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EAST AFRICAN STANDARD

Development, maintenance and management of groundwater resources — Part 4: Test-pumping of water boreholes

Draft for comments only — Not to be cited as East African Standard

EAST AFRICAN COMMUNITY

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Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in East Africa. It is envisaged that through harmonized standardization, trade barriers which are encountered when goods and services are exchanged within the Community will be removed.

In order to meet the above objectives, the EAC Partner States have enacted an East African Standardization, Quality Assurance, Metrology and Test Act, 2006 (EAC SQMT Act, 2006) to make provisions for ensuring standardization, quality assurance, metrology and testing of products produced or originating in a third country and traded in the Community in order to facilitate industrial development and trade as well as helping to protect the health and safety of society and the environment in the Community.

East African Standards are formulated in accordance with the procedures established by the East African Standards Committee. The East African Standards Committee is established under the provisions of Article 4 of the EAC SQMT Act, 2006. The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

Article 15(1) of the EAC SQMT Act, 2006 provides that "Within six months of the declaration of an East African Standard, the Partner States shall adopt, without deviation from the approved text of the standard, the East African Standard as a national standard and withdraw any existing national standard with similar scope and purpose".

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Introduction

In the preparation of this East African Standard, the following source was consulted extensively:

SANS 10299-4:2003, *Development, maintenance and management of groundwater resources — Part 4: Test-pumping of water boreholes*

Assistance derived from this source and others inadvertently not mentioned is hereby acknowledged.

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SANS 10299-4:2003

Edition 1.1

Any reference to SABS 0299-4 is deemed
to be a reference to this standard
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SOUTH AFRICAN NATIONAL STANDARD

Development, maintenance and management of groundwater resources

Part 4: Test-pumping of water boreholes

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Table of changes

Change No.	Date	Scope
Amdt 1	2003	Amended to delete the introduction, introduce normative references, renumber the subsequent clauses and delete the definitions, since reference has now been made to SANS 10299-0.

Acknowledgement

Standards South Africa wishes to acknowledge the valuable contribution made by Mr John Weaver, Geohydrologist, Stellenbosch.

Foreword

This South African standard was approved by National Committee STANSA SC 5120.12B, *Water supply, equipment and systems – Groundwater extraction*, in accordance with procedures of Standards South Africa, in compliance with annex 3 of the WTO/TBT agreement.

This edition cancels and replaces the first edition (SABS 0299-4:1998).

A vertical line in the margin shows where the text has been modified by amendment No. 1.

Annex A forms an integral part of this part of SANS 10299.

SANS 10299 consists of the following parts, under the general title *Development, maintenance and management of groundwater resources:*

Part 0: Glossary of terms.

Part 1: The location and siting of water boreholes.

Part 2: The design, construction and drilling of boreholes.

Part 4: Test-pumping of water boreholes.

Part 5: The design, selection and performance of pumping equipment for production boreholes.

Part 6: The installation and commissioning of pumping equipment for production boreholes.

Part 7: The rehabilitation of water boreholes.

Part 8: The management of water boreholes.

Part 9: The decommissioning of water boreholes.

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Development, maintenance and management of groundwater resources

Part 4:
Test-pumping of water boreholes

1 Scope

1.1 This part of SANS 10299 covers requirements for the test-pumping of a water borehole in order to obtain information about its possible long-term pumping rate.

1.2 The information can also be used to determine and check

a) for the purpose of groundwater resource evaluation, the aquifer characteristics, i.e. the ability of the aquifer to store and transmit groundwater,

b) the existence of barriers or recharge boundaries,

c) the spacing of production boreholes in the production well field,

d) borehole construction performance or well efficiency, and

e) the design of the production system, i.e. the pump size and the reticulation system.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of SANS 10299. All standards are subject to revision and, since any reference to a standard is deemed to be a reference to the latest edition of that standard, parties to agreements based on this part of SANS 10299 are encouraged to take steps to ensure the use of the most recent edition of the standard indicated below. Information on currently valid national and international standards can be obtained from Standards South Africa.

