MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT

Standard Operating Procedure for Groundwater Sampling

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Contents

1.0 GENERAL INFORMATION

1.1 Purpose

The purpose of this document is to give guidance in the performance of groundwater sampling and to provide recommended quality assurance and quality control (QA/QC) procedures.

1.2 Application

The procedures contained in this document are to be used by Hydrogeologists and Technicians when collecting groundwater samples for the National Groundwater Monitoring System.

1.3 Scope

This document describes procedures for groundwater sampling and will facilitate the acquisition of accurate and representative groundwater samples for the National Groundwater Monitoring System.

1.4 Groundwater division SOPs

The following documents form part of the series of Standard Operating Procedures for best management practices in groundwater management:

Document No.	**Title**
GW01/2012	Standard Operating Procedure: Drilling and Construction of National Boreholes
GW02/2012	Standard Operating Procedure for Aquifer Pumping Tests
GW03/2012	Standard Operating Procedure for groundwater level monitoring
GW04/2012	**Standard Operating Procedure for groundwater sampling**
GW05/2012	Standard Operating Procedure for operation and management of the national groundwater database
GW06/2012	Standard Operating Procedures: Water Use Permitting
GW07/2012	Standard Operating Procedure: Drilling and Construction of Production Boreholes

All official copies of the division's documents are kept, in electronic format and hard copies, by the office of the Deputy Director – Groundwater Resources.

1.5 Health and safety

Proper safety precautions must be observed when sampling groundwater. A health and safety plan must be prepared prior to field work and must be followed during monitoring. The plan should address all potential and known hazards.

The following personal protective clothing (PPE) is recommended, as a minimum requirement, during monitoring for health and safety reasons:

- Hard hat.
- Eye protection (when needed).
- Hearing protection (when needed).
- Dust protection (when needed).
- Gum boots
- Dust coat
- Gloves (when needed).

2.0 EQUIPMENT AND TOOLS

The following equipment and tools must be available on site before commencement of sampling.

1) Key to get into site and oil to lubricate locks.
2) GPS.
3) Dip meter, distilled water to clean dip meter, spare batteries.
4) Tape measure (100m).
5) Weight (fairly heavy, to attach to end of tape measure for borehole depth measurement)
6) Pump or purging device, power and compressor.
7) Bailer (conventional or clear plastic disposable bailer).
8) Container to measure pumping rate, 25 litre or 10 litre.
9) Sample record sheets to identify sample and/or sample sets and to record field measurements.
10) Shovel.
11) Torch.

12) Indelible ink fibre tip pen/s, pencils, ballpoint, and field note book.
13) PPE.
14) Digital camera.
15) Drop sheet (some type of sheeting to protect instruments from contamination in the event of their falling to the ground).
16) Calculator.
17) Decontamination kit, sprays, detergent, buckets, soap, rinse water and PVC pipe.
18) Conductivity meter and calibration solutions.
19) pH meter and calibration solutions (+ capacity to measure temperature).
20) Spare batteries for all the meters.
21) Distilled water.
22) Chain of Custody forms.
23) Sample bottles and caps.
24) Bottles containing preservatives (clearly labelled).
25) Equipment or field blank samples.
26) Filter apparatus for field filtered samples, including extra filters.
27) Preservation equipment e.g. ice box/cool box with cooling medium such as frozen ice.
28) Paper towels, rags, plus plastic garbage bags for discards.

3.0 PROCEDURE

3.1 Pre-sampling

1) Gather all the sampling equipment, containers and forms.
2) Clean all sampling equipment thoroughly and maintain the equipment in good working order.
3) Calibrate all field meters e.g. pH and EC meters prior to sampling, according to the manufacturer's instructions. pH meter calibration should include the pH range of the boreholes to be sampled i.e. 4 – 7 pH range for acidic to neutral, 7 – 10 pH range for neutral to basic.

