

TECHNICAL SPECIFICATIONS AND BOREHOLE CONSTRUCTION DESIGN

1. DRILLING SITE

The Contractor shall drill the borehole(s) at the exact location(s) designated by the Client or Supervising Consultant. Access to the site shall be the responsibility of the Client. The Contractor shall make access of drilling plant, gear, camp and accessories to the borehole site and shall as little as necessary interfere with existing fences and cultivated land.

2. ENVIRONMENTAL PROTECTION OF THE SITE

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

3. WORKMANSHIP

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

4. EQUIPMENT PROVIDED BY THE CONTRACTOR

All machinery, equipment and materials to carry out the drilling, construction, etc. as specified in BoQ, are to be mobilized to the site. At the start of the contract the Consultant will verify the specifications and state of repair of all major items of plant. He shall have the right to order the removal and/or replacement of any plant, which in his opinion is insufficient or unsatisfactory.

5. BOREHOLE DEPTH AND DIAMETER

The Contractor shall drill to the total depth and at such diameter as specified in the BoQ or by the Consultant. No borehole will be acceptable if drilled to such depth and diameter other than instructed by the Consultant or his appointed engineer.

6. DRILLING METHOD

The Contractor may use any rotary drilling technique that he feels applicable to achieve the depth and diameter required.

7. SAMPLING

Representative, continuous samples (min. 250 grams) of the strata penetrated shall be collected for each 2 m interval and by whatever method is standard for the drilling technique in use and approved by the Consultant. Samples are not to be washed! The samples shall be put into suitable polythene sample bags, labeled with the borehole number and the depth interval, and stored at a place where

they will not be contaminated or deteriorated by site conditions or drilling operations. Geological logging will be the responsibility of the Consultant.

8. TEMPORARY CASING

Installation and diameter of any temporary casing required for the construction of the boreholes will be left to the Contractor so long as the finished product meets the borehole specifications. Cost for supply, installation and removal of temporary casing shall be entirely for the Contractor. The Contractor cannot claim any casing left in the borehole, which is not retrievable.

9. WATER SUPPLY FOR DRILLING

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

10. BOREHOLE DESIGN

The Consultant in consultation with the Contractor shall make design of the borehole after drilling is completed. The standard borehole design is given Figure 1.

11. VERTICALITY

The Contractor will make a verticality test during and after drilling by approved methods to demonstrate that the departure from the vertical does not exceed 3 to 100 between ground level and the base of the borehole. If this departure is exceeded, the Contractor shall make the necessary corrections to the approval of the Consultant, without additional payment.

12. SANITARY SEAL

To provide an effective seal to the entry of contaminants, the upper 3 meters of the borehole will be grouted using cement slurry or bentonite granules 1.85-2.15 kg/liter. Grout is to be injected into the annulus between the casing and the wall of the hole, by a method to be approved by the Consultant.

13. YIELD ESTIMATES DURING DRILLING

When the air-rotary drilling method is used, a 90-degree V-notch flow measurement device shall be set up in an approved manner and level, in the drain line so that continuous monitoring of airlift yields can be obtained. Average yields shall be read and rated every 3 meters of penetration and as otherwise directed by the Consultant and recorded in the driller's log.

14. DEVELOPMENT AND CLEANING OF BOREHOLES

Upon completion of the drilling and installation of casing, the Contractor shall carry out development and cleaning of the boreholes. This will remove the native silts, clays and drilling fluid residues deposited on the borehole wall and adjacent portions of the aquifer during the drilling process. Development shall continue until water is completely free from fine particles, as to be decided by the Consultant. Upon completion of development, any accumulation of material shall be removed from the bottom of the borehole by airlifting.

15. PUMPING TEST

The Contractor shall perform test pumping to establish well performance and yield of the borehole. Test pumping unit shall be provided for the testing of the drilled boreholes. Standard test pumping will be for periods of 6 hours, which might be extended at the discretion of the Consultant if the water level has not stabilized after the 6 hours.

