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THE INFLUENCE OF THE TYPE AND DIAMETER OF OBSERVATION WELLS ON GROUND-WATER LEVEL MEASUREMENTS

INDFLYDELSEN AF BRØNDES TYPE OG DIAMETER PÅ MÅLINGER AF GRUNDVANDSTANDEN

BY

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INTRODUCTION

Observation wells have long been used in hydrologic investigations to determine ground-water levels. However, little consideration has been given to what size and type of observation wells are most suitable for accurate scientific studies. It seems reasonable to assume that the larger storage capacity of wells with relatively large diameters would make them less responsive to changes in ground-water levels when compared with wells with smaller diameters. It also seems reasonable to assume that some construction methods and casing materials will make wells more responsive to ground-water fluctuations than other methods and materials.

To investigate these questions, a study was conducted by the Danish Forest Experiment Station to determine if a significant difference existed between the measurements made in ground-water observation wells of various diameters and types. This study was conducted in May, 1966, during the Danish spring, and in November-December, 1966, after the autumn, when the trees were without leaves and the soil water capacity was filling up.

REVIEW OF LITERATURE

Few published studies have been made on the effect of well diameter and well type on ground-water level measurements. *Benz et al.* (1963) report the following from a study which compared 3/8 inch (.95 cm) and 4 inch (10.16 cm) diameter observation wells.

1. After periods of heavy rainfall, the 4 inch wells required a period of 48 hours to reach the same water-table level as that indicated by the 3/8 inch wells.
2. The 4 inch wells tended to be lower when the water-table was rising and higher when the water-table was falling.

3. "A statistical analysis of the data obtained indicated that there was a small but significant difference between the readings obtained between the two sizes of wells".

This study was the only published information located concerning this problem.

DESCRIPTION OF THE STUDY

Study area

Located near Vallø, approximately 50 km south of Copenhagen, the one-hectare study area is situated in a 90-year-old beech forest which is representative of the beech stands (*Fagus sylvatica*) on morainic clays throughout Denmark. High ground-water tables are a common characteristic of such sites.

The soil of the study area is a heavy clay, overlying a substratum of morainic material on Cretaceous chalk. Drainage is restricted and water-logging occurs because of the heavy clay subsoils and the flat topography.

The climate may be characterized by some arithmetical means based on measurements made during 25 years at Gjorslev (*Danmarks Klima*, 1933). The following table shows such arithmetical means —

Month	J	F	M	A	M	J	J	A	S	O	N	D	year
Precipitation (mm)	38	30	36	38	36	44	63	71	47	55	46	52	555
Mean temperature (°C)	—0.1	—0.2	1.8	5.7	10.9	14.7	16.6	15.6	12.4	8.1	3.9	1.3	7.6

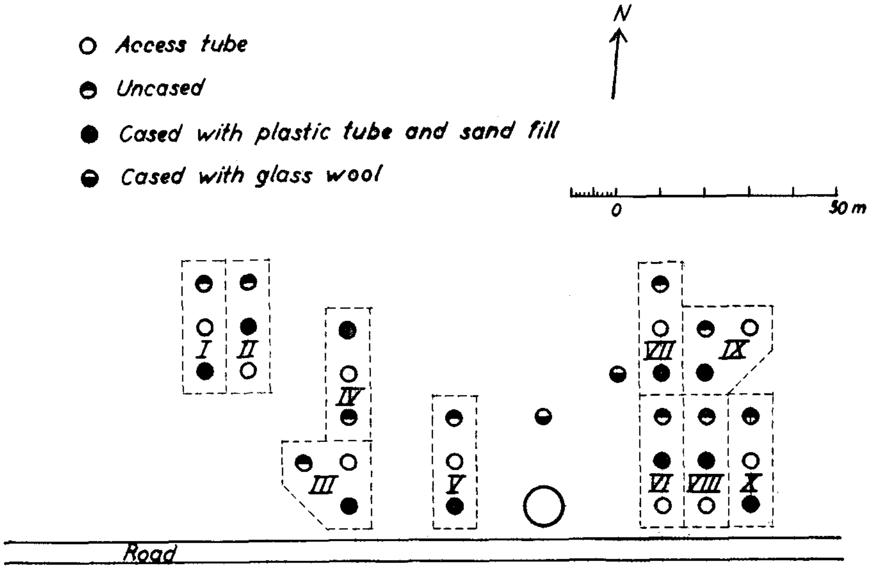
This study area was also used concurrently for studies concerning the determination of soil moisture with a neutron scattering device (*Holstener-Jørgensen, Eiselstein* and *Johansen*, 1968).