3.2 Field procedure

3.2.1 Groundwater level and borehole depth measurements

3.2.1.1 Introduction

Measure the total depth and depth to the water level within the borehole before any purging and sampling. Measuring these two parameters is important in the following ways:

- Groundwater level measurements can be used to provide information on lateral and vertical head distribution and hydraulic gradients within individual aquifers and between aquifers in layered aquifer systems
- Groundwater level measurements provide information on the temporal groundwater levels trends and infer groundwater flow direction and rates from long term records.
- To determine if it will be feasible to lower the sampling equipment down the borehole.
- To determine the depth of installation of the sampling pump when sampling an unknown borehole. If the borehole has been sampled previously, the depth measurement will indicate whether borehole collapse or silting has occurred.
- To calculate the volume of water to be purged so that a representative sample can be collected.

3.2.1.2 Measuring total depth of the borehole

The borehole depth shall be measured first when sampling unequipped boreholes, using a heavy weight attached to a tape measure. The borehole depth cannot be measured for production boreholes with pumping equipment permanently installed as there is no access to the borehole casing. The borehole depth for production boreholes should be obtained from borehole completion sheets or from the owner or custodian of the borehole.

Borehole depth measurements are conventionally taken from the top of the casing (at a marked point) called the datum. Therefore it is important to also measure the height above the ground surface of the reference point to reduce the measurement to metres below ground level.

The measured total depth reading should be compared to the depth documented at the time of construction (if available) to determine the status of the borehole i.e. whether the borehole has collapsed or not.

Procedure

1) Lower the weight into the casing until it reaches the bottom of the hole. As this happens the tape will become slack.
2) Lift and drop the tape several times to 'feel' the bottom of the borehole.
3) Remember to add the length of the weight onto the tape measurement (if this has not been accounted for).
4) Subtract the height of the casing above the ground level from the measurement.
5) Record the result as total depth (in metres) of the bore on the Bore Information Sheet.
6) Clean the tape before using it again.

3.2.1.3 Measuring depth to water table

Depth to water table should be measured and recorded before every sampling event. Water level cannot be measured in production bores that have permanently installed pumping equipment as there is no direct access to the bore casing. These bores cannot be used for water level monitoring. Some production bores may, however, have additional casing of small diameter (piezo tube) that was installed specifically for the purpose of water level monitoring. This casing will run alongside the main borehole casing used for water extraction.

Procedure

1. Lower the sensor of the dip meter down the borehole or the piezo-tube until the needle deflects, the buzzer or light goes on. Raise it until it stops deflecting or going off at the water-level.
2. Measure the water level depth using the datum point.
3. Re-check the water-level and record.
4. Note that lowering the dip meter to the bottom of the borehole will disturb the water column and dislodge particles that are loosely attached to the sidewall. If the borehole is to be purged, i.e. the borehole has a reasonable yield of water; this may not affect the sample integrity. However for low-yielding

boreholes for which purging may not be done, then rather first collect the water samples and measure the depth of borehole after completion of sample collection.

5. Remove the cable and clean off any rust or oil.

3.2.2 Purging

3.2.2.1 Introduction

Purging is the process of removing stagnant water from the borehole casing before a sample is taken. It is carried out to remove stagnant or non-representative water in the well casing, surrounding filter pack, and local geologic formation.

Using the measured borehole depth, water level and borehole depth, perform the following tasks before purging:

- calculate the volume of the water in the borehole casing before purging using the following formula:

$$V = \pi r^2 \times L \times 1000$$

  Where V is volume (in litres), r is the radius of the casing in metres, L is the length of the water column in metres (borehole depth minus water level) and π is a constant (3.14).

- Calculate the purge volume by multiplying the volume above by three (at least 3 casing volumes should be purged).

3.2.2.2 Purging using a bailer

A bailer can only be used to purge a borehole if a reasonably small volume of water is to be removed as it takes a considerable length of time to purge even a very shallow borehole using a bailer. The following steps shall be followed when purging using a bailer:

(1) Lower the bailer to the desired sampling depth, usually the level of the slotted part of the casing (screened interval).

(2) Withdraw the bailer slowly and try not to disturb the water column by splashing.

(3) Use a bucket of known volume to record the volume of water being discharged.

(4) Remove the calculated volume of water.

(5) Continue purging until pH, EC and temperature readings stabilise.