Before testing, the boreholes will be subject to a short-term testing (calibration) to establish the approximate yield/drawdown characteristics and to decide upon pumping rates for continuous yield tests. Sufficient time shall be allowed for the recovery of water levels in boreholes between each type of test. This shall be at the discretion of the Consultant.

Discharge measurements shall be made by volumetric method or otherwise approved calibrated measuring device. During the test pumping, the discharge water must be handled and disposed of in an appropriate manner to a point of overland drainage sufficiently far from the well to prevent recharge. The water shall be diverted over a distance of at least 100m from the wellhead. This condition may not be required when the pumped aquifer is confined.

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

When continuous pumping at a uniform rate is specified, failure of the pump operation for a period greater than one percent of the elapsed pumping time shall also require abortion of the test.

Any test, which is aborted due to the reasons above, shall be repeated after recovery of the water level. No payment shall be made for aborted tests or for standing time during water level recovery after aborted tests.

16. STEP DRAWDOWN TEST

The step drawdown test shall comprise pumping the well at least three separate discharge rates specified by the Consultant. The change from one pumping rate to the next shall be done without stopping the pump by means of a gate valve in the discharge pipe, or by any other means to be approved by the Consultant. The change from one step to the next shall take place in the shortest time possible.

17. CONSTANT DISCHARGE TEST

At the discretion of the Consultant, a constant discharge test for a maximum duration of 6 hours pumping and 3 hours' recovery may be implemented. The discharge rate at which the well is to be pumped shall be specified prior to the test. During the test water level and discharge measurements shall be made at the same time intervals as for the step drawdown test.

Pumping test data shall be supplied to the Supervising Consultant from all pumping tests conducted on each borehole and observation wells. These will show dates, water levels, discharge rates, electrical conductivity values, times of starting and stopping the pump, change in discharge, weather, and other conditions that could affect the test data.

18. WATER LEVEL OBSERVATIONS

The Contractor shall supply appropriate electric contact water level gauges for measuring water levels in the boreholes to the nearest 10 mm at pre-determined intervals. Wellhead arrangements shall permit these gauges to be inserted and passed freely. Hereto the Contractor shall be required to install a dipping tube, minimum 3/4" inner diameter, lowered to approximately 1m above the pump intake or approximately 2m below anticipated maximum drawdown level.

Other methods for measuring water levels are subject to approval by the Consultant.

19. WATER SAMPLING

Water samples for testing the chemical and bacteriological water quality will be taken at the end of the test pumping. The Contractor shall keep on site a minimum of 2 suitable one-liter capacity water containers per borehole and shall collect and store water samples as directed by the Supervising Consultant. The analysis should be conducted in a laboratory approved by the Supervising Consultant. The recommended list of water quality determinants is provided in Annex C.

20. CAPPING THE BOREHOLE

The Contractor shall cap the borehole at the end of a shift or after drilling is completed. During borehole construction, installation, and development, the Contractor shall use all reasonable measures to prevent entrance of foreign matter into the borehole. The Contractor shall be responsible for any objectionable materials that may fall into the borehole and any effect it may have on water quality or quantity until completion of the works and acceptance by the Consultant.

21. PLATFORM CONSTRUCTION

The Contractor shall construct concrete pad (extended apron facility including foundation bolts grid and borehole ID), drainage, trough and soak-away pit facility for each successful borehole.

22. CONCRETE MIX

The concrete used for the concrete pad, apron, and trough and soak-away facility construction shall be prepared using normal Portland cement with a mixture of coarse and fine aggregates. The concrete shall have a ratio of 1:2:4 and shall meet the following specifications:

Fine aggregate:	0.15mm to 9.5mm
Coarse aggregate:	2.4mm to 40.0mm
Minimum cement content:	320kg/m ³
Compressive strength at 28 days:	25Mpa

Water used for mixing concrete and for curing shall be clean, and free from injurious amounts of oil, acid, alkali, organic matter or other deleterious substance. It shall be equal to potable water in physical and chemical properties. The strength of the concrete will be periodically tested in the presence of the Client or Supervising Consultant to conform to the compressive strength of the concrete.

