EASTERN NILE IRRIGATION AND DRAINAGE STUDY/FEASIBILITY STUDY
DINGER BEREHA IRRIGATION PROJECT

ANNEX 2: TOPOGRAPHIC SURVEYS AND MAPPING

Table of contents

List of Tables

1. INTRODUCTION

The topographic survey of Dinger Bereha (DB) irrigation project was made under a separate contract entered with ENTRO to undertake field investigations (FI). The contract was awarded to BRLi in January 2009, with Metaferia Consulting Engineers as sub contracted firm. Under this contract the topographic survey of the command area, which was the base for conducting the feasibility study (FS) and design of the project, was availed and the feasibility design of the irrigation system was carried out. In this annex, apart from what has been presented in the topographic survey report of the FI, it is presented in brief how the topographic survey was conducted and what methodologies were deployed to undertake the surveying works. This chapter also describes what outputs were finally gained and how these final products are utilized in the design of the FS of the project. Furthermore, it incorporates the final survey works that were carried out during two phases.

As discussed in the draft main report of the FI investigation study that due to the onset of the rainy season in the Project area, during the previous survey of the command area and the weir site, the canal alignment and other detailed surveys of major crossing structures and the pump site could not be carried out. Whereas, in 2010 the survey activities, that were interrupted due to the reasons mentioned here with, were completed and made part of the FI final productions. Hence, currently all the required survey works were completed and the required survey data were attributed and accordingly the FS was subject for updating based on these outputs of the survey works.

2. SCOPE OF THE STUDY

Before mobilizing of the survey crew and start off the field work, the teams assigned to undertake the survey works were briefed about the objectives, methodology and planning of the survey work. The team was comprised of a significant experienced staff. For the surveying crew, camp accommodation within or close to the project area was arranged, in order to expedite the work in time, by the Consultant. Senior Surveyors were included in the team to ensure quality of the work. They were responsible for the general supervision and control of this important activity in order to strengthen the day-to-day follow up of the works undertaken. All survey work was carried out according to the requirements of the TOR and the Inception Report. The topographic survey of the command area was executed so as to prepare for the feasibility design of the irrigation scheme, including selection of irrigation methods, preparation of irrigation layouts, preparation of bill of quantities and cost estimates, design of irrigation infrastructure, etc.

As the Main Canal Route Alignment and other detail survey activities were part of the scope of the CS investigation assignment, some of these activities not undertaken timely in the previous survey work, whereas these activities are fully accomplished the database are delivered to the FS team for use.

Project command area delineation was one of the major scopes of the assignment, and accordingly the command area and the Project area boundaries were delineated and horizontal and vertical control points were established, with known X-Y-Z co-ordinates. The control points were tied to the national grid of the EMA points, through establishing four sets of benchmarks (BMs), with five in the command area and the other one at the weir/headwork site. These initial GPS points were established using differential GPS of dual accuracy under long period observation, which were tied with National Datum. Other benchmarks were extended from these points and leveling of the BMs was carried out. The BMs were established on stable features and clearly marked and painted with visible colors.

Furthermore, where there were no permanent features, the BMs were formed by installing 14mm iron bar of about 50 cm long in to the ground so that the top is made above the ground level and the encasing upper part of the bar is prepared in 250x250x250 mm above the top of the concrete, aiming at the use of the BMs for future reference. In addition to this, four Benchmarks (BMs) are installed on permanent features out of the command area, being three on high outcrops and one on the woreda telecommunication tower.

The command area survey/ground levels and benchmarks network establishment covering about a gross area of 10,600 ha was carried out at appropriate grid intervals, following appropriate methods as stipulated in the ToR and in the Inception Report. The topographic maps were prepared with 1m vertical contour interval and at a scale of 1:10,000 for the FS.

Although the main canal alignment survey, topographic survey of the pump site, survey of major structure sites cross sections and sample command area survey were part of the scope of the assignment, these activities were reported to be outstanding due to the onset of the rainy season in the previous survey time. These were completed in this year (from February to first week of March 2010) as the weather and accessibility conditions of the project site improved.

The topographic maps produced show every major feature of the areas including, rivers, springs, gullies, hills, settlements, footpaths, cattle crossings, water bodies, etc.

