FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF WATER AND ENERGY

Terms of Reference

for

Consultancy Service for

National Groundwater Monitoring System Assessment, Site Selection and Design of New Monitoring Wells

February 2024

Addis Ababa

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ABBREVIATIONS

GIS	–	Geographical Information System
HOA-GW4RP	–	Horn of Africa Groundwater for Resilient Project
IGAD	–	Intergovernmental Authority on Development
MoWE	–	Ministry of Water and Energy
pH	–	Power of Hydrogen
PMCU	–	Project Management and Coordination Unit
RS	–	Remote Sensing
TDS	–	Total Dissolved Solids
ToR	–	Terms of Reference

1. BACKGROUND

The Horn of Africa Groundwater for Resilience (HoA-GW4R) program was initiated with the aim of increasing sustainable access and management of groundwater in the Horn of Africa as a key contribution to strengthen the climate resilience of people living in the most vulnerable borderlands. Three countries: the Federal Democratic Republic of Ethiopia, the Republic of Kenya and the Federal Republic of Somalia together with the Intergovernmental Authority on Development (IGAD) started the program as Phase-1 project (P174867) with the financial support from the World Bank.

The Ethiopia-HoA-GW4R project, which has an approved budget of USD 210 Million, has been planned to be implemented in three main components: 1) Groundwater potential assessment and infrastructure development for inclusive community, 2) Strengthening groundwater institutions and information, and 3) Project management, knowledge, and operational support. This Terms of Reference (ToR) is prepared seeking consultancy service from potential consulting firms to implement parts of activities falling under Component 2b, which targeted at enhancing groundwater information and monitoring system through interventions that will enhance groundwater information management system.

According to information from the Water Resource and Information Desk of the Ministry of Water and Energy, the current groundwater monitoring coverage of the country is considered so low (or nil). Groundwater monitoring through installation of data loggers that could record data such as water level, water quality parameters (TDS, pH and EC) and temperature but data file transfer is done manually with Bluetooth was implemented in Rift Valley Basin, Awash Basin, Abay Basin, and Raya well field. In addition, there are few boreholes which have been installed with data loggers at Tana Lake. In addition, automatic data logger installation was tried in Mekelle with telemetric system had been implemented. Most of them are not functional due to various reasons such as vandalism, system failure due to software issue and battery problem.

Groundwater is a vital resource that requires careful monitoring and management to ensure its sustainability. One way to effectively monitor groundwater is through the implementation of a National Groundwater Monitoring System. This system involves the assessment of existing monitoring networks, as well as the selection and design of new monitoring wells to provide comprehensive data on groundwater levels and quality.

The Ministry of Water and Energy of the Federal Democratic Republic of Ethiopia is seeking a qualified consultant to assess the current national groundwater monitoring system, create a strategic master plan for national-level monitoring wells, prioritize site selection and design groundwater monitoring wells at 124 sites. Moreover, the consultant will design a system for transmitting data from monitoring devices (such as groundwater monitoring loggers) to a centralized database at MoWE. This project aims to improve understanding of the national groundwater resources, strengthen data acquisition capabilities, and inform sustainable water management decisions.

2. OBJECTIVES

2.1. General Objective

To comprehensively assess and enhance the national groundwater monitoring system.

2.2. Specific Objectives

- To evaluate the current status and effectiveness of the National Groundwater Monitoring System in monitoring groundwater quality and quantity.
- To identify gaps and shortcomings in the existing monitoring network that need to be addressed for more comprehensive and accurate monitoring.
- To formulate a comprehensive, long-term master plan outlining the strategic vision for the national groundwater monitoring system; conduct a detailed assessment of current and future groundwater challenges and trends to inform the master plan.
- To ensure that the master plan aligns with broader national policies related to water resource management, environmental protection, and sustainable development.
- To select new sites for monitoring wells that will provide better coverage of different geographical areas and groundwater resources.
- To design new monitoring wells in accordance with technical specifications and site-specific conditions that meet industry standards for data collection and analysis, and ensure the accuracy and reliability of the data collected.
- To improve the overall health and sustainability of groundwater resources through better monitoring and management practices.
- To facilitate better decision-making and policy development by providing accurate and up-to-date information on groundwater quality and quantity.
- To design a comprehensive data management system for efficient collection, storage, and analysis of groundwater data.
- To build capacity by providing training for relevant stakeholders on groundwater monitoring techniques and data interpretation.

3. PROJECT MANAGEMENT & GOVERNANCE

The **Horn of Africa Groundwater for Resilient Project,** Project Management Coordination Unit **(PMCU)** will administer the contract with the Consultant, supervises the services of the Consultant and assist the Consultant during the time of its assignment, and it will support in collecting relevant project information and facilitate official contacts with national and local stakeholders.

The PMCU shall review and approve all key deliverables. The deliverables of the 2 phases shall be subjected to stringent reviews. The PMCU is therefore recognized in this contract as a prime governing body of the project.

4. SCOPE OF SERVICES AND ESTIMATED PROJECT DURATION

The scope of the service is limited to undertaking assessment/evaluation of the existing groundwater monitoring system at the national level, developing a strategic plan for expanding the monitoring network, identify key locations for new groundwater monitoring well sites, offering recommendations for network operations and maintenance, developing a comprehensive data management system, and building capacity through stakeholder training on monitoring techniques and data interpretation.

Thus, the assignment is a mixture of LUMP SUM CONTRACT for consultancy services pertaining to three phases namely:

Phase-1: Inception Work – 2 months

Phase-2: Assessment for Site Selection of Monitoring Wells & Strategic Master Plan Development – 4 months

Phase-3: Monitoring Wells Design and Tender Document Preparation – 6 months

The detail scope of the assignment is to:

- Review existing hydrogeological data and literature.
- Collect additional data through field surveys, geophysical investigations, and hydrochemical analyses.
- Evaluate the adequacy of the existing groundwater monitoring network, identifying its strengths, weaknesses, and gaps.
- Develop site selection criteria for new monitoring wells based on hydrogeological considerations, monitoring objectives, accessibility, and cost-effectiveness.
- Identify and propose optimal locations for new monitoring wells to fill strategic gaps in the existing network and address specific monitoring needs (each specific site should be characterized according to its hydrogeological characteristic).
- Design and engineer new monitoring wells, considering depth, screen intervals, materials, wellhead protection, and equipment compatibility.
- Prepare detailed well design reports for each proposed well, including technical specifications, justification for location and design choices, and cost estimates.
- Select appropriate data loggers compatible with the MoWE Groundwater Database and Monitoring System.
- Develop a data management plan outlining data collection protocol, storage procedures, quality control measures, and analysis methods.
- Train relevant stakeholders on data retrieval, interpretation, and use for water management purposes.
- Organize and conduct training workshops on groundwater monitoring techniques, data analysis, and interpretation.
- Develop training materials capacity building in groundwater management.

