 119 | 0.643 | 0.741 | | | | | |
| | | | .2d | 50 | 156 | 0.840 | | 0.635 | 4.50 | 2.0 | 9.00 | 5.713 |
| 9 | 16.0 | 4.6 | .8d | 50 | 86 | 0.467 | 0.528 | | | | | |
| | | | .2d | 50 | 109 | 0.589 | | 0.637 | 4.80 | 2.0 | 9.60 | 6.119 |
| 10 | 18.0 | 5.0 | .8d | 50 | 129 | 0.696 | 0.747 | | | | | |
| | | | .2d | 50 | 148 | 0.797 | | 0.817 | 5.00 | 2.0 | 10.00 | 8.174 |
| 11 | 20.0 | 5.0 | .8d | 50 | 149 | 0.803 | 0.888 | | | | | |
| | | | .2d | 50 | 181 | 0.973 | | 0.868 | 5.00 | 2.0 | 10.00 | 8.681 |
| 12 | 22.0 | 5.0 | .8d | 50 | 126 | 0.680 | 0.848 | | | | | |
| | | | .2d | 50 | 189 | 1.016 | | 0.716 | 4.95 | 2.0 | 9.90 | 7.089 |
| 13 | 24.0 | 4.9 | .8d | 50 | 66 | 0.360 | 0.584 | | | | | |
| | | | .2d | 50 | 150 | 0.808 | | 0.504 | 4.70 | 2.0 | 9.40 | 4.738 |
| 14 | 26.0 | 4.5 | .8d | 50 | 63 | 0.344 | 0.424 | | | | | |
| | | | .2d | 50 | 93 | 0.504 | | 0.373 | 4.65 | 2.0 | 9.30 | 3.472 |
| 15 | 28.0 | 4.8 | .8d | 50 | 88 | 0.477 | 0.323 | | | | | |
| | | | .2d | 50 | 30 | 0.168 | | 0.456 | 4.80 | 2.0 | 9.60 | 4.378 |
| 16 | 30.0 | 4.8 | .8d | 50 | 118 | 0.637 | 0.589 | | | | | |
| | | | .2d | 50 | 100 | 0.541 | | 0.609 | 4.80 | 2.0 | 9.60 | 5.850 |
| 17 | 32.0 | 4.8 | .8d | 50 | 90 | 0.488 | 0.629 | | | | | |
| | | | .2d | 50 | 143 | 0.771 | | 0.579 | 4.75 | 2.0 | 9.50 | 5.498 |
| 18 | 34.0 | 4.7 | .8d | 50 | 90 | 0.488 | 0.528 | | | | | |
| | | | .2d | 50 | 105 | 0.568 | | | | | | |

(cont.)

(cont.)

Shebelli at Afgoi 9th May 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 34.0 | 4.7 | .8d | 50 | 90 | 0.488 | 0.528 | | | | | |
| | | | .2d | 50 | 105 | 0.568 | | 0.425 | 4.10 | 1.7 | 6.97 | 2.965 |
| 19 | 35.7 | 3.5 | .8d | 50 | 63 | 0.344 | 0.323 | | | | | |
| | | | .2d | 50 | 55 | 0.301 | | 0.309 | 2.55 | 1.6 | 4.08 | 1.262 |
| 20 | 37.3 | 1.6 | .8d | 50 | 54 | 0.296 | 0.296 | | | | | |
| | | | .2d | 50 | 54 | 0.296 | | 0.148 | 0.80 | 1.5 | 1.20 | 0.178 |
| 21 | 38.8 | 0.0 | - | 50 | | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 150.15 Total discharge (cumecs) = 89.12 Mean Velocity (m/s) = 0.59

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | |
|---|---|---|---|---|
| Station: | Jubba at Kamsuma | | Start | Finish |
| Date: | 11th May 1989 | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | Time | 1030 | 1205 |
| Origin: | Right Bank | Stage | 6.30 | 6.30 |
| Observers: | Peter Ede/Terry Evans/Ali/Ibrahim | | | |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | |

Calculations made by method of mean velocity over section between two verticals.

Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.0 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.444 | 2.45 | 6.0 | 14.70 | 6.528 |
| 2 | 12.0 | 4.9 | .8d | 50 | 92 | 0.499 | 0.888 | | | | | |
| | | | .2d | 50 | 238 | 1.277 | | 1.139 | 6.40 | 4.0 | 25.60 | 29.153 |
| 3 | 16.0 | 7.9 | .8d | 50 | 240 | 1.288 | 1.390 | | | | | |
| | | | .2d | 50 | 278 | 1.491 | | 1.404 | 7.65 | 4.0 | 30.60 | 42.968 |
| 4 | 20.0 | 7.4 | .8d | 50 | 245 | 1.315 | 1.419 | | | | | |
| | | | .2d | 50 | 284 | 1.523 | | 1.291 | 7.40 | 4.0 | 29.60 | 38.208 |
| 5 | 24.0 | 7.4 | .8d | 50 | 155 | 0.835 | 1.163 | | | | | |
| | | | .2d | 50 | 278 | 1.491 | | 0.649 | 7.50 | 4.0 | 30.00 | 19.482 |
| 6 | 28.0 | 7.6 | .8d | 50 | 23 | 0.131 | 0.136 | | | | | |
| | | | .2d | 50 | 25 | 0.141 | | 0.859 | 7.90 | 4.0 | 31.60 | 27.137 |
| 7 | 32.0 | 8.2 | .8d | 50 | 274 | 1.470 | 1.582 | | | | | |
| | | | .2d | 50 | 316 | 1.694 | | 1.503 | 8.10 | 4.0 | 32.40 | 48.692 |
| 8 | 36.0 | 8.0 | .8d | 50 | 240 | 1.288 | 1.424 | | | | | |
| | | | .2d | 50 | 291 | 1.560 | | 1.400 | 8.15 | 4.0 | 32.60 | 45.646 |
| 9 | 40.0 | 8.3 | .8d | 50 | 243 | 1.304 | 1.376 | | | | | |
| | | | .2d | 50 | 270 | 1.448 | | 1.339 | 8.15 | 4.0 | 32.60 | 43.646 |
| 10 | 44.0 | 8.0 | .8d | 50 | 219 | 1.176 | 1.301 | | | | | |
| | | | .2d | 50 | 266 | 1.427 | | 1.071 | 7.15 | 4.0 | 28.60 | 30.625 |
| 11 | 48.0 | 6.3 | .8d | 50 | 128 | 0.691 | 0.840 | | | | | |
| | | | .2d | 50 | 184 | 0.989 | | 1.012 | 6.20 | 4.0 | 24.80 | 25.101 |
| 12 | 52.0 | 6.1 | .8d | 50 | 200 | 1.075 | 1.184 | | | | | |
| | | | .2d | 50 | 241 | 1.293 | | 1.152 | 6.05 | 4.0 | 24.20 | 27.882 |
| 13 | 56.0 | 6.0 | .8d | 50 | 192 | 1.032 | 1.120 | | | | | |
| | | | .2d | 50 | 225 | 1.208 | | 1.061 | 6.00 | 4.0 | 24.00 | 25.475 |
| 14 | 60.0 | 6.0 | .8d | 50 | 157 | 0.845 | 1.003 | | | | | |
| | | | .2d | 50 | 216 | 1.160 | | 1.044 | 5.90 | 4.0 | 23.60 | 24.641 |
| 15 | 64.0 | 5.8 | .8d | 50 | 178 | 0.957 | 1.085 | | | | | |
| | | | .2d | 50 | 226 | 1.213 | | 0.969 | 5.80 | 4.0 | 23.20 | 22.491 |
| 16 | 68.0 | 5.8 | .8d | 50 | 154 | 0.829 | 0.853 | | | | | |
| | | | .2d | 50 | 163 | 0.877 | | 0.851 | 5.70 | 4.0 | 22.80 | 19.398 |
| 17 | 72.0 | 5.6 | .8d | 50 | 139 | 0.749 | 0.848 | | | | | |
| | | | .2d | 50 | 176 | 0.947 | | 0.804 | 5.05 | 4.0 | 20.20 | 16.243 |
| 18 | 76.0 | 4.5 | .8d | 50 | 126 | 0.680 | 0.760 | | | | | |
| | | | .2d | 50 | 156 | 0.840 | | | | | | |

(cont.)