3 METHODOLOGY

3.1 DELINEATION OF IRRIGABLE AREA FOR SURVEY

Prior to the commencement of the study, the 1:50,000 maps obtained from the Ethiopian mapping Agency (EMA) were reviewed as there was no other topographic study of the project area was available.

To start with the survey of the command area and in order to delineate the command area boundaries, the project area was divided in to two parts:

- The western part, bounded by Didessa River, Dabana River, Chekorsa/Boro River and contour +1260 m; and
- The eastern part, bounded by Chekorsa/Boro River, Didessa River and contour +1260m.

The delineation of the area was made using GIS software and geo-referenced map of EMA, which was digitized by the Consultant for the purpose. On the basis of this delineation, gross command areas below the contours +1240, +1260, and +1280 were determined. A partly forested buffer zone of 200 m wide along Didessa and Dabana Rivers was excluded from the envisaged irrigation command area.

Accordingly, considering the exclusion of areas for villages, roads, topographically unsuitable areas, and areas set aside for woodlots and buffer zones along streams, the net command area was assumed to be 70% of the gross delineated area below contour +1240 m and between the contours +1240 and +1260 m which are bounded by Didessa River from the northeast and Dabana River from southwest. The gross command area below and between these contours estimated to be over 12,000 ha.

Following the demarcation/delineation of the area, the command area boundary and the surrounding areas were identified and coordinates of its boundaries were delivered to the surveyors to carry out the work as planned. Furthermore, satellite images of January 2008 with high resolutions were acquired and interpretation of the area made at office level and the images were loaded on the computers of the surveyors for use at field level for verification of the survey works. Digitized EMA maps and the satellite images were employed to keep track of the orientation of the survey group and for directing the survey activity. The topographic survey was carried out for the planned study area, excluding the high spots, hills and mountains, buffer zones, villages, and other non-required areas located within the project sites. The work was planned for execution commencing with three survey crews, and increasing as required depending on the rate of progress of the field works. During the second surveying time, the surveying crew was one, assuming that the remained activities are confined in an area of difficulty blocking opportunity to many survey crews.

3.2 TOPOGRAPHIC SURVEY OF THE COMMAND AREA

The field level survey was carried out in order to collect spot heights in a grid network of 100 × 100 meters. The spacing between points was minimized to show the terrain undulation or specific features when such features occurred. Automatic and digital levels were used to collect the levels. Spot heights are tied and referred to mean sea level after GPS points were fixed by installing and tying the monuments with national grid referenced datum.

Three survey teams were mobilized to undertake the command area survey area demarcated in the Project site prior to the identification of the reference GPS points. The works started at the southern and in the middle of the command area near village number 4 and Chewaka town respectively. The surveying activities continued in northerly direction towards the confluence of Dabana and Didessa Rivers where as the other team was assigned to continue the survey work in the north eastern direction, towards Didessa River. In accordance with the TOR, during the topographic survey, every effort had been made to incorporate the main natural and man-made features like ridges, valleys, river courses, etc.

Although it was intended to survey the command area and the main canal alignment of the project at same time, it was not possible to attain this program at a one go. For the purpose of the design of the irrigation infrastructures of the project at FS level, a total area of about 10,600 ha was surveyed within 3 months after starting the survey of the command area. Accordingly the picked spot elevations were processed and topographic maps were produced to be used for the design of the system at a scale of 1:10,000. All office works of compiling and producing of topographic maps, after the field work, which was halted in mid June 2009 due to the onset of the rainy season in the project area, has longed for almost two (2) months, requiring more time than expected.

4. ESTABLISHMENT OF BENCHMARKS (GPS POINTS) AND CONNECTION WITH THE NATIONAL GRID

Six GPS points, which are tied up with National Grid reference points were established: five located in the command area periphery and one at the weir site. The other BMs network are extended from these GPS datum references and all the BMs are tied up with these GPS datum values by running a traverse of levels (see below table 4.1 for the GPS points location and datum value).

Following this, permanent benchmarks (BMs) were established at appropriate intervals (average 1-2 km) within the Project boundary. These are inter-visible. The BMs were established on solid natural or manmade objects such as rock outcrops or to the top of permanent structures, where available. These points are marked in permanent paint and a 200 mm circle diameter drawn around the point and also painted in red for the details refer to Complementary Survey (Investigation) report Volume I Main report, section topographic survey. Furthermore, additional BMs were established during the second survey schedule referring to the GPs points already fixed. For the survey of detail sample command area, pump site and canal route alignment, besides the previously established BMs few new BMs are established along the main canal alignment. For the details of the BMs utilized for the overleft surveying works see table 4.2 below.

