4.4 Lining Installation

Lining material shall be assembled and located in the well at the required depth in a continuous operation. The lining material shall be set concentric within the borehole by centralizing bars unless otherwise agreed with the Engineer.

If the lining jams or is lost before it is set to the specified depth, the Contractor shall endeavor to remove the lining material from the well or, if unable to effect removal, shall redrill the well and replace the lining material at his own expense.

4.5 Lining Material Accessories

The Contractor shall provide as necessary the following accessories to set the lining material to the required depth:

Centralizers to be affixed to the lining material at intervals of 10 m to locate the lining material in the center of the drill hole;

- Supporting clamps, equipment and tools;
- Reducing ones and connecting pieces;
- Casing hangers
- All other necessary equipment.

Except where expressly provided, all accessories shall be deemed to be included in the Bid Form for the provision and insertion of lining material.

4.6 Testing for Plumbness and Alignment

All boreholes shall be constructed, plumb and true to line as defined herein. To demonstrate the compliance of his work with this requirement, the Contractor shall furnish all labor, tools and equipment and shall provide the detailed drawings and the description of the tests to the satisfaction of the Engineer.

Test for plumbness and alignment must be made after the complete construction of the well and before its acceptance. Additional tests, however, may be made by the Contractor during the performance of the work. No specific payments shall be made for making these tests.

Should the results of the tests for plumbness and alignment show that the plumb bob or dummy fails to move freely throughout the length of the lining or borehole to a depth of the lowest anticipated pump setting and should the well vary from the vertical in excess of two-thirds of the smallest inside diameter of that part of the well being tested or beyond the limitations of this test, the plumbness and alignment of the well shall be corrected by the Contractor at his own expense. Should the Contractor fail to correct such faulty alignment or plumbness, the Engineer may refuse to accept the well and the Contractor shall drill a new well without charge to the Owner.

5 WELL SCREENS

5.1 Scope

The Contractor shall provide and install the well screens specified in the Contract Drawings, unless otherwise specified in the Special Provisions.

5.2 Type of Screens

The type of screens shall be as specified in the tentative well design and the Special Provisions.

Slotted screens, if specified for installation, shall be so fabricated as to ensure the maximum yield of the well and to prevent clogging and incrustation and shall be free from jagged edges and irregularities that may accelerate clogging or corrosion.

5.3 Responsibility for Malfunction

The Contractor shall assume full responsibility for any malfunction of the screen caused by the inadequate installation procedure and shall undertake any correction as approved by the Engineer at no extra cost for the Owner.

The screen must have no change of alignment at any of its joints after installation. If requested by the Engineer, the Contractor shall submit for approval by the Engineer the design and method of construction and installation of the screen.

In the event that the Contractor cannot correct a screen failure. the Contractor shall replace the screen with material complying with the specifications of this Contract at no extra cost for the Owner.

5.4 Screen Strength

The screens shall have adequate strength to resist the external forces that may be applied during and after installation.

5.5 Screen Accessories

All fittings, packers, couplings, joints, plugs and seals used during installation of well screen together with the installation procedure, shall be to the approval of the Engineer.

6 FORMATION STABILIZER/GRAVEL PACK

6.1 Scope

The Contractor shall provide and install formation stabilizer, or gravel pack if specified in the Contract Drawings and the Special Provisions.

6.2 Material

The formation stabilizer/gravel pack material shall consist of well rounded, water-worn siliceous grains. Angular chippings or road stone must under no circumstances be used as formation stabilizer/gravel pack material.

The Contractor shall. during the mobilization period, submit to the Engineer for his approval, samples of the formation stabilizer he proposes to use, stating the source of the formation stabilizer, quantities available, rate of delivery and any other information requested by the Engineer.

6.3 Method of Installation

The method of placing the formation stabilizer/gravel pack in the annulus shall be such that separation of the gravel and bridging is avoided.

The formation stabilizer/gravel pack shall immediately upon completion of lining installation, be placed in the annulus between the borehole and the lining, in the screened section(s) of the lining, as specified in the Final Well Design.

If the borehole was drilled by the rotary method, installation of formation stabilizer/gravel pack shall be done by circulation of the drilling mud.

7 WELL DEVELOPMENT

7.1 Scope

The Contractor shall furnish compressors, surge plungers, jetting tools, electric generators, chemicals and any other equipment required for satisfactory well development and shall undertake the development as directed by the Engineer.