(cont.)

Jubba at Kamsuma 11th May 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 76.0 | 4.5 | .8d | 50 | 126 | 0.680 | 0.760 | | | | | |
| | | | .2d | 50 | 156 | 0.840 | | 0.668 | 4.40 | 4.0 | 17.60 | 11.758 |
| 19 | 80.0 | 4.3 | .8d | 50 | 110 | 0.595 | 0.576 | | | | | |
| | | | .2d | 50 | 103 | 0.557 | | 0.404 | 3.95 | 4.0 | 15.80 | 6.384 |
| 20 | 84.0 | 3.6 | .8d | 50 | 58 | 0.317 | 0.232 | | | | | |
| | | | .2d | 50 | 26 | 0.147 | | 0.116 | 1.80 | 7.7 | 13.86 | 1.608 |
| 21 | 91.7 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 498.36 Total discharge (cumecs) = 513.07 Mean Velocity (m/s) = 1.03

# DISCHARGE MEASUREMENT BY CURRENT METER

| | |
|---|---|
| Station: | Flood Relief Canal, Mogambo Irrigation Project |
| Date: | 11th May 1989 |
| Method: | Suspension from bridge (u/s face) with 25kg weight |
| Origin: | Right Bank |
| Observers: | Peter Ede/Terry Evans |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 |

| | Start | Finish |
|---|---|---|
| Time | 1300 | 1345 |

Dip 2.62 m from deck level at expansion joint towards right bank on upstream side.

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.1 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.000 | 0.45 | 5.9 | 2.66 | 0.000 |
| 2 | 10.0 | 0.9 | .6d | 50 | | 0.000 | 0.000 | | | | | |
| | | | | 50 | | 0.000 | | 0.229 | 1.05 | 5.0 | 5.25 | 1.204 |
| 3 | 15.0 | 1.2 | .6d | 50 | 91 | 0.493 | 0.459 | | | | | |
| | | | .6d | 50 | 78 | 0.424 | | 0.473 | 1.25 | 5.0 | 6.25 | 2.959 |
| 4 | 20.0 | 1.3 | .6d | 50 | 88 | 0.477 | 0.488 | | | | | |
| | | | .6d | 50 | 92 | 0.499 | | 0.524 | 1.30 | 5.0 | 6.50 | 3.406 |
| 5 | 25.0 | 1.3 | .6d | 50 | 105 | 0.568 | 0.560 | | | | | |
| | | | .6d | 50 | 102 | 0.552 | | 0.540 | 1.30 | 5.0 | 6.50 | 3.510 |
| 6 | 30.0 | 1.3 | .6d | 50 | 93 | 0.504 | 0.520 | | | | | |
| | | | .6d | 50 | 99 | 0.536 | | 0.523 | 1.35 | 5.0 | 6.75 | 3.528 |
| 7 | 35.0 | 1.4 | .6d | 50 | 90 | 0.488 | 0.525 | | | | | |
| | | | .6d | 50 | 104 | 0.563 | | 0.520 | 1.45 | 5.0 | 7.25 | 3.770 |
| 8 | 40.0 | 1.5 | .6d | 50 | 97 | 0.525 | 0.515 | | | | | |
| | | | .6d | 50 | 93 | 0.504 | | 0.523 | 1.35 | 5.0 | 6.75 | 3.528 |
| 9 | 45.0 | 1.2 | .6d | 50 | 99 | 0.536 | 0.531 | | | | | |
| | | | .6d | 50 | 97 | 0.525 | | 0.547 | 1.25 | 5.0 | 6.25 | 3.417 |
| 10 | 50.0 | 1.3 | .6d | 50 | 102 | 0.552 | 0.563 | | | | | |
| | | | .6d | 50 | 106 | 0.573 | | 0.563 | 1.25 | 5.0 | 6.25 | 3.517 |
| 11 | 55.0 | 1.2 | .6d | 50 | 112 | 0.605 | 0.563 | | | | | |
| | | | .6d | 50 | 96 | 0.520 | | 0.536 | 1.20 | 5.0 | 6.00 | 3.216 |
| 12 | 60.0 | 1.2 | .6d | 50 | 95 | 0.515 | 0.509 | | | | | |
| | | | .6d | 50 | 93 | 0.504 | | 0.528 | 1.00 | 5.0 | 5.00 | 2.640 |
| 13 | 65.0 | 0.8 | .6d | 50 | 104 | 0.563 | 0.547 | | | | | |
| | | | .6d | 50 | 98 | 0.531 | | 0.460 | 0.70 | 5.0 | 3.50 | 1.610 |
| 14 | 70.0 | 0.6 | (.6d) | 50 | 67 | 0.365 | 0.373 | | | | | |
| | | | (.6d) | 50 | 70 | 0.381 | | 0.187 | 0.30 | 4.3 | 1.29 | 0.241 |
| 15 | 74.3 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 76.20 Total discharge (cumecs) = 36.55 Mean Velocity (m/s) = 0.48

