Lake Chad Basin: Sustainable Water Management

2nd Mission on Discharge Measurements at Chari, Logone and Koulambou River, Chad

Hannover, December 2013

On behalf of:
## Table of Content

- **Table of Figures** .......................................................... II
- **List of Tables** ........................................................... III
- **List of Boxes** .......................................................... III
- **List of Annex** .......................................................... III
- **Abbreviations** ......................................................... III
- **Timetable of the mission** ........................................ IV
- **Summary** ................................................................ 1
- **1 Participants of the mission** .................................. 2
- **2 Objective** ........................................................... 2
- **3 Location of Measurements and Gauging Stations** .......... 3
- **4 Materials and Methods** ........................................ 4
  - 4.1 Water Level Measurement ................................... 4
  - 4.2 ADCP Instrument of the DREM .......................... 4
  - 4.3 Guidelines for ADCP Measurements ................... 5
- **5 Results** .................................................................. 6
  - 5.1 N’Djamena TP Gauging Station, Chari River, 21.10.2013 ... 6
  - 5.2 Mailao Gauging Station, Chari River, 16.10.2013 ........ 8
  - 5.3 Logone - Gana Station, Logone River, 22.10.2013 ....... 10
    - 5.3.1 Logone River upstream of its confluence with Koulambou River ........ 10
    - 5.3.2 Koulambou River .............................................. 11
    - 5.3.3 Logone River downstream of its confluence with Koulambou River .......... 12
  - 5.4 Katoa Station, Logone River, 17.10.2013 ............... 13
  - 5.5 Bongor Station, Logone River, 18.10.2013 ........... 15
- **6 General Findings** .................................................. 17
- **7 Recommendations** ............................................... 20
- **8 References** .......................................................... 21
- **Annex I** .................................................................. 22
- **Annex II** .................................................................. 23
Table of Figures

Figure 1 Study area = inundation zone of the lower Logone River during and after the rainy season. Red points are gauging stations ................................................................. 2
Figure 2 Catchment area of Logone and Chari River and measured gauging stations .......... 3
Figure 3 Gauging station Mailao, Chari River ................................................................. 4
Figure 4 Gauge records October 2013 at Katoa, Logone River ........................................ 4
Figure 5 Rio Grande ADCP device fixed on the rubber boat equipped with engine .......... 5
Figure 6 ADCP connected with battery and with computer via serial RS-232 port .......... 5
Figure 7 Water levels N'Djamena TP gauging station in October 2013 (source DREM) .... 6
Figure 8 Chari River cross section at N'Djamena TP gauging station and distribution of flow velocity ........................................................................................................................ 7
Figure 9 Rating curve of N'Djamena TP station (pink squares = values formerly measured by DREM, red square = value measured in October 2013, green square value measured in February 2013).................................................................................................................. 7
Figure 10 Water levels Mailao gauging station in October and November 2013 (source DREM) ...................................................................................................................... 8
Figure 11 Chari River cross section at Mailao gauging station and distribution of flow velocity ........................................................................................................................ 9
Figure 12 Rating curve of Mailao station (pink squares = values formerly measured by DREM, red square = value measured October 2013, green square = value measured in February 2013) (source: DREM) ........................................................................................................... 9
Figure 13 Water level at Logone - Gana station in October 2013 (Source DREM)........... 10
Figure 14 Logone River cross section upstream of the confluence with Koulambou River at Logone - Gana station and distribution of flow velocity ......................................................... 11
Figure 15 Koulambou River cross section at Logone - Gana gauging station and distribution of flow velocity ................................................................................................................ 11
Figure 16 Rating curve of Logone - Gana station (pink squares = values formerly measured by DREM, red square = value measured in October 2013, green square = value measured in February 2013) (source DREM) ........................................................................................................... 12
Figure 17 Gauge height at Katoa gauging station during September and October 2013 .... 13
Figure 18 Logone River cross section at Katoa gauging station and distribution of flow velocity ......................................................................................................................... 14
Figure 19 Rating Curve Katoa gauging station (pink squares = values formerly measured by DREM, red square = value measured in October 2013) (source: DREM) .................. 14
Figure 20 Water levels of Bongor gauging station in October 2013 .................................. 15
Figure 21 Logone River cross section at Bongor gauging station and distribution of flow velocity ......................................................................................................................... 15
Figure 22 Rating Curve Bongor station (pink squares = values formerly measured by DREM, red square = value measured October 2013, green square = value measured in February 2013) (source: DREM)........................................................................................................16

Figure 24 Discharge values from 2001 to 2005 from Bongor, Katoa and Logone - Gana station (Vassolo, 2012) ........................................................................................................................................18

Figure 23 Loosing stream condition at Logone River between Bongor and Logone Gana ....18

Figure 25 Outflow in m³/s into the Yaéré and Naga plains (y-axis) versus discharge in Bongor (x axis) ................................................................................................................................................19

Figure 26 Outflow in m³/s into the Yaéré and Naga plains (y-axis) versus discharge in Katoa (x axis) ..................................................................................................................................................19

List of Tables
Table 1 List of participants ........................................................................................................ 2

Table 2 Summary of discharge values measured in February and October 2013 and comparison to the values taken from the existing rating curves ...............................................17

List of Boxes
Box 1 Measuring principle of ADCP, source (USGS, 2009) ........................................5

List of Annex
Annex I Field guide for discharge measurements with RDI Workhorse Rio Grande ADCP