Instrumentation

Twenty-three ground-water observation wells of various types and diameters were installed during April, 1966. These wells are described and the experimental lay-out is presented in Figure 1. The locations of the wells and access tubes were determined by the use of a table of random numbers. The description and location of the aluminium access tubes used in the neutron moisture probe study are also included, although they were not used in the study described in this paper.

The two cased wells with glass wool fill are of the type commonly used by the *Danish Heath Society.* These wells were included in the study in order to compare their performance, and were not included in the statistical analysis. The large one-metre well was also omitted from the statistical analysis and was used only for simple comparative purposes.

In addition to the above instrumentation, a manual rain gauge and a simple evaporimeter were installed and read during a two-week period in May.



F i g. 1: Well installations at the Vallø study area.
Uncased — These wells were approximately 2.8 m deep and 12 cm in diameter. The upper 80 cm was encased in a concrete collar to prevent caving-in of the well; however, the lower 2.0 m was uncased. The inside diameter of the concrete collar was 15 cm.
Cased with plastic tube and sand fill — These wells were also 2.8 m deep, but were cased for their entire depth with perforated plastic well casing of 6 cm diameter. A sand fill was used between the casing and the earth wall of the well and a concrete tile was again used in the upper 80 cm.
Cased with glass wool — These wells were also cased with the 6 cm diameter perforated plastic casing. Before the casing was inserted into the well, however, it was wrapped with glass wool cloth, approximately 2 cm thick. Sand was placed around the glass wool-wrapped casing.
Large concrete - cased well — A well of one metre diameter was dug and cased with concrete tile with open joints, this well was initially dug to 1.2 m depth and deepened to 2.4 m in July. The big circle shows the situation of this well.
Access tubes — Aluminium tubes, 44.5 mm inside diameter, were in-

(Continued).

Data collection

Ground-water level measurements were made daily from 4th May, 1966 to 22nd May, 1966. This 19-day period began a few days before the appearance of leaves on the beeches and ended after the trees were completely leafed-out.

This period, therefore, began when relatively little transpiration was occurring and concluded when the trees reached their growing-season transpiration rates.

Measurements were made daily at approximately 9.30 a.m. by measuring the distance from the water level to the ground surface with a folding two-metre stick. While appearing somewhat inaccurate, this method is actually very accurate since it is possible to just break the surface tension of the water surface with the end of the metre stick and take the reading. In some cases, it was necessary to use a flashlight to see the water surface.

The area was levelled with a T-2 theodolite to determine the elevation of each well opening and the top of each neutron probe access tube. The distance to the surrounding trees was measured using a surveyor's tape.

Moreover ground-water levels were measured daily in the period from 23rd November to 10th December during the rise of ground-water after the growing season. The figures from this period are treated less intensively than the May-figures.

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stalled to approximately 2.8 m depths. They were not used in the study described in this paper.

Fig. 1. Installation af brønde på Vallø-arealet.

(Uncased). Disse brønde var ca. 2.8 m dybe og 12 cm i diameter. De øverste 80 cm var forede med et betonmufferør for at forhindre sammenfald af brønden. Imidlertid var de nederste 2.0 m uforede. Den indvendige diameter af mufferøret var 15 cm.

(Cased with plastic tube and sand fill). Disse brønde var også 2.8 m dybe, men var foret i hele deres længde med perforeret plastikrør med en diameter på 6 cm. Mellem plastikrøret og jorden blev der fyldt op med sand; betonmufferør blev også her brugt i de øverste 80 cm af brønden.

(Cased with glass wool). Disse brønde var også forede med 6 cm perforerede plastikrør. Imidlertid var røret omviklet med en ca. 2 cm tyk glasuldmåtte, inden det blev sat ned i brønden. De således beklædte rør blev pakket med sand.

(Large concrete-cased well). En brønd med en diameter på 1 m blev gravet og foret med betonrør med åbne samlinger. Brønden blev oprindelig gravet til 1.2 m's dybde, men blev fordybet til 2.4 m i juli. Den store cirkel viser placeringen af brønden.

Access tubes. Aluminiumsrør med en indvendig diameter på 44.5 mm og gående til ca. 2.8 m's dybde. Disse rør blev ikke brugt i de i denne beretning beskrevne undersøgelser.