5. METHODOLOGY

The monitoring system will assess and select potential groundwater monitoring well sites in Ethiopia, with a focus on areas with intensive groundwater use and vulnerable to contamination. The project aims to protect groundwater sources, improve water quality, and promote sustainable water use, ultimately increasing resilience to droughts in targeted areas.

The methodology for conducting the assignment involves evaluating the current monitoring infrastructure, determining gaps in coverage, identifying priority areas for new monitoring wells, and designing well placement and monitoring protocols.

This methodology aims to provide decision-makers with the information needed to better understand groundwater dynamics, anticipate potential issues, and develop effective management strategies. It involves conducting of an inception work, assessment for monitoring wells site selection and detail design of monitoring wells and monitoring stations which shall be carried out in three phases. In addition, capacity building shall be provided to strengthen the capacity of the Client in undertaking assessment and design of monitoring wells.

5.1. Phase I - Inception Work

This step of the assessment is important for setting the project on the right track and it is during this period the consultant will lay the groundwork for the successful completion of the national groundwater system assessment, new monitoring well site selection and design, and design of monitoring stations on existing wells. Some of the key tasks for the consultant are detailed below:

5.1.1. Project Kick-off Meeting

The consultant will organize and lead a kick-off meeting with the client and key stakeholders to:

- Introduce the project team and establish communication channels.
- Review project objectives, scope, and deliverables.
- Discuss the client's expectations and priorities.
- Clarify roles and responsibilities of all parties involved.
- Identify any potential challenges or concerns
- Agree on the project timeline and milestones.

5.1.2. Desk Review of the Existing Groundwater Monitoring System

During inception work of the assignment, the consultant has to carry out desk review of the existing monitoring system focusing to conduct the following:

- assess the existing data and information related to the groundwater monitoring system including reviewing historical data, monitoring network layouts, data collection methods, and data management systems.
- evaluate the current infrastructure of the groundwater monitoring system that includes examining the condition and functionality of existing monitoring wells, instruments, sensors, telemetry systems, and data transmission networks.

- engaging with relevant stakeholders for their input and feedback to provide valuable insights into the strengths, weaknesses, and areas requiring improvement in the existing monitoring system.
- assess the performance of the groundwater monitoring system (data reliability, accuracy, coverage, frequency of monitoring, and compatibility with national and international standards).
- identify gaps and limitations in the current groundwater monitoring system such as identifying areas where improvements are needed (expanding the monitoring network to cover critical areas, enhancing data quality assurance and quality control protocols, improving data management systems, or upgrading obsolete monitoring equipment).
- review the existing groundwater monitoring system against relevant regulations, policies, and technical standards.
- evaluate the vulnerability of the existing monitoring system to potential risks and challenges, such as climate change impacts, contamination sources, or land use changes to help in determining necessary improvements or modifications to ensure long-term sustainability and resilience.

5.1.3. Development of Detailed Methodology

Based on the data review and client discussions, develop a detailed methodology for the upcoming project phases:

- **Assessment for Monitoring Wells Site Selection** - outline specific field investigations (hydrogeological investigations, geophysical surveys, water quality sampling), data analysis methods, and modeling approaches.
- **Monitoring Wells Design** - define criteria for well placement (aquifer targeted, parameter focus, accessibility), well design parameters (depth, screen intervals, materials), and cost considerations.

Prepare a work plan with timeframes, resource allocation, and budget estimates for each phase, and include detailed schedule with key milestones and deliverables.

5.1.4. Phase 1 Report Preparation

The consultant has to prepare and submit Inception report summarizing the initial activities, methodology, work plan, risk assessment, and stakeholder engagement strategy. Further, it has to establish a system for documenting all project decisions, data, and communication exchanges. The report should include:

- Proposed methodology, work plan, and timeline for the assessment of the existing groundwater monitoring system,
- Review result of analysis of the existing groundwater monitoring system and current status, performance, and adequacy of the existing groundwater monitoring wells, such as their location, depth, frequency, and method of measurement, data quality and reliability,
- Views, opinions, and feedback on the existing groundwater monitoring system and data, as well as their data needs, gaps, and challenges,

- Review the best practices and lessons learned from other countries or regions that have implemented or improved their groundwater monitoring networks.

5.1.5. Validation Workshop of the Inception Work

The consultant has to present the findings of the draft inception work at a validation Workshop-1 which shall be held in in a hotel acceptable to the Client and the cost of the workshop for an average of 50 participants (Venue, refreshment and lunch and daily subsistence allowance) shall be covered by the PMCU.

- Present the inception report and work plan to the client for approval and feedback.
- Refine the methodology and work plan based on client feedback.
- Submit the final Inception Report based on the outcome of Workshop-1 and the comments from the Client.

5.2. Phase 2 - Assessment for Site Selection of Monitoring Wells & Strategic Master Plan Development

The consultant should proceed in conducting detail assessment for selection of sites for new monitoring wells by conducting the following:

5.2.1. Inventory of Data

The inventory of borehole data provides crucial information on the location, depth, and characteristics of existing boreholes. This information allows for a better understanding of the current groundwater monitoring system and helps in assessing its adequacy and effectiveness. It helps identify any gaps or areas that need improvement in the existing system. Furthermore, the inventory of borehole data aids in the selection of sites for new monitoring wells.

The consultant will collect and analyze the existing boreholes data and other information which may include:

- Borehole information such as location coordinates (latitude, longitude), depth and diameter of the borehole, casing material and diameter, screen length and slot size (if applicable), well construction details, including grouting and sealing materials.
- Information about the site's geology, hydrogeology, and existing borehole data including geological maps, hydrogeological reports, well logs, and any available groundwater monitoring data.
- Hydrogeological data including aquifer characteristics (e.g., type, thickness, permeability, hydraulic conductivity), groundwater flow direction and velocity, water table elevation and fluctuations, groundwater chemistry and quality data, including major ions, contaminants, and pH.
- Secondary water quality data of boreholes and analyze various physicochemical parameters of the water, such as pH, temperature, conductivity, dissolved oxygen, turbidity, and total dissolved solids (TDS) to get first insight of the groundwater.