23. INSTALLATION OF BOREHOLE IDENTIFICATION NUMBERS

The Contractor shall prepare a brass plate (measuring 40 mm x 90 mm) with inscription of the borehole ID number and CRS logo and install it on the facility. The Consultant shall ensure that the ID numbering is consistent with the existing approved grid numbering system of the CWSA and the Water Resources Commission.

24. HAND-PUMPS INSTALLATION AND CARETAKER TRAINING

The Contractor shall supply and install the required number of AFRIDEV (Skat Revision 3 Edition-AISI 316) or INDIA II hand-pumps on the successful boreholes. The training of four (4) community caretakers (WATSAN Committee members-2 females and 2 males) is to be conducted for each of the communities. The Contractor shall also assist the communities to design pump maintenance plans.

25. DISINFECTION OF BOREHOLES

To affirm that there is no contamination of the borehole during the pump installation, the contractor should disinfect all pump parts and the borehole prior to placement in the borehole. During the disinfection process, the concentration of available chlorine in the well and filter pack should be at least 50 mg/l and that it remains for 2 hours. Borehole surfaces that are above the static water level must be completely flushed with the solution chlorine solution.

26. RECORDS

The Contractor shall keep daily activity records for each borehole. The records shall contain the information as specified below. In addition, separate records should be supplied for each borehole upon completion.

i) Daily Record

- Site name
- Reference number of borehole and GPS-coordinates
- Dates of reporting
- Names of foreman and drillers
- Method of drilling
- Diameter of hole, and depth of changes in diameter
- Depth of hole at start and end of shift or working day
- Depth and size of casing at start and end of shift
- Description of rocks drilled with depths of transitions encountered
- Depth at which water is struck
- Yield of air lifted water, when drilling or developing with air
- Time log showing rate of penetration in minutes per meter, type of bit, standby time due to breakdown
- Depth intervals at which each formation samples are taken

- Records of components and quantities used or added to the drilling fluid or air
- Water level at the start of each working day
- Problems encountered during drilling
- Details on installation in the borehole (if any)
- Depth and description of well casing

A copy of the daily drilling record shall be made available daily, including any other pertinent data as may be requested by the Consultant.

ii) Borehole Completion Record (as per standard Borehole Completion Checklist-See Annex (C)).

- Detailed driller's log.
- Borehole design and installation details (as-built drawing)

A copy of the Borehole Completion Record shall be made available to and approved by the Consultant on completion of each borehole, before being forwarded to the Client.

27. **ACCEPTANCE OF BOREHOLES**

The Consultant shall accept the boreholes only upon satisfactory completion of all drilling operations, installation of casing, and development works and pumps installation.

28. **LOSS OF EQUIPMENT**

Any equipment lost down a borehole must be removed, or the borehole will be considered a lost bore. A replacement borehole will have to be constructed at the Contractor's expense.

29. **LOST BORE**

Should any incident to the plant, behavior of the ground, jamming of the tools, or casing, or any other cause prevent the satisfactory completion of the works, a borehole shall be deemed to be lost and no payment shall be made for that bore or for any materials not recovered therefrom, nor for any time spent during drilling or while attempting to overcome problems. Also, the borehole should be permanently closed.

In the event of a lost bore, the Contractor shall construct a borehole immediately adjacent to the lost bore or at a site indicated by the Consultant. The option of declaring any bore lost shall rest with the Contractor, subject to the approval of the Consultant.

The abandoned hole shall be treated as follows:

- a) The borehole shall be sealed by concrete, cement grout, or neat cement and shall be placed from the bottom upward by methods that will avoid segregation or dilution of materials.

- b) The upper 2 meters of borehole shall be backfilled with native topsoil. Sealing of the abandoned boreholes shall be done in such a manner as to avoid accidents and to prevent it from acting as a vertical conduit for transmitting contaminated surface or subsurface waters into the water bearing formations.

30. WELL HEAD COVER

The Contractor shall on completion of each borehole cap the top of the borehole to fit neatly over the uPVC casing, which shall be 500mm above ground level.

