

TERMS OF REFERENCE

HYDROGEOLOGICAL & GEOPHYSICAL SURVEY FOR ONE BOREHOLE DRILLING IN DIMMA, GAMBELLA REGIONAL STATE, ETHIOPIA

1. BACKGROUND

UNHCR has a plan for drilling of a borehole to meet water demand /requirement for UNHCR staffs in Dimma. This was necessitate after it become apparent that existing water supply from the Dimma town could not sufficiently meet the water demand for agencies and at the same time for the town community. The borehole is intended to serve approximately 40 persons

In this regard, UNHCR intends to engage the services of a Consultant to carry out hydrogeological surveys of pre-selected areas. UNHCR will hire a Consultant/Consulting firm to conduct a comprehensive Hydrogeological /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. OBEJECTIVE OF THE SURVEY

The main objective of this project is to carry out a hydrogeological /geophysical survey with the aim to identify the aquifer system on the medium-scale, to localize drilling sites with high potential of good quality groundwater on the small-scale and finally to supervise the drilling process.

The survey shall be carried out in three phases:

- 1) evaluating the groundwater situation based on compilation of existing relevant data (e.g. drilling logs) with additional classical hydrogeological field data collection (e.g. survey of water points, water levels, water quality) leading to the identification of favourable exploration zones
- 2) carrying out groundwater exploratory field geophysical investigations to identify exact drilling locations, and
- 3) Supervising the drilling process and on the spot reporting on the progress.

3. HDROGEOLOGICAL AND GEOPHYSICAL SURVEY

The hydrogeological/geophysical survey will be done in Dimma and site will be shown by UNHCR technical staff.

4. TERMS OF REFERENCE FOR THE HYDROGEOLOGICAL AND GEOPHYSICAL SURVEY

PHASE 1: ASSESS GROUNDWATER SITUATION & IDENTIFY GEOPHYSICAL STRATEGY

- Compile and analyse all the available hydrogeological, geological, climatic, meteorological and hydrological data of the area and its environs in order to:
 - assess the groundwater potential of the project area by identifying the target aquifer(s), their types (porous, fractured or karstic) and spatial distribution
 - assess the groundwater potential by establishing a water balance for the area to present a conceptual hydrogeological model of the investigation area
 - assess geomorphological features relevant to groundwater dynamic process (e.g. drainage patterns, vegetation cover variations).
- Based on the conceptual model, design an appropriate geophysical investigation strategy that is coherent^(*) with the below defined criteria and with the identified target aquifer type (porous, fractured or karstic), the expected depth of the target aquifer and the baseline elevation (estimated depth to groundwater which determines the minimum required investigation depths). Unless a perfectly horizontally layered subsurface conditions can be assumed, a line profile should be defined within the geophysical strategy, to identify possible anomalies before

**UNHCR**United Nations High Commissioner for Refugees
Haut Commissariat des Nations Unies pour les réfugiés

running any VES.

The outcomes of the geophysical investigation strategy should be presented for approval within Phase 1 Hydrogeological report.

(*) Criteria to choose specific geo-electrical investigation methods:

- 1) VES (vertical electrical soundings): to be applied in horizontally layered aquifers. These can either be porous aquifers or, in many cases, the weathered carapace of the basement. At each measuring point, 2 perpendicular vertical electrical soundings to be carried out to guarantee the validity of the assumption of horizontal layering
- 2) Geo-electrical profiling: vertical, steep aquifers (fault zones, fractures)
- 3) ERT (electrical resistivity sounding): can be used for horizontal and vertical/steep structures.

Other geophysical methods:

If electromagnetic (VLF-EM) or IP (induced polarisation) methods are proposed, then specify the interpretation procedure and the expected response of the method to the expected aquifer type(s).

Maximum electrode spacing should be 5 times the expected investigation depth (minimum investigation depth='topographic elevation-baseline elevation'): specify required investigation depth and corresponding electrode spacings.