Annex II Discharge Summary Chart

Abbreviations
ADCP Acoustic Doppler Current Profiler
BGR Bundesanstalt für Geowissenschaften und Rohstoffe
Federal Institute for Geosciences and Natural Resources
LCBC/CBLT Commission du Basin du Lac Tchad/ Lake Chad Basin Commission
DBO Directory Basin Observatory of LCBC
DREM Direction des Ressources en eau et de la Météorologie, Ministère du Hydraulique Rural et Urbain, Tchad / Water Resource and Meteorological Directory of the Hydrological Ministry of Chad
EDF European Development Fund
GPS Global Positioning System
Q Discharge [m³/s]
Timetable of the mission

16.10.2013  Discharge measurements at Mailao gauging station, Chari River
17.10.2013  Discharge measurements at Katoa gauging station (access via boat), Logone River
18.10.2013  Discharge measurements at Bongor gauging station, Logone River
21.10.2013  Discharge measurements at N'Djamena TP gauging station, Chari River
22.10.2013  Discharge measurements at Logone - Gana gauging station, Koulampou River and Logone River
Summary

Author: Kristin Seeber
Title: 2\textit{nd} Mission on Discharge Measurements at Chari, Logone and Koulambou River, Chad
Keywords: Lake Chad Basin, hydrology, discharge, flow measurement, rating curve

In February 2013, during the dry season, the BGR-LCBC project and the Water Resource and Meteorological Directory of the Hydrological Ministry of Chad (DREM) carried out a first mission on Acoustic Doppler Current Profiler (ADCP) discharge measurements at four gauging stations (N'Djamena TP, Mailao, Logone - Gana, and Bongor) in the pilot zone (lower Logone floodplain). Purpose of the mission was capacity building in discharge measurements with an ADCP device as well as the verification of the existing rating curves for these gauging stations since some rating curves are rather old, e.g. from 1983.

The measurements showed that recorded discharges are generally lower than values taken from the rating tables. The differences between these values account for 10 – 50 % (Krekeler & Seeber, 2013). It was recommended to use the ADCP frequently to check the existing rating curves.

In October 2013 the project conducted a second ADCP discharge measurement mission. This time river discharges were at their maxima. Additionally to the four gauging stations measured in February 2013, the gauging station in Katoa was included.

Again, the ADCP measurements show lower discharges than the values estimated from the rating curves. The differences between these values account for 3 – 25 %. In comparison to the differences observed in February 2013, the rating curves correspond better to the measurements. Nevertheless, it is recommended to adjust the rating curve of Logone - Gana station since deviations are not negligible.

Further, measurements revealed that the Logone River between Bongor and Logone - Gana shows loosing stream conditions. About 500 m$^3$/s are lost between Bongor and Katoa and further 300 m$^3$/s between Katoa and Logone - Gana, due to river overflow into the adjacent floodplain.
1 Participants of the mission

The following Table 1 lists the participants of the mission. Since the Lake Chad Basin Commission (LCBC) aims to strengthen its cooperation and communication, as well as data exchange with national institutes of the member countries, the mission was planned by the directory Basin Observatory (DBO) of the LCBC and BGR and conducted with LCBC and one expert of the Water Resource and Meteorological Directory of the Hydrological Ministry of Chad (DREM).

Table 1 List of participants

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Function/Institution</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Michel Dimbele</td>
<td>Director Basin Observatory (LCBC)</td>
<td>Organisation of the mission</td>
</tr>
<tr>
<td>2</td>
<td>Abba Tapsala</td>
<td>Hydrologist (DREM)</td>
<td>Expert realization</td>
</tr>
<tr>
<td>3</td>
<td>Ahmed Sedick</td>
<td>Hydrologist (LCBC)</td>
<td>Expert realization</td>
</tr>
<tr>
<td>4</td>
<td>Aminu Magaji Bala</td>
<td>Environment and Wetland Expert (LCBC)</td>
<td>Expert realization</td>
</tr>
<tr>
<td>5</td>
<td>Khazali Abdoulaye</td>
<td>Driver (project BGR-LCBC)</td>
<td>Driver</td>
</tr>
<tr>
<td>6</td>
<td>Kristin Seeber</td>
<td>Expert Geoecologist (BGR)</td>
<td>Expert realization/organisation</td>
</tr>
</tbody>
</table>

2 Objective

Subsequent to the first Acoustic Doppler Current Profiler (ADCP) discharge measurements carried out within the pilot area during the low flow season in February 2013, a second mission at the end of the rainy season was considered essential.

The pilot area was selected to accomplish more detailed investigations in the frame of the LCBC-BGR project. It comprises the Yaéré plain in North Cameroon with an area of about 8000 km² and the Naga plain on the Chadian side with about 4500 km². The plains are periodically inundated every year by heavy rains and by the overflow of the Lower Logone River between Bongor/Yagua and N’Djamena/Kousseri and further north depending on the intensity of the rainfall (see Figure 1).

Figure 1 Study area = inundation zone of the lower Logone River during and after the rainy season. Red points are gauging stations.
Usually, water levels at the gauging stations in Bongor, Katoa, Logone - Gana and N'Djamena, as well as the respective discharges calculated from rating curves are transmitted by the DREM to the LCBC. Since the first mission showed that discharge values measured with the ADCP are generally lower than the values calculated from the rating curves, a second mission was conducted to compare discharge values during high flow and to verify the rating curves.

