

Annex A

TERMS OF REFERENCE

GEOPHYSICAL SURVEY IN AL SALAAM AND JABELEIN LOCALITIES, WHITE NILE, SUDAN 2020

1. BACKGROUND

The refugee camps located along the White Nile in the southern part of Sudan are all located at approximately 2 km from the White Nile (Figure 1). The position of the White Nile on the regional scale is just at the transition between the semi-arid regions in the south towards the arid regions in the North. Such a transitional position is usually combined with a transition from rivers acting as discharge areas towards rivers being sources of groundwater recharge. The White Nile in that area is characterized by low gradients which imply very fine sediment transport and associated deposition of fine sediments, acting as barriers to groundwater recharge.

In Sudan, White Nile State is the major refugee hosting state. An estimated 88,000 South Sudanese refugees live out of camps, while 149,693 refugees (39,459 households) live in the 9 refugee camps in Al Salaam and Jabelein localities: Alagaya (16,798), Al Kashafa (13,017), Alredis1 (11,397), Alredis2 (24,807), Dabat Bosin (3,187), Jourie (10,444), Khor Alwarel (43,280), Al Jameya (6,119), Um Sangour (20,644).

Water supply in the camps is predominantly surface water from river Nile and it's pumped and treated at the water treatment plants. There are 10 water treatment plants serving the 9 camps. Two of these treatment plants are Emergency Surface Water Treatment systems (SWAT) while the other eight are compact water treatment systems. Since beginning of the year, operation of these water supply systems has been greatly affected by erratic fuel shortages. This has greatly affected the delivery of water to the refugees and surrounding host communities. UNHCR has been exploring the possibility of ground water exploration.

The rationale of the survey is to investigate the possibility of developing groundwater resources closer to the refugee camps and to solarise systems, to complement existing water treatment systems, which get water from the river.

Prior to the development of new sites, UNHCR intends to engage the services of a Consultant to carry out geophysical surveys of pre-selected areas. UNHCR will hire a Consultant/Consulting firm to conduct a comprehensive geophysical survey and related studies for prospecting on identification of sites for drilling new boreholes and submit an accurate report to guide the drilling process.

2. OBJECTIVE OF THE SURVEY

The main objective of this project is to carry out a geophysical survey with the aim to identify the possible existence of shallow aquifer systems on the medium-scale which may be connected to the White Nile as groundwater recharge source in order to localise and propose drilling sites with high potential of good quality groundwater on the small-scale.

The survey shall be carried out in four different areas and with two different geophysical methods, carrying out groundwater exploratory field geophysical investigations (geoelectrical profiling and vertical electrical soundings) to assess potential aquifers.

3. GEOPHYSICAL SURVEY

The geophysical survey will be done in four locations along the White Nile, as shown in Figure 1.