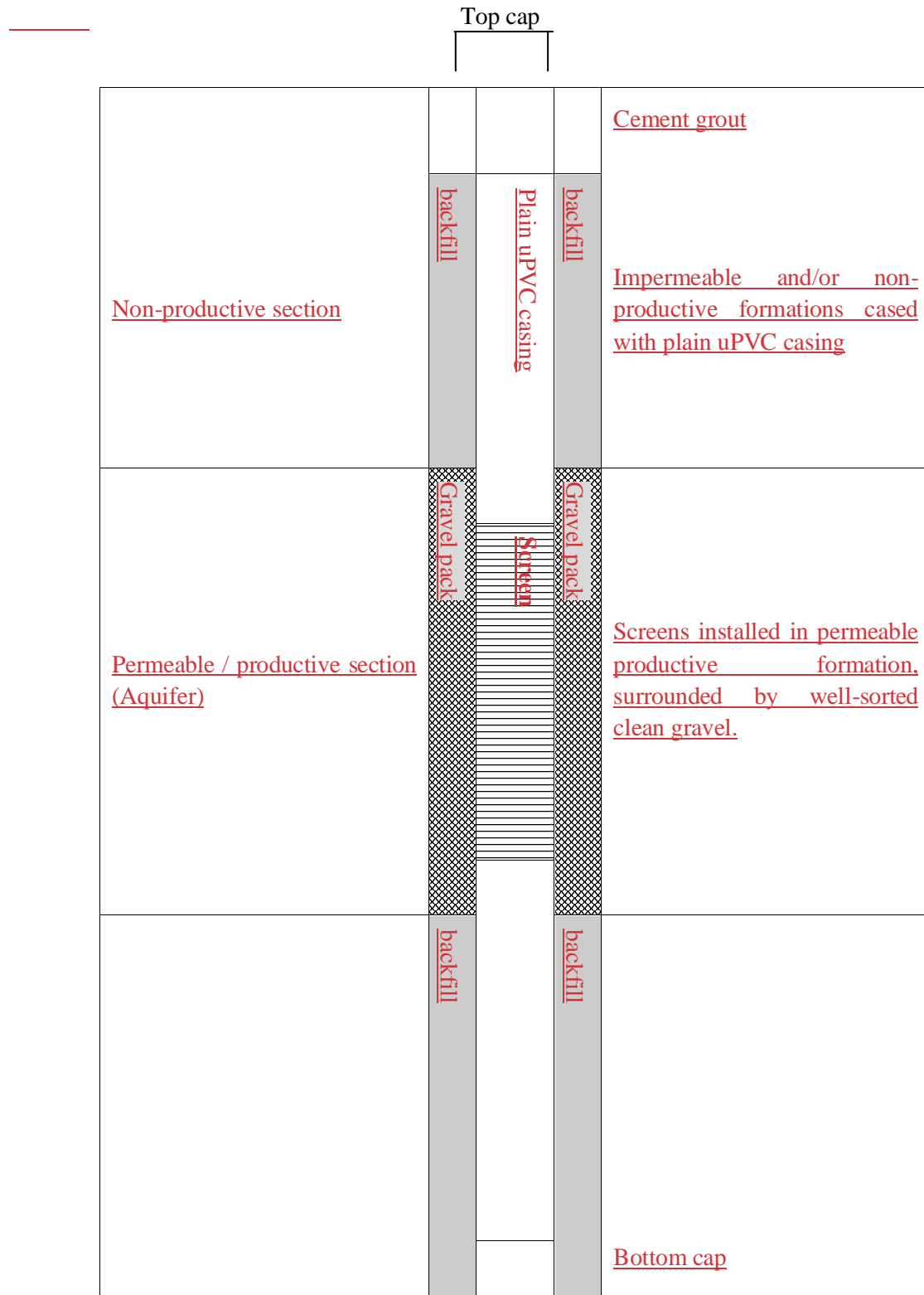
Prior to, during and after the construction of head works, the Contractor must ensure that no debris whatsoever falls into the borehole.

