



Technical Specification for Water Supply for Family Health Houses

**Ground water Investigations, Construction and Drilling of Water
Well, construction of Well Chamber**

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1 INTRODUCTION AND BACKGROUND

The purpose of this document is to provide technical specifications for Wash Facilities at FHH including ground water investigation, construction and Drilling of Water Wells, Water wells development and water Quality testing, supply and installation of solar water pump and construction of wells chamber. The output expected by IOM from successful contractor, engaged under contract to carry out construction of wash facilities.

The successful contractor, by accepting the terms of this contract with the IOM accepts and understands that the scope of work according to the Bill of Quantity, Specification, and design drawings) based on the norms and standards (IWS, AWWA). This document must be read and fully understood by the contractor prior to accepting these terms of reference.

2 LOCATIONS OF FHH

IOM is planning to drill 9 boreholes, supply and installation of solar water pumps and construction of well chamber in 9 Family Health Houses (FHHs) locations as listed below:

Table 1: Location of the FHHs

S/N	Province	District	Village	GPS Location		Water Source	Power needed for water transmission
				Latitude	Longitude		
1	Faryab	Dowlat Abad	Popalzai, Jangal	36.62854	64.87652	Tube Water Well	Solar powered pumping system
2		Pashton kot	Atakhan Khaja	36.20147	64.67438	Tube Water Well	Solar powered pumping system
3		Qaisar	As-hab Kahf	35.72268	63.93918	Tube Water Well	Solar powered pumping system
4		Qaisar	Khaja Asplan	35.84392	64.04062	Tube Water Well	Solar powered pumping system
5		Almar	Qara kol	35.86463	64.25462	Tube Water Well	Solar powered pumping system
6		Belcheragh	Kata Tash	35.99133	65.17716	Tube Water Well	Solar powered pumping system
7		Gurziwan	Ghulbian	35.73204	65.35552	Tube Water Well	Solar powered pumping system
8	Balkh	Shor Tepa	Islam Chongar	37.29822	66.47686	tube water well	Solar powered pumping system
9		Shor Tepa	Sar-e-Pata	37.32745	67.09493	tube water well	Solar powered pumping system

IOM is seeking for a contractor to carry out the ground water investigation, drilling and construction works of the boreholes, mobilize, and provide all the required tools,

machinery, materials, labour and ensure that all the necessary requirements of borehole development, testing and sanitation apron are up to the required standards as clearly specified on the technical specifications and the BoQ. This water well is intended to provide potable water supply for the above mentioned FHHs.

After the signature of the contract, IOM representatives in will coordinate with the selected contractor for a site visit at the FHH where it will be shown the boundaries of the area selected for drilling for each borehole. IOM makes notation that these areas are not definitive locations for the drilling and changes could be made within the FHH boundaries, and its land property based on the groundwater investigation conducted by the contractor that to be addressed in writing to IOM by the contractor and vice versa. IOM will have into consideration for change of locations based on the data resulting from the groundwater investigation.

3 SCOPE OF WORK

The selected contractor must perform in a satisfactory manner, ground water investigation and the drilling of 9 productive boreholes and with well chamber and installation of suitable solar Submersible water pump in each borehole, and Construction of well chamber in accordance with standard specifications.

The detailed description of activities is specified in the Bill of Quantities, which is part of this document and will constitute part of the contractual documents, therefore subject to validation for the actual completion.

The items described below expand the specifications in the items in the Bill of Quantity and provide further guidance.

The contractor is expected to carry out and perform all works as per required standards specified on the technical specifications, design/drawings and the BoQ.

3.1 GROUNDWATER INVESTIGATION

The selected contractor should perform Geophysical analysis (hydrogeological survey) in Project area using geo-electrical techniques to find the best locations, for borehole siting in coordination with IOM and all local stakeholders, and according to technical specification, the result of the test should present a clear vision from ground water aquifer in the area and the contractor must suggest a complete design for the drilling depth and drilling method to fulfil the water demand in Related FHHs as estimated in water demand part and present a comprehensive and complete report for the IOM.

In the case that the geophysical analysis brings up recommendations that might affect the design of the borehole under the specifications, a written agreement would need to be signed by both the parties before starting drilling operations. This must be ensured by the contractor before commencing of drilling. In consequence the contractor, and not IOM, is liable for the successful drilling of a productive borehole under the terms and conditions related in this document. Drilling conditions are not expected to be difficult although the contractor should be prepared to deal with unstable collapsing water bearing top formations.

3.2 DRILLING STIPULATION

The construction, development, and testing of production water well shall be include but not limited to:

1. Drilling of borehole in all geologic possible environments to a minimum internal diameter of 10 inches (25.4 Cm) bore hole according to the EPA norms, IOM will consider a borehole successful only if meets the conditions minimum yield of 0.85 Liters per second (determined by a 6-hour pump test – item)
2. If the borehole doesn't meet the stated need of the FHH according to this specification, IOM will not consider it successful and will not accept it neither pay any of the items in the contract, all expenses incurred in the process of the drilling, transportation, will all be under contractors' responsibility.
3. The contractors applying will quote in the Bill of Quantity taking in consideration that the borehole depth can vary, and IOM will not make any payment beyond this quoted amount, independently of the drilling depth beyond the indicated depths in section 10.2 table, that the selected contractor need to undertake to meet the design specification in terms of depth of water column and yield.
4. Borehole drilling and construction will be supervised by the IOM Engineer in collaboration with the local stakeholders, IOM engineer will have the final authority in making technical decisions to the contractor.
5. The contractor should ensure that the drilling rig to be used must have the capability of drilling beyond the anticipated depth by 30%.
6. The selected contractor will install U-PVC, class 10, drinking water standards, non-toxic plain casings with a 150mm (6") internal diameter and 6.5mm thickness for total depth of well except where screen casings are installed. There should be at least 2m of 150mm internal diameter U-PVC, class 10, plain casing at the bottom of each well.
7. The contractor will install screen casings with an internal diameter of 150mm (6"). The quantity/length of screen casings to be installed in the borehole will vary respectively to the soil/aquifer formations.
8. The contractor will install filter packs which is clean and of approved quality collected from riverbeds consisting of particles with a diameter of 5-7mm. The depth of the filter packs should allow for 20% settlement above screen casings and have a cover to separate it from the sanitary seal. For average borehole with diameter of 9" and 150 mm (6") internal diameter, U-PVC casings with thickness of 6.5mm the average amount of filter pack is estimated to be 0.06 m³ per meter of depth of the borehole Sieved washed gravel, relatively homogenous, and well rounded. The grains should be hard and of alluvial origin, and in size between 1-6mm diameter.
9. The selected contractor shall supply and install a submersible pump, with all the components including uPVC rising pipe class 10 according to the specification in the BOQ.

10. The contractor will coordinate with the competent authority, in the locality for the collection of samples of water from the borehole for full physical, chemical, and bacteriological analysis of the water to ascertain its suitability for human consumption. The Results need to be submitted to IOM project in standard format, filled and signed by the authorized authority.
11. Upon completion of the borehole, the selected contractor should submit a report of the borehole drilling in which all the relevant information and drilling velocity, well casing and other well construction operations will be recorded. The contractor will also annotate all information pertaining to the appearance of water filtrations and aquifer, types of rock found and sampling details including geophysical testing analysis, drilling log, GPS coordinates, casing details, filter pack details, constant rate testing procedures and results, recovery testing results, yield, draw-down, disinfectant calculations and procedures, pump cylinder installation depth and hand pump details including serial number, water quality analysis and photographs.
12. The boreholes must be developed by airlifting (Compressor) for a minimum of 6 hours and until satisfactory yield is reached, stabilized turbidity is less than 5 NTU.
13. Test pumping test should be done by the contractor for a minimum of 8 hours in total, as follows: 4 hours of step drawdown, 4 hours for constant rate pump test. Recovery test will be for two hours or such time when there is at least recovery of 80% of the static water level noted at the start of the pump test. Pumping yield, drawn back and recovery data should be reported on the borehole log and should contain at least: Date of Test (Day, Month, Year); Depth of BH at time of test (m); Static Water Level (SWL) before test (m); Type of Pump used; Depth of Pump Intake (m); Discharge (Ltrs/Minute); Dynamic/Pumping water level (m) After Pumping continuously for (Hrs); Time of recovery to original SWL (Minutes); Rate of Recovery (m), at 5 min, 20 min, 60 min, 120 min, 180 min, 240 min, 300 min, 360 min, 420 min and 480 min, .
14. After a successful completion of drilling and water testing, the boreholes will be disinfected using the required calculated amount of chlorine solution preferably granular Calcium Hypochlorite or Sodium Hypochlorite applied on the annular space along with the gravel pack material at a concentration of 500 grams per cubic metre of pack. This will initiate the process of sterilizing the borehole and the chlorine solution should stay in the well for at least 4 hours at the specified concentration.
15. Construction of water well chamber according to the typical drawings attached in bidding documents.
16. The system delivered to IOM shall offer a safe, steady, and continuous potable water production, delivered to the elevated water storage tank.

4 ROLE OF THE CONTRACTOR

The contractor will have to provide for the construction and completion in every detail of the work described in the contract and contractual documents such as ToRs and annexes (BoQ and Design). All labors, materials, tools, equipment, transportation, supplies required to complete the work in accordance with the drawings, specifications and terms of the contract should have to be well furnished. The contractor cannot deviate from the construction designs or specifications without seeking for permission and approval from IOM.

If the contractor is not able to finish the drilling or must abandon the borehole due to loss of tools, accidents or any unforeseeable circumstances, the contractor should remove the casings or drive pipes already in the hole and refill it with clay or concrete. All materials extracted from the hole, after refilling it will be the property of the contractor. IOM will not pay for any of the work carried out and will authorize in advance the drilling of a new hole, at a site near the abandoned one, if need be, at the contractor's expense.

5 REQUIREMENTS OF THE CONTRACTOR FOR THE TENDER

a. Experience:

For a contractor to be accepted to participate in the tender process, must provide evidence (satisfactory contract completion certificates) of at least 3 borehole drilling contracts in respected region and province during the last 3 years. The scope in the certifications should clearly mention drilling and are not valid for this purpose auger manual drilling.

b. Equipment and work force:

The contractor should present a list of the drilling equipment that is going to execute for the contract, specifying the following: Name; Model; Quantity; Year of manufacturing. All equipment listed should be in perfect operational conditions and if changes are required during the execution of the contract, an equipment of similar characteristics needs to be put in place and it has to be informed to IOM by written.

The contractor must provide a list of the workforce that intends to use for execution of the project, detailing percentage of females and males.

c. Time for completion.

The contractor should perform the activity in a maximum period of 2 months after the signature of the contract. For the tender process, the contractor should submit a work schedule (project Gant chart) aligning activities to match the completion period.

6 DEFECT LIABILITY PERIOD.

Boreholes will be guaranteed for a period of one year after completion. In an event that there are defects found on each borehole within the one-year period, the contractor will be notified and authorized to correct all the said defects before he/she is paid the retention amount.

7 WATER DEMAND FOR ONE FAMILY HEALTH HOUSE (FHH)

Water Demand calculation for FHH					
The FHH is open to provide services 24/7 all year around. A midwife from the community is trained and deployed at the FHH together with two community health workers. The UNDP assessment of existing FHHs shows a total staff count of between 5-9 people including: doctor, midwife, nurse, community health worker, vaccinators, and guards. Some reviewed facilities are significantly larger, but probably offer services beyond those of a basic FHH. The FHH houses admit 60-130 patients per day. Due to cultural traditions, a man will accompany a woman visiting the FHH.					
S/N	Population	Person	Water consumption (litres/capita/day)	Demand (litres/day)	Remarks
1	Staff	9	80	720	
2	patients per day	130	20	2600	
3	Health centre cleaning and Hygiene	1	1000	1000	
total water Demand				4,320.00	

8 PRE-AMBLE TO THE SPECIFICATION

This technical specification covers the minimum standards of workmanship and materials required by the Contract. All works shall be carried out with the approval of the IOM engineer. Any civil works or materials that do not meet this specification's requirements shall be repaired or demolished and re-instated at the Contractor's expense. The Contractor shall be liable for any delays to the project caused by construction or demolishing defective work.