- Existing monitoring data such as historical groundwater level measurements, if available, previous monitoring reports or studies conducted in the area, water quality data from previous sampling events, any existing monitoring equipment or infrastructure in place.
- Site-specific factors such as land use and potential sources of contamination near the borehole, topographic maps or aerial imagery of the site, geotechnical data, such as soil types and properties, climate data, including precipitation and evapotranspiration rates.

5.2.2. Selection of Optimal Sites for New Monitoring Wells

The consultant should conduct detail hydrogeological assessments to identify suitable locations for new monitoring wells that will help to ensure the monitoring network captures representative data for the targeted aquifers and provides valuable information for groundwater management and decision-making. Some of the key activities and assessments include:

- prepare location map of every selected well,
- analyze the current and future groundwater availability, demand, and use scenarios, as well as the potential impacts of climate change, land use change, and population growth.
- identify the main groundwater issues and challenges, such as overexploitation, depletion, contamination, degradation, and conflicts.
- conduct detailed geological and hydrogeological mapping to identify potential aquifers, geological formations, and groundwater flow patterns.
- conduct hydrogeological surveys, including geophysical and remote sensing surveys, to assess subsurface conditions and identify potential locations for monitoring wells.
- assess the hydrogeological properties of the aquifers, such as permeability, porosity, and hydraulic conductivity
- analyze existing groundwater level data and conduct additional monitoring to identify areas of significant groundwater abstraction, fluctuations and seasonal variations.
- evaluate the quality of groundwater in different areas to identify potential contamination sources and assess the overall groundwater quality status.
- define the criteria and indicators for selecting the new monitoring wells, such as groundwater level and quality variations, hydrogeological characteristics, land use and cover, population density, water demand and use, etc.
- assign weights and scores to the criteria and indicators based on their importance and relevance for groundwater monitoring.
- use GIS-based tools, such as ArcGIS, QGIS, etc., to overlay and analyze the spatial data layers of the criteria and indicators, and to generate a suitability map for the new monitoring wells.
- prepare maps and atlases to visualize and communicate important groundwater information to stakeholders and decision-makers.
- apply multi-criteria decision analysis methods, such as analytic hierarchy process, weighted linear combination, etc., to rank and select the optimal sites for the new monitoring wells based on the suitability map and the weights and scores.
- develop hydrological models to simulate groundwater flow and assess the impacts of various factors, such as climate change, land use changes, and groundwater abstraction.

5.2.3. Identifying Existing Boreholes for Logger Installation

The consultant in addition to assessing new groundwater monitoring wells, it should take into consideration the following strategic factors in identifying of existing boreholes where groundwater monitoring loggers can be strategically installed to provide comprehensive and representative data:

- Office review of data of existing boreholes focusing on boreholes with groundwater over-exploitation and those which are located in areas vulnerable to groundwater contamination.
- Conduct field confirmation of the selected boreholes and thoroughly characterize them their suitability to install data loggers.
- Ensure that the monitoring loggers capture data from different hydrogeological settings, land uses, and potential pollution sources.
- Select strategic locations to facilitate data integration and provide a comprehensive understanding of the groundwater system at the national level.
- Consider accessibility and logistical aspects of installing and maintaining the monitoring loggers.
- Engage with concerned bodies or relevant stakeholders to gather their input and incorporate their concerns into the site selection process.
- Define the criteria and indicators for identifying the key locations for the groundwater monitoring loggers, such as groundwater level and quality fluctuations, data transmission and accessibility, security and vandalism, etc.
- Assign weights and scores to the criteria and indicators based on their importance and relevance for groundwater monitoring.
- Use hydrogeological modeling and particle tracking methods to simulate the groundwater and contaminant flow direction and variation, and to identify the areas of high groundwater vulnerability and risk.
- Apply multi-criteria decision analysis methods to rank and identify the key locations (existing boreholes) for the groundwater monitoring loggers based on the groundwater vulnerability and risk map and the weights and scores.
- Evaluate the hydrogeological properties of the aquifers, such as permeability, recharge rates, and groundwater flow patterns.
- Assess the vulnerability of the aquifers to contamination based on factors such as land use, proximity to potential pollution sources, and geological conditions.
- Evaluate the yield of existing wells to identify areas with high groundwater availability and potential for sustainable extraction.
- Assess the well characteristics such as the depth, the well and casing diameter, and location of existing wells to determine their suitability for groundwater monitoring.
- Analyze the spatial distribution of existing wells to ensure adequate coverage of different regions and hydrogeological zones.
- Evaluate the construction quality of wells to ensure they meet the necessary standards for accurate monitoring.

- Evaluate the size of well casings to determine the appropriate dimensions of loggers that can be installed.
- Assess the specific monitoring needs and parameters to be measured, such as water level, temperature, conductivity, and pH.
- Evaluate the sensor capabilities of the loggers, such as measuring parameters like water level, temperature, conductivity, and pH.
- Consider the data transmission capabilities of the loggers, such as wireless connectivity or data logging options.
- Analyze the water quality of the wells to identify any existing contamination or potential risks.
- Consider the physical dimensions of the loggers and ensure they can be easily installed in the existing wells without compromising their functionality.
- Assess the power requirements of the loggers, including battery life and power source options.
- Ensure that the selected well locations provide adequate coverage and representativeness of the groundwater resources at a national level.
- Make sure that the existing borehole sites will not coincide with the newly selected monitoring well sites.

5.2.4. Phase 2 Report Preparation

The consultant shall prepare a draft assessment report that includes but not limited to the following:

- the analysis result of borehole data inventoried including depth and diameter of the borehole, casing material and diameter, screen length and slot size (if applicable), well construction details, aquifer characteristics, groundwater flow direction and velocity, water table elevation and fluctuations, groundwater chemistry and quality, historical groundwater level measurements.
- detail hydrogeological assessment result and suitability maps including selection of sites for new monitoring wells (include location map of the proposed monitoring wells).
- identified areas where groundwater abstraction, fluctuations and seasonal variations occur.
- identified locations for the groundwater monitoring logger's installation on existing wells considering groundwater level and quality fluctuations, data transmission and accessibility, security and vandalism.