Table 1. Average 24-hour water level changes (in centimetres) as recorded by the four types of wells for the 4—22 May, 1966 period.*)

Tabel 1. Gennemsnitlige ændringer (cm) i grundvandstanden i 24-timers perioder for de 4 typer af brønde. Perioden 4.—22. maj 1966.

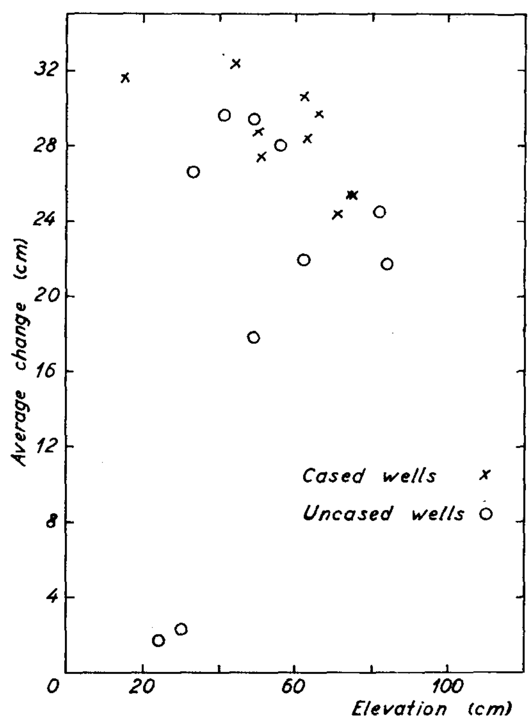
Date May *Dato Maj*	Average daily change of the 10 uncased wells — Direction considered *Gennemsnitlig døgnvariation for 10 uforede brønde — Beregnet med fortegn* (1)	Average daily change of the 10 uncased wells — Absolute *Beregnet uden hensyn til fortegn* (2)	Average daily change of the 10 cased wells with sand fill — Direction considered *Gennemsnitlig døgnvariation for 10 forede brønde pakket med sand — Beregnet med fortegn* (3)	Average daily change of the 10 cased wells with sand fill — Absolute *Beregnet uden hensyn til fortegn* (4)	Average daily change of the 2 cased wells with glass wool fill *Gennemsnitlig døgnvariation for 2 brønde forede med glasuld* (5)	Daily change of the one large well *Døgnvariation i den store brønd* (6)
4— 5	12.1	12.1	16.5	16.5	17.7	—
5— 6	—0.8	2.9	—0.7	2.6	—4.1	—
6— 7	—4.4	4.4	—6.2	6.2	—5.8	—1.4
7— 8	—2.0	2.4	—3.4	3.4	—2.7	—1.8
8— 9	—2.8	2.8	—4.1	4.1	—3.6	—2.3
9—10	2.7	3.0	4.9	4.9	6.4	1.9
10—11	2.1	2.2	3.2	3.2	2.8	4.0
11—12	—1.0	1.6	—1.6	1.9	—3.1	0.3
12—13	—4.3	4.3	—6.6	6.6	—5.8	—3.4
13—14	—2.6	2.6	—4.0	4.0	—4.0	—3.0
14—15	—2.7	2.7	—3.9	3.9	—3.4	—3.2
15—16	—3.3	3.3	—4.5	4.5	—4.1	—4.2
16—17	—2.2	2.2	—2.3	2.3	—2.2	—2.6
17—18	—1.8	1.8	—2.1	2.1	—1.9	—2.6
18—19	—3.5	3.5	—5.0	5.0	—4.0	—3.3
19—20	0.0	1.1	0.8	1.3	1.2	—1.2
20—21	—2.9	2.9	—4.6	4.6	—4.3	—1.5
21—22	0.0	1.3	—0.3	0.7	0.7	—1.0
Absolute subtotal	51.2	57.1	74.7	77.8	77.8	37.7
Average	2.8	3.2	4.2	4.3	4.3	2.4

*) *Explanation of Table 1:* Columns 1 and 2 present the average daily change of the 10 uncased 12 cm diameter wells for each of the eighteen 24-hour periods from 4—22 May, 1966. Column 1 was obtained by taking the average for each 24-hour period — with consideration of the direction of change. For certain 24-hour periods the ground-water level rose in some of the 10 wells, while in others the ground-water level dropped. In the calculation of Column 2, only the absolute change of each well was considered and the direction of the change in ground-water level was ignored. Columns 3 and 4 were similarly calculated for the 10 cased 6 cm diameter wells. The data in Columns 1 and 3 were used to prepare Figure 5.