Any items of work not described in this specification but forming part of the works shall meet the minimum standards of workmanship and materials. The IOM engineer needs to approve the civil works or materials, and there is a conflict between local standards and this specification, which shall take precedence. This document forms part of the Contract, and should be read in conjunction with the other Contract Documents:

- Contract Agreement,
- Conditions of Contract,
- Bid Forms,
- Contracted engineering design drawings,
- Other documents referred to any of the contract documents,
- Work plan and construction tracker.

8.1 8.1. QUALITY OF MATERIALS

The qualities of all construction materials are to be following the State Standards. The IOM engineer in charge shall check the quality of all materials delivered to the site and put his finding on the Engineers site Notebook (project Journal) every time he/she visit the project site. Any supplied materials, which do not meet the minimum standards, shall be rejected. Such materials shall be removed from the site and replaced at the Contractors expense with materials of the required quality.

The IOM engineer in charge shall check that the required quantity of materials has been delivered to the site according to the BoQ and put the inputs in the project journal and used in the works. The IOM engineer in charge will not certify payment for any materials, which have been specified in the Contract but have not been used in the works for whatever reason.

8.2 QUALITY OF WORKMANSHIP

The IOM engineer in charge shall be responsible for checking that the quality of workmanship by the Contractor is of an acceptable standard according to this specification. The IOM engineer in charge reject any works, which have not been executed to the required standard. The Contractor shall redo any rejected works at his own expense and no time delays to the overall scheme.

8.3 MOBILIZATION AND DEMOBILIZATION

The work shall consist of mobilizing equipment, supplies, and securing bonds and permits necessary to do the work as stated in the contract and/or agreement and demobilization of excess materials and equipment from the worksite.

8.4 SIGN BOARD FOR SCHEME IDENTIFICATION

The sign board shall be from 50mm Marble stone with the size of 75x60cm. Client details, Scheme and Project details, Contractor details, Project Start and End date, Placement of IOM Logos (as directed by the IOM engineer in charge) need to be plotted in marble board, It shall be fitted and need to be properly installed at start of the scheme (at Proper location subject to the approval of the IOM engineer in charge) including complete other necessary construction works as per recommendations of IOM engineer in charge.

8.5 CONTRACTOR'S OFFICES

The Contractor shall make his own arrangements, at his own expense, for all local accommodation he may require for offices, yards stores labour camps etc. and all buildings and all services in connection therewith which are required for the efficient

execution of the Works. The contractor is encouraged to discuss all arrangements with community elders for their input/help/suggestions.

8.6 TESTING

The Contractor shall allow in his rates and prices for the cost of carrying required tests necessary for compliance with the Specification in approved/certified private laboratories. IOM engineer in charge is authorised for QA tests to insure that the work and Material Quality is according to Technical specification.

8.7 DISPOSAL OF SURPLUS MATERIAL

The Contractor shall not, during the manufacturing, allow any accumulation of surplus earth, rock, clay, or other material. All broken precast structures should be dumped at proper places and should never be reprocessed to make new structures of the same or different types on no account shall the Contractor start making dumps of surplus materials except at places approved of by the. IOM engineer in charge.

9 GROUNDWATER INVESTIGATION (HYDROGEOLOGICAL /GEOPHYSICAL SURVEY)

9.1 OBEJECTIVE

The survey shall be carried out in three phases:

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

9.2 PHASE 1: ASSESS GROUNDWATER SITUATION

- Compile and analyse all the available hydrogeological, geological, climatic, meteorological, and hydrological data of the area and its environs to:
 - assess the groundwater potential of the project area by identifying the target aquifer(s), their types (porous, fractured, or karstic) and spatial distribution.
 - assess the groundwater potential by establishing a water balance for the area to present a conceptual hydrogeological model of the investigation area.
 - assess geomorphological features relevant to groundwater dynamic process.
- Based on the conceptual model, design an appropriate geophysical investigation strategy that is with the identified target aquifer type (porous, fractured, or karstic), the expected depth of the target aquifer and the baseline elevation (estimated depth to groundwater which determines the minimum required borewell depth). specific geo-electrical investigation method, should be chosen based on the conceptual model.

Criteria to choose specific geo-electrical investigation methods:

1) VES (vertical electrical soundings): to be applied in horizontally layered aquifers. These can either be porous aquifers or, in many cases, the weathered carapace of the basement. At each measuring point, 2 perpendicular vertical electrical soundings to be carried out to guarantee the validity of the assumption of horizontal layering.

2) Geo-electrical profiling: vertical, steep aquifers (fault zones, fractures)

3) ERT (electrical resistivity sounding): can be used for horizontal and vertical/steep structures.

Other geophysical methods:

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

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

9.3 PHASE 2: GEOPHYSICAL INVESTIGATION & SELECTION OF DRILLING SITES

Carry out the geophysical investigation according to the investigation strategy and interpret results: select the most suitable borehole drilling sites in the project area with coordination to local community and all stakeholders.

A separate description of each proposed borehole site is part of the report and shall include all relevant details of the interpretation of the investigations as well as sound recommendations on the most suitable sites for boreholes drilling, the recommended drilling depths, as well as the hydrogeological and geophysical rationale for choosing the sites.

- Present the results of the geophysical investigation, including the raw data sets, the qualitative interpretation of the type curves in terms of layer sequence (for VES investigations) and inversions results, and the identification of the drilling locations and precise description of drilling strategy and design.
- Based on the results from Phase 1 and Phase 2, a well-design has to be established and is an integral part of the study report. The design has to aim at maximising water inflow and minimising well-head-losses.
- The proposed drilling sites shall be marked, shown in topographical maps and indicated on appropriate site sketch maps. GPS coordinates have to be provided.
- Submit a complete hydrogeological/geophysical report to IOM: this report needs to be approved prior to the drilling process (e.g. the proposed well-design).

9.4 PHASE 2: DRILLING SUPERVISION

- The consultant shall supervise the drilling works and ensure the boreholes are drilled and completed according to stipulated technical specifications and sound professional standards.
- The consultant shall represent the client on site.
- The consultant shall supervise all the drilling process at all times on site, including the geological borehole logging and documentation of pumping test according to standard formats.
- The consultant shall supervise and document on a daily basis the drilling, development and test pumping of the proposed boreholes and hand-in a daily drilling progress report to IOM.
- After the borehole completion, the general well-design described in Phase-2 Geophysical Report may have to be adapted according to site conditions.
- Ensure that the drilling contractor do water sampling, geological logging, and water quality analysis (chemical and bacteriological).
- Adapt the general well-design according to the specific conditions at well location, basing it on the geological log and on the results obtained from the pumping test.
- Supervise installation of screens, casings, gravel pack, impermeable seals, well-heads etc. Ensure that the recommended drilling depths, design, and materials are followed and propose and carry out quality control measures upon well-completion, e.g. borehole camera inspection.
- prepare a detailed borehole completion report, with all necessary recommendations e.g. pump capacity, optimum depth of installation, periodic water quality analysis according to the standard format.

- All these documents shall be summarised in a Phase 3- Drilling Report, which will also include a quality control review of the drilling report from the drilling contractor.
- Compile all reports into a comprehensive final report (2 hard copies plus softcopy including all the raw data) and submit to IOM.

9.5 APPROACH, METHODOLOGY

The consultant will use a systematic and holistic approach to assess the project site and complete the study on time with the best Quality.

9.6 KEY DELIVERABLES

- The key deliverable is hydrogeological & geophysical survey report, which should be submitted to IOM The consultant will be expected to deliver 2 hard copies with approval from IOM using the recognized standard format.
- A soft copy on e-mail and 2 CDs with the final report will also be submitted to IOM.
- The consultant will also be required to deliver to IOM all study materials:
 - Soft copies of all data sets both quantitative and qualitative.
 - The geophysical interpretation model and the graphical plot of the curve and model.
 - Any other non-consumable documents/items that will be used during the planned consultancy.
- The borehole sites identified should be clearly marked, shown in a picture plate and indicated on a sketch map to be included in the final report.

The final and intermediate reports all need to have the same title page, including the following details:

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

9.7 EQUIPMENT AND FACILITIES REQUIRED FOR THE STUDY

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

- Hydro (geo) logical equipment
 - 1 EC meter
 - 1 TDS meter
 - Turbidity meter or
 - 1 compass
 - 1 electrical water level dipper: 200 m
- Geophysical Equipment:
 - Electric Resistivity/IP Equipment with accessories is recommended.
 - Geophysical interpretation software

- Any other equipment proposed by the consultant relevant to carry out the survey.
- Drilling supervision equipment
 - Viscosity Funnel
 - Turbidity probe or tube
- Field Office Equipment:
 - Notebook computers
 - Global Positioning System (GPS) devices
 - Drawing and tracing equipment/Computer with CAD can be used.
 - Digital Cameras

10 WATER WELL DRILLING

10.1 TRANSPORTATION AND WATER WELL DRILLING EQUIPMENT

- The Contractor shall provide drilling machine and equipment, transport and set it up on the site and shall carry out the drilling all in accordance with the IOM Engineering and supervising team instructions to be issued before commencement of the drilling work and during its progress.
- The Contractor shall be responsible for the supply and transport of all materials and equipment needed for the orderly progress of the drilling operation with closed coordination with IOM supervising team.
- The Contractor shall supply Casing pipes and slotted casing or filtered casing (screens) in the quantities and diameters required according to the approved drilling water well diameter and shall insert them in the water borehole in accordance with the specifications and the IOM engineer's instructions.

A typical tube-well section is shown in Designed drawings. Basic methods of drilling are indicated below for following as basic guide, mostly to maintain a few key dimensional specifications.

10.2 DRILLING METHODS OF WATER WELL

The preferred method of drilling in consolidated compact formations is rotary Boreholes will be drilled 10 inches (25.4Cm) in diameter.

In unconsolidated loose, unstable, collapsing formations, rotary with appropriate drilling stabilizer will be used. In such a case the drilling diameters will be 10 inches (25.4Cm). If other chemical fluids or solids are used to arrest collapsing of formations, the contractor must use proper tube-well development methods and tube-well cleaning methods to ensure the tube-well water is safe for drinking purposes. The contractor will use such fluids or solids with the agreement of the Supervision Firm. Boreholes will be constructed with U-PVC casing, screen, and sand trap. Quality of all these materials used should be in conformity with the drinking water standards. The length of casing and screen will be determined after the studying and waterlog and tube well crossing strata. All cost of using proper drilling fluids and solids is inclusive of the rate per m quoted. No additional payments will be made by IOM.

The procedures for drilling and installing the groundwater extraction wells are presented below:

1. Prior to extraction well installation, determine the expected volumes of filter pack and seal materials including bentonite and grout (neat cement or cement-bentonite)
2. Locate boring/well location, establish work zone for the storage of materials and equipment and delineate the work zone to hinder non-staff from approaching the site.
3. As it is necessary to install the extraction well into a permeable zone and the area is known to have two non-communicable aquifers with varying hydraulic parameters, the well will need to be formulated utilizing stickered screens.
4. The borehole (10-inch) shall be advanced allowing for the collection of soil samples and categorization every 1 meter below ground surface. Samples will be collected

by the Subcontractor and documentation associated with each sample will be identified the time of collection, described, and photographed.