31. CLEARING THE SITE

On completion of each borehole the site must be left clean and free from all debris, hydrocarbons and waste, and all pits filled to the satisfaction of the Consultant. A site not delivered clean may render the borehole unacceptable.

BOREHOLE CONSTRUCTION DESIGN

Figure: Standard Design for Installation of Boreholes in Non-Collapsible Formation



LIST OF WATER QUALITY PARAMETERS AND WHO/GSA LIMITS

<u>PARAMETERS</u>	<u>UNITS</u>	<u>WHO / GSA LIMITS</u>
<u>Conductivity</u>	<u>µS/cm</u>	<u>-</u>
<u>PH</u>	<u>pH Units.</u>	<u>6.5 - 8.5</u>
<u>Tot. Dis. Solids (TDS)</u>	<u>mg/l</u>	<u>1000</u>
<u>Tot. Susp. Solids (SS)</u>	<u>mg/l</u>	<u>-</u>
<u>Turbidity</u>	<u>NTU</u>	<u>5</u>
<u>Total Hardness</u>	<u>mg/l</u>	<u>500</u>
<u>Calcium (Ca) Hardness (CaCO₃)</u>	<u>mg/l</u>	<u>=</u>
<u>Magnesium (Mg) Hardness</u>	<u>mg/l</u>	<u>=</u>
<u>Total Alkalinity</u>	<u>mg/l</u>	<u>=</u>
<u>Ammonia (NH₄-N)</u>	<u>mg/l</u>	<u>0.00 - 1.5</u>
<u>Calcium (Ca²⁺)</u>	<u>mg/l</u>	<u>200</u>
<u>Magnesium (Mg²⁺)</u>	<u>mg/l</u>	<u>150</u>
<u>Sodium (Na⁺)</u>	<u>mg/l</u>	<u>200</u>
<u>Potassium (K⁺)</u>	<u>mg/l</u>	<u>30</u>
<u>Bicarbonate (HCO₃⁻)</u>	<u>mg/l</u>	<u>=</u>
<u>Sulphate (SO₄)</u>	<u>mg/l</u>	<u>0-250</u>
<u>Chloride (Cl⁻)</u>	<u>mg/l</u>	<u>250</u>
<u>Nitrate (NO₃-N)</u>	<u>mg/l</u>	<u>10</u>
<u>Nitrite (NO₂-N)</u>	<u>mg/l</u>	<u>1</u>
<u>Phosphate (PO₄⁻)</u>	<u>mg/l</u>	<u>=</u>
<u>Fluoride</u>	<u>mg/l</u>	<u>1.5</u>
<u>Arsenic</u>	<u>mg/l</u>	<u>0.01</u>
<u>Total Iron</u>	<u>mg/l</u>	<u>0.3</u>
<u>Silica Oxide (SiO₂)</u>	<u>mg/l</u>	<u>=</u>
<u>Manganese (Mn)</u>	<u>mg/l</u>	<u>0.4</u>

PROPOSED EQUIPMENT FOR THE PROJECT

<u>-</u>	<u>DESCRIPTION</u>	<u>CONDITION</u>	<u>QUANTITY</u>	<u>OWNED/LEASED</u>
<u>1</u>	<u>DRILLING RIG</u>			
<u>2</u>	<u>AIR COMPRESSOR</u>			
<u>3</u>	<u>DRILLING RODS (120m)</u>			
<u>4</u>	<u>DOWN-THE-HOLE HAMMER</u>			
<u>5</u>	<u>DRILLING BITS</u>			
<u>-</u>	<u>PUMPING TEST UNIT (SET)</u>		-	-
<u>6</u>	<u>Electric generator</u>			
<u>7</u>	<u>Submersible pump</u>			
<u>8</u>	<u>Water level indicator</u>			
<u>9</u>	<u>Hoses (at least 50m)</u>			
<u>-</u>	<u>VEHICLES</u>		-	
<u>10</u>	<u>Utility Truck</u>			
<u>11</u>	<u>Water tanker (optional)</u>			
<u>12</u>	<u>Pick-up</u>			