5.2.5. Validation Workshop of the Assessment Phase

Outcomes of the assessment phase shall be presented at a validation Workshop-2 which shall be held in in a hotel acceptable to the Client and the cost of the workshop for an average of 50 participants (Venue, refreshment and lunch and daily subsistence allowance) shall be covered by the PMCU.

Final assessment phase report shall be submitted based on the outcome of Workshop-2 and comments from the client on the draft report.

5.3. Phase 3 - Monitoring Wells Design and Tender Documents Preparation Phase

This phase involves developing a detailed design of monitoring wells and preparation of well drilling specifications and tender for the drilling and construction of monitoring wells.

The consultant should consider various aspects including well design, instrumentation, data management, security and calibration, data interpretation for constructing, installing, and developing groundwater monitoring stations on identified existing boreholes.

Thus, the consultant has to focus on well characteristics such as well depth, screen placement, casing materials, and well construction techniques ensuring that the wells are designed to prevent cross-contamination and provide accurate measurements. Further, it has to recommend appropriate instruments and sensors to measure water levels, water quality parameters, and other relevant data taking into consideration factors such as accuracy, reliability, compatibility with data logging systems, and ease of maintenance. The other factors are to design a robust data management system to collect, store, and analyze monitoring data considering using automated data loggers or telemetry systems to ensure real-time data acquisition. Data accuracy and integrity should be implemented for quality control measures.

The consultant shall forward standard procedures and protocols for regular calibration and validation of monitoring instruments and the data to maintain data quality and traceability. Finally, it has to develop a clear plan for data interpretation and reporting, define thresholds or trigger levels for action based on the monitoring objectives, approach to how to regularly analyze and interpret the collected data to assess groundwater conditions and trends.

5.3.1. Detail Design of Monitoring Wells

Once optimal locations have been identified, the consultant should move into the design phase for the new monitoring wells. This phase involves careful consideration of various factors to ensure each well effectively fulfills its monitoring objectives while complying with technical and environmental standards. The key task is defining of well specifications and the following factors should be considered:

- Determine the specific aquifer and depth at which the well screen should be installed to capture relevant water levels or contaminant plumes based on the chosen location and monitoring objectives,
- Choose a well diameter that accommodates desired monitoring equipment and borehole stability, considering cost and installation feasibility.
- Select appropriate casing materials that withstand corrosion, chemical interaction with groundwater, and local geological conditions.
- Design the well screen based on aquifer characteristics, including slot size and filter pack compatibility.
- Determine the screen interval that provides optimal access to relevant water levels or contaminants while minimizing clogging or interference from other formations.
- Choose grouting materials compatible with borehole geology and groundwater quality, ensuring effective sealing and preventing potential contamination pathways.

- Design the wellhead and surrounding area to protect the well from surface water infiltration, vandalism, and accidental damage.
- Define procedures for removing drilling fluids, sediments, and fines from the well to ensure clear flow and representative water samples.
- Establish clear protocols for collecting water samples.

5.3.2. Detail Design of the Groundwater Monitoring Stations

Once the new monitoring sites are selected and wells on which loggers will be installed are identified, the consultant should develop a detailed design for the installation of the groundwater monitoring station (logger, telemetric equipment, storage tools, data manipulation software and hardware, sensors and instrumentation, power supply systems) including the equipment, protocols, data management, and quality assurance. Thus, the following factors and activities are to be done:

- provide detailed information about the existing borehole, including its location, coordinates, and identification number if applicable,
- specify the depth of the borehole, measured from the ground surface to the bottom of the well to determine the appropriate length of the data logger cable and the depth range for monitoring groundwater levels,
- determine the type, size, depth, and casing of the new monitoring wells, as well as the sampling devices, filters, and screens to be used.
- specify the diameter of the borehole, which is essential for selecting the appropriate size of the data logger and ensuring compatibility with the existing well casing.
- provide information of the depth of the water table to determine the appropriate placement of the data logger within the borehole.
- include information about the existing well construction, such as casing materials, screen design, grouting details, and any other relevant construction features that help in assessing the suitability of the borehole for installing the data logger and understanding any limitations or challenges that may arise during the installation process,
- define the installation procedures and standards for the new monitoring wells, such as drilling, development, testing, and sealing.
- provide information about the target aquifer(s), including its depth, thickness, hydraulic conductivity, and water quality characteristics to gain understanding of the hydrogeological conditions and selecting appropriate monitoring parameters for the data logger,
- specify the required specifications for the data logger, including the measurement parameters (e.g., groundwater level, temperature, conductivity, etc.), accuracy requirements, data storage capacity, and power source (e.g., battery-powered or solar-powered) to allow in selecting the appropriate data logger model for the monitoring objectives.
- specify the installation requirements for the data logger, including the method of installation (e.g., suspended on a cable or attached to a well cap), the depth at which it should be installed, and any specific installation procedures or guidelines to follow.

- define the data management and reporting requirements for the monitoring stations and specify the frequency and format of data collection, data validation procedures, and reporting protocols in order to ensure that the collected data is reliable, consistent, and readily available for analysis and interpretation.
- include health and safety guidelines and requirements to ensure the installation process adheres to appropriate safety standards, emergency response procedures, and any specific regulations or guidelines related to working in or around boreholes.
- outline the project timeline, including key milestones, deliverables, and reporting deadlines which helps in managing the project effectively and ensures that the monitoring stations and data loggers are installed within the specified timeframe.
- establish the operation protocols and frequency for the groundwater monitoring network, such as sampling, measurement, data collection, and transmission.
- develop the data management and quality assurance system, such as data storage, processing, analysis, validation, and reporting.
- prepare the maintenance plan and schedule for the groundwater monitoring network, such as cleaning, repairing, replacing, and decommissioning.

Data Management System Design

The successful design and installation of monitoring stations and data loggers in boreholes rely not only on the hardware and software components but also on effective data management practices. Therefore, the consultant should give due attention to key data management considerations for data format, data collection, storage and transfer.

a) Data Format Compatibility

Review the requirements and specifications of the central groundwater information and monitoring system.