5. During soil boring advancement, all drilling events will be recorded by the contractor to include all relevant information (i.e., boring advancement rate, piping, mud mix, work stoppage, etc..).
6. Before determining the screen installation depth, it is important to confirm that the borehole has been advanced into the targeted saturated zone. To verify, it is necessary to measure the water level in the borehole. For boreholes drilled using water (e.g., water rotary with core or roller bit), monitor the water level in the borehole as it re-equilibrates to the static level. Document depth to water in the borehole on the appropriate field forms. If there are questions concerning the depth of the well/screen interval, consult with the IOM technical staffs prior to finalizing the determination of the well depth/screen interval.
7. Upon completing the borehole to the desired depth, install the extraction well by lowering the well cap or equivalent (equivalent methods require a previously validated written proposal that demonstrates a complete sealing of the well casing to prevent the potential fine sands from entering the casing), casing assembly with sump, slotted screen, and casing.
8. A blank sump will be attached below the well screen. Consequently, the annular space around the sump will be backfilled with neat cement grout using a tremie to the bottom of the well screen prior to placing the filter pack around the screen. A blank riser will extend from the top of the screen to approximately 1 meter above grade. As the well will exceed 15-meters depth, centralizers are desired to assist in centering the extraction well in the borehole during construction and will be placed every 30-meters below grade.
9. When the extraction well assembly has been set in place and the grout has been placed around the sump, the washed sieved filter pack will be placed in the annular space from the bottom of the boring to a height of 1-meter above the top of the well screen using a tremie. The filter pack is placed, and drilling equipment extracted in increments until the top of the sand pack is at the appropriate depth. Verify that the expected volume of filter pack matches the actual amount installed. There can be differences due to irregularities in the borehole. Washing out of the borehole will result in the need for greater than calculated well materials. If a difference of more than 10% is noted, the IOM engineer must be consulted prior to continuing. The well should be gently surged to prevent filter pack material bridging and to settle the filter pack prior to well seal installation.
10. A hydrated bentonite seal (a minimum of 2 meter thick) will then be placed in the annular space above the sand. If non-hydrated bentonite is used, the bentonite should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. *No coated bentonite pellets will be used in extraction well drilling or construction.* Potable water may be added to hydrate the bentonite if the seal is above the water table. Monitor the placement of the sand pack and bentonite with a weighted tape measure.
11. During the extraction of the temporary casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth

approximately 1-meter. below groundwater surface (bags). As with the filter pack, it is recommended that seal material be placed with a tremie pipe. Ensure that seal materials are mixed at the proper ratios with water.

12. After the extraction well completion, a steel protective casing (extended at least 2 feet above grade) over the riser casing and secure with a neat cement seal. In either case, the cement seal will extend approximately 1-meter below grade and laterally at least 0.5-meters in all directions from the protective casing and should slope gently away to promote drainage away from the well.
13. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook as well as appropriate field forms.
14. After completing the well installation, lock the well, and clean the area.

Drilling activities should be documented on appropriate field/log forms as well as in daily logs. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of well installation activities, soil descriptions, well construction specifications (screen and riser material and diameter, sump length, screen length and slot size, riser length, sand pack type), and quantities of materials used. In addition, the locations of newly installed wells will be documented photographically or in a site sketch.

10.3 WATER WELL DEPTH

Based on the primary and local collected data, which have been collected around the selected water point, the proposed depth of wells will be as below table, but it should be recommended by the contractor after successful completion of ground water investigation, as stated in BoQ.

the proposed depth in the related FHH is as following:

8	Province	District	Village	GPS Location		Depth proposed from Site Visit
				Latitude	Longitude	
1	Faryab	Dowlat Abad	Popalzai, Jangal	36.62854	64.87652	Construction of water well (120m drilling)
2		Pashton kot	Atakhan Khaja	36.20147	64.67438	Construction of water well (145m drilling)
3		Qaisar	As-hab Kahf	35.72268	63.93918	Construction of water well (80m drilling)
4		Qaisar	Khaja Asplan	35.84392	64.04062	Construction of water well (80m drilling)
5		Almar	Qara kol	35.86463	64.25462	Construction of water well (135m drilling)
6		Belcheragh	Kata Tash	35.99133	65.17716	Construction of water well (120m drilling)
7		Gurziwan	Ghulbian	35.73204	65.35552	Construction of water well (60m drilling)
8	Balkh	Shor Tepa	Islam Chongar	37.29822	66.47686	Drilling water well 110 m
9		Shor Tepa	Sar-e-Pata	37.32745	67.09493	Drilling water well 110 m

However, our expectation from contractor to drill the water well to such depths as to penetrate below the shallow water table aquifers and tap the first potential deeper aquifer or aquifers in confined/semi-confined conditions.

The minimum discharge for this tube-well is **0.85 liters per second** to sustain continuous pump testing for 6 hours to ensure reliable operation of pumps fitted on them. The depth to be drilled should be below the main aquifer to provide enough water yielding and be sustainable along the design span. If the discharge is less than **0.85 liters per second**, a decision to abandon the tube-well or continue to drill deeper will be at the discretion of the Implementing partner, validated by the IOM Engineering team.

Depth of drilling and diameters and length of the Casings and screens will be finally determined by both contractor's technical team and IOM engineering Team according to the collected underground layers (water well log), results of water Quality Tests and water well pump and compressor tests (water well development). In the case of any changes in the water well, the rate or unit price of work will be fixed by an agreement between the IOM and the Contractor.

The Contractor must be prepared to stop the water well drilling before reaching the above designed depth, or to continue drilling below the planned depth without making any change in the unit price quoted by him in the bid as long as the depth stays within the limits of +or- 25% of the design depth mentioned above.

10.4 WATER WELL DIAMETER

Tube-wells will be drilled with **10 inches (25.4Cm)** in diameter, but according to the ground water investigation in the area, the contractor may suggest the diameter which should fulfill the water demand requirement. From ground surface down up to water table will have concrete grouting for sanitary protection. For this the bore hole will be reamed to minimum diameter of 10 inches (25.4Cm) and concrete grouting will be placed in the annular space between the casing and open tube-well wall. Tube-well will be drilled with 10 inches (25.4Cm) bit.

The implementing partner (Contractor) must consider the depths he has to drill and lower temporary casing to complete the drilling. This cost must be built in the quoted unit cost for drilling.

The IOM will not be responsible for any loss of temporary casing which the Contractor is unable to pull out or lost due to snapping or breaking from the completed tube-wells.

10.5 DRILLING FLUIDS

Throughout the drilling operation, the Contractor will be permitted to use only compressed air, foam, clean water or (if approved by Engineer) a drilling mud consisting of clean water, bentonite, and polymer. Any other sealing materials and chemicals of any kind that will be added to the drilling mud shall not be used without the Engineer's prior approval in writing. The viscosity and the density of the mud during drilling will be subject to the Engineer's inspection and approval.

Should the drilling enter a stratum where loss of circulation occurs below water level the Contractor shall use clean water only. The addition of mud or chemicals in such case requires the Engineer's written approval. Drilling shall be accomplished using water or air for the removal of cuttings which may be assisted by the addition of a surfactant.

10.6 DRILLING PAD

The Contractor shall install the drill pad prior to the commencement of drilling activities. The Contractor shall be responsible for the design of the pad, and he shall execute all the required foundations necessary to support the greatest anticipated rig load under the most adverse conditions. The Contractor shall clearly indicate what those conditions would be (i.e., weight of rig, casing strings, etc.). The Contractor's design for the pad shall be submitted to the IOM for knowledge.

10.7 DRILLING ASSEMBLY

The Contractor shall incorporate a bottom hole assembly using adequate stabilizers and drill collars to ensure minimal deviation of the borehole. The configuration of the ream assembly shall be such that the reamed hole shall follow the straight alignment throughout the water well borehole.

10.8 CASING DESIGN DETAILS

10.8.1 Steel Casing and Couplings

Steel casing must be new (carbon steel, conforming to ASTM A139/A139M Grade B), standard weight, galvanized, black, steel pipe, conforming to ASTM A53/A53M, steel pipe conforming to AWWA C200, type 304, or type 316, stainless steel and Joints must be either threaded and coupled, or field welded in accordance with AWWA C206.

10.8.2 Plastic Casing and Couplings

Plastic casing pipe and couplings must be Class E, threaded flush joint or other joint type as approved by the IOM inspection team instruction.

10.8.3 Screen

The Contractor will use and consider the proprietary screen length and type for bill of quantity (unit price), but the actual length will be determined once the water well drilling samples are analyzed, water well log explained and the exact aquifer position is speechified. The slot size and screen length depend on the aquifer materials and aquifer thickness. The contractor will propose a scheme of equipment to the IOM technical team (Hydraulic Engineer) who will take responsibility for the design of the tube-well. The Contractor will then assemble and place the screen and casing at appropriate place along the tube water well hole.

Slotted screens should be of DIN 4925, ISO9002 and IS 12818, 2010 standard and have the following specifications:

- uPVC Class E,
- Drinking water standards,
- Non-toxic,
- Standard lengths of 4m or as available in Market,
- Diameter of 6 inches,
- Slot width 0.8 mm and not more than 1mm, and open area as percentage of internal surface area 9.26% per linear meter. Depending on the aquifer, the contractor may choose an appropriate slot width other than 0.8 mm.

Plastic pipe, and screen material must conform to ASTM F480. All PVC and plastic pipes must conform to ASTM D1785.

- Well Screens must be a minimum of **6 inches** nominal diameter and must be directly connected to the bottom of the inner casing by an approved method. The length of the screen must be sufficient to provide an intake area capable of passing not less than the minimum required yield of the water well, at an entrance velocity not exceeding 30.5 mm per Second.
- The opening, or slot size of the screen, must be designed based on analysis of the distribution of the grain size of the aquifer materials encountered during drilling or artificial filter pack, be compatible with the material surrounding the screen.
- The well screen must be of sufficient size and design to hold back and support the gravel used in the filter pack envelope and in-situ material surrounding the screen,
- Use screens and all accessories required for satisfactory operation that are standard products of manufacturers regularly engaged in the production of such equipment. Field constructed screen is not acceptable.
- "Blanks" in the well screen may be utilized in nonproductive zones, or where centering devices are needed in the screened area, and area considered "casing."

10.8.4 Casing Pipe and Sand Trap

Casing pipe should be of DIN 4925, ISO9002 and IS 12818, 2010 standard and have the following specifications:

- U-PVC Class E,
- Drinking water standards,
- Nontoxic and in
- Standard lengths of 4m or as available in Market,
- Diameter of 6 inches wall thickness 10 mm.

Plastic pipe, and screen material must conform to ASTM F480. All PVC and plastic pipes must conform to ASTM D1785.

The tube-wells will be fully cased up to bottom of the tube-well. The threads both male and female are properly cleaned with a brush and cloth before they are joined. If the pipes used are with bell and socket, these are cleaned using fluids and cemented with

recommended solvent cement by the manufacturers of the casing pipes and screen. Wait for the recommended time for the joint set firmly before lowering into the tube-well.

The Contractor will take all necessary precautions during the transportation and storage of casing pipes from their warehouse to drilling site to prevent distortions, bending or deformation of the pipe that could result in eccentricity along the length of the pipe.

A maximum of 3m length of sand trap will be part of the well design when tube-wells are cased to the bottom. The sand trap will be from PVC casing pipe with specifications described above; fitted to the end of last screen and bottom end with an end-cap. The end cap is glued with appropriate solvent cement or solutions as recommended by the UPVC manufacturer. Note that the joints sections are properly cleaned with cleaning fluids and recommended time given for the joint set firmly before lowering into the tube-well.

Pipes and screens must be stored on a proper location and should be kept away from prolonged sunlight exposure.

