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## A. TECHNICAL SPECIFICATIONS

### General

The specifications Technical Guidelines for the Construction and Management of Borehole Hand Pumps (April 2009, MWRI in partnership with UNICEF) shall apply. In case of contradiction to these specifications, these specifications shall supersede the guidelines stated above.

### 1. Scope of Works

The current situation of the Rural Water and sanitation sub-sector in the rural settings is dismal with many people lacking adequate access to improved water and sanitation facilities. As per SPEDP Emergency Response Strategic Work Plan: October 2016 – 2020, SPEDP planned to provide access to safe drinking water to communities affected by the conflict and other natural disasters by drilling and rehabilitating water facilities in the community.

As specified hereafter and as directed by the SPEDP WASH Manager, the works include:

- Conduct geophysical survey
- Drilling of 2 boreholes
- Installation of casings
- Litho logical sampling well development
- Execution of pumping tests
- Water sampling and water quality analysis
- Platform casting and installation of India mark II hand pumps
- Boreholes capping and cleaning upon site completion

***N.B. The client reserves the right to alter, reduce or increase the scope of the work.***

- Minimum Technical Requirements:
- Memorandum and Article of Association
- Certificate of Incorporation from GOSS (Ministry of Legal Affairs and constitutional Development)
- Registered and Licensed Drilling Company/Organization at the Directorate of RWSS
- Minimum Technical Requirements:
- Geophysical survey Equipment (Goelectrical Resistivity)
- Drilling Rig with a capacity to drill 120m depth
- Compressor (16 bar or more)
- Mud pump (960-1020 l/m at pressure range of 4-15 bars)
- Appropriate pumps and generators to conduct proper pumping test
- Sufficient temporary casing

### 2. Drilling Sites



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The Contractor is expected to identify 2 promising sites using geoelectrical resistivity survey and drill total of 2 boreholes in identified sites in Koch County.

### **3. Environmental Protection of the site**

Care must be taken in handling and storage of all drilling fluids, oil, greases and fuel on site, to avoid any environmental degradation. The contractor shall dispose off any toxic materials, drilling fluids and other additives, cuttings and discharged water in manner approved by the SPEDP Supervisor, so as not to create any damage to public and private property.

### **4. Workmanship**

The contractor is expected to carry out works as instructed by the client in a thorough and workman-like manner, and up today's professional standards. He shall carry out operations with due efficiency and dispatch in accordance with the terms of the contract and to the satisfaction of the employer. For this purpose, the contractor shall use suitable machinery and supply efficient and experienced staff.

### **5. Equipment and Materials**

All necessary machinery and equipment (as mentioned on Item 1 scope of work) to carry out the geophysical survey, drilling, pumping test, headwork construction, pump installation etc. have to be mobilized for the works. To minimize deterioration, machinery, equipment and materials shall be handled, transported and stored in accordance with the manufacturers' recommendations.

Prior to the access to the drilling site, the SPEDP Supervisor will verify the specifications and state of repair of all major items of plant and transport and shall have the right to order the removal and replacement of any items that in his opinion is insufficient or in unsatisfactory condition or suitable for the underground formation to drill.

However, acceptance by the SPEDP Supervisor of the contractor proposed plan and transport does not relieve the contractor of his obligations under this Contract. In case of such plant fails, to complete successfully the required works.

### **6. Supervision of the Works**

The execution of the works will be supervised by the SPEDP WASH Manager. The SPEDP Supervisor will be with the Contractor and supervise the works of the Contractor. The Contractor is obliged to work closely with the SPEDP Supervisor at all the time.

### **7. Geophysical Survey**

The Contractor is expected to execute geophysical survey- namely geoelectrical resistivity



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method. In the geoelectrical resistivity method both profiling and Vertical Electrical Sounding (Schlumberger Array) should be done. The geoelectrical resistivity Profiling should be done at potential electrode separation (MN/2) interval of 5m in order to properly sample the resistivity variation along the profile. Before conducting geoelectrical profiling and vertical electrical sounding, calibration of existing borehole should be done in order to characterize the underlying lithology in terms of their resistivity.

The data collected should be plotted manually on log paper immediately at the site in order to control the quality of the data. Later on analysis of geophysical data should be done using excel and other geophysical software. The data analysis should be carried out using correlation of the exploration and calibration soundings.