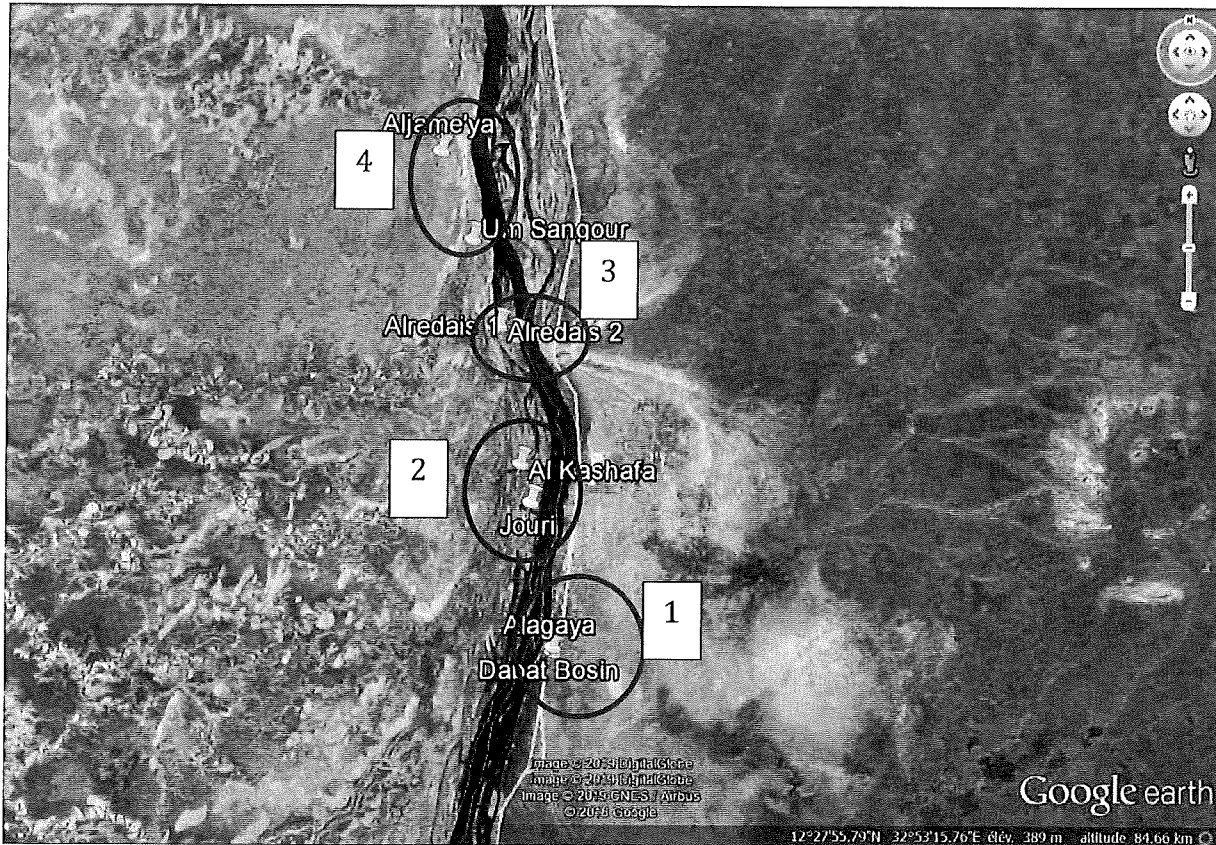


Figure 1. General setting of the refugee camps along the White Nile in Southern Soudan, with indicated close-ups discussed in the following.

The investigation strategy proposed hereafter to assess the potential of groundwater bodies in the different areas is described separately for each of the four geographical locations, shown in Figure 1.

A total of 7 horizontal geoelectrical profiles are requested, with an average of 40 data points along the profile and a total of 9 vertical sounding pairs (2 perpendicular soundings at each position). The coordinates of each profile is given by the start and end points, while the coordinates of the center point of the vertical soundings are indicated for each survey position.

Zone 1: Alagaya and Dahat Bosin: Horizontal and vertical profiling Right bank of the White Nile

A close-up of the two southern most located refugee settings along the right bank is shown in Figure 2. There is no morphological indication for Eolian deposits (sands) which could locally act as groundwater reservoir. In order to identify whether any potential groundwater bearing units are present and whether they are connected to the Nile, two horizontal geoelectrical profile HEP1a (approximately 1000 m long) and HEP1b (approximately 700 m long) along the red sections in Figure 2 shall be carried out, using a Schlumberger array and combined with one vertical geoelectrical sounding (VES 1a-1a' and VES 1b-1b') per section, as follows:

HEP1a (Coordinates of end points: 12.369206°N/ 32.793154°E; 12.366375°N/ 32.801196°E)

Electrode spacing: The constant electrode spacing to be chosen for the outer electrodes is $AB/2 = 150$ meters, which will lead to an approximate investigation depth of 50-120 meters.

Spacing of measuring stations: one measurement shall be carried out every 20 meters. This will lead to approximately 45-50 data points along the profile.