SANS 10299-0, *Development, maintenance and management of groundwater resources – Part 0: Glossary of terms.* **Amdt 1**

3 Definitions **Amdt 1**

For the purposes of this part of SANS 10299, the definitions given in SANS 10299-0 apply. **Amdt 1**

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4 General requirements **Amdt 1**

The effective utilization of a borehole is subject to a thorough knowledge of the appropriate parameters of the specific borehole. These parameters are analysed through the effective application of a system of test-pumping procedures. The system includes a variety of specific and detailed types of test method, the choice of a specific test or tests, the determination of the test duration and the collection of appropriate data during the tests.

4.1 Types of test **Amdt 1**

NOTE It is recommended that the borehole be adequately and acceptably developed before any of the tests given in 4.1.1 to 4.1.4 are done. **Amdt 1**

4.1.1 Step-drawdown test (multiple-rate test) **Amdt 1**

This test is the first test that is done during test-pumping. It serves to evaluate borehole performance, i.e. how much water can be pumped from the borehole, in order to check the hydraulic efficiency of the borehole and to determine the discharge rate needed for the constant discharge test.

4.1.2 Constant discharge test **Amdt 1**

This test is used to determine how much water the aquifer can yield on a long-term basis. The two aquifer parameters, transmission and storage capacity, are also determined from these test data. The constant discharge test is carried out at the periods given in table 1 or, otherwise, at periods as required by the project geohydrologist.

4.1.3 Recovery test **Amdt 1**

Upon completion of the constant discharge test, when the pump is switched off, the water level recovery is measured. This constitutes the recovery test. If only a step-drawdown test is done, recovery readings are collected after the last step of the step-drawdown test.

4.1.4 Extended step-drawdown test **Amdt 1**

This test is designed for application in specific cases only, namely where the expense of a constant discharge test is not warranted but more information about the aquifer is needed than the step-drawdown test alone can give. This test combines elements of the step-drawdown test and the constant discharge test. The extended step-drawdown test is used for boreholes that are intended to provide water for livestock or for domestic use, or for boreholes that will be fitted with hand-pumps. This test necessitates the performance of a recovery test.

4.2 Choice and duration of test **Amdt 1**

The type of test and its duration shall be selected to suit the level of reliability required, which is a function of the water user's dependence on the borehole(s) and of the consequences (usually financial) of borehole failure. Thus, a borehole for the watering of livestock needs a much lower duration of test than a borehole for the irrigation of apple orchards or one that supplies an entire factory. Table 1 gives recommendations regarding the type of test and its duration for various types of water use. These are minimum requirements and can be altered, if required, to suit any particular situation or to satisfy the project geohydrologist.

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Table 1 — Types of borehole test and their duration

1	2	3	4
Identification of use	**Type of test**	**Duration of test**	**Period of recovery**
Livestock or domestic	Extended step	Total 6 h	As given in 5.2.3
Hand pump	Extended step	Total 6 h	As given in 5.2.3
Irrigation (low cost consequence if failure occurs)	Step CD	4 x 1 h 24 h	As given in 5.2.3
Irrigation (high cost consequence if failure occurs)	Step CD	4 x 1 h 48 h or more	As given in 5.2.3
Engine-driven pump for rural village water supply	Step CD	4 x 1 h 48 h	As given in 5.2.3
Town water supply (low yield borehole)	Step CD	4 x 1 h 48 h	As given in 5.2.3
Town water supply (high yield or main borehole)	Step CD	4 x 1 h 72 h or more	As given in 5.2.3
Factory (water supply not critical to production)	Step CD	4 x 1 h 48 h	As given in 5.2.3
Factory (water supply critical to production)	Step CD	4 x 1 h 100 h or more	As given in 5.2.3
Power station and similar water user	Step CD	4 x 1 h 48 h to 30 d	As given in 5.2.3
Key CD = constant discharge test Step = step-drawdown test Extended step = extended step-drawdown test			

