



Technical specifications

Camera Survey, Disinfection, Development and Test Pumping of six (06) existing boreholes for motorization in Butebo (03) and Kaabong (03) Districts

1. Introduction

GOAL is desirous that the Contractor performs Camera Survey, Disinfection, Development, and Test Pumping of all the six (6) wells in conformity with the procedures outlined here. The output of the whole scope of works will form part of the report presented at the end of this implementation. Where borehole construction reports are available, the client requires that the tasks herein defined be carried out in the chronological order summarized below;

- a. Flushing and disinfection
- b. Test pumping
- c. and Camera survey

However, where the construction reports aren't available, camera survey shall be conducted before test pumping.

The extent of work done on the wells is dependent on the behaviour and structural integrity of each well at every stage. Brief onsite reports shall be prepared and reviewed by the supervising engineer and, a decision taken to either proceed or terminate the works on respective wells. Where works are terminated, GOAL shall pay the contractor an equivalent sum of funds computed from the rates provided in the contracted BOQs.

2. Scope of Works

The Contractor, by accepting the terms of this contract with GOAL, accepts and understands that the primary purposes of conducting this exercise of camera survey, disinfection, well development and test pumping on six (6) existing wells are as detailed in the following sections: -

2.1 Test pumping objectives:

1. To determine the reliable long-term yield (or 'safe' yield) of a borehole, and therefore whether the borehole can be regarded as a 'success,' and how many people it will be able to supply.
2. To assess the hydraulic performance of a borehole, usually in terms of its yield-drawdown characteristics thus how much drawdown it takes to yield a certain amount of water.
3. To derive the hydraulic properties of the aquifer.
4. Pumping tests are the classic (and perhaps the only) way to derive *in situ* aquifer hydraulic properties, such as transmissivity and the storage coefficient, or to reveal the presence of any hydraulic boundaries.
5. To test the operation of the pumping and monitoring equipment, to make sure that everything is working safely and efficiently, and if applicable, to confirm that the Contractors have done their job properly.
6. To determine the effects of abstraction on neighbouring abstractions (sometimes referred to as derogation).
7. To determine the environmental impact of the abstraction. All groundwater abstraction eventually has an impact; it is only a matter of where, when and whether the impact is acceptable.
8. To provide information on water quality. Is the water quality suitable for the intended use? Is it stable in the long term? Are there likely to be any problems such as drawing in saline or polluted water after extended periods of pumping?

9. To optimize operational pumping regimes (especially from multiple-borehole sources), including selecting the most suitable pumping plant for long-term use, and estimating probable pumping and/or treatment costs.
10. To help determine the correct depth at which the permanent pump should be installed in the borehole (the subjects of pump choice and installation are covered in other guidance documents).