VES1a-1a' (Coordinates: 12.367897°N/ 32.796981°E)

Two perpendicular vertical geoelectrical soundings shall be carried out on the mid-point of the horizontal profile HEP 1, as follows:

VES 1a: Parallel to the horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 1a': perpendicular to horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

HEP1b (Coordinates of end points: 12.360782°N/ 32.798338°E; 12.366375°N/ 32.801196°E)

Electrode spacing: The constant electrode spacing to be chosen for the outer electrodes is $AB/2 = 150$ meters, which will lead to an approximate investigation depth of 50-120 meters.

Spacing of measuring stations: one measurement shall be carried out every 20 meters. This will lead to approximately 30-35 data points along the profile.

VES1b-1b' (Coordinates: 12.363692°N, 32.799734°E)

Two perpendicular vertical geoelectrical soundings shall be carried out on the mid-point of the horizontal profile HEP 1b, as follows:

VES 1b: Parallel to the horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 1b': perpendicular to horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters



Figure 2. Refugee settings Alagaya and Davat Bosin located along the right bank of the White Nile with indicated location for horizontal geoelectrical profiles of HEP 1a and HEP1b.

Zone 2: Left bank southern refugee settings (Jouri and Al Kashafa)

The refugee camps Jouri and Al Kashafa are located on the right bank of the White Nile in an area where morphological features suggest both Eolian deposits as well as old river arms (Figure 3). Two profiles across all these features using horizontal geoelectrical profiling with Schlumberger array (HEP 2 and HEP 3, approximately 1650 meters and 3300 meters, respectively) shall be carried out to identify which features are potential local aquifers and whether they are connected (recharged) by the river Nile, by extending the section all the way to the river bank and combined with two vertical geoelectrical soundings (VES 2-2' and VES 3-3').