Amdt 1

4.3 Data to be collected

Amdt 1

In order to effectively analyse the various features of the borehole, the following data shall be collected during test-pumping:

For test-pumping analysis, the measurements to be taken are

a) the time and date of the test;

b) the water level drawdown;

c) the rate of discharge;

d) the static water level;

e) the depth of the borehole;

f) when relevant, the distance to observation boreholes;

g) the depth of pump suction;

h) the depth at which water was struck (if available);

i) the diameter of the borehole; and

j) when relevant, a measurement of any rainfall that occurs during the test period.

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5 Test requirements Amdt 1

5.1 Apparatus Amdt 1

5.1.1 Pump Amdt 1

The tests given in this part of SANS 10299 are conducted by means of a pump that is of predetermined capacity and acceptable design, and that has a suitable power drive. The pump should be installed by a pump supplier who has appropriate knowledge of borehole pumping equipment.

Various mathematical equations are used to analyse the test-pumping data. These equations are only valid if certain conditions are met, the most important being that the borehole be pumped at a constant rate. It is for this reason that the specification for the constant discharge test requires the variation in discharge to be less than 5 %. If the variation exceeds this limit, the test has to be stopped, water levels have to be allowed to recover and the test has to be restarted, using suitable equipment.

NOTE Many pumps present a problem in that the head increases and the yield decreases as the water level drops. This is particularly true of submersible pumps of the centrifugal type. With a sophisticated set of valves and flow gauges, this problem can be overcome. However, this solution relies on strict control and monitoring which are normally not possible during night testing. The recommended pump system is a positive displacement type pump. The chosen pump has to have a capacity appropriate to the yields planned for the multiple-rate tests. If the multiple-rate tests do not indicate the maximum yield of the borehole, and the user requires such yield to be evaluated, a suitable and higher capacity pump system has to be provided.

5.1.2 Discharge pipeline Amdt 1

Ensure that the discharge point is so far away from the borehole that the discharged water does not recharge the aquifer. If such short-circuiting occurs, the water level readings will give a lower drawdown than should be observed. In practice, this means that the discharge point has to be downstream of the borehole or at a down-gradient from the borehole, and, in the case of

a) a confined aquifer with a thick, impervious confining layer, at least 10 m away from the borehole,

b) an alluvial gravel subterrain, at least 300 m, and preferably more than 500 m away from the borehole, and

c) an aquifer of which the surrounding geological structure is not known, at least 1 000 m away from the borehole.

Leakage from discharge pipelines is unacceptable since it could lead to incorrect discharge measurements and short-circuiting.

5.1.3 Pump inlet Amdt 1

In a hard-rock situation, set the pump inlet at or just above the main water strike. In a primary aquifer where the lower one-third of the aquifer is screened, set the inlet just above the top of the screen.

Where no water strike information is available, set the pump inlet between 3 m and 5 m from the bottom of the borehole. During the last step of the step-drawdown discharge test, endeavour to draw the water level down to pump suction. The shape of this drawdown-versus-time curve will then usually tell the operator where the main water strike is.

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5.1.4 Pump suction

Amdt 1

Occasionally, the water level is drawn down to pump suction (i.e. to the level of the pump inlet) during a constant discharge test. This usually occurs when aquifers in fractured rock are being tested and barrier boundary conditions are present.

When pump suction occurs (i.e. when the water level has been drawn down to the level of the pump inlet), stop the pump and take recovery readings. No additional information will be gained by continuing the test and the data obtained will, in any event, be erroneous, because the discharge rate is no longer constant. If more information is needed, rather restart the constant discharge test after full recovery and at a lower discharge rate.