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | | |
|---|---|---|---|---|---|
| Station: | Jubba at Jamamme | | | Start | Finish |
| Date: | 11th May 1989 | | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | | Time | 1625 | 1750 |
| Origin: | Left Bank | | Br. dip | 4.28 | 4.27 |
| Observers: | Peter Ede/Terry Evans/Ali/Ibrahim | | Equiv. SG | 6.76 | 6.77 |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | | |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.1 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.391 | 2.80 | 6.5 | 18.20 | 7.111 |
| 2 | 13.6 | 5.6 | .8d | 50 | 158 | 0.851 | 0.781 | | | | | |
| | | | .2d | 50 | 132 | 0.712 | | 0.843 | 5.90 | 2.7 | 15.93 | 13.425 |
| 3 | 16.3 | 6.2 | .8d | 50 | 181 | 0.973 | 0.904 | | | | | |
| | | | .2d | 50 | 155 | 0.835 | | 0.997 | 6.90 | 5.0 | 34.50 | 34.412 |
| 4 | 21.3 | 7.6 | .8d | 50 | 208 | 1.117 | 1.091 | | | | | |
| | | | .2d | 50 | 198 | 1.064 | | 1.108 | 7.90 | 5.1 | 40.29 | 44.647 |
| 5 | 26.4 | 8.2 | .8d | 50 | 193 | 1.037 | 1.125 | | | | | |
| | | | .2d | 50 | 226 | 1.213 | | 1.135 | 8.35 | 5.1 | 42.59 | 48.326 |
| 6 | 31.5 | 8.5 | .8d | 50 | 197 | 1.059 | 1.144 | | | | | |
| | | | .2d | 50 | 229 | 1.229 | | 1.148 | 8.45 | 5.2 | 43.94 | 50.449 |
| 7 | 36.7 | 8.4 | .8d | 50 | 196 | 1.053 | 1.152 | | | | | |
| | | | .2d | 50 | 233 | 1.251 | | 1.140 | 7.95 | 5.2 | 41.34 | 47.133 |
| 8 | 41.9 | 7.5 | .8d | 50 | 195 | 1.048 | 1.128 | | | | | |
| | | | .2d | 50 | 225 | 1.208 | | 1.144 | 7.15 | 5.1 | 36.47 | 41.721 |
| 9 | 47.0 | 6.8 | .8d | 50 | 187 | 1.005 | 1.160 | | | | | |
| | | | .2d | 50 | 245 | 1.315 | | 1.157 | 6.80 | 5.2 | 35.36 | 40.928 |
| 10 | 52.2 | 6.8 | .8d | 50 | 187 | 1.005 | 1.155 | | | | | |
| | | | .2d | 50 | 243 | 1.304 | | 1.125 | 6.65 | 5.0 | 33.25 | 37.422 |
| 11 | 57.2 | 6.5 | .8d | 50 | 188 | 1.011 | 1.096 | | | | | |
| | | | .2d | 50 | 220 | 1.181 | | 0.961 | 6.50 | 5.4 | 35.10 | 33.747 |
| 12 | 62.6 | 6.5 | .8d | 50 | 160 | 0.861 | 0.827 | | | | | |
| | | | .2d | 50 | 147 | 0.792 | | 0.644 | 6.15 | 3.9 | 23.98 | 15.448 |
| 13 | 66.5 | 5.8 | .8d | 50 | 86 | 0.467 | 0.461 | | | | | |
| | | | .2d | 50 | 84 | 0.456 | | 0.231 | 2.90 | 5.9 | 17.11 | 3.947 |
| 14 | 72.4 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Total Area (sq.m) | = | 418.06 | Total discharge (cumecs) = | 418.72 | Mean Velocity (m/s) | = | 1.00 |

# DISCHARGE MEASUREMENT BY CURRENT METER

Station: Shebelli at Afgoi
Date: 28th May 1989
Method: Suspension from bridge (d/s face) with 25kg weight
Origin: Left Bank
Observers: Ali/Ibrahim/Peter Ede/Ahmed
Meter: Braystoke BFM 001 No. 75-880 Impellor No. 8011-1247

| | Start | Finish |
|---|---|---|
| Time | 1015 | 1145 |
| Stage | 5.48 | 5.47 |

Calculations made by method of mean velocity over section between two verticals.

Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | | | | | 0.017 | 0.95 | 2.0 | 1.90 | 0.032 |
| 2 | 2.0 | 1.9 | .8d | 50 | 0 | 0.000 | 0.034 | | | | | |
| | | | .2d | 50 | 11 | 0.068 | | 0.169 | 2.30 | 2.0 | 4.60 | 0.778 |
| 3 | 4.0 | 2.7 | .8d | 50 | 73 | 0.397 | 0.304 | | | | | |
| | | | .2d | 50 | 38 | 0.211 | | 0.404 | 3.00 | 2.0 | 6.00 | 2.424 |
| 4 | 6.0 | 3.3 | .8d | 50 | 122 | 0.659 | 0.504 | | | | | |
| | | | .2d | 50 | 64 | 0.349 | | 0.576 | 3.40 | 2.0 | 6.80 | 3.917 |
| 5 | 8.0 | 3.5 | .8d | 50 | 129 | 0.696 | 0.648 | | | | | |
| | | | .2d | 50 | 111 | 0.600 | | 0.719 | 3.75 | 2.0 | 7.50 | 5.391 |
| 6 | 10.0 | 4.0 | .8d | 50 | 143 | 0.771 | 0.789 | | | | | |
| | | | .2d | 50 | 150 | 0.808 | | 0.784 | 4.30 | 2.0 | 8.60 | 6.743 |
| 7 | 12.0 | 4.6 | .8d | 50 | 130 | 0.701 | 0.779 | | | | | |
| | | | .2d | 50 | 159 | 0.856 | | 0.743 | 4.55 | 2.0 | 9.10 | 6.759 |
| 8 | 14.0 | 4.5 | .8d | 50 | 106 | 0.573 | 0.707 | | | | | |
| | | | .2d | 50 | 156 | 0.840 | | 0.615 | 4.65 | 2.0 | 9.30 | 5.717 |
| 9 | 16.0 | 4.8 | .8d | 50 | 76 | 0.413 | 0.523 | | | | | |
| | | | .2d | 50 | 117 | 0.632 | | 0.692 | 4.95 | 2.0 | 9.90 | 6.852 |
| 10 | 18.0 | 5.1 | .8d | 50 | 155 | 0.835 | 0.861 | | | | | |
| | | | .2d | 50 | 165 | 0.888 | | 0.879 | 5.05 | 2.0 | 10.10 | 8.876 |
| 11 | 20.0 | 5.0 | .8d | 50 | 146 | 0.787 | 0.896 | | | | | |
| | | | .2d | 50 | 187 | 1.005 | | 0.868 | 5.10 | 2.0 | 10.20 | 8.855 |
| 12 | 22.0 | 5.2 | .8d | 50 | 126 | 0.680 | 0.840 | | | | | |
| | | | .2d | 50 | 186 | 1.000 | | 0.752 | 5.00 | 2.0 | 10.00 | 7.521 |
| 13 | 24.0 | 4.8 | .8d | 50 | 66 | 0.360 | 0.664 | | | | | |
| | | | .2d | 50 | 180 | 0.968 | | 0.607 | 4.80 | 2.0 | 9.60 | 5.825 |
| 14 | 26.0 | 4.8 | .8d | 50 | 85 | 0.461 | 0.549 | | | | | |
| | | | .2d | 50 | 118 | 0.637 | | 0.544 | 4.95 | 2.0 | 9.90 | 5.386 |
| 15 | 28.0 | 5.1 | .8d | 50 | 108 | 0.584 | 0.539 | | | | | |
| | | | .2d | 50 | 91 | 0.493 | | 0.627 | 5.00 | 2.0 | 10.00 | 6.267 |
| 16 | 30.0 | 4.9 | .8d | 50 | 109 | 0.589 | 0.715 | | | | | |
| | | | .2d | 50 | 156 | 0.840 | | 0.655 | 4.80 | 2.0 | 9.60 | 6.286 |
| 17 | 32.0 | 4.7 | .8d | 50 | 81 | 0.440 | 0.595 | | | | | |
| | | | .2d | 50 | 139 | 0.749 | | 0.441 | 4.55 | 2.0 | 9.10 | 4.017 |
| 18 | 34.0 | 4.4 | .8d | 50 | 48 | 0.264 | 0.288 | | | | | |
| | | | .2d | 50 | 57 | 0.312 | | | | | | |

(cont.)

(cont.)