The Contractor should involve local community in siting especially women since the burden of water collection typically fall on them and they know better about existing water sources.

The Contractor should identify promising zones using geophysical survey and local knowledge and handover promising drilling sites to SPEDP site supervisor and Local Authorities. Besides the drilling site should be properly marked to avoid drilling at the wrong site.

After completion of survey, the contractor should prepare groundwater assessment report (hard copy and softcopy) regarding potential number of aquifers and their characteristics, to identify geological structures (faults, lineaments etc), indicate depth to bed rock, water strikedepth, types of formations to be encountered during drilling, indicate thickness of weathering zone and specify recommended drilling depth etc.

### **8. Borehole Depth, Diameter and Acceptability**

The Contractor shall drill to a total depth and at such diameter as instructed by the Employer or site Supervisor. No borehole will be acceptable if drilled to a depth and diameter other than instructed by the Employer or SPEDP site Supervisor.

A borehole will be considered as positive while its yield is reached at least 700 litres of water per hour of pumping. This measure must be validated by a pumping test and could be renewed upon the Supervisor's request.

If the yield is below 700 litres/h the borehole has to be abandoned and the Contractor has to backfill the borehole with native soil from the bottom upwards and two of the last 3 m shall be sealed by concrete, cement grout or neat cement, which shall be placed by a method approved by the SPEDP site Supervisor that will avoid segregation or dilution of material.

The upper 1 m of the lost bore shall be backfilled with native topsoil. Sealing of such abandoned boreholes shall be done in such a manner to avoid accidents or subsidence and to prevent it from acting as a vertical conduit for transmitting contaminated surface or subsurface waters into water bearing formations.



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## 9. Drilling Method

The contractor may use any drilling technique that he feels applicable to achieve the depth and diameter required, approved that the techniques used are those specified in his technical proposal.

The use of bentonite mud, lost circulation agents or any form of plugging materials that may ultimately affect the production capacity of the water bearing strata will not be permitted.

## 10. Sampling

Representative, continuous samples (min. 300 g) of the formation penetrated shall be collected at every 3 m interval and as the formation changes. The Contractor shall take every possible precaution to guard against sample contamination. The drilling samples (cuttings) should not to be washed. Representative samples from cuttings shall be put into approved containers supplied by the Contractor labeled in a manner approved by the Supervisor with borehole location, number and depth interval, stored in a position where they will not be contaminated by site conditions or drilling operations.

## 11. Temporary Casing

Installation and diameter of any temporary casing required for the successful construction of the borehole will be at the discretion of the contractor, provided that the completed borehole meets the specifications and design required under this contract and is approved by the Supervisor.

The cost for supply, installation and removal of temporary casing shall be entirely met by the Contractor. The Contractor cannot claim from the client any casing left in the borehole that is not retrievable.

## 12. Water Supply for Drilling

The Contractor shall make his own arrangements for obtaining, pumping, transporting and storing of water required for drilling purposes and for use by the drilling crew at their camp site.

## 13. Borehole Design

The Contractor, in consultation with the SPEDP supervisor shall confirm the final design of the borehole during the drilling process or immediately after the drilling is completed.

### Design A:

Drilling at 12" or 105/8" bit diameter to the soft collapsible overburden until firm rock is encountered. Drill Further with 6.5" bit through non-collapsible formation. Drilling should be continued with 4 1/2" bit to the final depth. The borehole should be lined with 4.5" outer diameter UPVC class D casing of 5.3 mm wall thickness and Screened sections shall be adjacent to aquifer zones at appropriate depth. The screened sections have to be gravel packed with appropriate gravel size. The minimum level of the gravel pack should be of 6 m above the top installed screen.

### Design B:



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Drilling at 12" or 105/8" diameter (actual diameter depends on the size of the bits available) through unconsolidated overburden until hard formation is encountered.

Drilling further with 6.5" diameter bit to final depth as specified in the BOQ. Then the borehole should be lined with 4.5" outer diameter UPVC casing up to the bottom.

#### **14. Casing and Screening**

The permanent casing shall be of UPVC complying with DIN 8061/62 standard or other acceptable standards with tensile strengths of at least 45 MN/m<sup>2</sup>. The UPVC shall be joined by threads or other appropriate methods that shall ensure that the joints are water tight, strong and have the same structural integrity as the casings themselves.