5.2 Test methods

Amdt 1

5.2.1 Step-drawdown test

Amdt 1

5.2.1.1 Details of test

Amdt 1

The minimum requirement for the step-drawdown test is four steps, each of duration at least 1 h unless pump suction is reached before 1 h has elapsed. However, steps of 100 min or more can be specified by the project geohydrologist in special circumstances. When required by the project geohydrologist, the number of steps can be increased to five, or more.

5.2.1.2 Method of test

Amdt 1

Start the pump and pump water from the borehole, ensuring that, during each step, the discharge is kept constant. So choose the discharge rates for each step that the first step is lower but the last step is higher than the expected borehole yield.

Determine the pumping rate at the following intervals:

- Step 1: one-third of the expected yield;
- Step 2: two-thirds of the expected yield;
- Step 3: equal to the expected yield; and
- Step 4: one-and-a-half times the expected yield,

where the expected yield refers to the reported yield of an established borehole, the air lift yield of a new borehole or the hoped-for yield planned. The above rates are planned rates of testing. If, during the test, the data obtained show that these planned rates will not give enough information, the planned rates should be changed during the next steps.

For each step, measure and record the water levels at time intervals as shown in table 2.

During each step, measure the discharge rate at least three times and ensure that it remains constant.

If required by the project geohydrologist, conduct a recovery test (see 5.2.3 and table 3) immediately after the step-drawdown test. Amdt 1

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5.2.2 Constant discharge test Amdt 1

5.2.2.1 Details of test Amdt 1

The constant discharge test is used to determine the aquifer parameters (see 4.1.2) which, in turn, are used to estimate how much water the aquifer can yield on a long-term basis. The longer the test, the more reliable the estimate of the long-term yield, especially in the case of secondary aquifers. **Amdt 1**

An important aspect of the test is the constancy of the yield. If the yield is not constant, the data cannot be analysed. The major requirement for a constant discharge test is that the variation in yield during the test be less than 5 %.

5.2.2.2 Method of test Amdt 1

From the results of the step-drawdown test, determine the discharge rate required (see annex A). The actual discharge rate should be such that the water level is not drawn down too close to the level of the test pump inlet. Acceptable information will be obtained if the water level at the end of the constant discharge test has been reduced to a point below the static water level, and that does not exceed three-quarters of the available drawdown. (The available drawdown is the distance between the static water level and the level of the pump inlet.)

Immediately after the start of the test, measure and record the water level at the intervals given in table 4.

Measure the discharge rate during the first 10 min of the test, and then every 30 min for the first 300 min. Thereafter, measure the discharge rate at least every 3 h, but preferably, or if so required by the project geohydrologist, every hour.

After completing the constant discharge test, start collecting measurements of the water level recovery (see 5.2.3). **Amdt 1**

5.2.3 Recovery test Amdt 1

5.2.3.1 Details of test Amdt 1

The results gained from the recovery test are used to determine the aquifer parameters and to determine how rapidly the water level recovers. The recovery test is done after a step-drawdown test or a constant discharge test (or both), as required by the project geohydrologist. Ensure that the discharge pipeline from the test pump is fitted with a non-return valve and that the water in the discharge pipeline does not return to the borehole, since this would result in incorrect observations.

5.2.3.2 Method of test Amdt 1

NOTE The results of this test are recorded using the format given in table 3.

At the end of the pumping test (constant discharge test or step-drawdown test (or both)), switch off the pump and immediately start collecting residual drawdown readings at the intervals given in table 3, until,

a) the water level recovers to less than 5 % of the total drawdown during the constant discharge test, or

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b) at least three readings taken in succession are identical, or

c) a time equal to the total time taken for the constant discharge test has elapsed.

5.2.4 Extended step-drawdown test — Amdt 1

5.2.4.1 Details of test — Amdt 1

The extended step-drawdown test is used if the cost of a constant discharge test is not warranted by the proposed use of the borehole. It combines elements of the step-drawdown test and the constant discharge test, and is followed by a recovery test. The extended step-drawdown test starts with a step-drawdown test and, depending on the performance of the borehole, one of the steps is extended to obtain a total pumping time of 6 h. The step that is converted into an extended test is that step which, at the end of the 60 min pumping period, has drawn the water level down to between 0,6 and 0,75 of the available (or pumpable) drawdown.