STATISTICAL COMPARISON OF THE TEN UNCASED WELLS AND THE TEN CASED WELLS WITH SAND FILL USING MAY FIGURES

General

The changes in water level for each 24-hour period from 9.30 a.m. one day until 9.30 a.m. the next, were computed for each of the 20 wells during the 4—22 May data collection period. The average 24-hour change of the 10 uncased wells was subsequently computed for each of the eighteen 24-hour periods. The average change of the 10 cased wells with sand fill was also computed for each of the eighteen 24-hour periods. These data and the corresponding changes in the other two well types included in this study are presented in Table 1.



F i g. 2. Elevation of each site vs. average change of ground-water level from 12—19 May, 1966.

F i g. 2. Gennemsnitlig ændring af grundvandstand fra 12. til 19. maj (ordinat) i relation til brøndens kote.

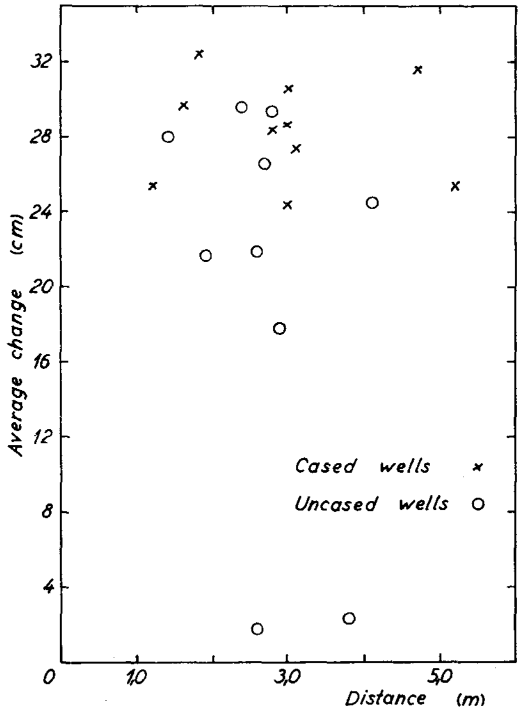


Fig. 3. Distance to the nearest tree from each well vs. average change of ground-water level from 12—19 May.

Fig. 3. Gennemsnitlig ændring af grundvandstand fra 12. til 19. maj (ordinat) i relation til brøndens afstand fra nærmeste træ.

Effect of trees, elevation, and initial depth of water table in May

Since the wells were randomly distributed throughout the forested study area, it was originally believed that (1) nearness of trees to the well, (2) elevation of the well mouth, and (3) initial depth of the ground-water table, as well as the type and diameter of the well itself, might influence water levels recorded in each well. In order to "remove" the effect of these three unwanted variables and to determine the effect of well diameter and type on water level observations, an analysis of covariance, with these variables as independent variables, was originally planned. These three variables were first plotted against the average water level change from 12—19 May. This period was selected since no rain occurred during this time, and only lowering of the ground-water table occurred. Consequently, the effect of depletion of the

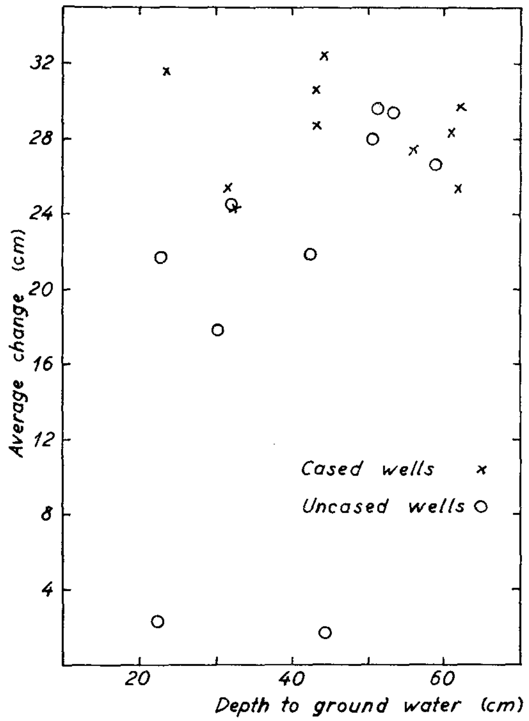


Fig. 4. Depth to ground-water on 4 May, 1966 vs. average change of ground-water level from 12—19 May, 1966.