Further objectives of the mission were on the job training in handling the ADCP device and associated software for DREM and LCBC experts and a water balance study.

3 Location of Measurements and Gauging Stations

Discharge measurements were carried out in the Chari River at Mailao and N'Djamena TP as well as in the Logone River at Bongor, Katoa and Logone - Gana (Figure 2). Additionally the Logone tributary Koulambou was measured at Gana station. The stations were selected mainly to achieve reliable discharge data within the inundation zone of the lower Logone River. Five gauging stations within this zone are operated by DREM: Bongor, Koumi, Katoa, Logone - Gana and N'Djamena.

Figure 2 Catchment area of Logone and Chari River and measured gauging stations

During the first mission in February 2013, the gauging station in Logone - Gana was rehabilitated. Actually, water levels are recorded from the Koulambou River, a tributary of the Logone River that collects the waters from the inundation zone and joins the Logone River at Logone - Gana. In other words, the gauging station Logone - Gana is placed along that tributary and not along the Logone River.
At the time of the first mission, the gauging station in Katoa was inoperable, but it was reinstalled in May 2013 by the DREM in the frame of the tenth development program of the European Development Fund.

The gauging station of the Chari River in Mailao, located at the same latitude as the Logone-Gana station, is the last gauging station upstream of the confluence of Chari and Logone River in N'Djamena and thus, gives information about the water volumes coming from Chari.

4 Materials and Methods

4.1 Water Level Measurement

In general the water level was measured with gauge plates (Figure 3). A gauge reader records the water level on a daily basis and sends monthly data to the DREM (Figure 4).

4.2 ADCP Instrument of the DREM

The DREM owns a Teledyne RD1 Rio Grande ADCP. This ADCP instrument is designed to operate from a boat equipped with an engine (Figure 5). During the measurements it is connected and operated via a serial RS-232 cable with a computer and a battery (Figure 6). A short description of the measurement principle is given in Box 1. For more technical details refer to the previous report of the first ADCP mission (Krekeler & Seeber, 2013).

At all measured gauging stations, the average discharges were calculated as the average of at least four measurements that do not differ more than 5% from the mean, in order to have reliable and comparable results.

The data received from field measurements are analysed with WinRiver II Software.
4.3 Guidelines for ADCP Measurements

Following the mission of ADCP discharge measurements in February 2013 a field guide for discharge measurements by BGR expert Torsten Krekeler was developed. This guideline lists the major steps to be taken in consideration when conducting discharge measurements with the Rio Grande device. During the mission, this guideline was used and complemented (Annex I).
5 Results

In the following, the ADCP measurements at each station are summarized and compared to the values measured in February 2013. Furthermore, the measured average discharge values are shown in the corresponding rating curves of each station. The discharge summary charts of each station are given in Annex II.

5.1 N’Djamena TP Gauging Station, Chari River, 21.10.2013

This station is located 3 km downstream of the confluence with the Logone River. The observed gauge height at N’Djamena TP station was 5.88 m. The daily water level changes within the month October are about 1 - 4 cm per day (Figure 7). Although the water table is still not at its maximum they do not change significantly and can be considered as stable, where hysteresis effects are unlikely to occur.

![Gauge Height N'Djamena TP](image)

*Figure 7 Water levels N'Djamena TP gauging station in October 2013 (source DREM)*

The discharge in N'Djamena was measured at about 1.5 km downstream of the N'Djamena TP gauging station since there is no public authorization to access the river at the stations location. In total four transects which differ not more than 1% from each other were measured (Figure 8 and Annex II). The mean discharge value is 2,140 m³/s.
The discharge value corresponding to the gauge height was calculated with the existing rating table developed by the DREM to 2,330 m³/s (Figure 9). The measured discharge is about 8% lower than the value from the rating table. This difference is in the same range as the values that were formerly measured by DREM (compare pink squares in Figure 9).

Figure 9 Rating curve of N'Djamena TP station (pink squares = values formerly measured by DREM, red square = value measured in October 2013, green square value measured in February 2013)
5.2 Mailao Gauging Station, Chari River, 16.10.2013

This station is located on the Chari River about 87° km upstream of N'Djamena TP. The observed water level at the 16.10.2013 was 5.01 m. The daily water level changes within the month October and November are shown in Figure 10. Daily water level changes during the measurement period (in October) are about 1 - 3 cm. The highest water level was reached at the beginning of the month November. Since now significant water level changes during the measurement period could be observed, hysteresis effects are not expected.

![Figure 10 Water levels Mailao gauging station in October and November 2013 (source DREM)](image)

Four out of six measurements were taken into consideration. They lead to an average discharge value of 1,340 m³/s (Figure 11 and Annex II). One of the measured transects differ more than 5 % from the mean value and had to be excluded. A second transect was excluded because of signal losses in several sectors.
For a gauge height of 5.01 m, the rating table gives a discharge of 1,377 m$^3$/s (Figure 12). The measured discharge is about 3 % lower. The deviance is low and in the same range as the values that were formerly measured by DREM.

Figure 12 Rating curve of Mailao station (pink squares = values formerly measured by DREM, red square = value measured October 2013, green square = value measured in February 2013) (source: DREM)

Figure 11 Chari River cross section at Mailao gauging station and distribution of flow velocity
5.3 Logone - Gana Station, Logone River, 22.10.2013

The gauging station in Logone - Gana is situated on the Koulambou River, a tributary of the Logone River, some 95 km upstream of N'Djamena TP. This station was rehabilitated during the mission in February 2013, when it was noticed that the station is inadequately located. The station is located in the center of the village, while the confluence of the Koulambou River and the Logone River is about 150 m downstream of the station.