NOTE For the purpose of illustrating this test, two examples are given in annex A.

5.2.4.2 Method of test — Amdt 1

Calculate

a) the available drawdown, i.e. the distance between the static water level and the level of the pump inlet, and

b) by applying the factors 0,6 and 0,75, the range of levels to which the water level can be drawn down before the extended tests are performed.

Now proceed with the normal step-drawdown test. When, during one of the steps, the water level is drawn down to between 0,60 and 0,75 of the available drawdown, then, maintaining the same pumping rate, so extend this step that the total pumping time becomes 6 h. At the end of this period, switch off the pump and collect water level recovery readings until one of the conditions described under the recovery test is met.

If the water level drops down to the level of the pump inlet during the test, stop the pump and take recovery readings for 1 h. Restart the test at the pumping rate of the previous step and continue at this rate until a total of 6 h of pumping has been reached. Switch off the pump and again take water level recovery readings.

6 Additional requirements — Amdt 1

6.1 Discharge rate measurement — Amdt 1

Discharge rate can be measured using any of the following:

a) a drum and a stopwatch; or

b) a flow meter; or

c) an orifice weir; or

d) a V-notch weir; or

e) any other acceptable and reliable method.

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The drum-and-stopwatch method is the most accurate method of measurement provided that the drum size is matched to the flow rate. If large flows are involved, large drums have to be used to prevent a decrease in accuracy. If a flow meter, an orifice weir or a V-notch is used, always check the flow rate using the drum-and-stopwatch method. Note that flow meters work only when the discharge pipe is full and the flow is not turbulent. If the borehole is not properly developed, any grit being pumped could jam the flow meter.

6.2 Water level measurement **Amdt 1**

Any of the following measuring equipment is recommended:

a) an electrical dip tape (encased in a dip tube); or

b) a pressure transducer with a fully automatic microcomputer-controlled system; or

c) a mechanical automatic water level recorder.

7 General control **Amdt 1**

7.1 Breakdown of discharge pump **Amdt 1**

Occasionally, a pump breakdown occurs. If this should happen during the step-drawdown test, fix the pump and restart the test at the beginning of the step during which the breakdown occurred. If the breakdown occurs during the constant discharge test, follow the following procedure:

a) Immediately record the time of the breakdown, and collect water level recovery readings.

b) If fewer than 10 h of pumping have taken place, fix the breakdown and restart the test from the beginning after full recovery of the water level (see 5.2.3). **Amdt 1**

c) If more than 10 h of pumping have taken place and the breakdown can be fixed within 5 % of the elapsed pumping time, restart the pumping test at the same discharge rate and continue pumping until the actual total pumping time equals the planned total pumping time.

d) If more than 10 h of pumping time have taken place and the breakdown cannot be fixed within 5 % of the elapsed pumping time, restart the test from the beginning after full recovery of the water level (see 5.2.3). **Amdt 1**

7.2 Observation boreholes **Amdt 1**

Specific yield (in unconfined aquifers) and storage capacity (in confined aquifers) can only be calculated from water levels or time data obtained from observation boreholes. The direction and distance of observation boreholes from the pumping borehole are site specific and have to be determined by the project geohydrologist.

However, if no project specifications exist, bear the following in mind:

a) If there is a borehole close to the borehole to be tested, water level observations collected from the adjacent observation borehole while the test borehole is being test-pumped will provide invaluable information.

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b) If the observation borehole is used for pumping purposes, switch off its pump at least a day before test-pumping the test borehole and do not allow it to be restarted until after the water level recovery test has been completed.

c) Measure the distance, in metres, between the two boreholes and record the information.