- familiarize with the data logger's capabilities and available data formats.
- identify the data format(s) supported by the central groundwater information and monitoring system at the MoWE.
- determine if the data logger's default format is compatible with the central system. if not, investigate if the data logger can be configured to output data in the required format.
- consult with the data logger manufacturer or technical support team to understand any necessary software or firmware updates that may be required for compatibility.
- test the data logger's data output in the required format to ensure it can be seamlessly integrated with the central groundwater information and monitoring system.
- document any necessary steps or modifications made to ensure compatibility between the data logger and the central system.
- communicate and collaborate with the relevant stakeholders, such as the project team, data management personnel, and IT support, to ensure a smooth integration process.
- provide training or guidance to the project team or field staff on proper data collection and formatting techniques to ensure ongoing compatibility with the central system.

- continuously monitor and assess data compatibility and troubleshoot any issues that may arise during the integration process.

b) Data Collection, Storage and Transfer

The consultant has to:

- suggest the best and up-to-date groundwater data collection, storage and transferring technology (data loggers).
- define the sampling frequency and duration of data collection of parameters to be collected such as groundwater level and water quality by the data loggers.
- outline the requirements for data storage and transfer, including the type of storage medium (e.g., hard drive, cloud-based storage), data backup procedures, and
- define the frequency of data transfer from the data loggers to the central database or server.

Thus, it is required of the Consultant to propose data loggers and telemetric equipment with:

- the best information logging capacity (able to log information at different time intervals or according to a variable scheme),
- a better alternative of event-based logging where a reading is sampled at e.g., 15 s intervals and only stored in memory if it differs from the previous stored value by more than a set amount,
- no frequent requirement of battery changes less often, as a function of measuring and storing frequency),
- technology that allows data download by hand-held units, e.g., laptop computers, rugged hand-held computers or organizers, or can also be accessed by way of telemetric equipment.
- a storage-and-control subsystem that can perform complex analysis of data in real time and use such analyses to compute derived information, compact data, or select some action (the subsystem that can collect additional data or send signals to the telemetry subsystem, transmitting a warning or alert message).
- make sure the data loggers' diameter is compatible and allow insertion into the well (installed casing).
- the telemetry with three elements, which are the remote site, a borehole or a group of near monitored locations, the communications medium, such as phone or radio communication links, and the central receiving station.
- the most common system of communication (either one-way in which the remote site starts transmission of data after a specified elapse of time or because data have exceeded some threshold value or a two-way communication system in which the remote station will transmit its data in reply to a command from the central station).
- capability of using solar panels and rechargeable battery packs if electrical power is unavailable.
- telemetric subsystems that rely on microwave, radio, or phone lines communications such that in microwave communication, the transmission is line of sight, while radio

transmission may be line of sight or relayed via an intermediate medium (this medium may be a terrestrial relay link or earth orbiting satellites).

Specification and Bill of Quantities of Tools

The consultant should determine the appropriate monitoring tools, such as data loggers, data storage, software, and hardware during designing of monitoring stations. The consultant should also prepare the specification and bill of quantities to guarantee that the necessary materials and equipment are found and included in the project plan. Here are some key specifications and items that should be included and focused on:

a. ***Telemetric Equipment*** - specify the required telemetric equipment for data transmission and remote monitoring. This may include:

- Telemetry units or devices.
- Communication antennas or modems.
- Data transmission protocols (e.g., GSM, satellite, radio).

b. ***Data Acquisition Equipment and Data Storage Tools*** - specify the data collecting equipment and storage tools required for storing, and managing monitoring data. This may include:

- Data loggers or data acquisition systems - specify the required specifications for the data loggers, including the measurement parameters (e.g., groundwater level and water quality), accuracy requirements, data storage capacity, and power source (e.g., battery-powered or solar-powered).
- Memory cards or storage devices
- Data backup and archiving systems - specify the tools required for retrieving the data from the data loggers, such as data cables, data downloaders, or wireless data transfer devices.

c. ***Data Manipulation Software and Hardware*** - specify the software and hardware components necessary for data manipulation, analysis, and visualization. This may include:

- Data management software.
- Data analysis and visualization tools.
- Computers or servers with appropriate specifications.

d. ***Sensors and Instrumentation*** - specify the sensors and instrumentation required for monitoring specific parameters in the borehole. This may include:

- Water level sensors.
- Temperature sensors.
- Pressure sensors.
- Flow meters.
- Water quality sensors (e.g., pH, conductivity).

e. Power Supply Systems - specify the power supply systems needed to ensure continuous operation of the monitoring stations and data loggers. This may include:

- Solar panels and associated equipment.
- Battery banks or backup power sources.
- Power management and control systems.

f. Materials and Supplies*:*

- Cables and Wiring: Specify the type, length, and specifications of the cables required for connecting the data loggers to the surface equipment or data collection system.
- Well Caps and Seals: Specify the type and specifications of the well caps and seals required for securing the data loggers in the borehole and ensuring proper sealing to prevent contamination.
- Mounting Hardware: Specify the mounting hardware required for securing the data loggers to the well casing or other installation locations.
- Power Supply: Specify the power supply requirements, such as batteries or solar panels, and any associated equipment needed for powering the data loggers.
- Protective Enclosures: Specify any protective enclosures or housings required to protect the data loggers from environmental conditions or vandalism.

g. Bill of Quantities - provide a detailed bill of quantities that includes the quantities and specifications of all the required equipment and materials. Ensure that the bill of quantities is comprehensive and accurately reflects the scope of the project.

5.3.3. Tender Documents Preparation for the Monitoring Wells

Preparation of Tender Documents shall commence upon the approval of the Detail Design Documents of the Monitoring Wells. The consultant will identify appropriate Contract Types and Packaging needed for procuring the works and possibly further services needed to deliver on the projects.

The Consultant shall prepare Tender Documents for the Drilling of Monitoring Wells, and its preparation shall commence upon the approval of the Detail Design.

The Tender/Bid Documents should be produced by the Consultant based on the WB procurement rules, procedures and standard bidding documents.

5.3.4. Phase 3 Report Preparation

The consultant shall prepare draft report of the design of monitoring wells and tools for monitoring stations that includes but not limited to the following:

- Well design for each proposed and selected existing well,
- Design specifications of all selected monitoring wells,
- Data management (storage, processing and validation),
- Data collection (data logger), storage and transfer (telemetric system),
- Data format standardization and data manipulation, and

- Specification and bill of quantities of well drilling and monitoring stations tools.