In all cases, where there were no permanent points, the benchmarks were formed by driving a 14 mm diameter steel bar 400 mm long into the ground with the top just above ground level and encasing the upper part of the bar in a 250 x 250 x 250 mm above the top of the concrete.

Table 4.1: GPS Points established in the Project area

Descriptions	Easting (UTM)	Northing (UTM)	Elevation (masl)	Site of Installation
GPS001	183609.587	997034.942	1209.404	Dabana & Didessa conflu. b1
GPS002	185123.526	992411.970	1246.266	Village 4 area1
GPS003	192140.452	991249.648	1259.141	Pump site 2
GPS004	188280.789	987085.297	1220.767	Chewaka town 2
GPS005	189111.294	981232.124	1272.959	Command area boundary 1
GPS006	203610.419	983252.504	1248.268	Weir site 1
GPS101	184460.572	996090.143	1245.614	Dabana & Didessa conful. b2
GPS102	185550.167	993004.519	1238.098	Village 4 area2
GPS103	191796.762	991359.053	1265.034	Pump site1
GPS104	187815.358	986420.432	1246.491	Chewaka town1
GPS105	189451.702	981924.378	1278.376	Command area boundary 2
GPS106	203035.333	983071.333	1256.323	Weir site 2

Table 4.2: List of Bench Marks established used for detail and canal route alignment survey works

	Descriptions	Easting (UTM)	Northing (UTM)	Elevation (masl)	Remarks
1	BM54	189017.374	987892.872	1246.168	BM54
2	BM57	186130.121	989541.462	1256.907	BM57
3	BM58	186498.102	990138.635	1248.839	BM58
4	BM59	185714.613	990380.735	1260.382	BM59
5	BM78	185768.542	989174.817	1247.812	BM78
6	BM79	184945.39	990295.298	1258.421	BM79
7	BM80	184415.362	990349.439	1264.202	BM80
8	BM81	184262.414	990304.256	1264.681	BM81
9	BM82	183767.702	990020.69	1256.566	BM82
10	BM86	186700.07	989489.976	1238.796	BM86
11	BM118	184701.755	991014.788	1247.254	BM118
12	BM122	186000.636	990867.969	1248.271	BM122
13	BM123	186355.399	990931.61	1241.415	BM123
14	BM124	186693.223	991773.425	1210.982	BM124
15	BM126	186842.849	990949.512	1210.472	BM126
16	GPS 004	188280.789	987085.297	1220.785	GPS 004
17	GPS 104	187815.358	986420.432	1246.573	GPS 104
18	BM139	201614.27	984873.76	1241.46	Newly established BM along the MC
19	BM140	201581.00	984863.70	1242.58	Newly established BM along the MC

5. ESTABLISHING NETWORKS OF BENCHMARKS AND TRAVERSING

For the production of topographic maps, networks of BMS were established in order to facilitate the detailed design activities and the construction of the project works during the implementation phase. Hence, adequate numbers of BMs were established for both vertical and horizontal control. Using the five GPS values in the command area and one GPS point at the weir site as a control, the BMs were traversed within the command area as densely as possible. Overall about 138 BMs (posts) were installed at locations where spacing ranged from 500 to 600 meter on average, thus insuring inter-visibility of any two adjacent structures. Out of this network of BMs, 4 of them are established out of the command area being three sets BMs on the Peak Mountains with indivisibility among the BMs, and one on a tele-tower located in the centere of the town, Illu-Harar.

The BMs consisted of one meter long concrete posts with steel bar of 1 meter embedded at the centre and extending to the bottom. The posts were installed in the ground at selected locations with the top 200 mm protruding above the ground. After the construction and curing of the BMs, an identification name was written on the top of each in white and red.

Further, to assist in locating the monuments, and their accessibility for supervision purposes, features like trees, rock outcrops, rocks et., which were in the vicinity were also marked in red and white ink such that they could be identified from a distance. The BMs Network was established with in the command area.

The BMS were traversed using leveling equipment and connected with the GPS points that are tied with the National Grid Datum. A total of 138 BMs which are inter-visible are established and traversed all over the command area envisaging that these BMs will be used for the detail design and implementation of the project. Furthermore four BMs which are out of the command area are located at higher points for further use.