Screens shall be of slotted UPVC complying with DIN or other acceptable standards. Sections of screens shall be not provided longer than 3 m lengths and joined watertight by flush threaded connections. In particular cases of the lower end of the screen should be completed with a sump length of a minimum of 0.5 m and maximum of 2 m. The bottom end of the borehole should be sealed with a bottom plug of UPVC or any other appropriate material approved by the SPEDP Supervisor.

#### **15. Verticality**

All boreholes shall be vertical, shall be drilled and cased straight and all casings/screens shall be set round, plum and true to the line. The Contractor shall make the necessary corrections to the approval of the Employer without additional payment. If the error(s) cannot be corrected, then drilling shall cease and a new well shall be constructed at a position nearby, verified by geophysical survey. The abandoned well shall be backfilled and/or capped by methods approved by the Employer. No payment will be made for re-drilling, the sealing/backfilling of the abandoned borehole, or for moving to the new site. Any materials (casings, screens, gravel, cement, etc.) lost in the abandoned borehole will be to the Contractor's cost.

#### **16. Gravel pack**

Suitable gravel pack shall be supplied by the Contractor. Prior to delivery, samples of the gravel pack shall be subjected to a grain size analysis at the Contractor expense and the result must be approved by the SPEDP Supervisor before the gravel pack is used. Gravel pack should consist of washed, well rounded particles of a uniform grading between 2.5 and 4.0 mm, shall comprise 90% siliceous material and must contain no clay, shale, silt, fines, excessive amount of calcareous material or crushed rock. Sufficient gravel pack shall be installed to cover completely the uppermost screen, plus an additional 6 m length. Emplacement should be by means of a conductor pipe and good supply of water should be introduced with the gravel to prevent "bridging". The conductor pipe should be raised gradually as the level of the gravel builds up. The pack should be capped with a clay seal to prevent contamination. The annular space above this clay seal can be back-filled with inert drill cuttings. The top 3-6 m of the annular space should be grouted. The Contractor should take the necessary measurement in order to implement instructions given by the Supervisor.



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### **17. Sanitary Seal**

To provide an effective seal against the entry of contaminants, the upper 3-6 m of the annular space between the casing and the borehole wall will be grouted using cement slurry (neat cement consisting of a mixture of ordinary cement and clean water in ratio of 22 Litres of water to 50 kg of cement). Grout is to be injected into the annulus in single operation so that a complete and continuous seal is achieved.

### **18. Yield Estimation during Drilling**

Yield estimates during the course of dewatering shall be made using a method agreed upon by the Contractor and the Employer Supervisor. Preferably the calibrated bucket or weir or velocity-area method should be used. Average yields shall be read as directed by the Employer or SPEDP site Supervisor and recorded in the daily records.

### **19. Development and Cleaning of Boreholes**

Development and cleaning of the boreholes, in order to remove native silts, clays, loose rock particles and drilling residues deposited on the borehole during the drilling process shall be carried out by the Contractor upon completion of the drilling process and installation of casing. If organic drilling fluids are used, they shall be broken down chemically according to the manufacture's recommendations before or during the development. Cleaning may be carried out by airlift pumping, surging, backwashing or jetting, to the approval of the Employer.

The method proposed by the contractor for borehole development shall be submitted to the Employer in writing for his approval. Development of boreholes shall be effective from the depth at which water is encountered to the bottom of each borehole. Development shall continue for such a time as directed by the Employer, and until the Employer or SPEDP Watsan Technician (Supervisor) is satisfied that the water is as free from fine particles as possible. Upon completion of development, any accumulation of materials shall be removed from the bottom of the borehole by airlifting.

### **20. Water Level Observations**

The contractor shall supply appropriate electrical contact water level gauges for measuring water level in the borehole. Measurements must be made to the nearest 5 mm at pre-determined intervals, dependent on the nature of the test. Well head measurements should permit these gauges to be inserted and passed freely. Measurements have to be taken from a well-defined measuring point. Water level measurement should be done immediately after drilling and also once water levels in the borehole have recovered.