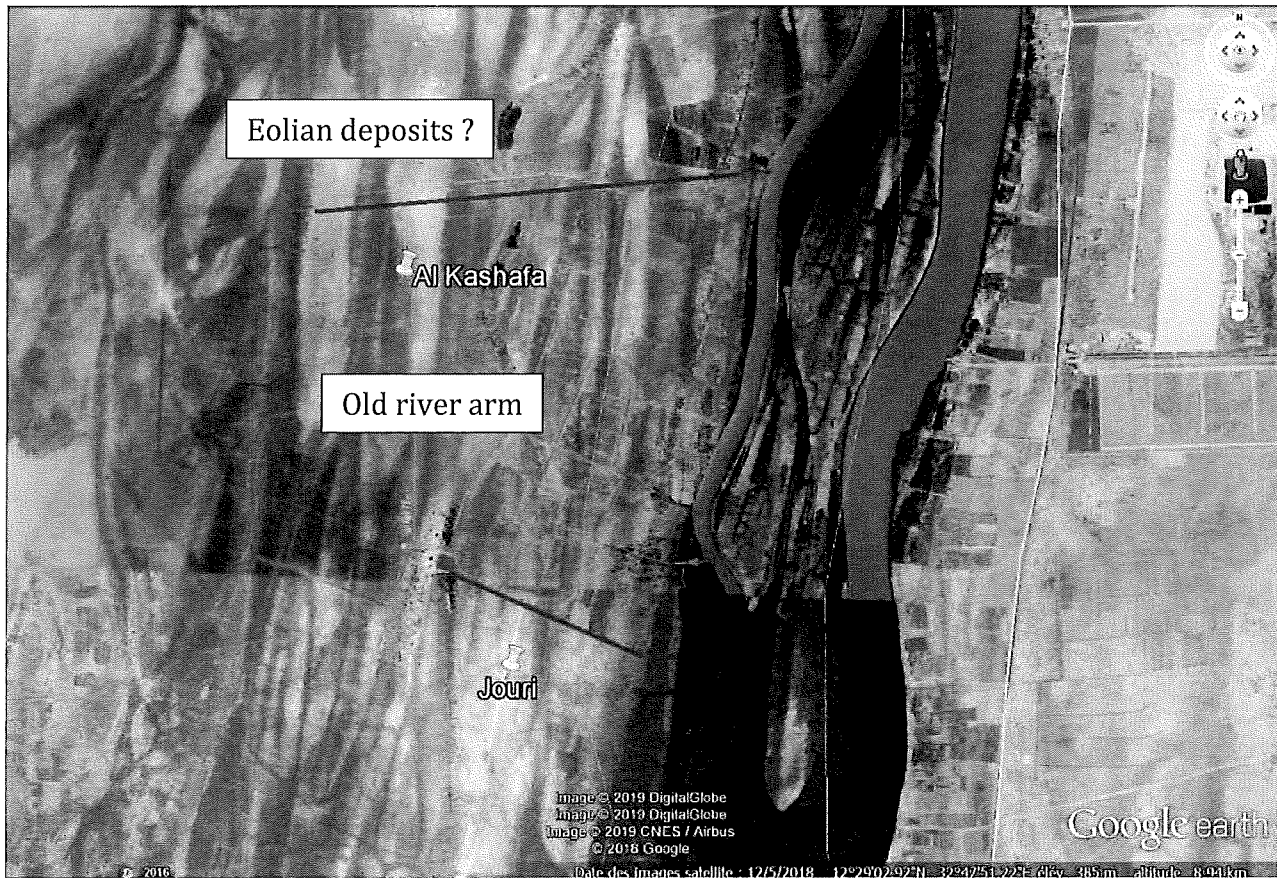


Figure 3. Close-up of the area and the morphological features encountered around the refugee settings Jouri and Al Kashafa along the right river bank, showing the proposed locations for horizontal geoelectrical profiling (HEP2 (south) and HEP3 (north)).

HEP2 (Coordinates of end points: 12.480088°N/ 32.783449°E; 12.474067°N/ 32.797091°E)

Electrode spacing: The constant electrode spacing to be chosen for the outer electrodes is $AB/2 = 150$ meters, which will lead to an approximate investigation depth of 50-120 meters.

Spacing of measuring stations: one measurement shall be carried out every 40 meters. This will lead to approximately 35-40 data points along the profile.

VES 2-2' (Coordinates: 12.478489°/ 32.787271°): vertical sounding located on a morphological dune feature

Two perpendicular vertical geoelectrical soundings shall be carried out on the mid-point of the horizontal profile HEP 1, as follows:

VES 2: Parallel to the horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 2': perpendicular to horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 3-3' (Coordinates: 12.476906°N/ 32.790599°E): vertical sounding located on a morphological meander feature

Two perpendicular vertical geoelectrical soundings shall be carried out on the mid-point of the horizontal profile HEP 1, as follows:

VES 3: Parallel to the horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 3': perpendicular to horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

HEP3 (Coordinates of end points: 12.505134°N/ 32.774319°E; 12.507147°N/ 32.804039°E)

Electrode spacing: The constant electrode spacing to be chosen for the outer electrodes is $AB/2 = 150$ meters, which will lead to an approximate investigation depth of 50-120 meters.

Spacing of measuring stations: one measurement shall be carried out every 60 meters. This will lead to approximately 45-55 data points along the profile.

VES 4-4' (Coordinates: 12.505720°N/ 32.782168°E) vertical sounding located on a morphological dune feature on the horizontal profile HEP 3

Two perpendicular vertical geoelectrical soundings shall be carried out as follows:

VES 4: Parallel to the horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 4': perpendicular to horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 5-5' (Coordinates: 12.506115°N/ 32.789203°E) vertical sounding located on a morphological meander feature on the horizontal profile HEP 3

Two perpendicular vertical geoelectrical soundings shall be carried out as follows:

VES 5 Parallel to the horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 5': perpendicular to horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

Zone 3: Left bank northern 1 refugee settings (Alredais 1 and 2)

Alredais 1 and 2 camps are located on the right bank of the White Nile. On the right bank, the Paleozoic bedrock crops out almost all the way to the river bank, close to the camps. It is therefore believed that the sedimentary deposits on the left bank are probably not thick, but may be coarse. The aim of this investigation is to assess the sedimentary thickness and the properties. A horizontal profile HEP 4 shall be carried out with Schlumberger array along the suggested section in Figure 4 (approximate length 2500 meters), and combined with one vertical geoelectrical soundings (VES 6-6') to investigate the depth to bedrock.