6. SURVEY OF WEIRSITE, MAIN CANAL ROUTE ALIGNMENT AND OTHER SITES

In line with the topographic survey of the command area, the weir site area was surveyed and the cross-sections made at three lines. The survey out puts were plotted and conveyed for use by the geotechnical study sector during the field level investigation as well as for final production of the weir site geotechnical works. To connect these survey works with known BM values, GPS points were established and BMs installed in the vicinity. The map of the diversion site is presented in Volume III: Maps and Drawings.

It was discussed in the Draft FI topographic survey report that although it was intended to complete all field survey works of the Complementary Survey investigations before the onset of the rainy season, and finalize the office works on time as scheduled for further use of the outputs for the feasibility study of the project, due to various reasons, the commencement of the activities was hampered. As result, the start of the survey works had to be shifted from the initial date in January 2009 to the end of March 2009. Even within this time it was achieved with strong initiative and commitment by the Consultant who initiated and financed the starting-up of activities from its own resources, when payment of the mobilizations advance by the Client was delayed due to circumstances beyond the control of the Client and the Consultant.

Despite the fact that the Consultant commenced the work as early as possible, due to the terrain of the project area and the canal alignment route, which is crossing through dense forest of the main course of Didessa River, coupled with the on set of the rainy season, it became impossible to finalize the survey of the main canal alignment during the previous survey time. Similarly, the detailed survey of pump station sites and major structure sites were not finalized as these sites were not identified exhaustively. Following this, to complete these outstanding activities the surveying crew was remobilized to the project site as of February 3rd to the first week of March 2010. During this second mobilization of the surveying team, the survey of the primary canal alignment was started from its upstream end and continued to downstream, the weir site, as the weir site was not cleared from the savannah grasses to start with. The survey of the canal route alignment was made starting from where the primary canal enters to the command area to the weir site, in line with this; a total length of 22 km is surveyed taking over 43 days.

Within this reach of the primary canal about 18 drainage crossing points are found, and of which for 6 to 8 of them, that are found to be big gullies and need huge structures to cross the natural drains entering to the main river, Didessa, a detail survey is undertaken as per the ToR. And the cross-sections of the crossing points of the gullies are prepared at scale 1:200.

The survey crew that was mobilized to this site for the second time faced chaos of big jungle and access to undertake the canal route alignment survey. The team was obliged to pass all their time in the jungle by residing with the farmers settled at the upper part of the left flank of the Didessa River. They also faced with wild animals and snakes besides the dense forest that was very difficult to clear and undertake the alignment survey. As a result, the canal alignment survey was carried out with great determination and scarification paid by the survey team.

Furthermore, besides the canal route survey, details of the crossing points were surveyed and prepared at various scales as found important.

It has been also discussed in the previous draft FI topographic survey report that the survey of detail structures and pump station were subject to pend, during the current survey, all the activities are carried out. Accordingly, in line with the primary canal alignment survey, details of the pump site survey, canal crossing points across the primary canal and sample command area surveys were undertaken and preparation of the topographic maps completed. All necessary maps and sections of the cross drainage sites are prepared at scale referred in the ToR. L-profile of the primary canal, topographic maps of the sample command areas and details of the pump-station surveys are among others prepared and made available for use during the current survey.

7. GENERATION OF TOPOGRAPHIC MAPS

The survey data collected each day were downloaded after working hours, and checked for consistency and errors. The terrain model was then prepared using the data for further comparing the land features generated with the actual features of the land they represented. For downloading, softwares COMMSP and TOPCON LINK were used and terrain model generation was conducted using Terramodel software installed on two laptop computers used during the field survey.

The contour maps with contour interval of 0.25 and 1 meter were prepared at office level from the collected field survey data. The digital topographic map with high resolution satellite image (as background) was prepared and printed at scale 1:10,000 (about 8 sheets). The maps show features such as rivers, water bodies, roads and tracks, villages, gullies, hills and footpath, etc. also the areas of dense trees and hills are superimposed on the produced topo-maps from the satellite images. A map at scale 1:10,000 for the FS design of the irrigation system and scale 1:25,000 for presentation of the area were prepared and printed for use. The maps are included in Volume: Maps and Drawings A1.