### **21. Pumping Tests**

The contractor shall perform pumping test to establish the performance and yield of the borehole, and shall provide a suitable, self-contained, mobile pumping test unit for this



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purpose. The method for varying the discharge rate of the pumps will depend on the type of pump used, but the contractor shall ensure the provision of a suitable means of achieving the range of constant flow rates specified by the SPEDP site Supervisor. Pumping test will be undertaken in each productive borehole, as assessed from the yields indicated during drilling.

In the case of boreholes with indicative yields of between 700 l/hr and 1500 l/hr, the borehole will be tested at a constant discharge rate of 700 l/hr for 6 hours or until the water level stabilizes.

In case of boreholes with an indicative yield greater than 1500 l/hr, the borehole will be tested in the manner of step test, with the initial step being at 700 l/hr. The duration of each step shall be 90 minutes and four steps of increasing discharge rate until water level reach above the level of the pump. Discharge for each step should be kept constant. On completion of the final step, the Contractor should monitor the recovery of water level until 95% of original water level recovery has been achieved or could be stopped as per instruction of the Supervisor.

If there is borehole at 20-30m distance from the pumped well, the contractor should use it as observation well. The contractor has to make arrangement to collect water level readings from pumping well and observation well at the same time.

After full recovery of Four Step test, the boreholes shall be tested with a Constant Discharge Test of 6 hours at  $\frac{3}{4}$  of the critical pumping rate.

***N.B. The client reserves the right to alter, reduce or increase the pumping duration.***

After completion of the Constant Discharge Test, the recovery shall be observed up to 95% of recovery of original static water level or could be stopped as per instruction of the SPEDP Supervisor. Water levels shall be measured during test pumping by the Contractor by means of an electrical contact gauge (dipper), suitable calibrated such that measurements can be made to an accuracy of 5 mm. The contractor has to insert pilot pipe so that the accuracy of water level reading will be better.

Discharge shall be measured by volumetric methods, or by means of some other approved calibrated measuring device. During the test pumping, the discharge water must be handled and disposed off in an appropriate manner to a point of overland drainage sufficiently far from the borehole to prevent recharge. This distance shall be at least 150 m from the borehole, but may be reduced with the approval by the SPEDP Supervisor if the pumped aquifer is confined.

During all testing operations, once the flow rate been determined and preliminary adjustments are made, the measured discharge rate shall be maintained within 5% of the required rate for the duration of the test or test stage. Persistent fluctuations beyond this tolerance will be required abortion of the test.

Any test which is aborted due to the reasons above shall be reported, after full recovery of the water level. No payment shall be made to the Contractor for aborted tests, nor for standing time



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during water level recovery after aborted tests.

## 22. Records

Daily activity records shall be kept by the Contractor for each borehole. The records shall contain the information as specified below. In addition separate records should be supplied for each borehole upon completion.

### 1. Daily Records

- Site name
- Reference number of borehole
- Co-ordinates of borehole (latitude/longitude)
- Date of reporting
- Names of foreman and drillers
- Method of drilling
- Diameter of hole, and depth of changes in diameter
- Depth of hole at start and end of shift or working day
- Depth and description of well casing
- Depth and description of well screens
- Description of strata drilled with depth of transition encountered
- Depth at which water is struck
- Water level at the start of each working day
- Yield of air lifted water, when drilling or developing with air
- Time log showing rate of penetration in minutes per metre, type of bit, standby time due to breakdown
- Depth intervals at which formation samples are taken
- Records of components and qualities used or added to the drilling fluid or air
- Problems encountered during drilling
- Electrical conductivity, PH, Temperature and TDS measurements during pumping test.
- Details of installations in the borehole (if any)
- Lithological description of chip samples
- Details of work to be invoiced at hourly rates (e.g. pumping test).
- Record and give reason for any interruptions

A copy of the daily record shall be made available daily to the Employer or SPEDP Watsan Technician (Site Supervisor), should include any other pertinent data as may be requested by Employer or SPEDP Watsan Technician (Site Supervisor).