10.8.5 Centralizers

All casings will be centred in the borehole with stave-type centralizers to ensure that the cement sheath will be evenly distributed around the casings. The centralizers can be commercially prefabricated or fabricated on site using available steel pipe. The centralizers will be installed at 90-degree intervals around the circumference of the casing at 30-meter intervals and aligned longitudinally as mentioned below to provide for insertion of pipes for cementing. Casing centralizers shall be of an approved design commonly known as the Halliburton type, or equally approved. Centralizers shall be of the same material as that of the casing. The Contractor shall install centralizers on the surface and other casings. The centralizers shall be placed as follows:

- One (1) centralizer 10 m above the bottom end of the casing.
- Three (3) centralizers at 20 m intervals above the bottom centralizer.
- Centralizers will be placed every 60m thereafter to 10 m below ground surface.
- The top centralizer shall be installed 10 m below the top end of the casing.

10.8.6 Verticality Requirement

At the end of drilling the borehole, a final verification for plumbness of casing shall be carried out for the whole borehole by using a dummy test. The outside diameter of dummy pipe shall be 13mm less than the inside diameter of the casing that will be tested, and its length shall be 12 meters. This dummy test will be performed for the entire cased borehole by lowering the dummy pipe to the bottom of the well using a sling wire.

The use of vertical turbine lines shaft pumps (submersible) in the well would require that the well meets strict straight and plumb (vertical) requirements (allowable percentage of misalignment is (0.5 degree). Inclination surveys will be performed at 20-meter

intervals during drilling the borehole by using a mechanical drift indicator known as TOTCO. The Contractor shall drill borehole straight and plumb. The straight borehole and verticality survey requirements are to allow for proper geophysical logging, cementing, casing settings and pump installation. The Contractor, at his own expense and under the Engineer's supervision, shall carry out tests of straightness and verticality while drilling. Straightness shall be checked by lowering a suitable template into the borehole in accordance with the Engineer's instructions to the depth determined to set the pump at.

The Contractor shall perform inclination surveys during the drilling every 20-m for that portion of the borehole in which the pump housing casing is to be set, and every 40-m for the lower section. The Contractor shall drill the boreholes in a manner that no doglegs or departures from a straight line occur. The deviation between two successive measurements should not exceed 0.3 degree.

The maximum allowable inclination from vertical at any portion of the borehole shall be less than (0.5degree). The Contractor shall correct any deviation greater than (0.5degree) from vertical at no additional expense to the IOM.

The Contractor shall utilize the services of a qualified specialist employed by the survey equipment manufacturer to teach/instruct the drilling crew on the performance and maintenance of the survey equipment. The specialist shall remain on the job until the drilling crews are proficient in the use of the equipment as determined by the Engineer. The driller/superintendent/tool-pusher of each crew should be able to interpret the raw data. A certification by the Contractor confirming that a crew member was fully trained on the use of the survey equipment and the interpretation of its output, which should include of the training sessions and the actual use of the equipment, may be substituted for the above requirements provided that such certification is approved by the Engineer. The survey equipment shall be maintained always on site. The Contractor shall take the appropriate corrective measures if the borehole indicates doglegs departures from the specified inclination requirement.

The Contractor may run additional surveys to demonstrate that the borehole is within the specified limits. The Contractor shall re-ream the borehole and repeat the surveys until the borehole is within the specified inclination limits and that the pilot and reamed holes are tracking one another. The Contractor shall make all corrections at no additional cost to the Owner.

10.8.7 Plumbness and Alignment Report

Upon completion of the plumbness and alignment measurements and prior to cementing the casing, the Contractor shall provide the data and calculations to it meets AWWA A100 standards. The IOM engineer will review the data and calculations, and -if acceptable- he will give the Contractor a "notice to proceed" with cementing operations. Upon completion of cementing and additional plumbness and alignment measurements, the Contractor will again verify

compliance of the new data and calculations with AWWA-A100 Standards before submitting to the IOM hydraulic engineer for his concurrence.

The casing and borehole alignment shall also be tested by lowering a 12 meters long section of dummy pipe to the bottom of the casing and into the upper portion of the borehole below the casing as specified by the Engineer. The outside diameter of the dummy shall be 13 mm less than the inside diameter of the casing being tested. The used dummy shall consist of a rigid spindle with a minimum of three cylindrical rings, each ring shall be a minimum of 13 mm less than the casing's inner diameter. The rings shall be located one at each end and one in the centre of the dummy. If the dummy does not move freely throughout the tested length, appropriate remedial actions shall be taken by the Contractor at his own expense.

10.9 GROUTING

10.10 GENERAL

Grout shall be placed in:

- The annular space around the 2" and according to the design of the water well and IOM hydraulic Engineer's instructions.
- The annular space around the 2" casing from the bottom of casing to the final depth of the well (if needed).

Before proceeding with placing the grout, the Contractor shall obtain the IOM hydraulic engineer's approval on the methodology and materials he intends to adopt or use. The Contractor shall have the required cementing equipment for all expected grout types handy; either available on site or immediate delivery to site upon request. Payment for grouting will be made according to the Bill of Quantities.

10.11 MATERIALS FOR GROUTING

All casings will be grouted in place with cement to support the weight of the casing string and to effectively seal the annulus outside of the casing for structural and sanitary purposes. Casings will be grouted with Type II (ASTM C150) neat Portland cement mixed with not more than 734 Litres of water per cubic meter of cement. The grout mixture may contain up to three percent (by volume) of bentonite clay.

Any other additives proposed to be used with the grout shall have prior approval of the IOM engineer. If the mix is a transit mix, up to 800 liters of water per cubic meter will be acceptable. Grouting will take place once the casing is lowered into position just above the bottom of the Borehole and hung. The cement grout should be applied neatly and be placed by the pressure grout method with a cement line which is installed on the outside of the casing until the annulus is filled with cement grout. The contractor will provide the method of grouting and the IOM hydraulic engineer shall approve the method of application. The method of application can be a combination of grouting through drill pipes outside the casing via non-return check valve or via tremie pipes installed in the annular space or via gravity.

In exceptional cases, when large openings are to be grouted, the addition of sand to the grout may be permitted, subject to the Engineer's approval. The water used for concrete mixing shall be potable. The cement grout shall be pumped into the annular space through a grout tremie pipe or other method approved by the Engineer. Grout shall be placed from bottom to top in a continuous operation. Once grout is placed from the required depth to ground level, no further work shall be performed on the well for a minimum of 36 hours or until grout is set as determined by IOM engineer. No standby time will be paid during the 36 hours period of grout setting.

10.12 GROUTING-IN OF THE CONDUCTOR PIPE

The annular space between the conductor pipe and the wall of the drilled hole shall be filled with cement grout of not less than 80-mm. thickness. The objective of this grout is to produce a complete sheath of cement-mortar around the conductor pipes for its entire length.

10.13 GROUTING AROUND THE CASING

Grouting around the casing shall be done by forcing grout into the space between the borehole wall and the casing string from the bottom end of the casing to the ground level or required depth fixed by the Engineer, by pumping the cement slurry through pipes and later through a non-return valve in the cement shoe.

10.14 GROUTING VIA GRAVITY

The Contractor may install the cement slurry using gravity method by placing the cement slurry between the casing and the borehole.

10.15 GRAVEL PACKING AND GROUTING

The annular space between the casing and tube-well wall is filled with filter packing materials in the screen intervals and back filling materials. The gravel packing mixture to be used is 1-5 mm. It can be adapted to the ground condition or based the water well sample analyzing.

Gravel packing is carried out as continuous feed operations done usually by two people filling uniformly along the circumference of the pipe. It is advisable to add some water with a pipe so that the gravel flows down. If the gravel gets inside the temporary casing, the casing is slowly pulled out and gentle well development is done to allow gravel to settle properly to a height of 3 m above the top of the screen interval or the targeted water bearing formation. The gravel will be installed using the inverse flowing: gravel is poured down during water injection from the bottom of the borehole.

Backfilling and grouting are done when the Minimum acceptable yield of 0.85 liters per second is confirmed by development. The tube-well cuttings or clayey soils are back filled up to 6m (or as per the underground layers situation) below the ground surface.

The grouting is done with a concrete mix in the ratio of 1:2:3 of cement sand and gravel respectively. The gravel size is not more than 10-12 mm.

11 TUBE-WELL DEVELOPMENT

On completion of drilling, the Contractor will choose a suitable and appropriate tube-well development method (Compressor Test). The tube-well shall be developed for a period of four hours to obtain a maximum yield of water that is free of suspended matter. Developing shall be carried out by airlift pumping and surging, jetting and block surging, or other techniques the contractor feels is more appropriate and efficient to suit the hydro-geological and drilling conditions prevailing in that tube-water well. All tube-water wells shall be presented for testing free of any bridging or obstruction to the total depth.

11.1 EXTRACTION WELL DEVELOPMENT STANDARD OPERATING PROCEDURE

11.1.1 Washing/Backwashing

This method is also known as over pumping with reintroduction; it involves removal of final particles from the formation allowing for a sand free yield to be achieved. The reintroduction of particle free water allows for dilution and agitation for suspension of fine particles, drilling fluids, and sediment. This method is considered a first step in extraction well development and is often combined with surging.

11.1.2 Mechanical Surging

This method involves the removal of particles and clogging materials liberated by forcing water in and out of the well intake. The introduction and movement of a surge block adjacent and within the screened portion of the well allows for a strong movement to water to dislodge fine particulates from the screen, filter pack, and adjacent formation. The lithology of for the formation should be taken into consideration when evaluating the use of this method and the type of surge block utilized (ventilated or solid).

11.1.3 Airlift

This method involves the introduction of air with the extraction well such that aerated slugs of water are lifted irregularly from the well casing, removing sediment and fine particles. For small diameter wells (4-inch or less) air is injected down the stem into the formation. For larger diameter wells an additional water pipe for extraction is utilized.

11.1.4 Jetting

This method involves the introduction of pressurized water into the well screen through horizontal jets. The jetting tool is lifted along the length of the well screen to dislodge particles along the well screen wall and filter pack. It is often used in combination with chemical agents.

In practice a combination of the well development methods is utilized either through phasing or in-conjunction, dependent on the aquifer and well construction. When completed directly after well construction (48hours after completion) at least three

times the volume of water introduced during the drill/pre-development or hydraulic jetting should be removed during the development process.

11.2 PROCEDURES

Water quality parameters to be collected throughout the development process:

- Specific conductivity
- pH
- Temperature
- Turbidity

Well development criteria are:

- *(When completed as part of the final step of construction)* Removal of at least three times the calculated volume (including the saturated filter pack with a 30 percent porosity) of standing water in the well.
- pH stabilizes to within +/- 0.1 pH units for three successive readings.
- Well water temperature stabilizes within +/- 1 degree Celsius.
- Well water conductivity stabilizes within +/- 3 percent.
- Turbidity is measured below 10 NTU for three successive readings and a differential of less than 1 percent is observed.
 - For formations known in areas known of turbid water, measurement stabilizes within +/- 10 percent.
- The sediment thickness in the well is less than 1 percent of the well screen length.

When constructing a well the following initial development should be completed: Once the screen and filter pack have been placed (before placing the bentonite seal), an initial well development will be performed to remove any drilling fluids (mud) from the well screen/gravel pack/formation immediately adjacent to the well (producing zone) and to ensure proper filter pack emplacement by alleviating potential for bridging within the pack. This initial development generally shall consist of:

- i) Measure depth to water and total depth of well
- ii) Use steel/weighted bailer to remove any fines that have accumulated in the bottom of the well.
- iii) Lower a double surge block into the screened portion of the well on a rigid pipe or high-density tubing and gently cycle up and down to force water in and out of the screen slots and formation. A one-meter throw is recommended (use tape or chalk marks on the pipe or tubing); however, the entire length of well screen must be surged.
- iv) Start above the screen and progressively surging one-meter sections, working down to the screen bottom.
- v) Surge the well screen for a minimum of ten throws per surge cycle. Each surge interval may require several surge cycles to achieve the best development.
- vi) Ensure that the developer surges the block upward faster than downward to pull the fines out of the filter pack, instead of forcing them back in.
- vii) Careful not to surge the well too aggressively at this point as the casing is only supported by centralizers and damage could occur.