UNHCR

United Nations High Commissioner for Refugees
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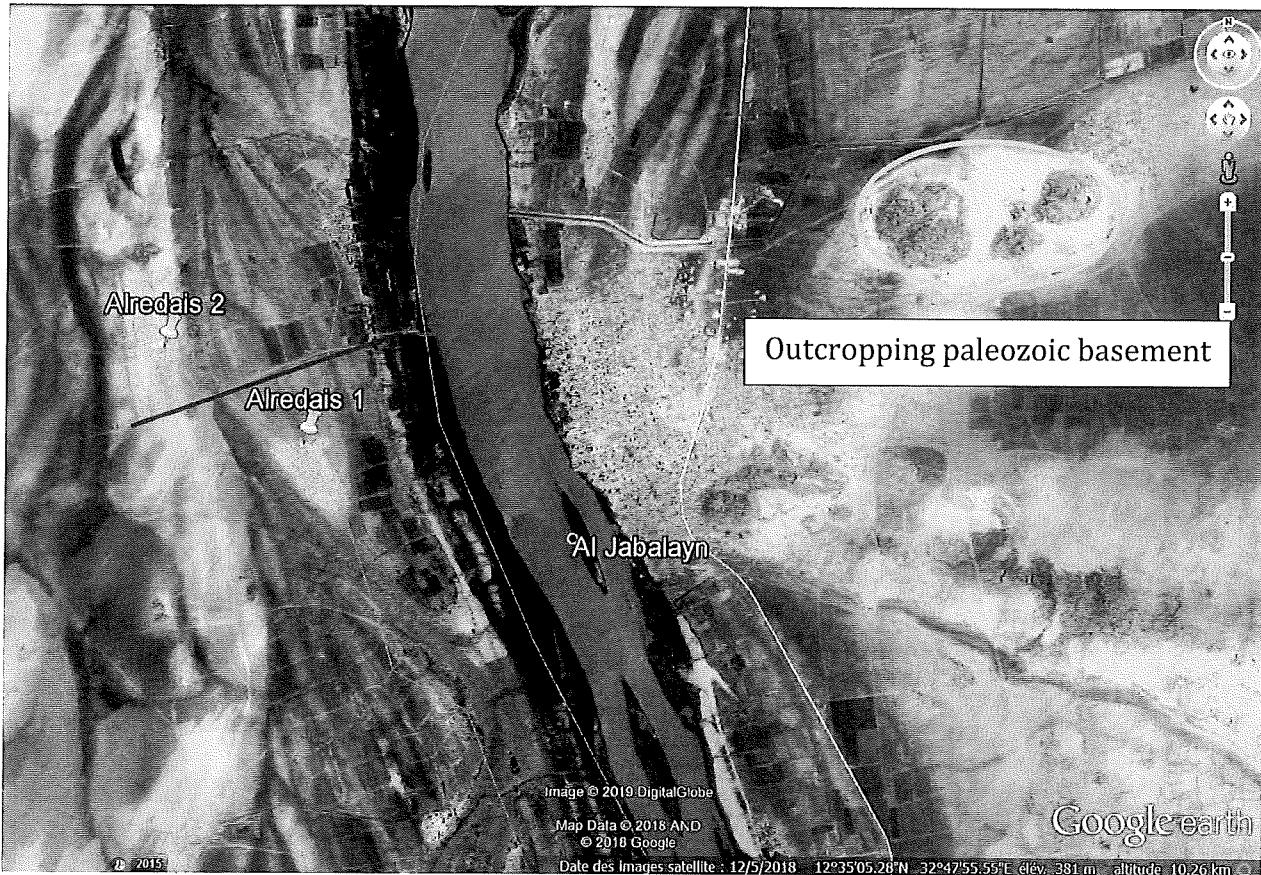


Figure 4. General setting of Alredais 1 and 2 with indicated section HEP 4 for geoelectrical profiling.