Fig. 4. Gennemsnitlig ændring af grundvandstand fra 12. til 19. maj (ordinat) i relation til grundvandstanden 4. maj 1966.

ground-water supply by trees should have been maximum during this period. These three graphs are presented in Figures 2, 3, and 4.

As can be readily seen from these graphs, these three variables seem to have had little effect on the water levels observed for the 12—19 May. Consequently, it was decided to ignore the negligible effects of these factors in the statistical comparison of the uncased wells with the ten cased wells with sand fill.

Regression analysis

The average daily changes of the cased wells with sand fill were plotted against the average daily changes of the uncased wells. This graph is presented in Figure 5, where the direction of change was considered (i.e. a rising water table being considered positive and a lowering water table, negative).

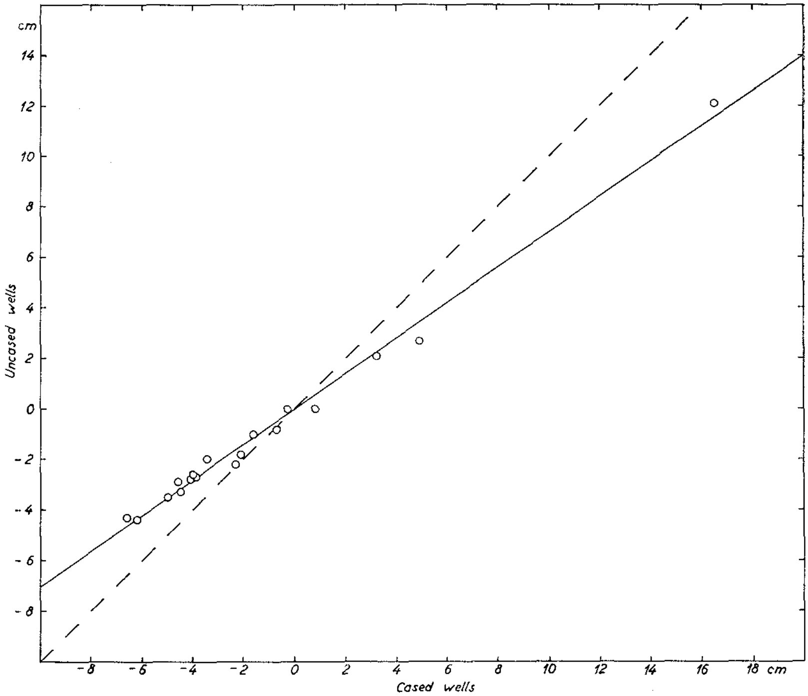


Fig. 5. The average daily change for the 10 uncased wells plotted against the average daily change for the 10 cased wells, May-figures, cf. Table 1.

Fig. 5. Den gennemsnitlige daglige ændring i grundvandstanden for de 10 uforede brønde (ordinat) lagt op over den gennemsnitlige daglige ændring for de 10 forede brønde, maj måned. Talværdier fra tabel 1.

From this graph there appears to be a definite difference between the line of best fit and a 45° line, which represents the graph that would result if both types of wells exhibited equal average changes.

To determine if a significant difference did exist between the data obtained from these two groups of wells, a simple regression analysis was made on the data of Figure 5:

$y = -0.04 + 0.70 \cdot x$ where x = the average daily change of the cased wells, and
y = the average daily change of the uncased wells.

A t-test was made on the simple regression coefficient and it was found to be significantly different from 1.0 at the 0.1 % level ($t = 17.4$ with d. f. $= 16$).

Other Statistical Analyses

A t-test was also performed to determine if a significant difference existed between the average daily change for the entire data collection period of each of the two well types (i.e., the hypothesis: $\bar{y} - \bar{x} = 0$).

A highly significant difference was found to exist between the means of the two types of wells (significant at the 0.1 % level with $t = 4.29$ with d.f. $= 17$).

Performance of the one-metre diameter well and the cased wells with glass wool fill

No statistical tests were made on the data from either the one-metre well or the two cased wells with glass wool fill. However, from Table 1 a few general comparisons may be made. The average absolute daily change of the cased wells with glass wool fill (Column 5) is nearly the same as that of the cased wells with sand fill (Column 3), i.e. 4.3 cm and 4.2 cm. Therefore, from this evidence it appears that these two types of observation wells react similarly to changing water levels.