Shebelli at Afgoi 28th May 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 34.0 | 4.4 | .8d | 50 | 48 | 0.264 | 0.288 | | | | | |
| | | | .2d | 50 | 57 | 0.312 | | 0.293 | 2.95 | 1.7 | 5.02 | 1.471 |
| 19 | 35.7 | 1.5 | .6d | 50 | 54 | 0.296 | 0.299 | | | | | |
| | | | .6d | 50 | 55 | 0.301 | | 0.228 | 1.35 | 1.6 | 2.16 | 0.493 |
| 20 | 37.3 | 1.2 | .6d | 50 | 30 | 0.168 | 0.157 | | | | | |
| | | | .6d | 50 | 26 | 0.147 | | 0.079 | 0.60 | 1.5 | 0.90 | 0.071 |
| 21 | 38.8 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 150.28 Total discharge (cumecs) = 93.68 Mean Velocity (m/s) = 0.62

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | |
|---|---|---|---|---|
| Station: | Shebelli at Mahaddey Weyn | | Start | Finish |
| Date: | 30th May 1989 | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | Time | 1140 | 1305 |
| Origin: | Left bank | Stage | 5.35 | 5.34 |
| Observers: | Peter Ede/Ibrahim/Ahmed/Marian | | | |
| Meter: | Braystoke BFM 001 No. 75-880 Impellor No. 8011-1247 | | | |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.055 | 2.00 | 2.8 | 5.60 | 0.308 |
| 2 | 2.8 | 4.0 | .8d | 50 | 26 | 0.147 | 0.110 | | | | | |
| | | | .2d | 50 | 12 | 0.073 | | 0.430 | 4.40 | 2.1 | 9.24 | 3.970 |
| 3 | 4.9 | 4.8 | .8d | 50 | 135 | 0.728 | 0.749 | | | | | |
| | | | .2d | 50 | 143 | 0.771 | | 0.807 | 5.00 | 2.3 | 11.50 | 9.278 |
| 4 | 7.2 | 5.2 | .8d | 50 | 155 | 0.835 | 0.864 | | | | | |
| | | | .2d | 50 | 166 | 0.893 | | 0.937 | 5.15 | 2.3 | 11.85 | 11.104 |
| 5 | 9.5 | 5.1 | .8d | 50 | 190 | 1.021 | 1.011 | | | | | |
| | | | .2d | 50 | 186 | 1.000 | | 1.071 | 5.00 | 2.6 | 13.00 | 13.920 |
| 6 | 12.1 | 4.9 | .8d | 50 | 200 | 1.075 | 1.131 | | | | | |
| | | | .2d | 50 | 221 | 1.187 | | 1.145 | 5.00 | 2.1 | 10.50 | 12.027 |
| 7 | 14.2 | 5.1 | .8d | 50 | 212 | 1.139 | 1.160 | | | | | |
| | | | .2d | 50 | 220 | 1.181 | | 1.215 | 5.10 | 2.3 | 11.73 | 14.250 |
| 8 | 16.5 | 5.1 | .8d | 50 | 227 | 1.219 | 1.269 | | | | | |
| | | | .2d | 50 | 246 | 1.320 | | 1.271 | 5.00 | 2.4 | 12.00 | 15.250 |
| 9 | 18.9 | 4.9 | .8d | 50 | 225 | 1.208 | 1.272 | | | | | |
| | | | .2d | 50 | 249 | 1.336 | | 1.255 | 5.00 | 2.4 | 12.00 | 15.058 |
| 10 | 21.3 | 5.1 | .8d | 50 | 208 | 1.117 | 1.237 | | | | | |
| | | | .2d | 50 | 253 | 1.358 | | 1.165 | 5.30 | 2.4 | 12.72 | 14.825 |
| 11 | 23.7 | 5.5 | .8d | 50 | 163 | 0.877 | 1.093 | | | | | |
| | | | .2d | 50 | 244 | 1.309 | | 0.940 | 5.25 | 2.2 | 11.55 | 10.858 |
| 12 | 25.9 | 5.0 | .8d | 50 | 94 | 0.509 | 0.787 | | | | | |
| | | | .2d | 50 | 198 | 1.064 | | 0.691 | 4.80 | 2.5 | 12.00 | 8.289 |
| 13 | 28.4 | 4.6 | .8d | 50 | 74 | 0.403 | 0.595 | | | | | |
| | | | .2d. | 50 | 146 | 0.787 | | 0.497 | 4.50 | 2.4 | 10.80 | 5.372 |
| 14 | 30.8 | 4.4 | .8d | 50 | 49 | 0.269 | 0.400 | | | | | |
| | | | .2d | 50 | 98 | 0.531 | | 0.240 | 3.95 | 2.3 | 9.09 | 2.182 |
| 15 | 33.1 | 3.5 | .8d | 50 | 1 | 0.009 | 0.080 | | | | | |
| | | | .2d | 50 | 27 | 0.152 | | 0.040 | 1.75 | 4.0 | 7.00 | 0.281 |
| 16 | 37.1 | 0.0 | - | 50 | | 0.000 | 0.000 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total Area (sq.m) | = | 160.57 | Total discharge (cumecs) = | 136.97 | Mean Velocity (m/s) | = | 0.85 |

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | | |
|---|---|---|---|---|---|
| Station: | Shebelli at Bulo Burti | | | Start | Finish |
| Date: | 30th May 1989 | | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | | Time | 1630 | 1805 |
| Origin: | Left bank | | Stage | 4.21 | 4.21 |
| Observers: | Peter Ede/Ibrahim/Marian/Ahmed | | | | |
| Meter: | Braystoke BFM 001 No. 75-880 Impellor No. 8011-1247 | | | | |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.3 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | 0 | | | 0.128 | 0.55 | 2.3 | 1.27 | 0.162 |
| 2 | 4.6 | 1.1 | .6d | 50 | 51 | 0.280 | 0.256 | | | | | |
| | | | .6d | 50 | 42 | 0.232 | | 0.556 | 1.50 | 2.4 | 3.60 | 2.002 |
| 3 | 7.0 | 1.9 | .8d | 50 | 107 | 0.579 | 0.856 | | | | | |
| | | | .2d | 50 | 211 | 1.133 | | 0.983 | 2.10 | 3.6 | 7.56 | 7.430 |
| 4 | 10.6 | 2.3 | .8d | 50 | 180 | 0.968 | 1.109 | | | | | |
| | | | .2d | 50 | 233 | 1.251 | | 1.161 | 2.35 | 3.3 | 7.76 | 9.007 |
| 5 | 13.9 | 2.4 | .8d | 50 | 217 | 1.165 | 1.213 | | | | | |
| | | | .2d | 50 | 235 | 1.261 | | 1.275 | 2.60 | 3.0 | 7.80 | 9.944 |
| 6 | 16.9 | 2.8 | .8d | 50 | 235 | 1.261 | 1.336 | | | | | |
| | | | .2d | 50 | 263 | 1.411 | | 1.335 | 3.00 | 3.6 | 10.80 | 14.416 |
| 7 | 20.5 | 3.2 | .8d | 50 | 228 | 1.224 | 1.333 | | | | | |
| | | | .2d | 50 | 269 | 1.443 | | 1.358 | 3.40 | 3.8 | 12.92 | 17.539 |
| 8 | 24.3 | 3.6 | .8d | 50 | 244 | 1.309 | 1.382 | | | | | |
| | | | .2d | 50 | 271 | 1.454 | | 1.358 | 3.90 | 3.3 | 12.87 | 17.471 |
| 9 | 27.6 | 4.2 | .8d | 50 | 223 | 1.197 | 1.333 | | | | | |
| | | | .2d | 50 | 274 | 1.470 | | 1.367 | 4.35 | 3.3 | 14.35 | 19.621 |
| 10 | 30.9 | 4.5 | .8d | 50 | 241 | 1.293 | 1.400 | | | | | |
| | | | .2d | 50 | 281 | 1.507 | | 1.382 | 4.25 | 3.9 | 16.57 | 22.898 |
| 11 | 34.8 | 4.0 | .8d | 50 | 255 | 1.368 | 1.363 | | | | | |
| | | | .2d | 50 | 253 | 1.358 | | 1.303 | 3.85 | 3.0 | 11.55 | 15.048 |
| 12 | 37.8 | 3.7 | .8d | 50 | 208 | 1.117 | 1.243 | | | | | |
| | | | .2d | 50 | 255 | 1.368 | | 1.248 | 3.30 | 3.0 | 9.90 | 12.357 |
| 13 | 40.8 | 2.9 | .8d | 50 | 213 | 1.144 | 1.253 | | | | | |
| | | | .2d | 50 | 254 | 1.363 | | 1.195 | 2.65 | 2.1 | 5.57 | 6.649 |
| 14 | 42.9 | 2.4 | .8d | 50 | 190 | 1.021 | 1.136 | | | | | |
| | | | .2d | 50 | 233 | 1.251 | | 0.996 | 2.00 | 1.7 | 3.40 | 3.387 |
| 15 | 44.6 | 1.6 | .8d | 50 | 148 | 0.797 | 0.856 | | | | | |
| | | | .2d | 50 | 170 | 0.915 | | 0.428 | 0.80 | 1.6 | 1.28 | 0.548 |
| 16 | 46.2 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 127.20 Total discharge (cumecs) = 158.48 Mean Velocity (m/s) = 1.25