Development shall, if the percussion drilling method is applied, comprise surging with plunger and development by airlifting unless otherwise specified in the Special Provisions.

Development shall, if the rotary method is applied, comprise deflocculation, removal of the mud cake formed during the drilling at the wall of the borehole, removal of fine formation materials and rearrangement of the gravel packed high velocity jetting in continuous slot screens, surging with plunger in slotted screens and development by airlifting by compressor and over pumping, unless otherwise specified in the Special Provisions.

7.2 Expected Yield

The Contractor shall develop the well to its maximum expected yield, as specified in the special provisions, by the methods specified in section 7.

7.3 Surging with Plunger

Upon completion of installation of lining or formation stabilizer/gravel pack, the Contractor shall develop the well by mechanical surging with a valve-type surge plunger approved by the Engineer

Before start of surging and with 1 hour interval during the surging operation, the depth to the well bottom and to top of gravel pack shall be recorded.

Surging shall be continued until accumulation of sediments in the sump pipe, during a 1 hour period surging operation, is negligible.

7.4 Deflocculation (applicable for rotary method only)

Upon completion of installation of lining or formation stabilizer/gravel pack, the drilling mud shall immediately be displaced from the well by pumping clean water into the sump pipe.

Mud displacement shall immediately be followed by injection and/or jetting through the screened sections with a polyphosphate solution to deflocculate the mud cake on the borehole wall. The concentration of the polyphosphate solution shall be 3.0 percent by weight of the quantity of the water in the borehole. The well shall then be left for 12-24 hours before developing is continued, to allow the polyphosphate to react.

7.5 High Velocity Jetting

After the deflocculation material has been allowed to work for 12-24 hours all sections screened with continuous slot screens shall be developed by high velocity jetting.

The jetting tool shall be equipped with two or four nozzles. The nozzles design shall be such that it produces a concentrated jetting action. The tool shall be presented to the Engineer for approval before start of drilling operation.

The jetting tool shall be supplied with water through a high-pressure pump capable of producing a nozzle velocity of 50-70 m per second. The pump shall be equipped with a suitable pressure gauge on the discharge side to facilitate monitoring of nozzle velocity.

The development shall be carried out by slowly rotating the jetting tool and gradually lowering it in order to cover the entire surface of the screen.

At the same time as the high velocity jetting is performed, the well shall be discharged with a discharge rate slightly higher than the discharge rate from the jetting tool.

Each Section of the screen shall be jetted until the return water is free from drilling mud, but no section shall be jetted less than 20 minutes per meter of screen.

7.6 Development by Airlifting

Upon completion of high-velocity jetting, and/or surging with plunger, the well shall be discharge by the airlifting method.

The compressor used for pumping by airlifting shall be capable of developing a minimum pressure of not less than 100 psi. The delivery shall be no less than 7 cum air per minute.

The quantity of water discharge from the well and the drawdown in the well at the commencement of the development shall be limited and shall be gradually increased only as the water clears. From time to time the air flow shall be stopped to facilitate loosening of trapped sand grains. The well may also be backwashed by pumping clean water into the well.

During the airlifting operation, position of air pipe and conductor pipe, drawdown in well, approximate yield and time for each change in position shall be recorded by the Contractor.

The development shall be completed with a conduct or pipe not more than 0.5 m above the bottom of the well to ensure that all sand has been cleaned out of the sump pipe.

7.7 Well Cleaning

Upon completion of the development operations, the Contractor shall demonstrate to the satisfaction of the Engineer that the bottom of the well is clear of all sand, mud and other foreign materials.

7.8 Freedom from Sand

The Contractor shall develop the well by the methods specified until the water pumped from the well is substantially free from sand and until the turbidity is less than 5 on the Silica Scale described in Standard Methods of Water Analysis (latest edition as published by AWWA, APHA and WPCT).

The water pumped from the well shall not contain an amount of fine material in excess of 1.0 mg per liter when the well is pumped at its maximum expected yield. The equipment for measurement of the sand content shall be furnished by the Contractor.

7.9 Acceptance of Development

The development by the specified methods shall be repeated and continued until the well is thoroughly developed in accordance with the criteria specified in section 7.8.