PHASE 2: GEOPHYSICAL INVESTIGATION & SELECTION OF DRILLING SITES

- Carry out the geophysical investigation according to the investigation strategy and interpret results: select the most suitable borehole drilling sites in the project area, also considering the legal framework and any promulgation or legislation applicable relating to borehole drilling. A separate description of each proposed borehole site is part of the report, and shall include all relevant details of the interpretation of the investigations as well as sound recommendations on the most suitable sites for boreholes drilling, the recommended drilling depths, as well as the hydrogeological and geophysical rationale for choosing the sites.
- Present the results of the geophysical investigation, including the raw data sets, the qualitative interpretation of the type curves in terms of layer sequence (for VES investigations) and inversions results, and the identification of the drilling locations and precise description of drilling strategy and design in the Phase 2 Geophysical investigation report.
- Based on the results from Phase 1 and Phase 2, a well-design has to be established and is an integral part of the Phase-2 Geophysical Report. The design has to aim at maximizing water inflow and minimizing well-head-losses.
- The proposed drilling sites shall be marked with a concrete marker, shown in topographical maps and indicated on appropriate site sketch maps. GPS coordinates have to be provided.
- Compile the Phase 1 and Phase 2 reports into an intermediate hydrogeological/geophysical report and submit to UNHCR: this report needs to be approved prior to the drilling process (e.g. the proposed well-design). Should the consultant delay the submission of the report and thereby induce a delay in the drilling process, a penalty of 0.1% will be charged.

PHASE 3: DRILLING SUPERVISION

- The consultant will assist in the application and follow-up of the borehole-drilling permits if required as per the Ethiopia borehole drilling legislation for the proposed borehole. The consultant should therefore provide a provisional sum for the permits (if applicable) and related follow-up costs.
- *(The consultant should be involved in the tendering process for the drilling campaign and by assisting with technical advice and assisting the client in identifying suitable partners for the work: with particular attention to be given to the well equipment materials that can be used and mobilised)*
- Upon completion of the Phase 1 and Phase 2, acquisition of the drilling permits and once a drilling firm has been selected to drill the proposed boreholes, the consultant shall supervise the drilling works and ensure the boreholes are drilled and completed according to stipulated technical specifications and sound professional standards.
- The consultant shall represent the client on site.

**UNHCR**United Nations High Commissioner for Refugees
Haut Commissariat des Nations Unies pour les réfugiés

- The consultant shall supervise all the drilling process at all times on site, including the geological borehole logging and documentation of pumping test according to standard formats.
- The consultant shall supervise and document on a daily basis the drilling, development and test pumping of the proposed boreholes and hand-in a daily drilling progress report to UNHCR.
- After the first borehole completion, the general well-design described in Phase-2 Geophysical Report may have to be adapted according to site conditions and would need final approval from UNHCR before the drilling process can continue. This updated general design must in no way interrupt the well-construction process and therefore needs to be done on the spot so that approval can be given within 24 hours.
- Ensure that the drilling contractor do water sampling, geological logging and water quality analysis (chemical and bacteriological). Ensure and retrieve proof that bacteriological analyses were carried out within 24 hours after sampling.
- Adapt the general well-design according to the specific conditions at each well location, basing it on the geological log and on the results obtained from the pumping test.
- Supervise installation of screens, casings, gravel pack, impermeable seals, well-heads etc. Ensure that the recommended drilling depths, design and materials are followed and propose and carry out quality control measures upon well-completion, e.g., borehole camera inspection.
- For each specific borehole, prepare a detailed borehole completion report, with all necessary recommendations e.g., pump capacity, optimum depth of installation, periodic water quality analysis according to the standard format.
- All these documents shall be summarized in a Phase 3- Drilling Report, which will also include a quality control review of the drilling report from the drilling contractor.
- Compile the Phase 1, Phase 2 and Phase 3 reports into a comprehensive final report (2 hard copies plus softcopy including all the raw data) and submit to UNHCR: this report needs to be approved prior to final payment.

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 and intermediate reports all need 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)

5.1. Hydrogeological Survey (Phase 1)

The first phase hydrogeological investigation will be carried out according to a multi-step approach, as follows:

- Desk review and data-acquisition: review of existing data, geological hydrogeological, topographical maps, satellite images, previous existing hydrogeological/geological studies and borehole site investigations in the area, borehole and surface water records, ground water quality data etc.
- Hydrogeological fieldwork: detailed reconnaissance survey of project area. (GPS coordinates, water level measurements, TDS and EC, condition, usage and performance where applicable) inspection of geological, geomorphological and structural characteristics of the investigated area; verification of existing data and findings.
- Analyse all the above data to:
 - Identify target aquifer(s), clearly stating their geometrical characteristics: horizontal (layered) or vertical (faults and fractures)? (→ this determines the choice of the geophysical investigation method. Horizontal aquifers = vertical electrical soundings with two perpendicular layouts at each position to assure horizontality. Vertical (steep) aquifers = e.g. localisation by geo-electrical profiling, or electromagnetic methods (e.g. VLF-EM) and combination with subsequent vertical sounding. ERT (electrical resistivity sounding appropriate in both geometrical configurations)
 - Identify and describe groundwater recharge and discharge areas and processes (diffuse versus concentrated recharge) and estimate the groundwater baseline elevation (elevation below which the subsurface is assumed to be saturated): elevation of nearby spring, elevation of lake, flowing river or

projected groundwater elevation from nearby wells.