- viii) Monitor the total depth of the well periodically during surging to ensure that excessive amounts of filter pack through the screen are not pulled. Develop the well, paying more attention to the “up” stroke to alleviate potential bridging of the sand pack and remove any debris accumulated in the well with a weighted bailer.
- ix) Re-measure the top of the sand in the annulus to see if more sand pack is necessary. Repeat as needed.

Following **construction** of a well the following final development should be completed:

Final well development shall commence approximately 48 hours after emplacement of the neat cement annular seal to allow sufficient time for curing. This period is a general guideline and is subject to change based upon field conditions encountered during and after well completion.

This final development standard should also be utilized for redevelopment of existing screen extraction wells.

1. To initiate the final well development process a dispersant, such as WELLCLEAN, or equivalent will be introduced within the well and allowed to stay overnight, or as recommended by the manufacturer, to break up the mud cake built up along the walls during the well drilling process.
2. Conduct initial specific capacity testing prior to development using a temporary submersible pump set mid-screen and pumping at a constant rate while monitoring the water level in the well until water levels stabilize (i.e., steady drawdown achieved at a constant rate). Flow should be measured using an inline flow meter or graduated buckets and a stopwatch from discharge piping to monitor flow rates and total volume of water removed. Pumping should be conducted at a rate high enough to create moderate drawdown (e.g., approximately several feet or at least 20% of the initial water column). Flow rate and drawdown will be recorded and the initial specific capacity (i.e., pumping rate divided by the drawdown in well) will be calculated for the well and used as a baseline comparison during well development.
3. Surge/brush the screen interval. The developers tooling should have the ability to brush, surge, and remove sediment simultaneously. Surge/brush the screen in 1-meter increments, moving up the screen approximately every 5 minutes.
 - If simultaneous activity is not possible:
 - Brush the entire well screen in increments of one meter to remove any accumulated material using an appropriate brush for the given screen type and material.
 - After brushing, use a submersible pump or weighted bailer to remove any fines that have accumulated in the bottom of the well.
 - Lower an appropriately sized double-surge block into the screened portion of the well on a rigid pipe or high-density tubing and cycle up and

down to force water in and out of the screen slots and formation. A one-meter throw is recommended (use tape or chalk marks on the pipe or tubing); however, the entire length of well screen must be surged.

- Start above the screen and surge over one-meter intervals while working down to the screen bottom.
4. Jet/air lift (reusing water from holding tank if adequately settled or freshwater). The jetting tool should be slowly raised through the screen interval in 1 meter increments every minute, and the tool should be turned from side-side by rotating the drop piping at the surface with a pipe wrench. The length of time spent jetting can be adjusted based on the observed results. Results include turbidity (either measured or just visual) and water drawdown/recovery.
- The down-hole jetting assembly should generally consist of following:
 - A minimum of three (3) jetting nozzles pointed outward in the horizontal plane. Select jet nozzles rated for velocities between 150 to 300 feet per second (ft/sec). Higher velocities may damage the well while lower velocities will be less effective at penetrating the filter pack.
 - Nozzles should spray in a wide-angle horizontal fan (e.g., 145°). An array of three (3) nozzles with overlapping fans is preferred with a combined spray arc of 360 degrees. If the combined spray arc is not a full 360°, the assembly will need to be rotated throughout development. Since a larger orifice will require higher injection rate for the same velocity, small-orifice jets are preferable (orifice diameter on the order of 0.016 to 0.065 inches).
 - Rate-controllable submersible pump, attached below the jetting nozzles. Pump capacity should be greater than the anticipated jetting flow required to jet at the target velocity (for the full array of jets). Pump assembly should be detachable so that it can be moved above the jetting nozzles if necessary (i.e., to reach bottom of well screen if insufficient sump area is below the screen).
 - Flexible rubber flange (or collar) should be attached between the nozzles and submersible pump. The flange's purpose is to prevent flow from the jet to the pump from occurring within the well casing, thereby forcing flow to occur through the screen and filter pack. Flanges should be constructed of flexible rubber and sized appropriately to slide freely up and down inside the well casing yet provide a partial seal against vertical flow.
5. At the conclusion of the jetting and surging cycle, lower a pump and check specific capacity using same flow rate used in the pre-development (baseline) specific capacity testing. Record flow rate and drawdown and calculate the new specific capacity. Evaluate improvement of specific capacity relative to the baseline calculation. Repeat development process (i.e., cycles of jetting/air lifting followed by surging/brushing/air lifting) as necessary until specific capacity shows no further improvement (i.e., less than 10 improvement).

6. Surge/brush/airlift the screen in one-meter increments, moving up the screen approximately every 5 minutes.
7. Well development criteria should be reached at the end of development.
8. After development, verify that the well construction (screen interval and total depth) is consistent with the original well construction log.

11.3 PUMPING AND RECOVERY TEST

The pumping test will be for 8 hours in total as follows 4 hours for step draw down test and 4 hours for constant rate pump test. The recovery test will be for 2 hours or such time when there is at least recovery of 80% as per IOM direction and including all sub activities according to technical requirements. Based on the estimated discharge, the Contractor will certify the tube well as either "successful" or "lost". The minimum discharge is 1.5 liters per second. If the discharge is below 1.5 liters per second, then the tube-well will be regarded as "Lost".

The contractor shall have on the site a 900 V-notch weir, preceded by a tank with baffles, for the measurement of flows. Small flow (less than 0.25 liters/second) can be measured by timing the filling of a vessel of known volume. The Implementing partner shall also have on site an operating electric dip meter, calibrated in centimeters, and with visual/audible indicator of when the water level is reached.

Readings of flow and water level shall be taken at the intervals defined on the test pumping form. For accurate measurement, an electrical/ sonic water level indicator with graduated tape for taking water level readings. Recovery readings shall be taken for a minimum of 1 hour, during which period airlifting or pumping equipment shall not be removed from the tube-well.

12 WATER QUALITY TESTING

Quality analysis for arsenic should be applied for every borehole.

The contractor should follow the standard of WHO Guidelines for drinking water quality Test and it should be included as following but not limited to:

Physical Parameters:

- EC, TDS, ORP, Turbidity, PH and Temperature.

Chemical Parameters:

- Alkalinity, Carbonate, Hydroxide, Chloride, sulphate, florid, Nitrate, Phosphate, Boron, Bromide, Iron, Lead, Manganese, Copper etc.
- Calcium, sodium, potassium, chromium, magnesium, ammonium, copper, aluminium, Iron, Arsenic, Uranium etc.
- Silica, Hydrogen sulphate, residual chlorine

Bacteriological Parameters:

- Total coliform and fiscal coliform, etc.

The referenced table are presented the primary maximum acceptable standard from the WHO for potable drinking water quality.

Parameter	Unit	WHO norm
Physical Parameters		
EC (Electro Conductivity)	μS/cm	1500
TDS (total dissolved solids)	mg/l.	1000
Turbidity	NTU	5
PH		6.5-8
T (Temperature)	C°	10 to 22
Chemical Parameters:		
Alkalinity	mg/l.	100
Chloride	mg/l.	250
sulphate	mg/l.	250
florid	mg/l.	1.5
Nitrate	mg/l.	50
Nitrite	mg/l.	0.2 to 3
Boron	mg/l.	2.4
Total Hardness as Calcium (CaCO ₃)	mg/l.	300
Calcium	mg/l.	100
sodium	mg/l.	200
chromium	mg/l.	0.05
magnesium	mg/l.	100
ammonium	mg/l.	1.5 to 35
manganese	mg/l.	0.4
Copper	mg/l.	2
aluminum	mg/l.	0.2
Iron	mg/l.	0.3
Lead	mg/l.	0.01
Arsenic	mg/l.	0.01
Hydrogen sulphate	mg/l.	0.1
residual chlorine	mg/l.	0.2 to 0.5
Bacteriological Parameters		
Total coliform	Col 100 ml s	0
Fiscal coliform	Col 100 ml s	0

12.1 SAMPLING AND DRILL-TIME-LOGS

Representative samples of the strata intersected shall be collected every three feet or less depending on the changes of geological formation. For collection, the Implementing partner shall cease drilling, circulate all cuttings to the surface, resume drilling and collect the cuttings then brought to the surface. The Implementing partner shall take every possible precaution to guard against sample contamination due to poor circulation, tube-well erosion, or caving. Cutting samples shall be bagged, labelled with tube-well depth at time of collection, and stored in a position where they will not be contaminated by site conditions or drilling operations. The Implementing

partner shall supply strong, transparent sample bags and labels as required. The driller in-charge will also record the drill time logs/penetration rate of each rod or at every three-meter interval. A sample of Lithological log with drill time log.

12.2 CHLORINATION AFTER TUBE-WELL COMPLETION

When the water well become successful, the contractor must chlorinate water well. The contractor will decide on the concentration of chlorine based on the volume of water in the tube-well.

12.3 STRAIGHTNESS AND VERTICALITY TEST

- Water well shall be drilled and cased straight and vertical and all casings and screens shall be set round, plumb and true to line. Any delays encountered in running casing and screen considered to be due to poor whole alignment shall be at the contractor's expense.
- The IOM may ask the contractor to perform random tests for straightness and verticality alignment after completion of the well and before its acceptance. The Implementing partner shall provide the necessary 15 m section of pipe (The plumb), not more than 15 millimetres diameter less than the inside diameter of the casing. Should the plumb fail to move freely throughout the length of the casing to the required depth or should the well vary from the vertical more than two-thirds of the smallest inside diameter of part of the tube-well being tested per 30 meters of depth, the verticality and straightness of the well shall be corrected by the contractor at his own expense. *Should the contractor fail to correct such faulty straightness or verticality, the IOM may refuse to accept the tube-well and no payment for those Works and materials used.*

12.4 PROTECTION

During the term of the contract, when the work is not in progress, the tube-wells must be closed to prevent the entry of any material. The contractor shall remove any unrelated material at its own expense. On completion of the tube-water well, the contractor shall supply and fit an approved permanent lock-up cap. Raised casings can be completed at not less than 0.5 meters above the ground level and should be fitted with approved lock-up cap.

12.5 ABANDONMENT

The IOM shall have the right at any time during the progress of the Works to order the abandonment of the tube-Water well. The contractor shall there upon remove the drilling rig, withdraw any casing and screen and salvage all such materials as the IOM orders. Therefore, the Contractor should fill back and leave the tube water well to the satisfaction of the IOM.

12.6 LOST (UNSUCCESSFUL) TUBE-WELLS

"Lost" tube-wells are either "dry" tube-wells or "uncompleted" tube-wells.

12.6.1 Dry Tube-Wells

Dry tube-wells are defined as:

A tube-well having no water bearing zones/aquifers. A Tube-Water well that has insufficient discharge (less than 0.1 litres per second) for 6 hours of continuous pumping test.

This situation may happen with time within the maintenance period because of one or more constructional defects such as ruptured / cracked casing, sections of tube-wells collapsed, heavy silting closing the screen, screen choked; lowering the discharge, or poor sitting of tube-well with no potential sustainable aquifers, drilling up to insufficient depths to tap potential sustainable aquifer.

In the above case, the Implementing partner shall either improve the discharge by appropriate well development methods or if the dynamic water level is less than 40m, lower the pump inlet with additional riser pipes and other needed connecting equipment. In the case of any remedial works not being effective, the contractor shall drill a new tube-well at an alternative site mutually agreed with the Water Point Committee and the IOM. If, after investigations, the Contractor feels *that there are no possibilities of drilling a successful tube-well in the village/ community*, then the contractor has the right to ask for classify the borehole as dry and to a move to a new location as per the IOM order. *This, however, can be accepted after two failed tube-well attempts.*

12.6.2 Uncompleted Tube-Wells

If for any technical reasons the Contractor is unable to continue drilling and complete the construction of tube-well, then this tube-well is deemed to be an "uncompleted" tube-well. This may be because of accident to the drilling rig, difficult drilling conditions or formations unsuitable for the drilling method or rig type used; heavy loss of air pressure or drilling fluids; loss of drilling bit or part of drill stem.