3.2.2.3 Purging using a pump

The use of a pump to purge a borehole can guarantee the integrity of the sample collected compared to the use of a bailer. It is difficult to ensure that all stagnant water has been removed from the borehole if a borehole is purged using a bailer.

The following steps shall be followed when using a pump to purge a borehole:

(1) Lower the pump to about 1 m above the screens (if known) or to about 1 – 2m from the bottom of the borehole if the screen depth is not known to reduce the risk of drawing silt/mud into the pump which can occur if it is set too close to the screens or borehole sump.

(2) After starting the pump, establish the highest flow rate possible without causing the borehole to stop yielding.

(3) Calculate the flow rate in litres per second. This is done by measuring the time needed to fill a 10 L bucket with discharge water and then dividing 10 by the time (in seconds) taken to fill the container.

(4) Once a constant flow rate is established, the borehole can be 'vacuumed'. This is done by slowly lifting the pump to near the top of the water column while pumping, then slowly lowering it to the previous depth. This way the column of stagnant water sitting in the casing above the slotted level is evacuated.

(5) Pump for calculated length of time needed to remove the three casing volumes of water or until pH, EC and temperature measurements stabilise.

3.2.2.4 Procedure for purging a production borehole

1) If the borehole is pumped only occasionally, turn on the pump and run it for the amount of time required to remove three casing volumes of borehole water or until pH, EC and temperature readings stabilize.

2) If the borehole is used for continuous pumping at certain times of the day (e.g., irrigation, town water supply) there is no need to purge, simply be prepared to take a sample whilst the borehole is pumping.

3.2.3 Sample collection

3.2.3.1 General

1) Collect groundwater samples, 2 litres each, immediately after purging. Use part of the collected sample to measure the field parameters: pH, electrical conductivity (EC)

and temperature. These parameters cannot be reliably measured in the laboratory as their characteristics change over a very short time scale.

2) The following general guidelines shall apply during sampling:
   i) Use a fresh, clean pair of gloves for sampling
   ii) Open each sample container immediately prior to sample collection
   iii) Do not touch the insides of sample containers
   iv) Sampling containers shall be filled completely, but not overfilled to avoid spillage and cross contamination
   v) Filled sample containers shall be labelled, prepared for transport, and stored in an ice chest or cooler.
   vi) Record the field measurements made immediately prior to sample collection on the groundwater sample form or field log book.
   vii) Store all collected samples in an ice chest or cooler
3) Samples collected for dissolved metals will be filtered using a 0.45-μm filter or equivalent and acidified with nitric acid before storage. The volume of each sample for dissolved metals shall be 500ml.

3.2.3.2 Sampling monitoring boreholes

A bailer or a pump has to be used to draw water from a monitoring or unequipped borehole (typically with no pump installed). The use of a pump is preferred for its effectiveness in delivering a representative water sample.

Procedure for sampling using a bailer:

1) Lower the bailer slowly and gently into the water column of the borehole until it is submerged. Do not allow the bailer to come into contact with the bottom of the borehole.
2) Carefully remove the water sample and empty it from the bottom of the bailer into a prepared sample container.
3) If using a conventional bailer, the equipment should be cleaned after each use to avoid contamination of the next sample. Wash the bailer thoroughly, using tap water and detergent.

Procedure for sampling using a pump:

1) After purging, collect a sample, with the pump still in the same purging position.

2) The pump should be cleaned thoroughly after each use to avoid contamination of the next sample. Cleaning is done by submerging the pump in a container of pure (tap) water and pumping continuously for several minutes to ensure the pump and plastic hose are rinsed thoroughly.
3) Make sure the pumping technique used is consistent and every sample is obtained following the same procedure.

3.2.3.2 Sampling production (equipped) boreholes

(1) If the bore is pumped only occasionally, turn on the pump and run it for the length of time estimated to purge the bore (i.e. remove three casing volumes).
(2) Collect water sample after purging is completed.
(3) If the bore is used for continuous pumping at certain times of the day (irrigation, town water supply), there is no need for purging; correlate time of sampling with times when bore is used, or has just been used.