Before and after the measurements, a gauge height of 5.95 m was observed. The daily changes during this period are about 1 – 3 cm, although the water table is still rising (Figure 13).

![Gauge Height Logone Gana](image)

Figure 13 Water level at Logone - Gana station in October 2013 (Source DREM)

To be able to estimate the discharge of the Logone River at this site, it was decided to additionally measure on the Logone itself. Since measurements downstream of the confluence were impracticable and did not reveal reliable data, it was decided to measure the Logone River upstream of the confluence with the Koulambou River.

5.3.1 Logone River upstream of its confluence with Koulaambou River

Four out of four measurements could be taken into consideration. They reveal an average discharge value of 520 m³/s (Figure 14 and Annex II).
5.3.2 Koulambou River

All four discharge measurements carried out at the Koulambou could be taken into consideration for the calculation of the average discharge value of 306 m³/s (Figure 15 and Annex II).
5.3.3 Logone River downstream of its confluence with Koulambou River

The discharge of the Logone River upstream of the confluence and that of the Koulambou River result in an average discharge value of 826 m³/s for the Logone River downstream of the confluence.

The corresponding discharge value for a gauge height of 5.95 m is 1,095 m³/s (Figure 16). The measured value is 25% lower.

Figure 16 Rating curve of Logone - Gana station (pink squares = values formerly measured by DREM, red square = value measured in October 2013, green square = value measured in February 2013) (source DREM)
5.4 Katoa Station, Logone River, 17.10.2013

Katoa gauging station is located on the Logone River about 190 km upstream of N’Djamena TP station. During the rainy season this station is not accessible by car, since routes along the river are inundated. Nevertheless, there is a dyke between Bongor and Katoa that allows access by motorbike and sometimes by car. This station has been rehabilitated in May 2013 by the DREM in the frame of the tenth program of the European Development Fund and is now available for measurements.

The water level during the measurements was falling very slowly with daily changes of 1 to 3 cm (Figure 17). Gauge height was 4.09 m and is considered as stable, where hysteresis effects are not expected.

Figure 17 Gauge height at Katoa gauging station during September and October 2013
All six measurements were taken into consideration for the evaluation of recharge (Figure 18 and Annex II). They reveal an average discharge value of 812 m³/s.

Figure 18 Logone River cross section at Katoa gauging station and distribution of flow velocity

According to the rating curve, the corresponding discharge value for a gauge height of 4.09 m is 1,069 m³/s (Figure 19). The measured discharge is about 24% lower.

Figure 19 Rating Curve Katoa gauging station (pink squares = values formerly measured by DREM, red square = value measured in October 2013) (source: DREM)
5.5 Bongor Station, Logone River, 18.10.2013

This station is located on the Logone River about 270 km upstream of N’Djamena TP. The gauge height was 4.01 m and remained stable for the period in which the measurements were carried out. The highest water level had been observed on the 26.09.2013. The daily changes (rise and fall) from the 1st to the 25th of October are 1-4 cm, since the 25th water levels fall more than 6 cm per day (Figure 20). However, no hysteresis effects are expected during the measurements.

![Gauge Height Bongor Station](image)

Figure 20 Water levels of Bongor gauging station in October 2013

Four out of six measurements were taken into consideration, which revealed an average discharge value of 1,350 m$^3$/s (Figure 21 and Annex II). Transect four and six were excluded since they showed many sections with signal losses.

![Logone River cross section at Bongor gauging station and distribution of flow velocity](image)

Figure 21 Logone River cross section at Bongor gauging station and distribution of flow velocity
According to the rating curve (Figure 22), the discharge corresponding to a gauge height of 4.01 m is 1,543 m³/s. The measured discharge is about 13 % lower.

Figure 22 Rating Curve Bongor station (pink squares = values formerly measured by DREM, red square = value measured October 2013, green square = value measured in February 2013) (source: DREM)
6 General Findings

The discharges measured in February and October 2013 with the ADCP instruments of the DREM installed on a Zodiac rubber boat equipped with an engine, the values obtained from the rating tables, and the difference between calculated and measured discharges are listed in the following Table 2.

Table 2 Summary of discharge values measured in February and October 2013 and comparison to the values taken from the existing rating curves

<table>
<thead>
<tr>
<th>Gauging Station (measurement point)</th>
<th>River</th>
<th>February 2013</th>
<th>October 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gauge height [m]</td>
<td>Discharge from rating curve [m³/s]</td>
</tr>
<tr>
<td>N'Djamena TP</td>
<td>Chari</td>
<td>1.78</td>
<td>300</td>
</tr>
<tr>
<td>Mailao</td>
<td>Chari</td>
<td>2.30</td>
<td>190.2</td>
</tr>
<tr>
<td>Bongor</td>
<td>Logone</td>
<td>1.18</td>
<td>89</td>
</tr>
<tr>
<td>Katoa</td>
<td>Logone</td>
<td>inoperable</td>
<td>-</td>
</tr>
<tr>
<td>Logone - Gana (upstream confluence)</td>
<td>Logone</td>
<td>1.48</td>
<td>no rating curve</td>
</tr>
<tr>
<td>Logone - Gana (downstream of confluence with Koualambou)</td>
<td>Logone</td>
<td>1.48</td>
<td>138</td>
</tr>
<tr>
<td>Logone - Gana (upstream confluence)</td>
<td>Logone</td>
<td>1.50</td>
<td>no rating curve</td>
</tr>
</tbody>
</table>

It can be observed, that the discharge of the Logone River at Bongor in October 2013 is almost 20 times higher than that of February 2013. Similarly, the discharge of the Chari River at N'Djamena TP is more than 10 times higher than in February 2013.