5.3.5. Validation Workshop of the Design Phase

Outcomes of the assessment phase shall be presented at a validation Workshop-3 which shall be held in in a hotel acceptable to the Client and the cost of the workshop for an average of 50 participants (Venue, refreshment and lunch and daily subsistence allowance) shall be covered by the PMCU.

Final design of monitoring wells and monitoring stations report shall be submitted based on the outcome of Workshop-3 and comments from the client on the draft report.

5.4. Capacity Building Training Workshop

The objective of this activity is to strengthen the capacity of the Client in undertaking assessment and design of monitoring wells which overall will aid to understand aquifer dynamics, monitor any changes in chemical, biological and physical characteristics of the groundwater resource.

5.4.1. Roles and Responsibilities of the Consultant

The roles and responsibilities of the consultant are to conduct needs assessment, workshop design and development, facilitation and delivery, tailoring the workshop, providing expertise and guidance, evaluation and feedback (gather feedback from the participants), follow-up support and professionalism and ethical conduct.

The Consultant shall undertake the following 3 tasks in order to achieve the above stated objectives.

Task 1 - Develop Training Module

The Consultant shall develop a short-term training Module on Groundwater Monitoring System, Assessment for Selection and Design of Monitoring Wells and Installation of Data Loggers and Associated Facilities which shall be used for the training of the Client staff. The proposed outline of the Module is summarized below. The consultant shall enrich and expand the proposed outline.

1. Introduction to Groundwater Monitoring Systems

- Groundwater resources and management: Importance of groundwater, aquifer systems, and sustainable use.
- National groundwater monitoring program: Current system overview, data types, limitations, and potential improvements.
- Role of monitoring in water resource management: Data use for decision-making, drought preparedness, and pollution control.

2. Technical Skills Development

- Hydrogeology and well siting: Identifying target aquifers, potential contamination sources, and optimal well locations.

- Well design and construction: Understanding specifications, construction materials, drilling methods, and borehole logging.
- Monitoring equipment and data acquisition: Types of sensors, loggers, telemetry systems, and data collection protocols.

3. Monitoring System Design and Configuration

- Design considerations for monitoring stations based on specific project requirements.
- Selection and placement of sensors and data loggers.
- Configuration of monitoring system components.
- Integration of data loggers with existing infrastructure, if applicable.

4. Hardware and Software

- Overview of the hardware components, such as data loggers, sensors, communication devices, and power supply systems.
- Configuration and setup of the monitoring system hardware.
- Software installation, configuration, and operation.
- Troubleshooting hardware and software issues.
- Data transmission and remote access capabilities.

5. Data Management and Analysis

- Data quality control and assurance: Ensuring data integrity, chain of custody, and standardized procedures.
- Data storage, organization, and backup procedures.
- Data analysis and interpretation: Software tools and techniques for analyzing water quality, water levels, and trends.
- Reporting and communication: Presenting data, summarizing findings, and effectively communicating with stakeholders.
- Data validation and quality control techniques.

6. Advanced Skills and Technologies

- Geospatial analysis and modeling: Using GIS for data visualization, aquifer mapping, and contaminant transport modeling.
- Advanced groundwater modeling: Assessing aquifer characteristics, predicting water availability, and managing resources sustainably.
- Emerging monitoring technologies: Introduction to drones, remote sensing, and real-time monitoring systems.

7. Institutional Capacity Building and Sustainability

- National groundwater monitoring strategy development: Setting objectives, designing a sustainable program, and integrating with existing water management plans.
- Stakeholder engagement: Communication strategies for communities, government agencies, and other stakeholders.

- Data sharing and accessibility: Planning for data storage, dissemination, and integration into existing information systems.
- Operation and maintenance: Budgeting, equipment maintenance, and long-term program sustainability within the client's organization.

Task 2 – Training

The Consultant shall organize and undertake training locally for 30 staffs of the Client using the modules developed in Task 1. The trainees shall be drawn from both MoWE and Regional Water Bureaus. The training shall be carried out in two batches. Each batch shall consist of 15 trainees and the duration of the training for each batch shall be 15 days (120 hours). The Consultant shall support his training with relevant software packages the supply of which is the component of this activity. The Consultant shall make the training modules ready before the start of the training. Other documents (electronically via memory stick or hard copies) could be provided during the course. *The training shall be conducted in a hotel acceptable to the Client and all associated cost related to the training will be covered by the consultant.*

Task 3 – Supply Relevant Software and Manual of Practices

The Consultant shall identify relevant software packages and manual of practices with the required licenses for the Client's future use.

The consultant shall submit responses to feedback from all workshops to the client.

5.4.2. Roles and Responsibilities of the Client and the Consultant

The role of the client in a training workshop prepared by the consultant is crucial for the success of the workshop and achieving the desired outcomes. The client's involvement and active participation are essential in the following ways:

- Providing input and objectives
- Clearly communicating training needs
- Collaborating on workshop design
- Participant selection
- Engaging in pre-workshop communication
- Participating in the workshop
- Providing feedback and evaluation

The Ministry of Water and Energy shall disseminate all generated data and information to be ready for website uploading/printable version based on data and information sharing policy and regulation.

6. TEAM COMPOSITION AND QUALIFICATION REQUIREMENTS

The Consulting Firm should provide a team of experts all of whom shall be qualified and experienced in their respective fields and be eligible for registration with the relevant professional bodies. The following is the minimum qualification and number of personnel for both the Lump sum and time-based contract of the assignment:

6.1. Team Composition and Task Assignment

In this section, the Consultant is required to identify the Team Composition it intends to deploy for the Assessment and Design Phases of the assignment. It should also identify and assign the Tasks involved in order to deliver satisfactorily on the assessment and design outputs. However, a minimum number and type of key personnel to be deployed for these phases are given in the Table 1:

Table 1: Proposed positions and maximum man-month of assessment and design service

SN	Proposed Position	Person	Person-Month		Total Man-month	Remark
			Office	Field		
1	Project Manager/ Team Leader	1	9	3	12	**12 Months**
2	Senior Hydrogeologist	1	8	4	12	
3	Senior Geologist	1	3	4	7	
4	Senior Geophysicist	2	3	3	12	
5	Junior Hydrogeologist	2	3	4	14	
6	Senior GIS and Remote Sensing Specialist	1	4	2	6	
7	MIS Specialist	1	6	-	6	
8	IT Systems Specialists	1	6	-	6	
9	Instrumentation Engineer or Technician	1	3	4	7	
10	Data Management Specialist	1	6	-	6	
11	Procurement Specialist	1	6	-	6	
	Total		**57**	**24**	**94**	

6.2. Qualification Requirements of Key Personnel

In general, the consultant is expected to deploy sufficient and competent experts/professionals and technical and non-technical support staff for the current undertaking.