In case of "uncompleted" tube-wells, no payment shall be made for that tube-well either for drilling or materials that cannot be salvaged, and the rig's unproductive time spent. If the contractor chooses to deviate from standard procedure and the agreed method of drilling and wishes to adopt any other procedure or techniques that involves any additional cost and time required, it will be done so entirely at the contractor's own risk and cost.

13 TEST OF ACCEPTABILITY AND REPORTS

Subject to meeting the requirements of the maintenance period, the tube-water well shall be accepted for payment on presentation of the following reports at schedules shown in the table below and sample of the formats will be prepared by the IOM engineering team.

NAME	DESCRIPTION	FREQUENCY
Pre-execution report (could be per site)	This report indicates all data about the work to implement (location, drawings, the rig tools to be used	At least one week before site intervention
Certificate of Completion of drilling activities	This certificate of Completion will comprise: <ul style="list-style-type: none">• Strata or underground layers log,• Pumping tests interpretation results,• Construction log showing casings and filters and all installation for the tube-well,• Result of the quality analysis	At least 2 weeks after drilling activities completion
Certificate of Completion of civil work and electro mechanic activities	This certificate of Completion will comprise: <ul style="list-style-type: none">• Drawings of the constructions completed.• All documents on the material installed	At least 2 weeks after civil work and electro mechanic activities completion

All reports can be delivered on electronic copy.

14 WELL CHAMBER REQUIREMENTS

The well should chamber should be constructed according to the design and drawings, with consideration of civil works standards, attached in section 17 CIVIL WORKS AND MATERIAL REQUIREMENTS.

15 SOLAR WATER PUMP REQUIREMENTS

15.1 SOLAR WATER PUMP

The contractor is entirely responsible to provide the Solar Water Pump System according to the following requirements and specification in consideration to the specific location for different FHH water well depth and pumping test, as per BOQ but not limited to.

Groundfos SQ5 - 70, Lorentz or Similar and well-known European standard manufacturer, with primary estimated capacity from 3 to 4 HP capable to deliver at least 4 m³/hr. at the calculated depth of installation in accordance with the pumping test performed. The installation should be inclusive of cabling, uPVC class 10 rising pipes (min. diameter 50 mm) and connected to the existing water tank and interconnection with electrical system. The position of the pump must be identified to allow an efficient yield without damaging the pump. Complete system including required valves, off-grid solar water pump power conditioner and control, cables, and needed fittings and must be compatible to work as a system. A float switch to stop the pump when the reservoir is full. * Dry-run protection of the pump with automatic reset. * All components to be compliant with local water quality. * All components CE-approved, * The system must be installed according to manufacturer's installation guidelines.

Pump Cable: Estimated cable size: 10 mm², but the type of cable is highly dependent on the choice of pump and pump inverter and control. but must be heavy duty, with all connections in watertight function boxes with strain relief connectors. * A suggestion for a complete system solution is to be provided by the contractor to IOM for technical review and approval before the contractor can proceed with supply and installation, Supply, and installation of 10mm Stainless steel cable for holding solar submersible including necessary fitting, fixing etc. The pump system should be possible to power with external backup generator. Solar inverter and pump control: Estimated nom. electric power: 4 kW Incl. maximum power point tracking for PV modules.

16 CIVIL WORKS AND MATERIAL REQUIREMENTS

16.1 STONE FOR CONSTRUCTION:

Stones used for construction purposes like the hydraulic structures or buildings are prepared by breaking raw pieces from large rocks or stones into stone quarry of the appropriate size. The quality of the stone can be assessed by striking the stone lightly with a hammer. A bell-like high sound indicates good quality, and a dull low sound indicates a bad quality one. This test is very important when using sedimentary rocks. Another test can be done by laying the stone in water, take it out after one day, let it dry out, clean it from organic matter and put it back into the water again. Continue with this procedure for at least two weeks. If the stone does not break into pieces or develop cracks, it is considered adequate for construction purposes.

16.2 GRAVEL PACK

The gravel to use as a filtering layer must be between 3 and 5 mm, and they must be washed and clean. Rotary drilling. The capacity of the drilling machine (Rotary) must be at least 120 meters in depth. The machines must be able to drill on a diameter of 12" (depending on the soil's nature). The contractor to keep a log of the well drilling and present the data to the IOM engineer in charge for approval for selected casing pipes (blinds and strains); during the perforation, the cuttings will be taken at each change of ground, or every two meters drilled as a maximum. The samples taken at the borehole outlet will be placed in a sample box with different compartments to visualize the geological section. After the drilling operation, the samples will be kept in plastic bags at the building site, and a borehole log will be provided to IOM engineer. The materials will be at the disposal of the IOM Engineer, which will decide on their conservation or not. A borehole log report will be written and submitted to IOM as a draft.

16.3 WATER

The water used in the construction shall be of potable quality and shall be tested at the contractor's cost. The contractor has to make his own arrangements at his cost for water required for construction, testing, filling, etc., either from local bodies or from elsewhere, by paying the charges directly and arranging tanker etc., as per necessity. No claim for extra payment on account of non-availability of water nearby or extra lead for bringing water shall be entertained. All required piping arrangements and pumping if required for water shall be made by the contractor at his cost. Water for mortar, mixing and curing of concrete shall be free from harmful matter or other substances that may be deleterious to concrete or steel and taken from a source approved by the Engineer. Ground water for mixing and curing shall confirm to the provisions in the class 4.3 of IS 456/ 1978.

16.4 SAND

Sand shall be clean and free from contaminants such as oil, silt, soil, wood, metal, or vegetable matter. Very fine or smooth Sand shall not be used.

- Coarse Sand (used for concrete) shall have a maximum size of 5mm.

- Medium Sand (used for mortar) shall have a maximum size of 2mm.
- Fine Sand (used for plaster) shall have a maximum size of 1 mm.

16.5 AGGREGATES

The coarse aggregate used for concrete mix shall be angular crushed rock varying from 5mm to 20mm. It shall be clean and free from contaminants such as oil, silt, soil, wood, metal, or vegetation. If this type of aggregate is not available, the CONTRACTOR/SUPPLIER must seek the IOM Engineer's approval in the Journal book on which other types to use.

There are two types of aggregates used in construction works.

- Fine aggregate with size of 4.75 mm and less,
- Coarse aggregate with size of bigger than 4.75 mm.

All aggregates shall be hard, durable, chemically inert, clean, and free from adherent coatings, organic matter etc. And shall not contain any appreciable amount of clay balls or pellets and harmful impurities e.g., iron pyrites, alkaline, salts, coal, mica, shale, or similar laminated materials in such form or in such quantities as to cause corrosion of metal or affect adversely the hardening, the strength, the durability or the appearance of mortar, plaster, or concrete. The sum of the percentages of all deleterious material shall not exceed 5%. Fine aggregate must be checked for organic impurities such as decayed vegetation humps, coal dust etc.

Fine aggregate (it consists of natural sand from river or crushed sand from stone) shall conform to the following requirements bellow:

16.6 PHYSICAL TEST

The hand filled with the aggregates to be tested is clenched and then opened again. If the material is clean, it should not stick together in a lump. When the material is rubbed between the hands, the hands should remain almost clean. Otherwise, the silt and foreign material must be washed out by thorough rinsing with water.

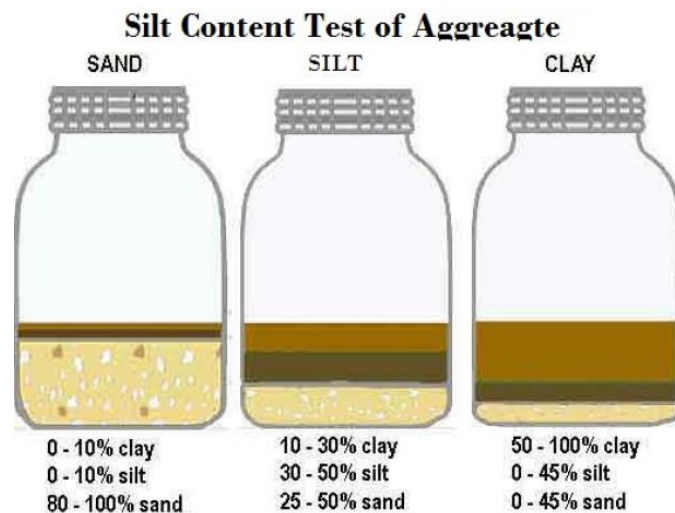
16.7 SILT OR SEDIMENT TEST

This test estimates the amount of fines (silt and clay sizes) present in the natural sand. This estimate is because the particles settle in water at a rate proportional to their size.

Procedure:

- I. Fill a measuring cylinder up to about 50 ml mark of a 250 ml measuring cylinder with salt-water solution (one teaspoonful salt to 570 ml).
- II. Pour the sand until the level of sand is up to the 100 ml mark,
- III. Add more salt water until it reaches 150 ml.,
- IV. Shake the cylinder vigorously,
- V. Stand the cylinder on a level surface and tap it until the top of the sand is level,
- VI. Leave it to stand till the water clears,
- VII. Measure the volume of the silt - clay layers and the volume of the sand.

The percent of soil content in sand can be calculated from the following relations:



$$\text{Silt content (\%)} = \frac{\text{Thickness of layer of fines}}{\text{Thickness of layer of sand}} \times 100$$

If the silt content is more than 5%, the sand is not clean enough for use and must be washed.

17 CONCRETE WORKS

17.1 SCOPE

The work covered by this specification shall consist of furnishing all labor, materials, permits, and related miscellaneous work necessary to complete the work as specified herein or as shown on the design drawings. The concrete work under this specification shall include all clearing and grubbing, preparation of subgrade, furnishing and placing concrete, shouldering, and construction of fills and embankments, unless such items appear of the proposal to be bid separately. It is the intent of these specifications that a sub-grade of uniform stability is obtained by a suitable construction method for placement of concrete.

This section covers all matters involving use of concrete for the construction and improvement of pump houses, water tanks, valve chambers, irrigation canals and other concrete related works at implementation sites.

17.2 CONCRETE GENERAL INFORMATION

Concrete shall consist of cement, graded aggregates, and water thoroughly mixed, placed and compacted as specified. Before starting to concrete the Contractor shall obtain formal written permission for concreting from the IOM engineer in charge or his representative on site. The IOM Engineer or his representative shall allow concreting after ascertaining the required lines and levels, suitability of formwork, availability of required plant and labors, proper fabrication and spacing of the steel bars and quality and quantity of cement and aggregates.

17.3 CONCRETE MATERIALS

a) Delivery, Storage, and Handling

All materials shall be delivered, stored, and handled as to prevent the inclusion of foreign materials and the damage of materials by water or breakage. Package materials shall be delivered and stored in original packages until ready to be used. Packages or materials showing evidence of water or other damage shall be rejected.

b) Portland cement

Cement shall be Portland Type originating from approved manufacturers in sealed and labelled bags, each 50 Kgs. Net capacity, name and brand of the manufacturer shall plainly be identified thereon and Delivered to the Site in good condition Cement delivered in bulk shall be accepted only if a central mixing plant is used. The Quality of cement shall conform to the Standard Specification for Portland cement of ASTM designation:

- Portland cement shall conform to ASTM Standard Specifications C 150 Type I or Type 1A latest edition.
- High-Early strength Portland shall conform to ASTM Standard Specification s C 150 Type III or Type IIIA.
- All cement poured under extreme heat conditions shall use ASTM Standard Specifications C-150 Type II,
- All cement poured when high sulphate resistance is desired shall use ASTM Standard Specifications C-150 Type V.