OUTPUT 1: Phase 1 - Hydrogeological report including:

- a) A conceptual hydrogeological model of the study area, clearly identifying the target aquifer types (porous, fractured or karstic), their geometrical characteristics (horizontal or vertical-steep aquifer), the recharge processes and assumed groundwater flow direction as well as a water balance of the area.
- b) A figure illustrating the conceptual model and indicating preferential areas for groundwater prospection
- c) Data base including the compiled geological and hydrogeological data in electronic form (Excel, MS Access, etc)
- d) Based on the conceptual hydrogeological model detailed description of the investigation strategy and its rational:
 - a. Justification of chosen method and investigation depth (recalling target aquifer and groundwater baseline elevation) and description of calibration method (e.g. with borehole logs), description of expected geophysical response of the target aquifer (e.g. electrical resistivity range),
 - b. Localisation of the geophysical measuring points on a map and on the figure of the conceptual model.

The Phase 1 hydrogeological report and in particular the geophysical investigation strategy has to be approved by UNHCR prior to onset of the geophysical investigations. For the purpose of rapid approval, a draft version of the report is sufficient at this stage.

5.2. Borehole Siting: Geophysical Survey (Phase II)

The consultant will plan and execute the geophysical exploration phase according to the investigation strategy described in Phase 1. The geophysical survey includes retrieval of data, interpretation of all geophysical data as well as reporting and selection of the most suitable sites for drilling in the Phase-2 Geophysical Report.

Specific investigation method requirements

Vertical electrical soundings: for any vertical electrical soundings that are carried out, the qualitative type-curve analysis identifying the number of layers and the respective resistivity contrasts has to be included in the interpretation and the reporting and has to be used to constrain the computed inversion.

For vertical electrical soundings, two perpendicular measurement directions have to be carried out to assure that the inversion assumption of horizontally layered subsurface conditions is valid.

During the execution of the survey programme, the geophysical investigations will include compilation and interpretation of all the collected geophysical data.

OUTPUT 2: Phase 2 - Geophysical Survey Report

- a) The geophysical campaign has to be documented, repeating the rational of the choice each measurement site (already stated in Phase 1 report): a table with the exact measurement locations (GPS coordinates) and also indicating the measurement directions shall be provided.
- b) Then, the results and interpretations of each measurement site are described separately.
- c) Finally, the rational for the sites selected for drilling have to be clearly stated in the report and presented together with all the raw data as well as all the interpretation steps.

Based on the results from Phase 1 and Phase 2, a well-design has to be established and is an integral part of the Phase-2 Geophysical Survey Report. The design has to aim at maximizing water inflow and minimizing well-head-losses: how this optimization is addressed has to be clearly stated in the report.

In the field, the selected sites shall be marked with a concrete marker and shown in a picture plate (Google Earth) and indicated on a sketch map to be included in the Phase 2 Geophysical Survey Report.

The equipment used for the geophysical investigation has to be described and the specifications given in the Appendices.