The discharges measured during this mission are 3 to 25 % lower than the values estimated from the existing rating tables. Yet the differences are inferior to those observed in February 2013 during the dry season (10 - 50 %). Because during rainy season river water at Bongor and Katoa burst its banks into the Yaéré and Naga plains the differences between measured and estimated discharges should be regarded with caution. Rating curves are invalid during overbank flow since there is no longer any clear water level-discharge relationship detectable.
The measurements show that the Logone River loses discharge between Bongor and Logone-Gana. A discharge of 1,350 m³/s was measured at Bongor, but 80 km further downstream at Katoa station the Logone River transported only 812 m³/s. Therefore, between Bongor and Katoa the river loses around 500 m³/s into the inundation plains.

About 95 km further downstream (from Katoa station), at Logone-Gana, only 520 m³/s were measured upstream of the confluence with the Koulaumou River. This represents another loss of around 300 m³/s between Katoa and Logone-Gana (Figure 23). However, 300 m³/s reflow into the Logone by the Koulaumou River at Logone-Gana.

Nevertheless, a total loss of about 500 m³/s is observed between Bongor and Logone-Gana. These water is retained in the inundation zones where it either evaporates, infiltrates, recharges the groundwater, and/or enters into a tributary that derives the waters back into the Logone River.

Summing up the discharge of 826 m³/s at Logone-Gana station with the discharge of 1,340 m³/s measured at Mailao gauging station, at the Chari River, a total discharge of 2,152 m³/s can be expected downstream at the confluence of the two rivers. At N’Djamena TP, a slightly lower discharge (0.5%) of 2,140 m³/s was measured.

Since no continuous discharge values of the Logone River at Bongor, Katoa, and Logone-Gana from the last years are available, discharge values from the years 2001 to 2005 are presented to discuss the findings below.
Figure 23 shows that minimum discharge values at all three stations are reached in April/May during the dry season. Furthermore, it can be seen that discharge increases rapidly during the rainy season beginning in May/June whereby peakflows are reached at the end of the rainy season either in September in Bongor and Katoa or with a delay of at least one month in Logone - Gana. This delay was detected during the actual study period. The water level readings at Bongor and Katoa station showed a maximum value at the end of September (26th), while the water levels in Logone - Gana and N'Djamena TP were still rising (refer to Figure 7, Figure 13, Figure 17, and Figure 20).

Former studies (Ngounou Ngatcha et al., 2007; Vassolo & Daïra, 2012) have calculated the overflow value in m³/s into the Yaéré and Naga plains at the stations Bongor and Katoa, respectively (Figure 25 and Figure 26).

On Figure 25, the differences of the discharge values at Bongor and Katoa stations are illustrated against the discharge values at Bongor station. It shows that the overflow into the Naga and Yaéré plains north of Bongor and between Bongor and Maga Lake starts when the river discharge exceeds 1055 m³/s at Bongor. The same analysis between Katoa and Logone - Gana stations indicates that the overflow into the Yaéré and Naga plains north of Katoa initiates when the discharge surpasses 356 m³/s at Katoa station (Figure 26).


7 Recommendations

As already recommended after the first mission in February 2013, the operator should regularly check the state of the gauge plates after the rainy season, since they are exposed to a high risk of damage. Furthermore, the correct fit should be checked by leveling in accordance to one or better two benchmarks that are part of each gauging station. It has been observed during both missions that benchmarks are rather old and improperly fixed to the ground. Thus, there is a high risk of displacement of the reference points.

It is recommended to check the rating curves more frequently by further discharge measurements (report to Krekeler & Seeber, 2013), particularly at Logone - Gana and Katoa since measured discharges show deviations of 24 to 50 % against values obtained from the rating curves. On the other hand, the discharge values measured during the two missions in 2013 correspond very well to the measurements carried out in the past. Hence, as a first step, the rating curves should be recalculated on the basis of all existing measurements.

Further, it has to be mentioned that the rating curves at Bongor and Katoa stations are not valid once the river water burst over the banks, since there is no longer any clear water level-discharge relationship detectable. Thus, rating tables should not be established for a discharge value above the value where river water burst its banks.

It should be noted that the gauging station for the Logone River in Logone - Gana is placed at the Koulaambou River, a tributary of the Logone River. Although the water level-discharge relationship for this station corresponds very well to the Logone River, a displacement of the station is considered to be meaningful. Nevertheless a new station further downstream should only be considered if the access to the new station during the rainy season is guaranteed. The actual station could be used at the beginning to transfer the water level – discharge relation to the new gauging station downstream of the confluence. After the new station is constructed, the old one should be either dismantled or installed further upstream. As it is, it cannot be used for the Koulaambou River since it is too close to the confluence with the Logone River and thus influenced by this one.