HEP 4 (Coordinates of end points: 12.592067°N/ 32.783449°E; 12.598707°N/ 32.784355°E)

Electrode spacing: The constant electrode spacing to be chosen for the outer electrodes is $AB/2 = 150$ meters, which will lead to an approximate investigation depth of 50-120 meters.

Spacing of measuring stations: one measurement shall be carried out every 50 meters. This will lead to approximately 40-50 data points along the profile.

VES 6-6' (Coordinates: 12.595673°N/ 32.774025°E)

Two perpendicular vertical geoelectrical soundings shall be carried out on the mid-point of the horizontal profile HEP 4, as follows:

VES 6: Parallel to the horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 6': Perpendicular to horizontal profile VES6 (Schlumberger array) with maximum $AB/2$ of 500 meters

Zone 4: Left bank northern 2 refugee settings (Um Sangour and Alame'ya)

In the area of the two northern most located refugee camps on the left bank there are some prominent features of Eolian dune deposits which may, if connected to the river, be highly productive shallow aquifers. Hence, investigating this option is important in this area. Two sections are indicated along which horizontal profiling shall be carried out with Schlumberger array (approximate lengths of HEP5 and HEP6, 2800 meters and 1000 meters, respectively) and combined with mid-profile vertical soundings to investigate the dune depth.



Figure 5. General setting of the two northern most located refugee camps with indicated possible dune deposit, with unknown depth and connection to the River, with indicated horizontal profiling sections HEP 5(south) and HEP6 (north).

HEP5 (Coordinates of end points: 12.659603°N/ 32.740446°E; 12.664163°N/ 32.765709°E)

Electrode spacing: The constant electrode spacing to be chosen for the outer electrodes is $AB/2 = 150$ meters, which will lead to an approximate investigation depth of 50-120 meters.

Spacing of measuring stations: one measurement shall be carried out every 60 meters. This will lead to approximately 40-45 data points along the profile.

VES 7-7' (Coordinates: 12.661844°N/ 32.753226°E): vertical sounding located on mid-profile point of HEP5

Two perpendicular vertical geoelectrical soundings shall be carried out on the mid-point of the horizontal profile HEP 5, as follows:

VES 7 Parallel to the horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

VES 7': perpendicular to horizontal profile (Schlumberger array) with maximum $AB/2$ of 500 meters

HEP6 (Coordinates of end points: 12.719422°N/ 32.742972°E; 12.717456°N/ 32.752575°E)

Electrode spacing: The constant electrode spacing to be chosen for the outer electrodes is $AB/2 = 150$ meters, which will lead to an approximate investigation depth of 50-120 meters.

Spacing of measuring stations: one measurement shall be carried out every 20 meters. This will lead to approximately 35-40 data points along the profile.

VES 8-8' (Coordinates: 12.718573°N/ 32.747373°E): vertical sounding located on mid-profile point of HEP6

Two perpendicular vertical geoelectrical soundings shall be carried out on the mid-point of the horizontal profile HEP 6, as follows:

VES 8: Parallel to the horizontal profile (Schlumberger array) with maximum AB/2 of 500 meters

VES 8': perpendicular to horizontal profile (Schlumberger array) with maximum AB/2 of 500 meters

4. TERMS OF REFERENCE FOR THE GEOPHYSICAL SURVEY

- Present a work plan to address the above investigation strategy
- Plan and carry out the geophysical investigations according to the above investigation strategy and interpret results.
- Present the results of the geophysical investigation (horizontal and vertical soundings), including all the raw data sets, the qualitative interpretation of the type curves in terms of layer sequence (for VES investigations) and inversions results
- Elaborate a geophysical report.

5. APPROACH, METHODOLOGY AND REQUIRED OUTPUTS

The consultant will use a systematic and holistic approach to assess the project site, following the below described step-by-step procedure with specific outputs, serving as milestones and as documentation.