7.3 Water level measurement in observation boreholes **Amdt 1**

Use the equipment given in 6.2, except that the electrical dip tape need not be encased in a dip tube. **Amdt 1**

7.4 Water samples **Amdt 1**

If the water is intended for consumption or irrigation, the user or owner might require water samples to be collected for analysis. The samples should be taken towards the end of the test-pumping and by an acceptable method. If any other sampling details are required, the project geohydrologist will have to specify the sampling programme. Water samples should be evaluated and analysed in terms of an acceptable standard procedure for the analysis of water.

In order to monitor any water quality changes that occur in the aquifer during test-pumping, measurements (the commonest of which are temperature, electrical conductivity and pH value) should also be taken during test-pumping.

7.5 Long-term monitoring **Amdt 1**

The appropriate of the tests given in 4.1 can be carried out as an experiment to predict the long-term yield of a borehole or an aquifer. However, proper testing of a borehole and subsequent long-term yield prediction do not guarantee that this long-term yield prediction is the sustainable yield. To guarantee such a long-term prediction, long-term monitoring is required. Long-term monitoring is done over a few years, and should preferably include a drought cycle and a high rainfall (wet) cycle. **Amdt 1**

In the case of well field management, it is usual practice to have two or more boreholes dedicated to water level monitoring. These boreholes will be outside the zone of immediate influence of pumping boreholes, i.e. they will monitor the performance of the aquifer, either manually or with automatic water level recorders.

If the budget does not allow dedicated boreholes, pumping boreholes can be used as a second choice. When the production pump is installed in a pumping borehole, ensure that a 25 mm piezometer tube is installed at the same time taking care that the dip tape does not get tangled with the pumping equipment. Water level measurements have to be taken when the pump has been switched off for at least 12 h. This is because the water level measurement that is needed to evaluate the aquifer has to be its water level at rest and not its dynamic pumping water level. Any other pumping boreholes in close proximity to the aquifer will also have to be switched off for at least 12 h before the water level of the aquifer is measured.

In the case of long-term monitoring, it is vital to know the total amount of water extracted with time. The best data are yielded by obtaining the monthly volume per borehole. Other, less acceptable, data include total volume per well field, or total pumping time plus pumping rate per borehole.

During the monitoring of a production borehole, it is recommended that the pumping level of water in the borehole be measured. The pumping level should remain relatively constant. Any significant changes in the pumping level, excluding seasonal fluctuations of the water levels at rest, indicate a change in efficiency of the borehole. If the pumping level (drawdown) increases for the same

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pumping rate, it is an indication that the borehole is losing efficiency. This loss in efficiency could be due to the encrustation, biofouling or silting-up of fractures. In other words, a change in the specific yield of a borehole indicates either an increase or a decrease in borehole efficiency. Should the efficiency of a borehole decrease to such an extent that the borehole yield is affected, the borehole should be redeveloped.

Long-term monitoring also requires rainfall data and periodic water quality data.

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Table 2 — Data sheet for step-drawdown test

Project:			Pumped borehole No.:
Project No.:			Observation borehole No.:
Contractor:			Distance to observation borehole, m:
Observer:			Pumped borehole depth, m: Borehole diameter, mm:
Pump type:			Static water level, m:
Pump inlet depth, m:			Base of aquifer, m:
Datum (above ground level), m:			Available/pumpable drawdown, m:
1	2	3	4
Step number:[1)]			
Planned discharge L/s (m^3/h):[2)]			**Date:**
Real time	**Elapsed time** min	**Drawdown** m	**Remarks and discharge rate**
	0		
	0,5		
	1		
	1,5		
	2		
	2,5		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	12		
	15		
	20		
	25		
	30		
	40		
	50		
	60		
	70		
	80		
	90		
	100		

1) A separate data sheet is used for each step that might be required. Insert the number of the step in the appropriate space on the data sheet.
2) See 5.2.1.2.