2. Borehole Completion Record as per the standard borehole completion forms of the MWRI:
  - Detailed driller's geological log
  - Borehole design and installation details.
3. End of Contract Report, the contractor is required to prepare an end of Contract report which should address minimum of the following issues:  
The selected sites (suitability, accessibility);
  - a. The drilling/pumping test methodology (type of drilling, designs used, pumping test





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- methods);
- b. Contract schedules and duration (summarized diary of events, and actual durations);
  - c. Summary of results and analysis (table showing locations, well numbers, depths, Casing type and depths, driller's and pumping test yields, and any other information deemed necessary);
  - d. Casing and screens used in the contract (table showing casing and screen installation intervals);
  - e. Problems encountered (with accessibility, formations, equipment and community);
  - f. Suggestion for improvement (on supervision, documentation, durations, etc.);
  - g. Borehole completion records (original drilling and pumping test logs bound separately from the report);
  - h. Any other information the Contractor deems important.
  - i. Pumping test data analysis using accepted hydrogeological software.

One copy of this report, one soft copy and borehole Completion Records, should be submitted to the Employer and another copy to the Rural Water Department through the Employer.

### **23. Electrical Conductivity Measurement**

The contractor shall provide an operational electrical conductivity meter to take electrical conductivity readings of the discharged water during drilling and pumping test.

### **24. Water Sampling**

The quality of the water from the borehole should be tested for physical, bacteriological, and chemical contamination before commissioning for public consumption. Water samples for quality testing (bacteriological, physical and chemical analysis) will be taken at the end of the pumping test. Microbiological parameters to be analyzed are both Total Coliforms and Faecal Coliforms. Physical water quality analysis should include the following parameters Taste, Odour, Colour, Appearance, Temperature, Turbidity, PH, TDS and Electrical conductivity. While chemical water quality analysis should be done for the following parameters (Arsenic, Ammonia, Calcium, Chloride, Fluoride, Iron, Nitrate/Nitrite, Manganese, magnesium, Sulphate, Total Hardness).

A sample of water should not be less than 2 liters, preferably two samples from each borehole. The sample should be sent to the authorized institute in a clean and sealed water container, for chemical testing. Three samples of water in clean, sterilized and sealed plastic or glass containers, not less than 100ml each should be sent for bacteriological analysis within 6 hours from the time of sample collection.



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## 25. Capping of Borehole

During well construction, installation, and development the Contractor shall use all reasonable measures to prevent entrance of foreign matter into the well. The Contractor shall be responsible for any objectionable materials that may fall into the borehole and any effect it may have on water quality or quantity until completion of the works and acceptance by the Employer or SPEDP Site Supervisor.

## 26. Borehole Disinfection

A water supply borehole should be disinfected on completion to kill bacteria that have been introduced into the borehole during drilling. This is done by adding chlorine into the borehole. Sufficient disinfectant needs to be added to produce a concentration of about 200 mg/l of active chlorine within the borehole. After addition of the disinfection the borehole should stand for at least 4 hrs at the specified concentration, after which water should be pumped out and discarded until the water smells strongly of chlorine. At this point, no more water should be pumped out for at least 24 hours, after which water should be pumped out and discarded until the taste of chlorine is just noticeable in the water.

## 27. Platform and drainage apron construction

The Contractor shall for each well carry out the following in order:

Excavate square pit 760 mm wide x 760 mm long x 400 mm deep around casing pipe and dispose excavated material to the approval of Site Supervisor.

Place stand assembly (pedestal) over casing pipe, ensuring third leg (corresponding to the water tank spout pipe position) faces the direction of the drain.

Make sure that the pedestal is vertical, construct concrete (mix 1:2:4/20 mm aggregate) in layers of 100 mm up to top of legs.

Cover stand assembly with a cover plate; level the ground around the pump pedestal and lay the mild steel shuttering (moulds as per design of platform).

Cast the platform and drainage channel in reinforced concrete (mix 1:2:4/20 mm aggregate) conforming to the dimensions and other requirements in drawing 1. Cure concrete for 3 days and protect it from evaporation (using gunny bags) and protect from disturbance (using thorny bushes etc)

Plaster platform and drain in cement screed to smooth finish.

Dig a soak away pit of 1 m diameter to a depth of at least 1.2 m. Fill pit with hard core and cover leaving good space for wastewater to drain completely into pit.

## 28. Hand Pump Installation

The contractor should supply and install below and above ground Indian Mark II pump structures to



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discharge a minimum of 0.28 l/s. The contractor should be aware of the standard hand pump in Southern Sudan, which are Indian Mark II standard handpumps and Afridev hand pumps for depth of boreholes up to 45 m and Dubba deep well hand pumps for depth of wells over 45 m. For this project either Indian Mark II or Dubba deep well hand pump should be supplied and installed.