# DISCHARGE MEASUREMENT BY CURRENT METER

| | |
|---|---|
| Station: | Shebelli at Beled Weyn |
| Date: | 31st May 1989 |
| Method: | Suspension from bridge (d/s face) with 25kg weight |
| Origin: | Left bank |
| Observers: | Peter Ede/Marian/Ibrahim/Ahmed |
| Meter: | Braystoke BFM 001 No. 75-880 Impellor No. 8011-1247 |

| | Start | Finish |
|---|---|---|
| Time | 1140 | 1320 |
| Stage | 2.13 | 2.11 |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.8 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.525 | 0.70 | 2.1 | 1.47 | 0.772 |
| 2 | 8.9 | 1.4 | .6d | 50 | 194 | 1.043 | 1.051 | | | | | |
| | | | .6d | 50 | 197 | 1.059 | | 1.031 | 1.55 | 1.8 | 2.79 | 2.876 |
| 3 | 10.7 | 1.7 | .8d | 50 | 187 | 1.005 | 1.011 | | | | | |
| | | | .2d | 50 | 189 | 1.016 | | 1.060 | 1.85 | 2.3 | 4.26 | 4.511 |
| 4 | 13.0 | 2.0 | .8d | 50 | 192 | 1.032 | 1.109 | | | | | |
| | | | .2d | 50 | 221 | 1.187 | | 1.144 | 2.25 | 2.4 | 5.40 | 6.178 |
| 5 | 15.4 | 2.5 | .8d | 50 | 184 | 0.989 | 1.179 | | | | | |
| | | | .2d | 50 | 255 | 1.368 | | 1.247 | 2.70 | 2.8 | 7.56 | 9.426 |
| 6 | 18.2 | 2.9 | .8d | 50 | 227 | 1.219 | 1.315 | | | | | |
| | | | .2d | 50 | 263 | 1.411 | | 1.335 | 3.05 | 1.7 | 5.18 | 6.921 |
| 7 | 19.9 | 3.2 | .8d | 50 | 239 | 1.283 | 1.355 | | | | | |
| | | | .2d | 50 | 266 | 1.427 | | 1.291 | 3.40 | 2.4 | 8.16 | 10.533 |
| 8 | 22.3 | 3.6 | .8d | 50 | 188 | 1.011 | 1.227 | | | | | |
| | | | .2d | 50 | 269 | 1.443 | | 1.280 | 3.75 | 2.5 | 9.38 | 12.001 |
| 9 | 24.8 | 3.9 | .8d | 50 | 228 | 1.224 | 1.333 | | | | | |
| | | | .2d | 50 | 269 | 1.443 | | 1.346 | 3.80 | 2.2 | 8.36 | 11.248 |
| 10 | 27.0 | 3.7 | .8d | 50 | 235 | 1.261 | 1.358 | | | | | |
| | | | .2d | 50 | 271 | 1.454 | | 1.391 | 3.65 | 1.6 | 5.84 | 8.123 |
| 11 | 28.6 | 3.6 | .8d | 50 | 251 | 1.347 | 1.424 | | | | | |
| | | | .2d | 50 | 280 | 1.502 | | 1.454 | 3.45 | 2.6 | 8.97 | 13.038 |
| 12 | 31.2 | 3.3 | .8d | 50 | 271 | 1.454 | 1.483 | | | | | |
| | | | .2d | 50 | 282 | 1.512 | | 1.464 | 3.20 | 2.5 | 8.00 | 11.713 |
| 13 | 33.7 | 3.1 | .8d | 50 | 261 | 1.400 | 1.446 | | | | | |
| | | | .2d | 50 | 278 | 1.491 | | 1.378 | 3.05 | 2.6 | 7.93 | 10.924 |
| 14 | 36.3 | 3.0 | .8d | 50 | 228 | 1.224 | 1.309 | | | | | |
| | | | .2d | 50 | 260 | 1.395 | | 1.300 | 2.90 | 1.1 | 3.19 | 4.148 |
| 15 | 37.4 | 2.8 | .8d | 50 | 219 | 1.176 | 1.291 | | | | | |
| | | | .2d | 50 | 262 | 1.406 | | 1.232 | 2.75 | 2.3 | 6.33 | 7.793 |
| 16 | 39.7 | 2.7 | .8d | 50 | 203 | 1.091 | 1.173 | | | | | |
| | | | .2d | 50 | 234 | 1.256 | | 0.613 | 2.35 | 2.2 | 5.17 | 3.171 |
| 17 | 41.9 | 2.0 | .8d | 50 | 6 | 0.043 | 0.053 | | | | | |
| | | | .2d | 50 | 10 | 0.063 | | 0.027 | 1.00 | 1.2 | 1.20 | 0.032 |
| 18 | 43.1 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 99.18 Total discharge (cumecs) = 123.41 Mean Velocity (m/s) = 1.24