If the well yield after the well has been confirmed sand-free is still below the yield, which is considered acceptable for the penetrated aquifer, then the Engineer may instruct the Contractor to perform further development.

8 WELL TESTING

8.1 Scope

The Contractor shall, unless otherwise specified in the Special Provisions, provide and operate a Pumping Unit for the following purposes:

- Step-drawdown pumping tests on the completed well
- Constant discharge pumping test on the completed well.

8.2 Equipment Capacity

The Contractor shall provide and operate pumping machinery capable of carrying out the specified pumping and shall provide adequate controls to allow discharge rates to be kept constant at varying pumping water levels and to permit pumping with a variation of not more than 5% of the designated discharge rate during any period of yield or aquifer testing.

The Pumping Unit set shall be able to deliver a discharge rate, which is min. 50% higher than the expected yield of the well and a minimum discharge, which is maximum 15% of the expected yield of the well when suitably throttled by use of a gate valve.

8.3 Suitable pumping machinery will be deemed to be:

Submersible electric pump unit together with generator and such accessories needed to run the pump.

Line-shaft pump and internal combustion prime mover together with all accessories needed to run the pump.

8.4 Equipment Operation

The Contractor shall supply and operate all equipment and accessories necessary for installation and removal of pumps.

The Contractor shall maintain on site sufficient fuels, lubricants, spares and other accessories needed to run the Pumping Unit for whatever period may be specified by the Engineer.

The Contractor shall provide sufficient competent personnel including a qualified fitter and electrician, as may be necessary to install and operate the Pumping Unit.

8.5 Control of Discharge Rate

The Contractor shall, during the pumping tests, provide a suitable gate valve on the discharge pipeline, to facilitate easy control of the discharge rate.

8.6 Water Level Sounding Pipe

The Contractor shall, if instructed by the Engineer, provide and install a temporary tube of at least 1 inch diameter from the top of the well to 2 m above the pump bowl assembly to facilitate easy measurements of water level. The tube shall be open only at the bottom and top.

Payment for providing, installing and removing the tube shall be deemed to be included in the rates given for pumping tests.

8.7 Discharge Rate Monitoring

Discharge rates up to 15 lps (54 cum/hr) may be measured by drum filling. Discharge rates in excess of 15 lps shall be recorded with a water meter or by a V-notch weir. All items are subject to the Engineer's approval before start of drilling.

8.8 Definition of "Pumping Unit"

The equipment specified in Clause 8.2 – 8.6 is referred to as the Pumping Unit.

8.9 Pumping Procedure

The Engineer will determine the pumping procedure necessary to obtain the objectives of this Contract.

8.10 Suspension of Pumping

If the Engineer condition of any equipment, personnel, fuel, lubricants or accessories will prejudice the quality of data obtained from any pumping test he may suspend the work in accordance with the provisions of the Conditions of Contract.

8.11 Equipment Breakdown During Pumping

The pumping must be continuous and at a constant rate during the pumping tests. The Engineer will instruct the Contractor as to the expected maximum duration of each pumping test before start of each test.

If pumping is interrupted or the discharge rate fluctuates by more than 5% of the designated discharge rate, the test may be repeated after a period of recovery determined by the Engineer.

If any pumping test is interrupted because of equipment breakdown or inadequate supervision or discharge control, no payment will be made for any pumping period before recommencing the test.

8.12 Duration of Tests

The step-drawdown pumping tests shall be performed on 5 steps with a duration of 1 hour each.

The constant discharge pumping tests shall be performed for a period of 2-5 days, unless otherwise specified in the Special Provisions or unless otherwise instructed by the Engineer.

8.13 Temporary Pipeline

The Contractor shall provide a temporary pipeline as directed by the Engineer for the discharge from pumping tests and for clearance to a suitable water course or drain.

Under certain circumstances when re-infiltration cannot be avoided or it is costly to provide for this condition, the Engineer shall decide to what distance from the well, water may be discharge on the ground.

9 CEMENT GROUTING

9.1 Scope

The Contractor shall, unless otherwise specified in the Special Provisions, provide the cement and mixing equipment required for the mixing of the grouting indicated in the Tentative Well Design and shall place the cement grout as specified.

9.2 Grouting Material

Cement grout shall consist of a mixture of 95% Portland Cement, 5% bentonite and clean water, mixed in the proportion of 52.5 kg of Portland Cement/bentonite to max. 30 liters of water.