Finally, a careful handling of the measurements devices such as the ADCP, the rubber boat and the engine is recommended. All instruments should be properly cleaned after each mission and stored in a clean and dry room to protect them against dirt and rodents.
8 References


Annex I
Field Guide for Discharge Measurements with RDI Workhorse Rio Grande ADCP

Necessary Equipment:

ADCP, mounting material, belt, tools, boat, paddle/engine, air pump, life vests, screen shade /rain cover, computer, charger for computer, connecting cables, USB – serial adaptor, battery, distance measuring device, multimeter (EC and T measurement), safety line, information on gauging station (earlier measurements, location of gauge plates),

Before start, test the equipment using the WinRiverII software.
Process of measurement:

1. Read water level from gauge plate
2. Set up instrumentation and boat, make sure that beam 3 mark shows forward, mount ADCP horizontal to minimize pitch and roll
3. Attach safety line to ADCP
4. Measure depth of ADCP surface under water
5. Turn on computer
6. Connect cables: 1. ADCP, 2. Computer, 3. battery
7. Start WinRiver II software
8. If an existing file is loaded, close file (File – Close Measurement)
9. Carry out a pre-test to measure the total water depth and to verify if the river bed is in motion:
   a. Using the Measurement Wizard, set an estimated depth and velocity
   b. On the Acquire menu click Start Pinging or use the shortcut key F4
   c. Move the ADCP to the middle of the section, or the point at which the highest velocities can be seen
   d. On the Acquire menu click Moving Bed Test. Select Stationary and click the Start button
   e. Hold the unit in position for ten minutes and try to minimize any movement
   f. Keep a close eye on the Ship Track graph. Any movement indicated on here above actual movement would indicate a Moving Bed
   g. On the Acquire menu click Stop Moving Bed Test
   h. Review the data; if this indicates bed movement, move to a more suitable section
   i. Use data to set a better configuration for transects.
10. Measure water temperature and salinity with multimeter
11. Set up new measurement (File – New Measurement) Insert requested information

12. Choose Rio Grande 1200 kHz – If ADCP is not identified by the software, click Check ADCP, finish setup

13. Check system settings: Configure – Reference – Bottom Track, Coordinate System – Earth, Units – All SI

14. Check ADCP: Acquire – Set ADCP Clock, Execute ADCP Test, Execute Pressure Sensor Test, Execute Compass Calibration (minimize ferrous material and electromagnetic field interference in the vicinity of the instrument)

15. Start measurement: Acquire – Start Pinging – Start Transect, Type in distance to shore, wait 10 seconds then start moving

16. Smooth boat operation is essential – if feasible it is recommended to cross the river in a straight line rectangular to the main flow direction

17. When reaching the other edge, wait 10 seconds then click Stop Transect

18. Measure at least four transects. The single results for Total Discharge should not differ more than 5 % from the mean. Otherwise four more measurements should be carried out

19. Read water level from gauge plate again
Troubleshooting

If there is no communication between PC and ADCP first try the **Auto Detect** function.

If this doesn’t help, check cables and power; serial port settings: 9600 baud, no party, 8 data bits, 1 stop bit

It may happen that a measurement consists of too many blank and invalid signals. This is often the case when the river bed is unstable. In moving bed conditions, discharge measurements from a moving boat are often impossible. This can be solved by carrying out section-by-section measurements. The *WinRiverII* software is not capable for this kind of measurements. RDI provides the *SxS Pro River Discharge Software* for section-by-section measurements.

General Handling

Dry the ADCP before storing, do not store it in temperature over 60°C
Never set the ADCP on a hard surface
Do not expose the ADCP to the sunlight for longer time
Do not lift the ADCP on the cable
The desiccant bags must be changed at least once a year (see technical manual)
Annex II
### Station Information

- **Station Number:** NDJAMENA TP
- **Station Name:** NDJAMENA TP
- **Meas. No.:** 1
- **Date:** 10/21/2013
- **Party:** TK
- **Boat/Motor:** ZODIAK YAMAHA

### Measurement Details

- **Gage Height:** 5.880 m
- **G.H. Change:** 0.000 m
- **Area:** 2358.8 m²
- **Discharge:** 2,140 m³/s
- **Mean Velocity:** 0.907 m/s
- **Width:** 326.9 m
- **Area Method:** Avg. Course
- **Nav. Method:** Bottom Track
- **MagVar Method:** Aucun (0.0°)
- **Depth Sounder:** Not Used
- **ADCP Depth:** 0.330 m
- **Index Vel.:** 0.00 m/s
- **Adj. Mean Vel.:** 0.00 m/s
- **Shore Ens.:** 10
- **Bottom Est:** Power (0.1667)
- **Top Est:** Power (0.1667)
- **Screening Thresholds:**
  - **ADCP:**
    - Type/Freq.: Rio Grande / 1200 kHz
    - Serial #: 8547
    - Firmware: 10.16
    - Bin Size: 25 cm
    - Blank: 25 cm
    - BT Mode: 5
    - WT Mode: 12
    - WV: 175
    - WO: 13, 4
- **Performed Diag. Test:** NO
- **Performed Moving Bed Test:** NO
- **Performed Compass Test:** NO

### Measurement Location

- **Meas. Location:** 1KM EN AVAL
- **Project Name:** StationNDJAMENA2_1.mmt
- **Remarks:**