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | | |
|---|---|---|---|---|---|
| Station: | Sabuun Canal (supply to Jowhar reservoir) | | | Start | Finish |
| Date: | 1st June 1989 | | | | |
| Method: | Suspension from bridge (u/s face) with 25kg weight | | Time | 1230 | 1305 |
| Origin: | Left bank | | Stage | 1.03 | 1.03 |
| Observers: | Peter Ede/Ibrahim/Marian/Ahmed | | | | |
| Meter: | Braystoke BFM 001 No. 75-880 Impellor No. 8011-1247 | | | | |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.7 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.268 | 0.50 | 2.2 | 1.10 | 0.295 |
| 2 | 4.9 | 1.0 | .6d | 50 | 101 | 0.547 | 0.536 | | | | | |
| | | | .6d | 50 | 97 | 0.525 | | 0.621 | 1.05 | 2.3 | 2.42 | 1.501 |
| 3 | 7.2 | 1.1 | .6d | 50 | 131 | 0.707 | 0.707 | | | | | |
| | | | .6d | 50 | 131 | 0.707 | | 0.700 | 1.15 | 2.2 | 2.53 | 1.771 |
| 4 | 9.4 | 1.2 | .6d | 50 | 128 | 0.691 | 0.693 | | | | | |
| | | | .6d | 50 | 129 | 0.696 | | 0.693 | 1.15 | 1.5 | 1.73 | 1.196 |
| 5 | 10.9 | 1.1 | .6d | 50 | 126 | 0.680 | 0.693 | | | | | |
| | | | .6d | 50 | 131 | 0.707 | | 0.708 | 1.15 | 2.5 | 2.88 | 2.036 |
| 6 | 13.4 | 1.2 | .6d | 50 | 136 | 0.733 | 0.723 | | | | | |
| | | | .6d | 50 | 132 | 0.712 | | 0.713 | 1.20 | 2.6 | 3.12 | 2.226 |
| 7 | 16.0 | 1.2 | .6d | 50 | 132 | 0.712 | 0.704 | | | | | |
| | | | .6d | 50 | 129 | 0.696 | | 0.685 | 1.20 | 2.3 | 2.76 | 1.892 |
| 8 | 18.3 | 1.2 | .6d | 50 | 124 | 0.669 | 0.667 | | | | | |
| | | | .6d | 50 | 123 | 0.664 | | 0.632 | 1.20 | 2.5 | 3.00 | 1.896 |
| 9 | 20.8 | 1.2 | .6d | 50 | 116 | 0.627 | 0.597 | | | | | |
| | | | .6d | 50 | 105 | 0.568 | | 0.517 | 1.05 | 2.3 | 2.42 | 1.250 |
| 10 | 23.1 | 0.9 | .6d | 50 | 84 | 0.456 | 0.437 | | | | | |
| | | | .6d | 50 | 77 | 0.419 | | 0.219 | 0.45 | 2.2 | 0.99 | 0.217 |
| 11 | 25.3 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total Area (sq.m) | = | 22.93 | Total discharge (cumecs) = | 14.28 | Mean Velocity (m/s) | = | 0.62 |

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | | |
|---|---|---|---|---|---|
| Station: | Jubba at Kamsuma | | | Start | Finish |
| Date: | 7th June 1989 | | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | | Time | 1145 | 1300 |
| Origin: | Left bank | | Stage | 3.22 | 3.20 |
| Observers: | Peter Ede/Ibrahim/Ahmed | | | | |
| Meter: | Braystoke BFM 001 No. 75-880 Impellor No. 8011-1247 | | | | |

Calculations made by method of mean velocity over section between two verticals.

Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Velocity Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9.6 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | | | | | 0.107 | 0.90 | 2.4 | 2.16 | 0.230 |
| 2 | 12.0 | 1.8 | .8d | 50 | 42 | 0.232 | 0.213 | | | | | |
| | | | .2d | 50 | 35 | 0.195 | | 0.504 | 3.25 | 4.0 | 13.00 | 6.553 |
| 3 | 16.0 | 4.7 | .8d | 50 | 125 | 0.675 | 0.795 | | | | | |
| | | | .2d | 50 | 170 | 0.915 | | 0.912 | 4.30 | 4.0 | 17.20 | 15.688 |
| 4 | 20.0 | 3.9 | .8d | 50 | 155 | 0.835 | 1.029 | | | | | |
| | | | .2d | 50 | 228 | 1.224 | | 0.825 | 4.05 | 4.0 | 16.20 | 13.372 |
| 5 | 24.0 | 4.2 | .8d | 50 | 142 | 0.765 | 0.621 | | | | | |
| | | | .2d | 50 | 88 | 0.477 | | 0.312 | 4.30 | 4.0 | 17.20 | 5.367 |
| 6 | 28.0 | 4.4 | .8d | 50 | 32 | 0.179 | 0.003 | | | | | |
| | | | .2d | 50 | -31 | -0.173 | | 0.299 | 4.65 | 4.0 | 18.60 | 5.556 |
| 7 | 32.0 | 4.9 | .8d | 50 | 195 | 1.048 | 0.595 | | | | | |
| | | | .2d | 50 | 25 | 0.141 | | 0.861 | 4.75 | 4.0 | 19.00 | 16.367 |
| 8 | 36.0 | 4.6 | .8d | 50 | 190 | 1.021 | 1.128 | | | | | |
| | | | .2d | 50 | 230 | 1.235 | | 1.085 | 4.60 | 4.0 | 18.40 | 19.973 |
| 9 | 40.0 | 4.6 | .8d | 50 | 172 | 0.925 | 1.043 | | | | | |
| | | | .2d | 50 | 216 | 1.160 | | 1.019 | 4.50 | 4.0 | 18.00 | 18.338 |
| 10 | 44.0 | 4.4 | .8d | 50 | 164 | 0.883 | 0.995 | | | | | |
| | | | .2d | 50 | 206 | 1.107 | | 0.672 | 3.80 | 4.0 | 15.20 | 10.216 |
| 11 | 48.0 | 3.2 | .8d | 50 | 94 | 0.509 | 0.349 | | | | | |
| | | | .2d | 50 | 34 | 0.189 | | 0.629 | 3.25 | 4.0 | 13.00 | 8.182 |
| 12 | 52.0 | 3.3 | .8d | 50 | 139 | 0.749 | 0.909 | | | | | |
| | | | .2d | 50 | 199 | 1.069 | | 0.909 | 3.25 | 4.0 | 13.00 | 11.823 |
| 13 | 56.0 | 3.2 | .8d | 50 | 145 | 0.781 | 0.909 | | | | | |
| | | | .2d | 50 | 193 | 1.037 | | 0.892 | 3.15 | 4.0 | 12.60 | 11.241 |
| 14 | 60.0 | 3.1 | .8d | 50 | 137 | 0.739 | 0.875 | | | | | |
| | | | .2d | 50 | 188 | 1.011 | | 0.856 | 2.85 | 4.0 | 11.40 | 9.760 |
| 15 | 64.0 | 2.6 | .8d | 50 | 134 | 0.723 | 0.837 | | | | | |
| | | | .2d | 50 | 177 | 0.952 | | 0.688 | 2.85 | 4.0 | 11.40 | 7.844 |
| 16 | 68.0 | 3.1 | .8d | 50 | 105 | 0.568 | 0.539 | | | | | |
| | | | .2d | 50 | 94 | 0.509 | | 0.575 | 3.05 | 4.0 | 12.20 | 7.012 |
| 17 | 72.0 | 3.0 | .8d | 50 | 84 | 0.456 | 0.611 | | | | | |
| | | | .2d | 50 | 142 | 0.765 | | 0.563 | 2.35 | 4.0 | 9.40 | 5.290 |
| 18 | 76.0 | 1.7 | .8d | 50 | 73 | 0.397 | 0.515 | | | | | |
| | | | .2d | 50 | 117 | 0.632 | | | | | | |

(cont.)

Jubba at Kamsuma 7th June 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 76.0 | 1.7 | .8d | 50 | 73 | 0.397 | 0.515 | | | | | |
| | | | .2d | 50 | 117 | 0.632 | | 0.476 | 1.50 | 4.0 | 6.00 | 2.856 |
| 19 | 80.0 | 1.3 | .6d | 50 | 82 | 0.445 | 0.437 | | | | | |
| | | | .6d | 50 | 79 | 0.429 | | 0.219 | 0.65 | 4.9 | 3.19 | 0.697 |
| 20 | 84.9 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 247.15 Total discharge (cumecs) = 176.36 Mean Velocity (m/s) = 0.71

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | |
|---|---|---|---|---|
| Station: | Jubba at Kamsuma | | Start | Finish |
| Date: | 7th June 1989 | | | |
| Method: | Suspension from bridge (u/s face) with 25kg weight | Time | 1350 | 1510 |
| Origin: | Right bank | Stage | 3.20 | 3.18 |
| Observers: | Peter Ede/Ibrahim/Ahmed | | | |
| Meter: | Braystoke BFM 001 No. 75-880 Impellor No. 8011-1247 | | | |

Calculations made by method of mean velocity over section between two verticals.

Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10.3 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | | | | | 0.265 | 0.40 | 1.7 | 0.68 | 0.180 |
| 2 | 12.0 | 0.8 | .6d | 50 | 129 | 0.696 | 0.531 | | | | | |
| | | | .6d | 50 | 67 | 0.365 | | 0.720 | 2.20 | 4.0 | 8.80 | 6.337 |
| 3 | 16.0 | 3.6 | .8d | 50 | 146 | 0.787 | 0.909 | | | | | |
| | | | .2d | 50 | 192 | 1.032 | | 0.949 | 4.00 | 4.0 | 16.00 | 15.191 |
| 4 | 20.0 | 4.4 | .8d | 50 | 144 | 0.776 | 0.989 | | | | | |
| | | | .2d | 50 | 224 | 1.203 | | 0.948 | 4.45 | 2.0 | 8.90 | 8.438 |
| 5 | 22.0 | 4.5 | .8d | 50 | 107 | 0.579 | 0.907 | | | | | |
| | | | .2d | 50 | 230 | 1.235 | | 0.453 | 4.50 | 2.7 | 12.15 | 5.509 |
| 6 | 24.7 | 4.5 | .8d | 50 | | 0.000 | 0.000 | | | | | |
| | | | .2d | 50 | | 0.000 | | 0.000 | 4.55 | 4.9 | 22.30 | 0.000 |
| 7 | 29.6 | 4.6 | .8d | 50 | | 0.000 | 0.000 | | | | | |
| | | | .2d | 50 | | 0.000 | | 0.545 | 4.60 | 2.4 | 11.04 | 6.021 |
| 8 | 32.0 | 4.6 | .8d | 50 | 174 | 0.936 | 1.091 | | | | | |
| | | | .2d | 50 | 232 | 1.245 | | 1.061 | 4.30 | 4.0 | 17.20 | 18.257 |
| 9 | 36.0 | 4.0 | .8d | 50 | 164 | 0.883 | 1.032 | | | | | |
| | | | .2d | 50 | 220 | 1.181 | | 0.988 | 3.75 | 4.0 | 15.00 | 14.822 |
| 10 | 40.0 | 3.5 | .8d | 50 | 152 | 0.819 | 0.944 | | | | | |
| | | | .2d | 50 | 199 | 1.069 | | 0.780 | 3.65 | 4.0 | 14.60 | 11.389 |
| 11 | 44.0 | 3.8 | .8d | 50 | 110 | 0.595 | 0.616 | | | | | |
| | | | .2d | 50 | 118 | 0.637 | | 0.342 | 3.50 | 2.0 | 7.00 | 2.397 |
| 12 | 46.0 | 3.2 | .8d | 50 | 2 | 0.017 | 0.069 | | | | | |
| | | | .2d | 50 | 21 | 0.120 | | 0.517 | 3.35 | 2.0 | 6.70 | 3.465 |
| 13 | 48.0 | 3.5 | .8d | 50 | 153 | 0.824 | 0.965 | | | | | |
| | | | .2d | 50 | 206 | 1.107 | | 0.941 | 3.45 | 4.0 | 13.80 | 12.992 |
| 14 | 52.0 | 3.4 | .8d | 50 | 143 | 0.771 | 0.917 | | | | | |
| | | | .2d | 50 | 198 | 1.064 | | 0.872 | 3.25 | 4.0 | 13.00 | 11.337 |
| 15 | 56.0 | 3.1 | .8d | 50 | 129 | 0.696 | 0.827 | | | | | |
| | | | .2d | 50 | 178 | 0.957 | | 0.812 | 2.95 | 4.0 | 11.80 | 9.583 |
| 16 | 60.0 | 2.8 | .8d | 50 | 127 | 0.685 | 0.797 | | | | | |
| | | | .2d | 50 | 169 | 0.909 | | 0.764 | 2.80 | 4.0 | 11.20 | 8.558 |
| 17 | 64.0 | 2.8 | .8d | 50 | 119 | 0.643 | 0.731 | | | | | |
| | | | .2d | 50 | 152 | 0.819 | | 0.365 | 2.75 | 1.4 | 3.85 | 1.407 |
| 18 | 65.4 | 2.7 | .8d | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | .2d | 50 | 0 | 0.000 | | | | | | |

(cont.)

(cont.)

Jubba at Kamsuma 7th June 1989

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Velocity Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 65.4 | 2.7 | .8d | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | .2d | 50 | 0 | 0.000 | | 0.365 | 2.65 | 1.6 | 4.24 | 1.549 |
| 19 | 67.0 | 2.6 | .8d | 50 | 119 | 0.643 | 0.731 | | | | | |
| | | | .2d | 50 | 152 | 0.819 | | 0.683 | 2.60 | 3.0 | 7.80 | 5.325 |
| 20 | 70.0 | 2.6 | .8d | 50 | 99 | 0.536 | 0.635 | | | | | |
| | | | .2d | 50 | 136 | 0.733 | | 0.575 | 2.45 | 4.0 | 9.80 | 5.632 |
| 21 | 74.0 | 2.3 | .8d | 50 | 85 | 0.461 | 0.515 | | | | | |
| | | | .2d | 50 | 105 | 0.568 | | 0.428 | 2.00 | 4.0 | 8.00 | 3.424 |
| 22 | 78.0 | 1.7 | .8d | 50 | 54 | 0.296 | 0.341 | | | | | |
| | | | .2d | 50 | 71 | 0.387 | | 0.171 | 0.85 | 5.0 | 4.25 | 0.725 |
| 23 | 83.0 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 228.11 Total discharge (cumecs) = 152.54 Mean Velocity (m/s) = 0.67

# DISCHARGE MEASUREMENT BY CURRENT METER

| | |
|---|---|
| Station: | Shebelli at Afgoi |
| Date: | 18th June 1989 |
| Method: | Suspension from bridge (d/s face) with 10kg weight |
| Origin: | Left bank |
| Observers: | Ibrahim/Ali/Ahmed |
| Meter: | Braystoke BFM 001 No. 75-880 Impellor No. 8011-1247 |