The experience of the team members shall be sufficient to undertake their respective assignments competently.

SN	Job Title	#	Qualification and Education	Experiences
1	Project Manager/ Team Leader	1	MSc Degree in project management, hydrogeology, engineering, or a related field	At least 15 years general experience in water sector of which 5 years in management
				At least 10 years of specific experiences in managing projects, including planning, coordination, and resource management, knowledge of project management methodologies and tools.
2	Senior Hydrogeologist	1	MSc Degree in hydrogeology	At least 15 years of general experience in hydrogeological investigations, groundwater modeling, water resource management, aquifer remediation, well design and construction, data collection and analysis, environmental impact assessment to various sectors
				At least 12 years of specific experiences in groundwater monitoring, borehole characterization, and data interpretation, knowledge of hydrogeological principles, groundwater flow, and aquifer properties.

SN	Job Title	#	Qualification and Education	Experiences
3	Senior Geologist	1	MSc Degree in geology or relevant and related fields	At least 13 years of general experiences in geological and geomorphological mapping works, able to use remote sensing images to extract geological structures and mapping of geology
				At least 10 years experiences in geological investigation and mapping for water supply and groundwater investigations.
4	Senior Geophysicist	1	MSc Degree in geophysics or relevant and related fields	At least 10 years general experiences in geophysical investigation for groundwater exploration, able to apply various geophysical exploration methods, experience in borehole geophysical logging
				At least 8 years experiences in geophysical application to water source mapping (groundwater investigation and borehole logging), analysis and interpretation
5	Junior Hydrogeologist	2	BSC/MSc Degree in geology, hydrogeology or relevant and related fields	At least 12/10 years general experiences in groundwater studies and drilling works, hydrogeological mapping
				At least 10/8 years specific experiences in geological and hydrogeological investigations and mapping for water supply and groundwater potential studies, experience in well design, drilling works, pumping test, borehole geophysical logging and interpretation, borehole construction design
6	Senior GIS and Remote Sensing Specialist	1	MSc Degree in	At least 12 years of general experience in GIS and Remote Sensing, experience in various GIS and Image analysis software, use and analysis of various satellite images
				At least 10 years of GIS, Remote Sensing or relevant mapping experience in water supply works and resource mapping
7	MIS Specialist	1	MSc Degree in IT, MIS or related field	At least 15 years general experiences in IT services such as building communications networks, safeguarding data and information, and troubleshooting computer problems
				At least 12 years specific experiences in IT background with application development and platform management, open-source software and systems integration best practices, data management techniques, strong execution skills, and ability to overcome and work around operational obstacles, strong communication and relationship management skills; able to communicate complex technology concepts with non-technical staff, highly Analytical and good in relationship management
8	IT Systems Specialists	1	MSc Degree in computer science and programming	At least 10 years general experiences in IT services such as building communications networks, safeguarding data and information, and troubleshooting computer problems
				At least 8 years specific experience providing tech support services to organizations and individual users, typically addressing issues with both hardware and software systems, assist with installation and integration processes, security

SN	Job Title	#	Qualification and Education	Experiences
				issues, and program upgrades, provide remote tech support and troubleshooting services, make recommendations to guide future technology plans or purchases.
9	Instrumentation Engineer or Technician	1	MSc Degree in in instrumentation engineering, electrical engineering, or a related field.	At least 12 years general experiences in instrument selection, system integration, calibration and validation, troubleshooting, data acquisition and analysis, safety and risk assessment to various industries and sectors
				At least 10 years of specific experience in installing and maintaining data loggers, sensors, and other monitoring equipment, knowledge of electrical systems, wiring, and troubleshooting techniques.
10	Data Management Specialist	1	Masters/ degree in data science, computer science, or a related field.	At least 12 years general experiences in data collection and storage, data quality assurance, data governance, data analysis and reporting, database management, data integration, data security and compliance, data visualization, data migration and conversion to various industries and sectors
				At least 10 years specific experiences in data management, including data collection, storage, and validation, and analysis, knowledge of data formats, quality control procedures, and data management software.
11	Senior Environmentalist	1	MSc Degree in environmental science, environmental engineering, or a related field.	At least 15 years of general experience in environmental impact assessment, environmental policy and regulation, conservation and biodiversity, sustainable development, environmental education and advocacy, environmental monitoring and data analysis, climate change and adaptation, environmental management systems to various sectors
				At least 12 years specific experiences in environmental monitoring and compliance, knowledge of relevant regulations, standards, and best practices for groundwater monitoring.
12	Senior Socio-Economist	1	Degree in Sociology or relevant and related fields	At least 13-years of general experiences in socio-economic study and design of water supply projects
				At least 10 years of specific experiences in socio-economic study works in the water sector
13	Procurement Specialist	1	MSc/MA in Engineering, Law, Procurement and Logistics, Economics or relevant and related fields	At least 10 years of General Experience in Procurement in any sector.
				At least 5 years related experience in world Bank Financed Water and sanitation/WRM/Irrigation sub-sector projects. A high familiarity of World Banks and Governmental procurement guidelines and procedures needed and knowledge of Preparation of Standard Bidding Documents for procurement of goods works and non-consultancy services mandatory. Strong capability of communication on the subject matter required.

6.3. Facilities to be Provided by the Consultant

The Consultant shall be responsible for provision of the following:

a) Office accommodation in Addis Ababa for all phases.

b) The Consultant shall provide all the furniture necessary for its offices as well as office equipment (computers, printers, telephone, fax, photocopying equipment, binding machines etc.).

c) The cost-of-service connections and water and electricity consumption, as well as Watchman and office cleaning services shall be paid for by the Consultant.

d) The consultant shall provide all survey instruments and equipment required by the survey teams for all three phases to establish (and verify) reference center line levels and for conducting evaluations of Service Level Criteria;

e) The Consultant shall provide any other junior personnel such as site assistants, and secretarial staff that are necessary for the proper execution of the services

6.4. Services to be Provided by The Employer

The Employer will establish a Project Management Unit led by an appointed Project Co-coordinator (PC) through whom all requests for information, guidance and assistance should be addressed. All reasonable assistance will be provided, including liaison with other Employer departments and access to any relevant data that is not classified as restricted.