Amdt 1

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Table 3 — Recovery data sheet for step-drawdown test

1	2	3	4	5	6	7
Project:			**Borehole No.:**			
Date	**Real time**	**Time t_1 elapsed since pumping stopped** min	**Time t[1)] elapsed since pumping started** min	$\frac{t^{1)}}{t_1}$	**Residual drawdown** m	**Remarks**
		0				
		0,5				
		1				
		1,5				
		2				
		2,5				
		3				
		4				
		5				
		6				
		7				
		8				
		9				
		10				
		12				
		15				
		20				
		25				
		30				
		40				
		50				
		60				
		70				
		80				
		90				
		100				
		120				
		150				
		200				
		250				
		300				
		400				
		500				
		600				
1) Time t and ratio $\frac{t}{t_1}$ are for interpretation only.						

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Table 4 — Drawdown data sheet for constant discharge test

Project:			Borehole No.:		
Project No.:			Observation on borehole No.:		
Contractor:			Distance to observation borehole, m:		
Observer:			Pumped borehole depth, m:		Borehole diameter, mm:
Pump type:			Static water level, m:		
Pump inlet depth:			Base of aquifer, m:		
Datum (above ground level):			Available/pumpable drawdown, m:		
1	2	3	4	5	6
Date	**Real time**	**Elapsed time** min	**Drawdown** m	**Discharge** L	**Remarks**
		0			
		0,5			
		1			
		1,5			
		2			
		2,5			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			
		12			
		15			
		20			
		25			
		30			
		40			
		50			
		60			
		70			
		80			
		90			
		100			
		120			
		150			
		200			
		250			

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Table 4 *(concluded)*

1	2	3	4	5	6
Date	**Real time**	**Elapsed time** min	**Drawdown** m	**Discharge** L	**Remarks**
		300			
		400			
		500			
		600			
		700			
		800			
		900			
		1 000			
		1 100			
		1 200			
		1 300			
		1 400			
		1 500			
		1 600			
		1 700			
		1 800			
		1 900			
		2 000			
		2 100			
		2 200			
		2 300			
		2 400			
		2 500			
		2 600			
		2 700			
		2 800			
		2 900			
		3 000			
NOTE If so required for extended testing, further time measurements may be taken in steps of 100 min.					

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Annex A
(normative)

Determination of discharge rate (see 5.2.2.2) Amdt 1

A.1 Example 1

Static water level	5,0 m below datum
Water strike	65,0 m below datum
Pump inlet	installed at water strike (65 m below datum)
Blow yield	6,0 L/s
Available drawdown	65 m – 5 m = 60 m
Apply factors 0,60 and 0,75	36 m to 45 m
Planned pumping rates for steps 1 to 4	Step 1: ⅓ x 6 = 2 L/s Step 2: ⅔ x 6 = 4 L/s Step 3: 1 x 6 = 6 L/s Step 4: 1½ x 6 = 9 L/s

The step-drawdown test is started and, during step 3 which was planned at 6,0 L/s, the water level at the 50 min measurement has been drawn down to 42,6 m. Since this is the target level, this pumping rate is maintained for a further 3 h, after which water level recovery readings are taken.

A.2 Example 2

Static water level	3,6 m below datum
Water strike	No information, but the borehole is 35 m deep and the pump is therefore set at 30 m
Blow yield	No records available, but reported to be 4 500 L/h (1,25 L/s)
Available drawdown	= 30 m – 3,6 m = 26,4 m
Apply factors 0,60 and 0,75	= 15,8 m to 19,8 m
Planned pumping rates for steps 1 to 4	Step 1: 0,42 L/s Step 2: 0,83 L/s Step 3: 1,25 L/s Step 4: 1,88 L/s

During step 4, which was planned at 1,88 L/s but was actually at 1,7 L/s, the drawdown at 50 min was 20,0 m. Since this drawdown is very close to the 19,8 m calculated, this discharge rate is maintained for a further 2 h, after which water level recovery readings are taken.

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