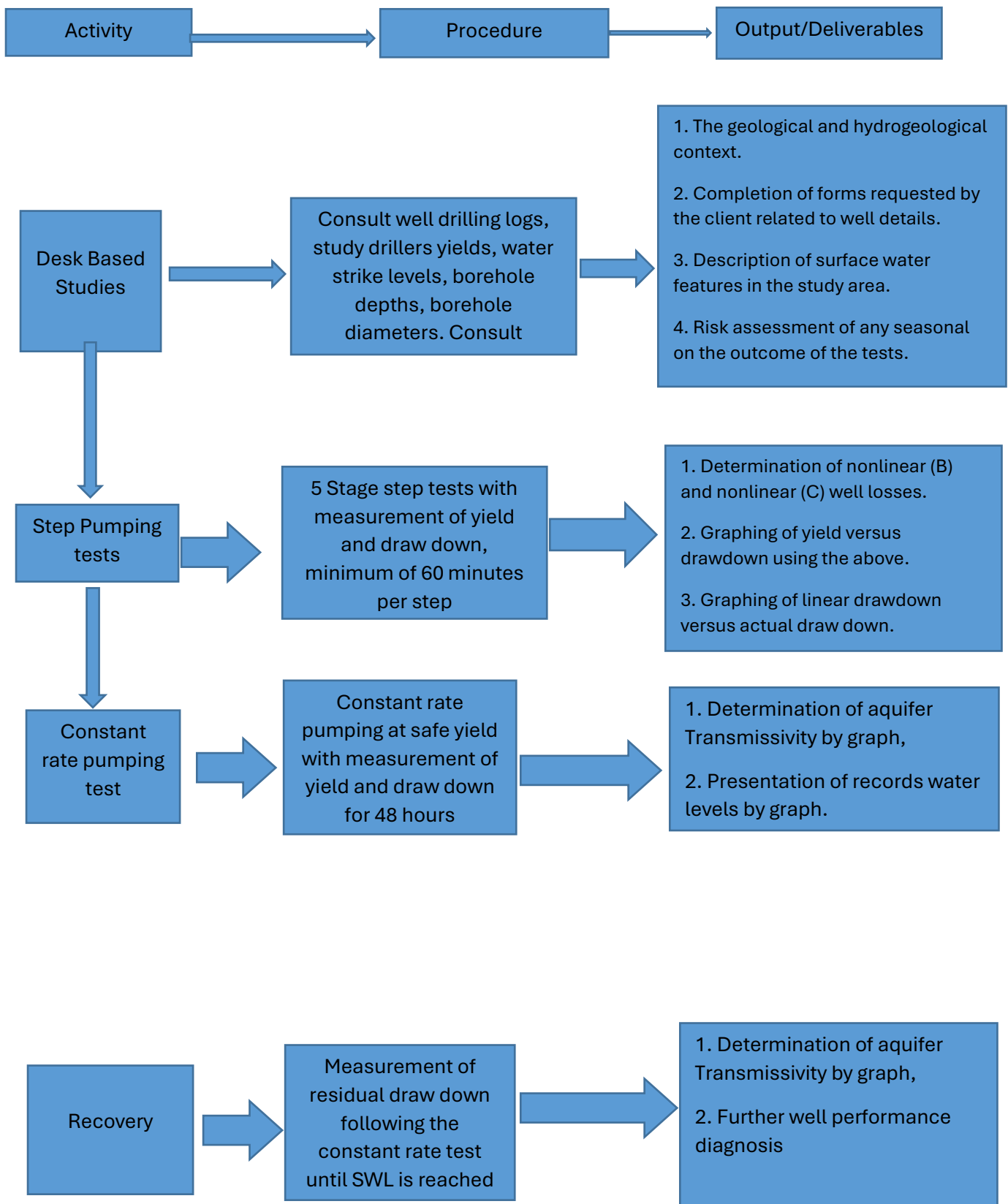
The test pumping scope of works:

- I) Carry out desk study on the drillers yields (where available), borehole depths, well diameters and screen depths of the drilled boreholes.
- II) Perform Test pumping for all the drilled wells and the following tests will be conducted:
 - At least 5 step tests each of a duration of 60mins.
 - Constant rate test for a minimum duration of 48hrs.
 - Aquifer recovery shall be monitored until 90% of the created draw down is achieved or for a period equivalent to a quarter of the duration of the constant test, whichever occurs first.
- III) Complete all forms related to test pumping as detailed by MWE guidelines.
- IV) Carry out interpretation of all the test pumping results according to the methodology described by MWE guidelines.
- V) Present all findings in a comprehensive report, of which the contents must comply with the demands of the technical specifications herein. All field and raw data will also be made available and shall be a property of GOAL.

2.2 Test Pumping Procedure and expected output

GOAL expects the Contractor to follow the laid down pump testing procedure in the technical specifications (also mentioned in the ToR) for coming up with the results that will form part of the report. The chart hereunder outlines the procedure and expected output of the test pumping.

Flow chart and test procedure and Deliverables.



2.3 Equipment for the Test Pumping

The Contractor shall provide the following equipment to conduct the test pumping detailed in these Terms of Reference:

- i) An appropriately sized pump fitted with a non-return valve (NRV) to be able to conduct the recovery test, as detailed in section 2,
- ii) A rising main fit for the purpose of conducting these tests, i.e. without any leaks,
- iii) Adequate pipework to ensure that discharge from the well achieves a minimum distance of 100m from the well and that the risk of recharge to the aquifer/well is minimised for the duration of the tests,
- iv) The power generating capacity and necessary fuel to run the pumping equipment,
- v) Means to accurately control the yield of the pump by either inducing extra pumping head by valve or varying the frequency of electrical supply to the pump, should the pump be compatible with this technology,
- vi) An accurate and well calibrated means of measuring flow from the well. Note that any device such as a V-Notch weir used for measuring flow MUST be calibrated on site using the 'stopwatch and container' method,
- vii) An accurate means with which to measure water levels in the well throughout the duration of the test. Note that if a dipper meter is used then it should be of a type with sensitivity adjustment to avoid erroneous errors caused by 'cascading fractures and any pumping induced turbulence in the well,
- viii) An accurate means to measure time, e.g. stopwatch,
- ix) A conductivity, temperature, and pH meter (combination or individual), calibrated prior to each of the tests that will be used for (step and constant rate test),
- x) A means to measure turbidity, either manual or electronic,
- xi) A camera for taking pictures of the site, related installations and any observed water quality issues, e.g. high turbidity and/or sand content,
- xii) Copies of the field data forms provided in this document and additional note paper for unforeseen needs,
- xiii) Sets of graph paper, both linear/logarithmic and linear/linear, for the plotting of field curves to verify data and make some field calculations for better conducting other tests.

As stated in section 4, the consultant will provide details of all the above equipment in the final report.

The Desk-based Study

The desk-based study will include collecting the following information:

- i) All drilling and construction details of the borehole(s)/wells(s) to be tested.
- ii) Gathering of information on static water levels, water quality information, well depth, well diameter, height of measurement points above ground level.
- iii) Gathering of information related to the basic geology and hydrogeology of the area. If a previous geophysical survey is available from the site, then the consultant must mention these and, if possible, present the findings in the final report,
- iv) Ascertain if there are any surface water features in the study area which might reasonably be expected to have an interaction with the aquifer and could be affected by a pumping test,

- v) Conduct a risk-based assessment of the validity of these tests in terms of seasonal factors that might affect the performance of the aquifer and/or the well at other times of the year from that during which the tests are conducted.

The Step Test

Introduction

The Contractor will understand that the purpose of conducting a step test is to establish the short-term relationship between yield and drawdown for the well/borehole being tested. This is achieved by measuring drawdown at a range of yields. The following can reasonably be expected to be determined from the test:

- i) The performance of the well, i.e. the relationship between drawdown and yield for a range of flows even when that flow might not have been achieved during the test,
- ii) The linear well losses, or B factor, and non-linear well losses, or C factor, for the well according to the relationship¹;

$$s_w = BQ + CQ^2$$

Where, s_w is the drawdown in the well (m), Q has the dimensions [L^3/T], B has the dimensions [T/L^2] and C has the dimensions [T^2/L^5].

And the following equation relationship should yield a straight line²;

$$s_w/Q = B + CQ$$

Where Q/s_w is termed the specific drawdown and has dimensions [$L/L^3/T$]

- iii) The maximum safe yield of the well, often taken to be the yield (and associated drawdown) where linear well losses (BQ) by themselves account for at least 50% of the drawdown.
- iv) The safe yield of the well, often taken to be 80-90% of the maximum safe yield.

Note: Information obtained from the step test will be critical in the proper design of the constant rate test. For example, yield can decline during a constant rate test as drawdown deepens and pumping head increases – data from the step test can help the hydro geologist to ensure that the correct adjustment are made at the appropriate time during the constant rate test.

The Contractor will ensure the following:

- i) The datum for all water level measurements must be chosen and adhered to for the duration of this test and all others conducted subsequently and this point must be reported,
- ii) The test shall comprise three steps with yields set using the following calculation.

$$Q_1 = Q_{des}/3, Q_2 = Q_{des}/2, Q_3 = Q_{des}$$

Where; Q_{des} is the design yield, estimated from the constant test and allowing for a safety factor that will ensure that the last step is not beyond the capacity of the well and the depth of installation of the pump, i.e. that the PWL³ should not arrive at the level of the pump,

- iii) Each step will continue for a minimum duration of 60 minutes,
- iv) Multiple and accurate flow measurements shall be made throughout the duration of the test and especially immediately after the change in yield from one step to another,

¹ After Jacob (1946), note that some hydrogeologists consider that the quadratic relationship in this equation is too simplistic and that CQ^2 should be replaced by CQ^n , where n is >1 . However, the quadratic relationship often serves as a good enough relationship.

² Often termed the Hantush-Bierschenk plot.