The Employer shall provide the Consultant the following without charge:

a) Assistance in obtaining any required customs clearances, visas and any other official permits; as may reasonably be required; and

b) Such other support facilities as may reasonably be needed for the expeditious performance of the required services, including pertinent files and documents.

6.5. ORGANIZATION SETUP

Contractual Arrangements

The contractual arrangements for the specified activities are under lump sum contract payment schedule. The Consulting Firm shall show the cost of the proposed service in accordance with these contractual arrangements.

Services and Facilities to be provided by the Consulting Firm

The Project manager acting for the Consulting Firm as Engineer's Representative will undertake and retain the powers and authorities.

The site office shall be equipped with the basic equipment, latest computers and software, materials and engineering and office programs necessary to carry out the assignments (desk top, printer, shelves, tables, chairs and etc...).

Liaison with MoWE

MoWE for purposes of this assignment will nominate a member of staff from the Authority as Counterpart staff. It will be the Consulting Firm's duty to maintain close contact with the Counterpart staff on all aspects of work. All formal communications related to changes in site, scope of works, substantial volumes, new orders, new drawings, and any similar to these, the work will be directed to the attention of the Counterpart staff prior to the issuing of the instruction to the Contractor.

Logistical Setup and Staffing

Within the technical proposal, the Consulting Firm shall elaborate on the envisaged logistical setup and deployment of appropriate skills for the execution of the assignment.

The Consulting Firm shall present the project staffing schedule in a manner that clearly shows the stage and duration where each of the proposed team members is planned to be involved in the Project. An organization reflecting the responsibilities of each staff member and line management setup of the proposed team shall be part of the proposal.

7. PROGRAM OF WORKS

7.1. Consulting Firms Schedule of Assignments

The assignment is expected to be finalized within Twelve [12] months after signing of the contract agreement.

SN	Activities	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
A	**Phase 1 – Inception Work**	■	■										
i	Project Kick-off Meeting	■											
ii	Desk Review of Existing GW Mon. System	■	■										
iii	Development of Detailed Methodology		■										
iv	Phase 1 Report Preparation (Inception Report)		■										
v	Validation Workshop of the Inception Work		■										
B	**Phase 2 – Assessment Phase**			■	■	■	■						
i	Inventory of Data			■									
ii	Selection of Sites for New Monitoring Wells				■	■							
iii	Identifying Existing Boreholes for Loggers				■	■							
iv	Phase 2 Report Preparation					■	■						
v	Validation Workshop of the Assessment						■						
C	**Phase 3 –Design Phase**							■	■	■	■	■	■
i	Detail Design of Monitoring Wells							■	■	■	■		
ii	Detail Design of the GW Monitoring Stations							■	■	■	■		
iii	Tender Documents Preparation							■	■				
iv	Phase 3 Report Preparation											■	■
v	Validation Workshop of the Design Phase												■
vi	Capacity Building Training Workshop												■

7.2. Program of Works

The Consulting Firm shall submit a program of works which shall be adopted in consultation with the Client.

8. REPORTING AND SCHEDULE OF DELIVERABLES

The consultant will submit the following deliverables:

- Inception report outlining the proposed methodology, work plan, and timeline.
- Draft and final reports on the national groundwater system assessment, including maps, figures, and technical appendices.
- A report on the new monitoring wells site selection process, including detailed well location proposals and justification.
- Well design reports for each proposed well.
- Training materials and manuals for groundwater monitoring and data interpretation.

In accordance with the implementation schedule, the Consulting Firm shall submit the following reports at different stages to the Client.

All deliverables shall be accompanied by the corresponding electronic copy.

Table 2 Reporting Types and Submission Time-Frame

SN	Report/Content	Form	Receiving Person/Office	Reporting Period (months from commencement date
Phase 1 – Inception Work				**Phase 1 (6 months)**
1	**Draft Inception Report** including outline of the initial plan and approach for the assessment of the existing groundwater monitoring system, includes a detailed description of the objectives, methodology, scope, work plan, risk assessment, and stakeholder engagement strategy, review of existing monitoring systems.	5 Hard and Soft Copy	PMCU	M+1
2	**Final Inception Report**	5 Hard and Soft Copy	PMCU	M+2
Phase 2 - Assessment for Monitoring Wells Site Selection and Strategic Master Plan Development				
3	**Draft Groundwater Monitoring Well Site Selection Assessment Strategic Master Plan Development Report** that evaluates the inventory result on existing boreholes, site selection of new monitoring wells based on various factors such as location, geological conditions, proximity to pollution sources, and	5 Hard and Soft Copy	PMCU	M+5

SN	Report/Content	Form	Receiving Person/Office	Reporting Period (months from commencement date
	representativeness of the groundwater system, hydrogeological assessment result and suitability maps, identification of existing boreholes suitable for logger installation,			
4	**Final Draft Groundwater Monitoring Well Site Selection Assessment Strategic Master Plan Development Report**	5 Hard and Soft Copy	PMCU	M+6
Phase 3 – Monitoring Wells and Stations Design Phase				**Phase 2 (6 months)**
1	Draft tender document of the Monitoring Wells	5 Hard and Soft Copy	PMCU	1 (One) Month from start of Phase 2
2	Final tender document of the Monitoring Wells	5 Hard and Soft Copy	PMCU	2 (Two) Months from start of Phase 2
3	**Draft Design of Monitoring Wells and Tools for Monitoring Stations Report** that includes the design of monitoring wells, design of monitoring stations with the associated specifications and bill of quantities for wells and tools	5 Hard and Soft Copy	PMCU	4 (Four) Months from start of Phase 2
4	Final **Detail Design of Monitoring Wells and Tools for Monitoring Stations Report** including all deliverables	5 Hard and Soft Copy	PMCU	6 (Six) Months from start of Phase 2
5	Validation Workshops (4) – at the end of Draft Inception, Draft Assessment and Draft Design			M+1, M+5 and M+10, respectively
6	**Capacity Building Training** groundwater monitoring wells and stations assessment and design, installation, hardware and software, data management and analysis	Training materials (30), software, manuals	MoWE and Region Water Bureau	5 (Five) Months from start of Phase 2