3.2.4 Sample handling procedures

3.3.2.1 Sample Identification

Samples will be identified using the borehole number and the date. For example, the sample name GN68-10022012 will represent the sample collected from borehole GN68 on 10 February 2012. The sample identification for trip, field and equipment blanks will be TB, FB, and EB respectively. Sample names for field duplicates will have a D immediately after the well identification.

3.3.2.2 Labels

Sample labels attached to a sample shall include the following information, marked using waterproof, non-erasable ink:

a. Region where sample was collected
b. Sample identification
c. Date (day/month/year) and time
d. Name or initials of the sampler(s)
e. Nature of the sample i.e. if preserved or unpreserved

3.3.2.3 Chain of custody procedures

A chain-of custody form (Table 1) will be completed for all the samples collected and submitted for laboratory analysis. Details of all the people handling the samples and their signatures will be entered on the form to track movement of the samples from the sampler to the laboratory custodian. Preservation details and the analyses required for each sample will be indicated on the chain of custody form.

Table 1 Example of chain of custody form

Company name: ____________			**E-Mail**	**Tel No.:**
Technical Contact: ____________			**Name of Lab:**	
Job No.:				
Tick each analysis required:				
Total Dissolved Solids			Nitrite NO2 as N	
Suspended Solids			Aluminium as Al	
Chlorides as Cl			Cadmium as Cd	
Total Alkalinity as CaCO3			Total Chromium as Cr	
Fluoride as F			Copper as Cu	
Sulphate as SO4			Nickel as Ni	
Total Hardness as CaCO3			Lead as Pb	
Calcium Hardness as CaCO3			Selenium as Se	
Magnesium Hardness as CaCO3			Boron as B	
Calcium as Ca			Zinc as Zn	
Magnesium as Mg			Barium as Ba	
Sodium as Na			Cobalt as Co	
Potassium as K			Arsenic as As	
Iron as Fe			Strontium as Sr	
Manganese as Mn			Molybdenum as Mo	
Conductivity at 25° C in mS/m			Antimony as Sb	
pH-Value at 25 ° C			Hexavalent Chromium as Cr6+	
Bicarbonate HCO3			Free & Saline Ammonia NH3 as N	
Nitrate NO3 as N			Ammonium as NH4	

Sample I.D	Date & time sampled		Sample I.D	Date & time sampled

Name:	Date:	Signature:	Company
Compiled/Sampled by:			
Received by:			
Received by:			
Received by:			
Received by:			

3.2.5 Sample Shipment

1) Immediately following sampling, the samples will be stored in coolers with wet ice and maintained at a temperature of 4^{o}C or less.
2) The samples will continue to be stored in this manner until the samples are analysed in the laboratory.
3) The presence of solid ice within and the internal temperature of the cooler will be checked periodically in the field. On hot days, the field samplers will periodically monitor the cooler to remove melted ice and add ice, as needed, to maintain the acceptable volume of ice.

4.0 Quality Assurance and Quality Control (QA AND QC)

1) Groundwater sampling shall be conducted by trained personnel, mainly Technicians, under the guidance of Regional Hydrogeologists.
2) Groundwater sampling equipment shall be decontaminated at the beginning of each day of sampling, between each borehole and at the end of each day of sampling. Decontamination eliminates cross contamination of monitoring boreholes.
3) Duplicate samples and equipment (or field) blanks (where necessary) will be collected and analysed to ensure reliability and consistency in the sampling results. A *duplicate sample* comprises of two samples of the same matrix, an original and a duplicate, collected at the same time, at the same location and using the same method of sampling. A single duplicate sample will be collected for every 10 samples and will be analysed for the full set of analyses as used for the main sample collected.

Equipment and field blanks will be used to assess the integrity of equipment decontamination procedures and sample collection and handling procedures respectively. Equipment and field blanks are water samples collected when rinsing equipment and sample bottles using distilled water. The samples are assigned unique sample numbers so as to not be identified by the laboratory blanks.

5.0 REFERENCES

The following documents were consulted in the preparation of this SOP:

GeoSyntec Consultants, 2006. APPENDIX C Standard Operating Procedures for Groundwater Sampling, URL: http://ndep.nv.gov/bmi/docs/appendix_c07.pdf, retrieved on 8 February 2012.

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