³ PWL = pumping water level

- v) The interval of measurement for the water level in the well (PWL) during each step adheres to the MWE recommendation set forth on the test pumping data recording sheets.

Every 30 seconds for the first 10 minutes,
Every minute up until 30 minutes, and then
Every 5 minutes up until 120 minutes.

- vi) Ideally the drawdown should stabilise - reach a 'steady' or 'quasi-steady state' - before the end of each step. If this is not the case, then the consultant understands that the method of interpretation of the data differs from that of a standard 'steady state' analysis and must present this in the final report⁴

7. Constant rate test

Introduction

The Contractor shall carry out constant-rate test for all the four boreholes. The wells are to be pumped at a constant rate for 48 hrs while the water levels and pumping rates are monitored simultaneously. The same equipment used for step test shall be used.

Constant-rate test procedure

If all the equipment is ready, and people have been assigned their tasks, the procedure for conducting a constant-rate test is as follows:

1. Choose a suitable local datum (such as the top of the casing) from which all water-level readings will be taken and measure the rest-water level. The water level must be at rest before the start of the test, so the test should not be conducted on a day when the borehole is being drilled or developed, or when the step test is taking place.
2. Open the valve to the appropriate setting and switch the pump on, starting the stopwatch at the same time. Do not keep changing the valve setting to achieve a pumping rate (a round number in liters per minute, for example). Rather, aim for an approximate rate and measure the actual rate.
3. Measure the water level in the borehole every 30 seconds for the first 10 minutes, then every minute until 30 minutes have elapsed, then every 5 minutes until 2 hours have elapsed. After 2 hours, observe how quickly the water level is still falling, and decide an appropriate frequency for water-level readings until the end of the test. If the water level is falling very slowly, then a reading every 30 minutes or even every hour may be enough. If the test is to continue for several days, review the measurement frequency depending on the behaviour of the water level. If you miss the planned time for a water-level reading, write down the actual time the reading was taken. Record all the readings on the standard form recommended by MWE.
4. Measure the pumping rate soon after the start of the test, and then at intervals during the test (every 15 minutes would be reasonable for the first few hours, then decide a suitable frequency for the remainder of the test). If there is a noticeable change in the rate of increase of drawdown, or if the pump sounds different, then measure the pumping rate at those times as well. If the pumping rate changes significantly (say by more than 10%), then adjust the valve setting to maintain as steady a pumping rate as possible throughout the test but be careful not to over-adjust and make the problem worse.
5. At the end of the test, switch the pump off, note the time (or restart the stopwatch), and immediately start measuring the water level recovery.

8. The Recovery Test

Introduction

The recovery test for the four wells must be done and the results presented together with the test pump results. The purpose and benefits of conducting a recovery test is outlined below:

- i) They provide a means to verify results from the constant rate test,
- ii) The absence of variations in pumping rate that might occur during the constant rate test lead to smoother graphing of residual drawdown⁵ data,
- iii) They can help GOAL's supervisor propose a future pumping regime.
- iv) Water levels in the well can be easier to measure during this type of test due to the absence of cascading fractures and/or pump induced turbulence in the well,

The Recovery Test Procedure

The following procedure shall be followed for the recovery test:

- i) The pump shall be provided and installed by the Contractor and ensure that a non-return valve (NRV) has been fitted immediately above the pump to prevent backflow of Water in case of pump failure.
- ii) This test MUST be started immediately after the constant rate test described above and not after any other pumping event at the site,
- iii) Water level measurement intervals will be the same as for the constant rate test, detailed in MWE well recovery data monitoring tool.
- iv) Data will be recorded on the form developed or recommended by MWE.
- v) Aquifer recovery shall be monitored until 90% of the created draw down is achieved or for a period equivalent to a quarter of the duration of the constant test, whichever occurs first.

9. Analysis, Interpretation and Reporting

The analysis and interpretation of the test pumping results will be based on the time taken for the well water level to return to its original level before pumping. For wells that do not recover more than 50% of their original static water level in a period of one hour such wells will be deemed unsuccessful. The Contractor will be expected to produce accurately measured raw field data in the final report and this is the basis for consideration of successful execution of the contracted works.

The Contractor's final report will indicate the actual yield of the well.