All cement shall be from reputable manufacturers and conform to international standards. Cement shall be stored where it cannot be damped by rain or moisture and shall be free of lumps when used. Any opened bag should be immediately used. Sulphate-resisting cement shall be used for foundations and ordinary Portland cement for other works or as directed by IOM Engineer or by his representative.

17.4 CONCRETE AGGREGATES

All concrete aggregates (sand & gravel) shall be furnished by the Contractor from any source approved by the IOM engineer. They shall be free from organic material, lumps of soft material, clay, chalk, lime, peat, loam, soft clayey shale or decomposed stone, vegetable and other impurities that may be harmful to concrete.

17.5 SAND (FINE AGGREGATE)

All sands (fine aggregates) shall conform to Standard Specification for Concrete Aggregates of ASTM Designation: C-33 and to the detailed requirements give in Table A (appended here below). It shall not contain harmful materials such as iron pyrites, coal, mica, and shale. Alkali, coated grains, or similar laminated materials such as soft and flaky particles, or any material which may attack the reinforcement, in such a form and in sufficient quantity to affect adversely the strength and durability of the concrete. Fine Aggregate passing sieve No. 4 shall not contain any voided shells. Fine Aggregate from different sources of supply shall not be mixed or stored in one pile nor used alternately in the same class of construction or mix.

Sand for concrete work shall be capable of developing 80% of the tensile strength of local sand. Or lignite when tested according to ASTM methods. It shall not show darker than light amber when tested by the color metric test method. All fine aggregate shall conform to the following requirements:

Sieve Size	% Passing
3/8 inch	100%
No. 4	95-100%
No. 16	45-80%
No. 50	5-30%
No. 100	0-10%
Fineness modulus	2.50-2.15

Fine aggregate for concrete shall be free of stones larger than 2 mm and not include significant amounts of silt and clay. If sand, when dried after wetting, adheres together then it shall be considered unsuitable.

17.6 COARSE AGGREGATE

Gravel for concrete shall be uniformly graded and consist of hard and dense rock. The gravel shall be free of materials finer than 5 mm and the surface shall be clean. Gravel for use in all types of concrete shall be crushed rock. Generally, natural gravel and/or crushed rock particles shall be spherical or cubical in shape. The maximum size of the gravel shall be eighty (40~80) mm in mass concrete, forty (25~40) mm in structural concrete and twenty (20~25) mm in other thin concrete structures like slabs.

All crushed stone or gravel for concrete work shall be well graded and shall pass the following sieve analysis:

Sieve Size	% Passing
2 inches	100%
1-1/2"	90-100%
1 inch	20-55%
3/4 inch	0-15%
3/8 inch	0-5%
No. 4	0%

17.7 WATER FOR CONCRETE

Water for mixing of concrete shall be fresh, clean, and free from injurious amounts of oil, acid, salts, or any other deleterious mineral and/or organic matter. It shall not contain chlorides such as sodium chloride more than 700 ppm. It shall not contain any impurities in amount sufficient to cause a change in the time of setting of Portland cement of more than 10 percent, nor a reduction in compressive strength of mortar of

more than 5 percent compared to results obtained with distilled water. The PH of the water for mixing and curing of concrete shall not be less than PH 4.5 or more than PH 8.5. The water for mixing shall be provide by sole expense of the Contractor and no additional allowance will be made thereof. The Contractor will furnish water for concreting and curing and for rest of project implementation.

17.8 CONCRETE COMPRESSION AND SLUMP TESTS

17.9 CUBICAL TEST

The Compression Strength of Concrete shall be obtained according to cubical tests locally done. Test cubes made in the field shall have a dimension of 15cm, at least 3 separate batches of concrete shall be made for trial and these shall be tested for compliance with the requirements of the table below, at least 3 test cubes being made from each batch of concrete. Once a mix is approved no substantial change in the materials or proportions of materials being used shall be made without the approval of the director of works who may then require further trial mixes to be produced. The compressive strength of the concrete will be taken as the arithmetic mean of the strength of all the cubes tested. The following table will be used to compare test results:

Mark of Concrete	Specimen No.			
	1	2	3	4
	Mean value at 28 days Kg / cm ²	Minimum Individual Value at 28 days Kg / cm ²	Mean value at 28 days Kg / cm ²	Minimum Individual Value at 28 days Kg / cm ²
B - 150	190	130	180	120
B - 200	240	180	230	170
B - 300	340	280	330	270

Table of Compressive Strength results of samples of concrete at 28 days. (Mixed by Weight)

17.10 SLUMP TESTS

Slump tests shall be carried out periodically to ensure the appropriate water cement ratio in accordance with the Standard Method of Test of Slump of Portland Cement Concrete of the ASTM Designation: C-143.

THE FOLLOWING SLUMP VALUES ARE GENERALLY ACCEPTED:

Allowable Slump	Degree of Workability	Suitable for Works
0-25 mm	Very low	Pre-cast and vibrated concrete work in roads & piles
25-50 mm	Low	Road works, mass concrete in foundation, lightly reinforced section

50 - 100 mm	Medium	Slabs, normal reinforced concrete, heavily reinforced section.
100-200 mm	High	For cast in situ pile

Concrete Max Slump(mm)	Concrete Class	Characteristic Cube Strength at 28 days (kg/cm ²)	Maximum Aggregate size(mm)	Maximum Water/ cement ratio (%)	Approx. cement content	Nominal Mix proportions (Kg/m ³)
75	M25	250	20	45	400	1 : 1 : 2
75	M20	200	20	45	400	1 : 1.5 : 3
75	M15	150	40	50	310	1 : 2 : 4
100	M10	100	80	55	220	1 : 3 : 6
100	M5	50	20	60	170	1 : 4 : 8
Type	Description					
M25, M20	Reinforced concrete for superstructure of bridge, flume, pre-cast concrete					
M15	Reinforced concrete for various types of concrete structures and					
M10	Concrete lining. Plain concrete for mass concrete					
M5	Plain concrete for foundation and filling purpose (blinding).					

17.11 FIELD MIXED CONCRETE:

Concrete shall be mixed in a batch mixer for not less than 1-1/2 minutes after all the materials are in the mixer drum. Mixing shall continue until there is a uniform distribution of materials and the mass is homogenous in consistency and colour. The mixer shall rotate at a peripheral speed of about 1 m/sec. Mixer shall be equipped with a locked timing and locked water measuring device. No hand mixing or re-tempered concrete will be allowed by the IOM engineer in charge.

17.12 VIBRATION OF CONCRETE

Only Table vibrator (Surface Vibrator) should be used to vibrate concrete in the moulds for lining. Except where otherwise permitted by the IOM Engineer in charge, concrete shall be fully compacted throughout the full extent of the layer and shall be brought up in level layers of such depth that each layer is readily and properly incorporated with the layer below with the use of internal vibrators or by spading, slicing or ramming. It shall be thoroughly worked against formwork and around any reinforcement or embedded items without displacement. The internal concrete vibrator be arranged by Contractor himself.

The duration of vibration shall be limited to that required to produce satisfactory consolidation, without causing segregation. Vibration shall, on no account, be continued after water or excess grout (if any) appears on the surface.

17.13 TEST OF HARDENED CONCRETE IN THE STRUCTURE

Where the results of specimens indicate that the concrete does not meet specification requirements, core boring tests conforming to the current issue of

ASTM Designation: C-42 shall be performed, as directed by the IOM Engineer in charge, all at the Contractor's expense.

17.14 GENERAL CONCRETE CLASSES

17.15 STANDARD STRENGTH CONCRETE GRADES

➤ C10 Concrete Grade

C10 is also known as Gen 1 concrete and is designed with a 10 Newton/28 day strength. C10 is one of the most versatile concrete mixes and is used on many residential applications. Typical uses for C10 mixtures are in trench fills, agricultural formations, general floor binding, and drainage. C10 is not suitable for any structural mass formations.

➤ C15 Concrete Grade

C15 is also known as Gen 2 concrete and is designed with a 15 Newton/28-day strength. For anyone wishing to develop foundations for smaller walls or concrete steps, Gen 2 concrete is an excellent choice. Though C15 is still not rated for large industrial projects, it provides excellent material for residential flooring.

➤ C20 Concrete Grade

C20 or Gen 3 is rated at 20 Newton/28-day strength. This mixture can be used to form lightweight foundations and applications in residential projects. Typical uses for this grade of concrete are in the formation of internal floor slabs, driveways, garages, and sheds.

➤ C25 Concrete Grade

C25 is by far one of the most versatile concrete mixes on the market. Also referred to as ST2, C25 can be used in many different residential and commercial building projects. These projects can include a variety of different concrete foundations, large mass fills, footings, and reinforced bases.

➤ High-Performance Strength Concrete Grades

▪ C30 Concrete Grade

One of the lower strength commercial grades is C30. Also known as ST3 or PAV1, C30 grade is mostly used during pavement construction. C30 is designed to withstand 30 Newton/28-day strength and is strong enough to use in reinforced bases, any outside paved area, or other lighter external applications.

▪ C35 Concrete Grade

C35 or PAV2 is designed to withstand 35 Newton/28-day strength. Offering more substantial strength than C30 grade, C35 can be used on larger commercial buildings and foundations for added support. C35 also has special additives to reduce the likeliness of air bubbles forming, protecting against surface cracks from freezing temperatures.

▪ **C40 Concrete Grade**

C40 is an extremely strong commercial-grade concrete with 40 Newton/28-day strength. C40 is the ideal choice in the construction of large industrial support beams and foundations. It is also used in a variety of roadwork applications and agricultural yards.

When using concrete in any construction project, it's important to know which grade will best suit your application. By better understanding the concrete grade system, you'll be able to make the right choice for the job at hand and ensure you have a strong finished product that will last.

Family owned and operated since 1969, Knight's Companies is a concrete company in Columbia, SC. Knight's upholds the highest standards in all aspects of the business and will complete commercial concrete jobs other companies won't even quote.

17.16 ADMIXTURES

Only where a beneficial effect is produced shall any admixture be used and that too after test has been carried out to convince the IOM hydraulic engineer that no harmful effect will be produced using such admixture and after approval by the IOM engineer. The admixture shall conform to IS 9103/ 1972.

17.17 STEEL BARS

- a) For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colors.
- b) Steel reinforcement shall ordinarily be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting.
- c) Bars of different classification, sizes and lengths shall be stored separately to facilitate issues in such sizes and lengths to minimize wastage in cutting from standard lengths.
- d) In case of long storage, reinforcement bars shall be stacked above ground level by at least 150 mm.
- e) Structural steel of different classification, sizes and lengths shall be stored separately. It shall be stored above ground level by at least 150 mm upon platforms, skids or any other suitable supports to avoid distortion of sections. In case of long storage, suitable protective coating of primer paint shall be given to prevent scaling and rusting.

All steel bars shall be delivered to the site in either straight lengths or cut and bent forms. No reinforcement shall be accepted in long lengths, which have been transported while doubly bent.

The reinforcing bars shall be stored properly and prior to placing concrete, Reinforcing steel, which is to be embedded, shall be free from rust, dirt, mud, loose scale, paint, oil, or any other foreign substance. If considered necessary by the designer, grit blasting shall be employed to clean bars at no extra cost to the Contract.

Bent or damaged reinforcing bars, which will cause an impediment to the construction work, shall not be used. Steel reinforcement shall be the correct diameter, as shown on the drawings. The bars shall be clean and free from rust. They shall be securely fixed with wire before placing the concrete. The minimum cover to reinforcement shall be 25mm.