5.3 Drilling Supervision – Phase III

**UNHCR**United Nations High Commissioner for Refugees
Haut Commissariat des Nations Unies pour les réfugiés

- The consultant shall represent the client on site.
- The consultant shall supervise all the drilling process at all times on site and carry out a separate geological and hydrogeological borehole logging, which is updated each day.
- Documentation and monitoring of the well-development process: measuring the evolution of the yield versus time (since well-development started) and the temporal evolution of the turbidity.
- Monitoring and following the pumping test according to standard formats: step-draw-down test to be carried out with at least 4 steps (see UNHCR Pump Testing Quality Control Guidelines - QGC) present in the daily progress report the characteristic curve and the safe yield. If the pumping test has not been carried out according to the QGC then this has to be reported immediately to UNHCR and the test needs to be repeated.
- After the first borehole completion, the general well-design described in Phase-2 Geophysical Report may have to be adapted according to site conditions and would need final approval from UNHCR. This updated general design must in no way interrupt the well-construction process and therefore needs to be done on the spot so that approval can be given within 24 hours.
- Ensure that the drilling contractor carries out water sampling, geological logging and water quality analysis (chemical and bacteriological). Ensure and retrieve proof that bacteriological analyses were carried out within 24 hours after sampling: carry out parallel measurements of water quality (electrical conductivity and turbidity).
- Adapt the general well-design according to the specific conditions at each well location, basing it on the geological log and on the results obtained from the pumping test.
- Supervise installation of screens, casings, gravel pack, impermeable seals, well-heads etc. Ensure that the recommended drilling depths, design and materials are followed and propose and carry out quality control measures upon well-completion (e.g. borehole camera inspection).
- For each specific borehole, prepare a detailed borehole completion report with all necessary recommendations (e.g. pump capacity, optimum depth of installation, periodic water quality analysis) according to the standard format.

OUTPUT 3: Phase 3 - Drilling Supervision

- a) Daily drilling progress report with attached borehole log and a short summary of daily activities and special observations and difficulties encountered. If any difficulties that are slowing down the process have been encountered, then the daily activity report needs to suggest remedial measures and needs to be approved by UNHCR.
- b) After the first borehole completion, the general well-design described in Phase-2 Geophysical Report has to be re-evaluated and either adapted or confirmed: if the well-design needs to be adapted, then an amendment to the Phase 2 geophysical report for the well-design has to be delivered and requires approval (within 24 hours) before drilling can proceed.
- c) All the documents established during the drilling phase by the consultant shall be summarised in a Phase 3- Drilling Report, which will also include a quality control review of the drilling report from the drilling contractor
- d) Compile the Phase 1, Phase 2 and Phase 3 reports into a comprehensive final report (2 hard copies plus softcopy including all the raw data) and submit to UNHCR: this report needs to be approved prior to final payment. This report includes a chapter on the efficiency of the hydrogeological-geophysical investigations with respect to the actual findings during the drilling campaign.

6. EQUIPMENT AND FACILITIES REQUIRED FOR THE STUDY

The Consultant shall have available the following equipment and other relevant kits for the Survey:

- Hydro (geo) logical equipment
 - 1 EC meter
 - 1 TDS meter
 - Turbidity meter or
 - 1 compass

**UNHCR**

United Nations High Commissioner for Refugees
Haut Commissariat des Nations Unies pour les réfugiés

- 1 electrical water level dipper: 200 m
- Geophysical Equipment:
 - Electric Resistivity/IP Equipment with accessories is recommended
 - Geophysical interpretation software
 - Any other equipment proposed by the consultant relevant to carry out the survey
- Drilling supervision equipment
 - Viscosity Funnel
 - Turbidity probe or tube
- 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 hydrogeological survey field mission is expected to take a maximum of 1 week (7 days).

7.1. FINANCIAL SCHEDULE:

- The consultant should draw up a detailed financial proposal, including all consultant's fees for the consultancy work in ETB.

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 2 debriefing sessions before and 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 hydrogeological & geophysical survey report, which should be submitted to UNHCR. The consultant will be expected to deliver 2 hard copies with approval from UNHCR using the recognized government format.
- A soft copy on e-mail and 2 memory sticks 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.
- The borehole sites identified should be clearly marked with concrete markers, shown in a picture plate and indicated on a sketch map to be included in the final report.
- Based on the survey, the consultant shall provide together with the report a detailed BoQ for the overall scope of drilling work

10. CONSULTANTS REQUIREMENTS (QUALIFICATIONS AND EXPERIENCE)

- A Master or postgraduate degree in Hydrogeology/Geology or Environmental Sciences or engineering or water engineering
- Must be registered by the Geological Registration Board and preferably an active member of the Geological Society of Ethiopia
- At least 10 years proven experience in conducting and interpreting hydrogeological/geophysical survey using diverse techniques
- Proven experience in drilling supervision and borehole documentation
- A reliable and effective analyst with extensive experience in conducting analyses and a proven record of delivering professional results
- Excellent computer skills and desirable skills in Arc GIS and groundwater modelling software's
- Excellent presentation and report writing skills.

12. CONTACTS, COMMUNICATION AND SUPERVISION

The consultant will be under the direct supervision of the UNHCR technical team based in Gambella Sub Office for the duration of the contract. The consultant will maintain official communication with the UNHCR supply unit.

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 hydrogeological 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)