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### Additional Details

- **Gage Height Change:** 0.000 m
- **Processed by:** TAPSALA
- **Mean Velocity:** 0.907 m/s
### Station Information
- **Party:** DREM/CBLT/BGR
- **Boat/Motor:** Zodiak/Yamaha
- **Gage Height:** 5.010 m
- **G.H. Change:** 0.000 m
- **Station Number:** MAILAO
- **Station Name:**

### Measurement Details
- **Meas. No:** 1
- **Date:** 10/16/2013
- **Processed by:** Seeber
- **Discharge:** 1,340 m³/s
- **Mean Velocity:** 0.811 m/s
- **Area Method:** Avg. Course
- **Nav. Method:** Bottom Track
- **MagVar Method:** Keine (0.0°)
- **G.H. Change:** 0.000 m
- **Gage Height:** 5.010 m
- **Area:** 1661.5 m²
- **Width:** 436.2 m

### Depth Sounder
- **ADCP Depth:** 0.330 m
- **Index Vel.:** 0.00 m/s
- **Adj. Mean Vel.:** 0.00 m/s
- **Rated Area:** 0.000 m²
- **Control1:** nicht spezifiziert
- **Control2:** nicht spezifiziert
- **Control3:** nicht spezifiziert

### Screening Thresholds
- **Type/Freq.:** Rio Grande / 1200 kHz
- **Serial #:** 8547
- **Firmware:** 10.16
- **BT 3-Beam Solution:** YES
- **WT 3-Beam Solution:** NO
- **BT Error Vel.:** 0.10 m/s
- **WT Error Vel.:** 1.07 m/s
- **BT Up Vel.:** 0.30 m/s
- **WT Up Vel.:** 0.50 m/s
- **Use Weighted Mean Depth:** YES

### Measured Values
- **ADCP Temp.:** 30.7 °C
- **Water Temp.:** 30.0 °C
- **Max. Vel.:** 1.90 m/s
- **Max. Depth:** 6.55 m
- **Mean Depth:** 3.82 m
- **% Meas.:** 62.00
- **Rated Area:** 0.000 m²
- **Control1:** nicht spezifiziert
- **Control2:** nicht spezifiziert
- **Control3:** nicht spezifiziert

### Meas. Location
- **échelle

### Edge Distance and Discharge Values

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### Remarks:

- **Remarks:**

### Project Information
- **Project Name:** tkstation_1g.mmt
- **Software:** 2.08
Station Number: Kouloumbou  
Station Name: Kouloumbou  
Meas. No: 1  
Date: 10/22/2013

Party: DREM/CBLT/BGR  
Boat/Motor: ZODIAK YAMAHA

Gage Height: 5.950 m  
Area: 380.1 m²  
G.H.Change: 0.000 m  
Discharge: 306 m³/s

Width: 77.2 m  
Area Method: Avg. Course  
Nav. Method: Bottom Track  
MagVar Method: Keine (0.0°)  
Depth Sounder: Not Used

ADCP Depth: 0.130 m  
Area Method: Avg. Course  
Nav. Method: Bottom Track  
MagVar Method: Keine (0.0°)  
Depth Sounder: Not Used

Index Vel.: 0.00 m/s  
Adj.Mean Vel: 0.00 m/s  
Mean Velocity: 0.806 m/s  
Discharge: 306 m³/s  
Rated Area: 0.000 m²  
Diff.: 0.000%

Control1: nicht spezifiziert  
Control2: nicht spezifiziert  
Control3: nicht spezifiziert

Screening Thresholds:

Performed Diag. Test: YES  
Performed Moving Bed Test: NO  
Performed Compass Test: NO

Meas. Location: 50M EN AVAL STATION

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SDev  | 0.00 | 0.82 | 16 | 1.04 | 9.16 | 2.03 | 0.657 | 0.265 | 10.6 | 2.4 | 21.0 | 0.28 | 0.02 |
| SD/M | 0.00 | 0.41 | 0.20 | 0.02 | 0.04 | 0.05 | 0.27 | 0.32 | 0.03 | 0.03 | 0.06 | 0.24 | 0.03 |

Remarks:
Station Number: LOGONE GANA  
Station Name: LOGONE GANA  
Party: TK  
Boat/Motor: ZODIAK YAMAHA  
Gage Height: 5.950 m  
G.H.Change: 0.000 m  
Mean Velocity: 0.661 m/s  
Mean Velocity: 0.661 m/s  
Discharge: 520 m³/s  
Discharge: 520 m³/s  
Area: 786.4 m²  
Area: 786.4 m²  
Area Method: Avg. Course  
Area Method: Avg. Course  
Nav. Method: Bottom Track  
Nav. Method: Bottom Track  
MagVar Method: Aucun (0.0°)  
MagVar Method: Aucun (0.0°)  
Depth Sounder: Not Used  
Depth Sounder: Not Used  
ADCP Depth: 0.130 m  
ADCP Depth: 0.130 m  
Index Vel.: 0.00 m/s  
Index Vel.: 0.00 m/s  
Rated Area: 0.000 m²  
Rated Area: 0.000 m²  
Control1: Non Spécifié  
Control1: Non Spécifié  
Control2: Non Spécifié  
Control2: Non Spécifié  
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Control3: Non Spécifié  
Rating No.: 1  
Rating No.: 1  
Qm Rating: N  
Qm Rating: N  
Diff.: 0.000%  
Diff.: 0.000%  
Screening Thresholds: 
- ADCP: 
  - Type/Freq.: Rio Grande / 1200 kHz  
  - Serial #: 8547  
  - Firmware: 10.16  
  - Bin Size: 25 cm  
  - Blank: 25 cm  
  - BT Mode: 5  
  - BT Pings: 1  
  - WT Mode: 12  
  - WT Pings: 1  
  - WV : 175  
  - WO : 13, 4  
- BT 3-Beam Solution: YES  
- WT 3-Beam Solution: NO  
- BT Error Vel.: 0.10 m/s  
- WT Error Vel.: 1.07 m/s  
- BT Up Vel.: 0.30 m/s  
- WT Up Vel.: 1.00 m/s  
- Use Weighted Mean Depth: YES 