10 Camera Survey

Camera survey investigations will be carried out in all the six wells to determine:

- The current depth of the wells,
- The status of the wells with respect to silting,
- The openness and completeness of the well (check/verify if there are no foreign objects),
- The construction design of the well (Open hole design or Closed hole design - cased to the bottom design)
- The verticality of the well and, stability of the well linings for open holes.
- The type and quantity of the permanent casings used in the well construction. Provide any details of defective casings.
- The cased and screened sections of the well – produce design of the well.

- The presence of bio film growth if any on the casings with more attention paid to the screen.

Technical specifications of the camera survey equipment

At minimum, Borehole camera Rental (Built in lighting camera, submersible with depth on powered non-cracked, easily rollable winch (cable at least 15MPa in strength), shaped to fit inside borehole permanent casings of 5" minimum internal diameter, to inspect from top to bottom, variable pan and tilt angles to view different directions **in real time**, logged in detail and able to automatically record and store videos for future reference, allows for side views of casing or screens be observed at accurate, recorded depths, able to observe dropped in objects or debris. Able to view water cascades, water quality (chemical precipitates, turbidity, and any other form of growth film). Video monitor should be provided in a camera package.

Note:

The contractor is expected to develop their own technical proposal and financial offer, using a logically drafted template which should include supply of all equipment, technical expertise, workmanship, and all taxes (VAT, WHT) for the camera survey, only if different from the BoQ. The rate which is lump sum shall be that in the BoQ and provide attachment of the details.

11 Disinfection and Development of the wells

The contractor shall carry out the chlorination of all the wells in conformity with the procedures outlined here in the Terms of Reference (TOR). The output of the chlorination will form part of the report presented at the end of the assignment.

The contractor, by accepting the terms of this contract with the client, accepts and understands that the primary purpose of conducting chlorination is to kill or reduce certain kinds of bacteria. This includes coliform bacteria that may indicate the presence of disease-causing organisms and other nuisance bacteria (example iron and sulphur bacteria) that can cause unpleasant taste and odour in the water.

The scope of works in this output will include: -

1. Measuring depths and static water levels of boreholes and using the results of the CCTV survey for determining the well diameter and screen depths of the boreholes to be disinfected and flushed.
2. Disinfecting both boreholes using High-Strength Calcium Hypochlorite (HSCH) in powder or granular form which contains 60 to 80% of available chlorine.
3. Produce a detailed report giving the static water level, diameter of the well, depth of the well, dose rate and volume of water in the well for each of the four wells/boreholes.

Procedures

1. Dismantle the borehole removing all the below and above the ground components leaving the pedestal open.
2. Pour chlorine liquid of the right dose rate into the borehole through the pedestal taking into consideration the amount of water in the well got earlier through calculations.
3. Using hosepipe connected to compressor and lowered into and at the bottom of the well, introduce low pressure from the compressor into the borehole to agitate the water (surging); forcing water up and down a borehole and more importantly, back and forth through the screen, gravel pack and adjacent aquifer matrix for one hour.
4. Flush out the chlorinated water from the borehole for one hour until there is no smell of chlorine in the water.

5. Calculating the chlorine dosage for disinfecting a borehole using high-strength calcium hypochlorite (HSCH)

1.1 Equipment

- A 20-litre bucket
- HSCH granules and powder

1.2 Calculate the volume of the water in the borehole using the formula:

$$V = \frac{\pi D^2 h}{4}$$

Where;

$V = \text{volume of water in the borehole}(m^3)$

$D = \text{diameter of the well}(m)$

$h = \text{depth of water}(m)$

$\pi = 3.142$

- Multiply your answer by 1000 to convert the answer to litres.
- Divide the volume of water (in litres) in the borehole by the volume of the bucket to establish how many buckets of disinfectant will be needed to replace the total volume of water in the borehole.
- Fill the bucket with clear water.
- Add 1g of HSCH powder and stir until dissolved (0.5g for every 10 litres in the bucket)
- Pour the disinfectant into the borehole.
- Make up sufficient buckets of disinfectant to replace the total volume of water in the borehole.

1.3 Precaution

HSCH give off chlorine gas which is a serious health hazard. Always add chlorine compounds to water rather than water to chlorine. Work in an area with a good flow of air to take away the chlorine fumes. Wear protective clothes, especially face, and eye masks and gloves. Do not allow anyone to use the hand pump during the cleaning process.