Metric bar size	Linear Mass	Nominal diameter	Cross-sectional Area
	Density (kg/m)	(mm)	(mm ²)
6,0	0.222	6	28.3
8,0	0.395	8	50.3
10,0	0.617	10	78.5
12,0	0.888	12	113
14,0	1.21	14	154
16,0	1.58	16	201
20,0	2.47	20	314
25,0	3.85	25	491
28,0	4.83	28	616
32,0	6.31	32	804
40,0	9.86	40	1257
50,0	15.4	50	1963

17.18 CEMENT

Cement is the binding material for the ingredients of concrete. Generally, Ordinary Portland cement is used in most cases and will be tested before use. Attributes to be tested are as follows:

- Fineness
- Setting time
- Strength test by using mortar cube specimens.

However, the quality of cement can mainly be assured by performing the following field tests:

17.19 FEEL TEST

Plunge the hand into a bag of cement and rub the cement between the thumb and forefinger. If it feels cool but not warm and does not have a lumpy or gritty feel the cement is good.

1) Floating Test

Throw a handful of cement into water. If it does not float but sinks, the cement is good.

2) Other Test

Procedure:

- a) Make a thick paste of cement with water on a piece of thick glass. Immerse it under water for 24 hours. If it does not crack, the cement is good.

- b) Make a 1" x 1" x 8" block of cement with water. Immerse it under water for three days. Place it on supports 6 inches apart. Place a weight of 30 lbs. uniformly over it. If it shows no sign of failure, the cement is good.

17.20 BRICK MASONRY IN CEMENT MORTAR

The sand used shall be medium coarse, clean, sharp, free from clay, mica, and other organic matter. The cement used shall satisfy the requirement of common Standard; the Mortar is designated in the specified proportion of cement and sand. The materials are weighed or measured and mixed on a watertight platform after allowing the bulk age of Sand. Bricks before laying shall be thoroughly soaked in water, and the brickwork shall be kept wet for at least 10 days.

17.21 BURNT BRICK AND FILE TEST

The quality requirements of locally burned bricks can be checked as follows:

17.22 MARKING TEST

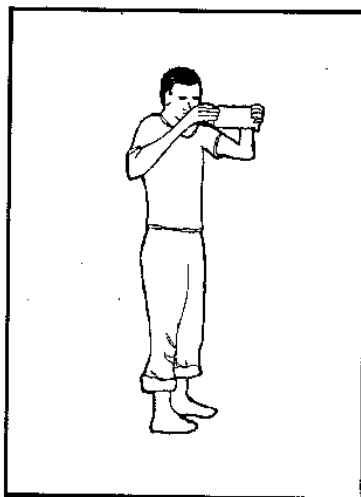
Try to make a mark on the surface of the brick by nail. If it is possible to mark, it is not a good brick; if not, it is very hard and compact.

17.23 SOUND TEST

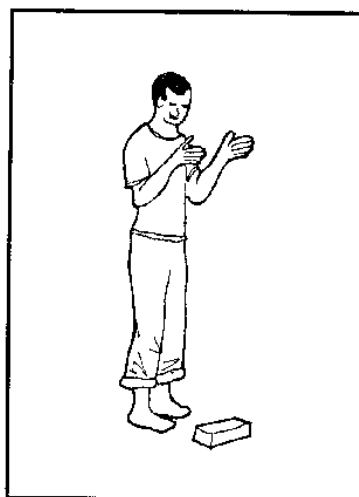
Strike a brick with another brick. If the brick gives clear metallic sound, the brick is good one, if not a bad one.

17.24 DROPPING TEST

A good quality brick should not break or crack after dropped from shoulder level of height. Always test with the hammer after the brick has been dropped, to ensure that there are no cracks inside.



Drop a brick from shoulder height.



A strong brick will not break or crack.

17.25 CLAY

The clay must be of industrial quality and delivered in small aggregates, if possible. If not available, the clay used to create the plug of the borehole should come in chunks of small size (less than 5 cm) to avoid them being stuck in a higher position than supposed to. The aggregates mix, cement, and water content ratio shall be selected

to obtain the best results for compressive strength, density, water tightness, durability, workability, and finish quality. The concrete mix must be such that the design is compatible with the minimum water content ratio to give each grade adequate concrete workability.

After placement, the concrete shall be vibrated by mechanical means. The vibration method is to be approved by the WASH Site Engineer/works personnel before the operation. The vibrated and consolidated concrete is finished by towelling or floating the surface to a smooth and flat finish.

Following placement, vibration, and finishing work to the concrete and after the initial set has occurred not to damage the surface of the concrete, appropriate measures, approved by the site Engineer/Works personnel are to be implemented to cure the concrete for a minimum period of 14 days.

Where concrete previously placed as part of the works is to be butted, jointed, or raised with the addition of further concrete, except in the case where the initial concrete is blinding concrete, the first concrete surface must be suitably prepared by the scrabbling, i.e., removing the laitance (fine concrete surfacing) before placement of the other concrete. The method is to be approved by the Site Engineer/Works personnel. After scrabbling, the concrete shall be a thoroughly wetted and thin layer of 1:2 cement: sand mortar applied before pouring the new concrete.

Steel reinforcement shall be positioned with a clearance of 40mm to the face of the concrete unless otherwise directed by the IOM Hydraulic Engineer/Works personnel or shown in the Contract drawings.

Formwork for the concrete shall be to the approval of the IOM field Engineer and shall not allow grout loss from the concrete mix.

Prior to the concrete placement, the formwork is to be inspected and all harmful materials removed to the approval of the IOM Hydraulic Engineer/Works personnel.

The Contractor must undertake no mixing or placement of concrete without prior permission by the IOM Hydraulic Engineer.

17.26 FRAMEWORK

The exact dimensions and positions shall be as per the issued execution drawing. All formworks shall be designed and built to maintain rigidity throughout the concrete placement, ramming, vibration, and setting to the required shape, position, level, and specified class of finish. All joints shall be sufficiently tight to prevent leakage of concrete.

Before concreting commences, the formwork shall be thoroughly cleaned and freed from all sawdust, tie wire, shavings, earth, dirt, and other debris. Release agents should be applied and compatible with the class of finish; care must be taken not to contaminate the reinforcement.

Striking of formwork shall be done without damage to the concrete, including removal without shock to prevent impact load on the partially hardened concrete. For columns, walls, and other parts not supporting, the weight of the concrete may be removed as soon as the concrete has hardened sufficiently to resist possible damage due to removal operations. For suspended slabs or supporting formworks, at least 14 days of hardening are required before striking forms.

S/N	Concrete structures	Shuttering remaining duration
1	Sides of beams, walls of rectangular channel, columns and piles	3 days
2	Soffits of secondary slabs (props left in) Soffits of main slabs (props left in)	4 days
3	Soffits of beams (props left in)	8 days
4	Removal of props - secondary slabs	10 days
5	Removal of props - beams and main slabs	21 days
6	Arch centres, wedges eased	8 days
7	Arch centres, struck	21 days

17.27 STONE MASONRY

The stone must be granite, and the Stone shall be of uniform size and shape and the specified dimensions. The Contractor may substitute alternative-sized Stone with the prior approval of the IOM Hydraulic Engineer and at no additional expense.

Walls shall be straight, perpendicular, and dimensionally correct, constructed as shown on the drawings (if they are included). The lines of mortar shall be horizontal with no excess mortar staining the faces of the walls. The faces of walls shall be regular and even, with no irregular stones.

17.28 MORTAR

Mortar for stone and brick masonry shall be mixed in the proportion 1 cement: 4 Medium Sand by volume. Sufficient water shall be added to achieve the desired workability. The surfaces of the stones must be smooth and have a medium size; the mortar shall be placed on all horizontal and vertical faces between the Stone, with no gaps. Each Stone shall be placed to the correct line and level and shall be level in all directions. Any gaps shall be filled with additional mortar rammed in with a small wooden rammer. The outside faces of stone walls shall be pointed. No excess mortar shall be allowed to stain the faces of the Stone.

17.29 PLASTER AND POINTING

Plaster and pointing for internal walls and external rendering shall be mixed in the volumetric proportions of 1 cement: 4 sands for plaster and 1 cement: 3 sand for pointing. Sufficient water shall be added to achieve the desired workability.

The walls shall be wetted before applying the plaster and pointing. The plaster shall be 10mm to 20mm thick and pointing according to the stone construction state and shall have a uniform flat finish free of irregularities and blemishes. The finish shall be clean and precise at corners and between walls and ceilings in a straight line. Untidy or poorly finished plaster shall be rejected. When the plaster is still damp, the wall shall be floated to a smooth finish with a wet steel float.

17.30 PLUMBING WORK (PIPES EXTENSION)

The contractor shall ensure that all pipes and fitting comply with the requirements of IOM design and drawing and except those of a minor nature shall be carried out by a designated person, the service shall not run through individual premises, besides this, plumbing installation shall be arranged to avoid water contamination, water quality deterioration, water leakage and to ensure proper environmental consideration during installation of pipe network materials. The plumbing equipment is required to be certified by the IOM engineer in charge.

17.31 EXCAVATIONS

Excavations shall be clean and free of water. The IOM Engineer in charge shall inspect all excavations before work proceeds. The Contractor shall give the IOM Engineer in charge 5 days' notice of the inspection date. Excavations are dangerous and liable to collapse, particularly in wet weather or waterlogged ground. The Contractor shall take all necessary precautions to ensure that all excavations are adequately protected to prevent accidental or unauthorized entry. Excavations depth must be according to drawing and design; depth shall not be entered unless they are shored up with wooden or another temporary bracing. The Contractor shall be responsible for safety, and be liable for any accidents, which may occur.

17.32 PAINTING

For the outer side shall be used, weather sheet paint 75% and for inner side shall be used plastic colour 75% two times, and for stone, masonry shall be used oil paint two times IOM as per site engineer coordination.

17.33 DRAINAGE SYSTEM

Used and surface rain runoff water: All water from the Facility must be collected and channelled through the drainage channel into soak away pits. The water drained from the high risk shall be channelled to the high-risk soak away pit, while the water drained from the low risk shall be channelled to the low risk soak away pit. All water from the Facility, including water from hand washing basins and surface rainwater, must be collected, and channelled through manholes into a soakaway pit as per site need.

18 SITE CLEANING

The contractor is responsible for keeping the work site in good order to ensure the safety of staff, the quality of the construction work and the protection of construction material.

After completing each step in the construction process, the contractor must remove all remaining sand, gravels, and cuttings from the site.

He/she must also remove all rubbish and waste from the construction activities on the site to ensure that these do not affect the works, the workers, the local environment or people in the vicinity of the construction site. The waste should be reused, recycled or dealt with according to best available practices.

19 LEGAL, SAFETY AND LABOUR ASPECTS

The contractor is entirely responsible for the safety and security of all employees who are deployed to carry out any of the aspects described in these terms of reference document and as detailed in the terms of the contract agreed between the client and the contractor. The list of client responsibilities presented below is not intended to be entirely exhaustive but only for guidance. Any matters that obstruct the potential of the contractor to carry out all duties detailed in this document must be discussed with the client prior to or during the contract.

The contractor shall ensure all of the following:

- i) All relevant permissions for access are sought and gained by the contractor prior to conducting any of the studies detailed in this document in the field,
- ii) All permissions that might be necessary from owners, occupiers or operators must be obtained by the contractor,
- iii) No unqualified persons should be involved in conducting this study,
- iv) The client is not responsible for any aspect of the work of sub-contracted parties engaged by the contractor,
- v) All employees who work on site in the field shall be fully informed of all risks and safety aspects of the work, but their safety and security will remain entirely the responsibility of the contractor, for whom they work,
- vi) The contractor must inform the client of any factor – legal, safety, security or other – that represents a serious impediment to fulfilling the activities detailed in this document or within the contract.
- vii) The contractor is responsible for the security of the construction site and any material, tools or machinery stored on site.

20 REFERENCES

- (2018). Solar Pumping: The Basics. Washington, DC.: World Bank.
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- Technical Review: Practical guidelines for Test Pumping in Water Wells, The International Committee of the Red Cross
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