Performed Diag. Test: YES  
Performed Moving Bed Test: NO  
Performed Compass Test: NO  
Meas. Location: 1KM EN AMONT  

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- Remarks:

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Date: 10/17/2013

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<td>G.H.Change: 0.000 m</td>
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<td>Boat/Motor: zodiak yamaha 25cw</td>
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<td>Gage Height: 4.090 m</td>
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<td>Discharge: 812 m³/s</td>
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| Area Method: Avg. Course |
| ADCP Depth: 0.100 m |
| Nav. Method: Bottom Track |
| Shore Ens.:10 |
| MagVar Method: Keine (0.0°) |
| Bottom Est: Power (0.1667) |
| Depth Sounder: Not Used |
| Top Est: Power (0.1667) |

| Mean Velocity: 1.01 m/s |
| Discharge: 812 m³/s |

| Mean Velocity: 1.01 m/s |
| Discharge: 812 m³/s |

| Index Vel.: 0.00 m/s |
| Adj.Mean Vel: 0.00 m/s |
| Rated Area: 0.000 m² |
| Diff.: 0.000% |

| Area Method: Avg. Course |
| ADCP Depth: 0.100 m |
| Nav. Method: Bottom Track |
| Shore Ens.:10 |
| MagVar Method: Keine (0.0°) |
| Bottom Est: Power (0.1667) |
| Depth Sounder: Not Used |
| Top Est: Power (0.1667) |

| Mean Velocity: 1.01 m/s |
| Discharge: 812 m³/s |

| Index Vel.: 0.00 m/s |
| Adj.Mean Vel: 0.00 m/s |
| Rated Area: 0.000 m² |
| Diff.: 0.000% |

| Area Method: Avg. Course |
| ADCP Depth: 0.100 m |
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| Mean Velocity: 1.01 m/s |
| Discharge: 812 m³/s |

| Index Vel.: 0.00 m/s |
| Adj.Mean Vel: 0.00 m/s |
| Rated Area: 0.000 m² |
| Diff.: 0.000% |

**Screening Thresholds:**

| BT 3-Beam Solution: YES |
| Max. Vel.: 2.03 m/s |
| WT 3-Beam Solution: NO |
| Max. Depth: 5.46 m |
| BT Error Vel.: 0.10 m/s |
| Mean Depth: 3.90 m |
| WT Error Vel.: 1.07 m/s |
| % Meas.: 67.19 |
| BT Up Vel.: 0.30 m/s |
| Water Temp.: 30.0 °C |
| WT Up Vel.: 0.80 m/s |
| ADCP Temp.: 29.9 °C |

| Use Weighted Mean Depth: YES |

**ADCP:**

| Type/Freq.: Rio Grande / 1200 kHz |
| Serial #: 8547 |
| Firmware: 10.16 |
| Bin Size: 25 cm |
| Blank: 25 cm |
| BT Mode: 5 |
| WT Mode: 12 |
| WV : 175 |

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**Remarks:**
Station Name: Bongor

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- **Area Method:** Avg. Course
- **ADCP Depth:** 0.100 m
- **Nav. Method:** Bottom Track
- **MagVar Method:** Keine (0.0°)
- **Depth Sounder:** Not Used
- **Index Vel.:** 0.00 m/s
- **Adj. Mean Vel.:** 0.00 m/s
- **Rated Area:** 0.000 m²
- **Diff.:** 0.000%
- **Control1:** nicht spezifiziert
- **Control2:** nicht spezifiziert
- **Control3:** nicht spezifiziert
- **Rating No.:** 1
- **Qm Rating:** n
- **Screening Thresholds:**
  - **ADCP:**
    - Max. Vel.: 2.14 m/s
    - Max. Depth: 5.45 m
    - Mean Depth: 3.91 m
    - % Meas.: 64.60
    - Water Temp.: 30.0 °C
    - ADCP Temp.: 29.6 °C
- **Use Weighted Mean Depth:** YES

- **Perf. Diag. Test:** YES
- **Perf. Moving Bed Test:** NO
- **Perf. Compass Test:** NO
- **Meas. Location:** 100 EN AVAL

### Remarks:

- **Mean Vel.:** 1.06 m/s
- **Discharge:** 1,350 m³/s
- **Mean Velocity:** 1.06 m/s
- **Gage Height:** 4.010 m
- **G.H.Change:** 0.000 m
- **Area Method:** Avg. Course
- **Nav. Method:** Bottom Track
- **MagVar Method:** Keine (0.0°)
- **Depth Sounder:** Not Used
- **Index Vel.:** 0.00 m/s
- **Adj. Mean Vel.:** 0.00 m/s
- **Rated Area:** 0.000 m²
- **Diff.:** 0.000%
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- **Control3:** nicht spezifiziert
- **Rating No.:** 1
- **Qm Rating:** n

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