All cement shall, unless otherwise specified in the Contract Documents, conform to the "Specifications for Portland Cement" (ASTM C150- latest revision).

9.3 Method of Placing Grout Material

The method and equipment for placing the grout shall be to the approval of the Engineer. No method will be approved that does not provide for the forcing of grout from the bottom of the casing/hole/annulus to be grouted, to the surface. Flushing of the annular space with fluid to assure the space is open and to remove loose material will be required by the Contractor before grouting is commenced.

Any grouting operation shall be continuous and before starting, sufficient grout shall be mixed to complete the whole operation. During the grouting operation, the mixed grout shall be continuously stirred. The Contractor shall provide such tanks, hoppers and other equipment as may be necessary to meet these requirements.

9.4 Setting Time

No work will be allowed on the well within a period of 72 hours after completion of grouting unless a quick setting cement is used. In such case, the idle period may be reduced to 24 hours subject to the Engineer's prior approval.

10 WELL DISINFECTION AND CLEANING

10.1 Scope

The Contractor shall upon completion of well construction and well testing thoroughly clean the well of all foreign substances including tools, timbers, rope, debris of any kind, cement, oil, grease and scum.

The casing pipe shall be thoroughly swabbed using alkalis, if necessary, to remove oil and grease of joint dope. The Contractor shall then, unless otherwise specified in the Special Provisions, disinfect the well with a chlorine solution.

10.2 Chlorine Solution

The chlorine solution for disinfecting the well shall be of such volume and strength that a concentration of at least 50 mg/liter of chlorine shall be obtained in all parts of the borehole.

The chlorine solution shall be prepared and applied in accordance with the directions of and to the satisfaction of the Engineer and shall remain in the well for a period of at least two hours.

10.3 Cleaning of Test Pump

In the event that the test pump is to be installed after the well has been disinfected, all exterior parts of the test pump coming in contact with the water shall be dubbed with a chlorine solution as directed by the Engineer.

10.4 Disinfection Procedure

Method A: Where practical, the chlorine solution of standard concentration used to disinfect the well shall be prepared on the surface in containers having a volume of water contained in the well. This prepared solution shall then be discharged rapidly into the well, care being taken to flush the walls of the well above the water level.

Method B: In lieu of using Liquid chlorine solutions, a perforated pipe container capped at both ends containing a granular chlorine compound, HTH or Perchloron, may be moved up and down in the well by means of a weighted cable. The amount of compound applied should be such as to provide the standard concentration.

11 WELL COMPLETION

11.1 Scope

The contractor shall provide and operate all equipment necessary to restore the site as near as possible to its condition before commencement of drilling and shall furnish and install a well head cap as specified in the Contract Drawings.

11.2 Site Restoration

The site shall be restored to a condition as nearly possible to that which existed before the well drilling and testing activities commenced. This work shall include, but not limited to, restoration of fences and structures, removal of drill cuttings, levelling of the disturbed ground surfaces and replacement or compensation for the destroyed plants and landscaping.

11.3 Well Head Capping

The well head shall be completed with a well head assembly fully welded to the upper casing as well as a water level sounding tube with screw cap in order to prevent any unauthorized tampering of the well.

12 SUBMITTAL OF REPORTS AND BOREHOLE DATA

12.1 Scope

The Contractor shall submit to the Engineer daily records in duplicate containing the following information:

Site
Date
Description of each stratum encountered
Depth below ground of each change of stratum
Depths and details of all disturbed samples

The Contractor will be required to keep a record of penetration rate, mud losses and mud conditions.

At the end of the well construction and before final payment is made, the Contractor shall submit to the Engineer a report containing the following information:

- The total depth of the well
- Description of the strata encountered
- The sizes and the lengths/specifications of the casing installed
- The date of the start and the completion of the well construction
- The locations and the description of the casing perforations or the well screen placement
- The locations of the gravel, the size of gravel, if applicable, and the amount of cement grout installed
- Records of discharge rates and drawdown during well development together with description of the methods of the development
- The well yield (expressed as discharge rate and drawdown), the dates and the duration of the test(s)
- The methods of measuring the discharge rate and the drawdown
- The cost of records shall be deemed to be included in the contract rates.