| | Start | Finish |
|---|---|---|
| Time | 0950 | 1100 |
| Stage | 3.03 | 3.02 |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.8 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.325 | 0.35 | 2.2 | 0.77 | 0.251 |
| 2 | 4.0 | 0.7 | .6d | 50 | 118 | 0.637 | 0.651 | | | | | |
| | | | .6d | 50 | 123 | 0.664 | | 0.712 | 0.85 | 2.0 | 1.70 | 1.211 |
| 3 | 6.0 | 1.0 | .6d | 50 | 149 | 0.803 | 0.773 | | | | | |
| | | | .6d | 50 | 138 | 0.744 | | 0.808 | 1.20 | 2.0 | 2.40 | 1.939 |
| 4 | 8.0 | 1.4 | .8d | 50 | 143 | 0.771 | 0.843 | | | | | |
| | | | .2d | 50 | 170 | 0.915 | | 0.813 | 1.70 | 2.0 | 3.40 | 2.766 |
| 5 | 10.0 | 2.0 | .8d | 50 | 129 | 0.696 | 0.784 | | | | | |
| | | | .2d | 50 | 162 | 0.872 | | 0.808 | 2.05 | 2.0 | 4.10 | 3.313 |
| 6 | 12.0 | 2.1 | .8d | 50 | 147 | 0.792 | 0.832 | | | | | |
| | | | .2d | 50 | 162 | 0.872 | | 0.644 | 2.20 | 2.0 | 4.40 | 2.834 |
| 7 | 14.0 | 2.3 | .8d | 50 | 86 | 0.467 | 0.456 | | | | | |
| | | | .2d | 50 | 82 | 0.445 | | 0.500 | 2.50 | 2.0 | 5.00 | 2.500 |
| 8 | 16.0 | 2.7 | .8d | 50 | 120 | 0.648 | 0.544 | | | | | |
| | | | .2d | 50 | 81 | 0.440 | | 0.640 | 2.70 | 2.0 | 5.40 | 3.456 |
| 9 | 18.0 | 2.7 | .8d | 50 | 125 | 0.675 | 0.736 | | | | | |
| | | | .2d | 50 | 148 | 0.797 | | 0.764 | 2.65 | 2.0 | 5.30 | 4.050 |
| 10 | 20.0 | 2.6 | .8d | 50 | 132 | 0.712 | 0.792 | | | | | |
| | | | .2d | 50 | 162 | 0.872 | | 0.665 | 2.65 | 2.0 | 5.30 | 3.527 |
| 11 | 22.0 | 2.7 | .8d | 50 | 67 | 0.365 | 0.539 | | | | | |
| | | | .2d | 50 | 132 | 0.712 | | 0.340 | 2.45 | 2.0 | 4.90 | 1.666 |
| 12 | 24.0 | 2.2 | .8d | 50 | 22 | 0.125 | 0.141 | | | | | |
| | | | .2d | 50 | 28 | 0.157 | | 0.171 | 2.30 | 2.0 | 4.60 | 0.787 |
| 13 | 26.0 | 2.4 | .8d | 50 | 62 | 0.339 | 0.201 | | | | | |
| | | | .2d | 50 | 10 | 0.063 | | 0.346 | 2.40 | 2.0 | 4.80 | 1.660 |
| 14 | 28.0 | 2.4 | .8d | 50 | 110 | 0.595 | 0.491 | | | | | |
| | | | .2d | 50 | 71 | 0.387 | | 0.545 | 2.40 | 2.0 | 4.80 | 2.618 |
| 15 | 30.0 | 2.4 | .8d | 50 | 93 | 0.504 | 0.600 | | | | | |
| | | | .2d | 50 | 129 | 0.696 | | 0.511 | 2.25 | 2.0 | 4.50 | 2.298 |
| 16 | 32.0 | 2.1 | .8d | 50 | 74 | 0.403 | 0.421 | | | | | |
| | | | .2d | 50 | 81 | 0.440 | | 0.211 | 1.05 | 2.6 | 2.73 | 0.575 |
| 17 | 34.6 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 64.10 Total discharge (cumecs) = 35.45 Mean Velocity (m/s) = 0.55

# DISCHARGE MEASUREMENT BY CURRENT METER

| | | | | | |
|---|---|---|---|---|---|
| Station: | Shebelli at Mahaddey Weyn | | | Start | Finish |
| Date: | 26th September 1989 | | | | |
| Method: | Suspension from bridge (d/s face) with 25kg weight | | Time | 1100 | 1220 |
| Origin: | Left bank | | Stage | 3.92 | 3.91 |
| Observers: | Peter Ede/Zakia/Ibrahim/Ahmed | | | | |
| Meter: | Braystoke BFM 001 No. 75-306 Impellor No. 8011-503 | | | | |

Calculations made by method of mean velocity over section between two verticals.
Two measurements at each vertical.

| Vertical number | Distance (m) | Depth (m) | Depth of observation | Time (s) | Revs | Velocity Point | Velocity Mean (m/s) | Section | Mean depth (m) | Width (m) | Area (sq.m) | Discharge (cumecs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |
| | | | | 50 | | | | 0.253 | 1.65 | 4.7 | 7.76 | 1.965 |
| 2 | 4.7 | 3.3 | .8d | 50 | 94 | 0.509 | 0.507 | | | | | |
| | | | .2d | 50 | 93 | 0.504 | | 0.576 | 3.55 | 2.4 | 8.52 | 4.908 |
| 3 | 7.1 | 3.8 | .8d | 50 | 111 | 0.600 | 0.645 | | | | | |
| | | | .2d | 50 | 128 | 0.691 | | 0.681 | 3.80 | 2.4 | 9.12 | 6.215 |
| 4 | 9.5 | 3.8 | .8d | 50 | 131 | 0.707 | 0.717 | | | | | |
| | | | .2d | 50 | 135 | 0.728 | | 0.759 | 3.80 | 2.5 | 9.50 | 7.208 |
| 5 | 12.0 | 3.8 | .8d | 50 | 148 | 0.797 | 0.800 | | | | | |
| | | | .2d | 50 | 149 | 0.803 | | 0.825 | 3.95 | 2.3 | 9.09 | 7.499 |
| 6 | 14.3 | 4.1 | .8d | 50 | 153 | 0.824 | 0.851 | | | | | |
| | | | .2d | 50 | 163 | 0.877 | | 0.837 | 4.20 | 2.5 | 10.50 | 8.793 |
| 7 | 16.8 | 4.3 | .8d | 50 | 128 | 0.691 | 0.824 | | | | | |
| | | | .2d | 50 | 178 | 0.957 | | 0.828 | 4.20 | 2.2 | 9.24 | 7.652 |
| 8 | 19.0 | 4.1 | .8d | 50 | 137 | 0.739 | 0.832 | | | | | |
| | | | .2d | 50 | 172 | 0.925 | | 0.817 | 3.95 | 2.4 | 9.48 | 7.749 |
| 9 | 21.4 | 3.8 | .8d | 50 | 129 | 0.696 | 0.803 | | | | | |
| | | | .2d | 50 | 169 | 0.909 | | 0.793 | 3.95 | 2.3 | 9.09 | 7.208 |
| 10 | 23.7 | 4.1 | .8d | 50 | 134 | 0.723 | 0.784 | | | | | |
| | | | .2d | 50 | 157 | 0.845 | | 0.669 | 3.65 | 2.4 | 8.76 | 5.864 |
| 11 | 26.1 | 3.2 | .8d | 50 | 43 | 0.237 | 0.555 | | | | | |
| | | | .2d | 50 | 162 | 0.872 | | 0.480 | 3.30 | 2.3 | 7.59 | 3.644 |
| 12 | 28.4 | 3.4 | .8d | 50 | 45 | 0.248 | 0.405 | | | | | |
| | | | .2d | 50 | 104 | 0.563 | | 0.401 | 3.00 | 2.2 | 6.60 | 2.649 |
| 13 | 30.6 | 2.6 | .8d | 50 | 58 | 0.317 | 0.397 | | | | | |
| | | | .2d | 50 | 88 | 0.477 | | 0.359 | 2.40 | 2.3 | 5.52 | 1.980 |
| 14 | 32.9 | 2.2 | .8d | 50 | 56 | 0.307 | 0.320 | | | | | |
| | | | .2d | 50 | 61 | 0.333 | | 0.160 | 1.10 | 2.9 | 3.19 | 0.510 |
| 15 | 35.8 | 0.0 | - | 50 | 0 | 0.000 | 0.000 | | | | | |

Total Area (sq.m) = 113.95 Total discharge (cumecs) = 73.84 Mean Velocity (m/s) = 0.65