The final report needs to have the same title page, including the following details:

- Name and address of Consultant
- Project title
- Date
- Project Phase (this refers to the labelling of the different intermediate reports and final reports, as per below description of outcomes)

Geophysical Survey report

- a) The geophysical investigation has to be documented, repeating the rationale of the choice each measurement site (if different from the proposed sites): a table with the exact measurement locations (GPS coordinates) and also indicating the measurement directions shall be provided.
- b) The results and interpretations of each survey site are described separately with all the raw data as well as all the interpretation steps.

6. EQUIPMENT AND FACILITIES REQUIRED FOR THE STUDY

- Geophysical Equipment:
 - Electric Resistivity Equipment allowing for electrode spacings up to AB/2 500 meters
 - Geophysical interpretation software
 - Any other equipment proposed by the consultant relevant to carry out the survey
- Field Office Equipment:
 - Notebook computers
 - Global Positioning System (GPS) devices
 - Drawing and tracing equipment/Computer with CAD can be used
 - Digital Cameras

7. PROPOSED TIME/ACTIVITY SCHEDULE

Due to the nature of the proposed work, the geophysical survey field mission is expected to take a maximum of two months.

Financial Schedule: XXXX

The consultant should draw up a detailed financial proposal, including consultant's fees where applicable.

8. RESPONSIBILITIES

UNHCR

For the execution of the survey, UNHCR shall ensure that the local authorities are informed of this survey. UNHCR shall inform and update the consultant on the security situation, or changes therein. UNHCR shall also make available the following information and facilities to the consultant:

- Relevant reports, documents, maps, data at contracting authorities disposal;
- Counterpart staff for necessary support in the field.

The consultant

- Prepare and deliver consultancy services as per the TOR
- Deliver the key deliverables in time; submit a final report duly approved by UNHCR after full incorporation of views and editions from the client.
- Facilitate two debriefing sessions, one before and one after the field mission.
- The consultant and his team will make their own arrangements on transport, security and accommodation and meals during the duration of the assignment.

9. KEY DELIVERABLES

- The key deliverable is the geophysical survey report, which should be submitted to UNHCR. The consultant will be expected to deliver 2 hard copies with approval from UNHCR
- A soft copy on e-mail with the final report will also be submitted to UNHCR.
- The consultant will also be required to deliver to UNHCR all study materials:
 - Soft copies of all data sets both quantitative and qualitative.
 - The geophysical interpretation model and the graphical plot of the curve and model.
 - Any other non-consumable documents/items that will be used in the course of the planned consultancy.

10. CONSULTANTS REQUIREMENTS (QUALIFICATIONS AND EXPERIENCE)

- A Master or postgraduate degree in Geophysics/Hydrogeology/Geology or engineering
- At least 10 years proven experience in conducting and interpreting geophysical survey using diverse techniques
- A reliable and effective analyst with extensive experience in conducting analyses and a proven record of delivering professional results
- Excellent presentation and report writing skills.

12. CONTACTS, COMMUNICATION AND SUPERVISION

The consultant will be under the direct supervision of the UNHCR assigned technical staff for the duration of the contract. The consultant will maintain official communication with the UNHCR supply unit and UNHCR technical lead staff

13. SUBMISSION OF EXPRESSION OF INTEREST

Submission Details

- Capability statement, including commitment for availability for the entire assignment, demonstrable capacity to undertake the assignment and 3 referees/organizations worked for within the past 3 years carrying out geophysical investigations (3 reports will be expected at the interview stage).
- Detailed statement on the proposed study, clearly stating the study methodology and data collection methods.
- Detailed financial proposal, the financial proposal should include daily cost per major activity.
- A detailed work schedule for the study indicating activity timeline and assessment duration.
- Updated curriculum vitae of the consultants who will undertake the work that clearly spells out qualifications and experience. Where more than one consultant is to be involved, clearly indicate the overall lead consultant and responsible persons.
- Commitment that the consultants whose CVs are presented and interviewed will be engaged through out if the consultancy is awarded (UNHCR will not accept replacements).

Interested and qualified consultants should submit their application to UNHCR Khartoum Supply Unit

Submission should be done by:.....