### **29. Acceptance of Borehole**

The boreholes shall only be acceptable by the Supervisor upon satisfactory completion of all drilling operations, installation of casing and screens, development works, pumping test and final capping.

### **30. Loss of Equipment**

Any equipment lost down in a borehole must be removed by the Contractor or the borehole will be considered a lost borehole. A replacement borehole will have to be constructed and test pumped at the contractor's expense. The contractor will not be entitled to any payment for such tools or equipment.

### **31. Lost Borehole**

Should any incidence to the plant, behaviour of ground, jamming of the tools or casing, or any other cause prevent the satisfactory completion of the borehole, the borehole shall be deemed to be lost and no payment will be made for that borehole or for any materials not recovered, nor for any time spent during drilling or while attempting to overcome problems.

In the event of a lost borehole, the contractor shall construct a replacement borehole at a site indicated by the Employer or Site Supervisor. The option of declaring any lost borehole shall rest with the Contractor and with the approval of the Employer.

A lost borehole should be treated as follows:

- The contractor may salvage as much casing and screen from the borehole as possible and may use it, if not damaged, in a replacement borehole, with the approval of the Supervisor.
- Any material supplied by the Employer and salvaged damaged shall become the property of the contractor, and the contractor shall compensate the Employer accordingly.
- The lost borehole shall be backfilled with native soil from the bottom upwards and two of the last 3 m shall be sealed by concrete, cement grout or neat cement, which shall be placed by a method approved by the Employer that will avoid segregation or dilution of material.
- The upper 1 m of the lost bore shall be backfilled with native topsoil.
- Sealing of such abandoned boreholes shall be done in such a manner to avoid accidents or subsidence and to prevent it from acting as a vertical conduit for transmitting contaminated surface or subsurface waters into water bearing formations.

### **32. Standby Time**



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In the event of delays occurring as a result of action or inaction by the client, for which the Contractor would be entitled to claim standby time, the Contractor should notify the Supervisor immediately in writing that such claims are becoming applicable. Standby time is only effective if all the Contractor's plant, equipment and personnel are on site, available for work and in a serviceable condition. Standby time should not exceed the standard working day as defined in the Contract Data, and any claim shall only be deemed to start at the date and time of a notice in writing to the Supervisor.

### **33. Clearing the Site**

On completion of each borehole the site should be restored as far as possible to the condition found on the team's arrival, hydrocarbons and waste, and all pits filled to the satisfaction of the Supervisor. A site not delivered clean may render the borehole unacceptable.

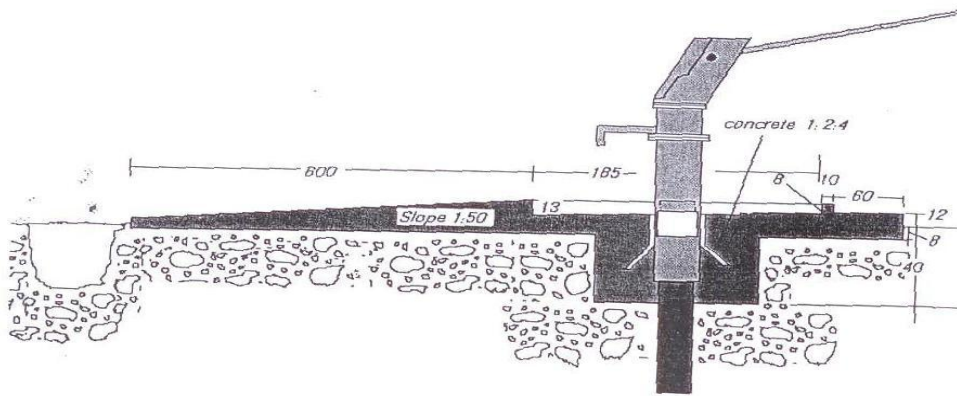
END OF TECHNICAL SPECIFICATIONS



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## B. Appendix 1

DRAWING 1: Hand pump Platform



**Source: Technical Guidelines for the Construction and Management of Borehole Hand Pumps (April 2009, MWRI in partnership with UNICEF)**



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