In comparison, however, the average daily change of the one-metre well (Column 6) was only 2.4 cm as compared to the 4.2 cm average daily change for the cased 6 cm diameter wells. Therefore, the large one-metre well appears to be approximately one-half as responsive to a change in ground-water level as the small cased wells.

STATISTICAL COMPARISON OF THE TEN UNCASED WELLS AND THE TEN CASED WELLS WITH SAND FILL USING AUTUMN FIGURES

General

The changes in the depth to the water-table were measured for each 24-hour period from 3.30 p.m. on one day to 3.30 p.m. on the next. The measurements were made daily from 23rd November to 10th December, 1966, making a total of 17 periods. The results of these measurements are presented in Table 2, and as to the interpretation, reference is made to Table 1.

T a b l e 2. Average 24-hour water level changes (in centimetres) as recorded by the four types of wells for the November 23rd—December 10th, 1966 period. (For further explanation see footnote at Table 1).

T a b e l 2. Gennemsnitlige ændringer (cm) i grundvandstanden i 24-timers perioder for de 4 typer af brønde. Perioden 23. november—10. december 1966.

Date Nov.-Dec. / *Dato Nov.-Dec.*	Average daily change of the 10 uncased wells / *Gennemsnitlig døgnvariation for 10 uforede brønde*		Average daily change of the 10 cased wells with sand fill / *Gennemsnitlig døgnvariation for 10 forede brønde pakket med sand*		Average daily change of the 2 cased wells with glass wool fill / *Gennemsnitlig døgnvariation for 2 brønde forede med glasuld*	Daily change of the one large well / *Døgnvariation i den store brønd*
	Direction considered / *Beregnet med fortegn* (1)	Absolute / *Beregnet uden hensyn til fortegn* (2)	Direction considered / *Beregnet med fortegn* (3)	Absolute / *Beregnet uden hensyn til fortegn* (4)	(5)	(6)
23—24/11	0.2	0.9	0.2	0.6	0.3	1.5
24—25/11	—0.1	1.9	—0.1	1.2	1.5	2.0
25—26/11	—0.2	0.7	0.2	0.3	0.0	0.0
26—27/11	—0.1	1.1	—0.2	1.3	—0.3	1.0
27—28/11	8.8	8.8	10.8	10.8	9.0	5.5
28—29/11	13.6	13.6	15.5	15.5	12.0	7.5
29—30/11	9.7	9.7	7.2	7.2	11.3	13.5
30/11—1/12	42.8	42.8	47.0	47.0	48.0	39.5
1— 2/12	7.4	7.4	6.6	6.9	6.0	9.5
2— 3/12	—5.7	5.7	—6.8	6.8	—5.5	—5.5
3— 4/12	—5.9	5.9	—6.6	6.6	—5.8	—4.5
4— 5/12	—4.3	4.3	—4.6	4.6	—4.0	—3.5
5— 6/12	—2.9	2.9	—2.4	2.4	—1.5	—2.5
6— 7/12	—2.6	2.6	—3.2	3.2	—2.5	—5.0
7— 8/12	—1.5	1.5	—1.3	1.3	—2.5	—2.0
8— 9/12	15.6	15.6	16.5	16.5	18.3	13.0
9—10/12	4.2	4.2	4.9	4.9	3.5	4.5
Absolute subtotal	125.6	129.6	134.1	137.1	132.0	120.5
Average	7.4	7.6	7.9	8.1	7.8	7.1

A study of the graphs based on the spring figures showed that factors such as elevation, distance between well and tree, and depth to ground-water-table were only of little importance for the comparison of mean values for the types of well. These factors have therefore been left out of account at the working-up of the autumn figures.

REGRESSION ANALYSIS

The average daily changes for the 10 cased wells (Column 3, Table 2) have in Fig. 6 been compared graphically with the average changes for the 10 uncased wells (Column 1, Table 2).

The following regression equation has been computed :

$y = 0.16 + 0.91\ x$ where y = the average daily change of the uncased wells, and
x = the average daily change of the cased wells.

A t-test of the regression coefficient showed that at the 0.1 % level it was significantly different from 1.0, which is the degree of inclination of the angle bisector ($t = 4.81$ with d.f. = 15).

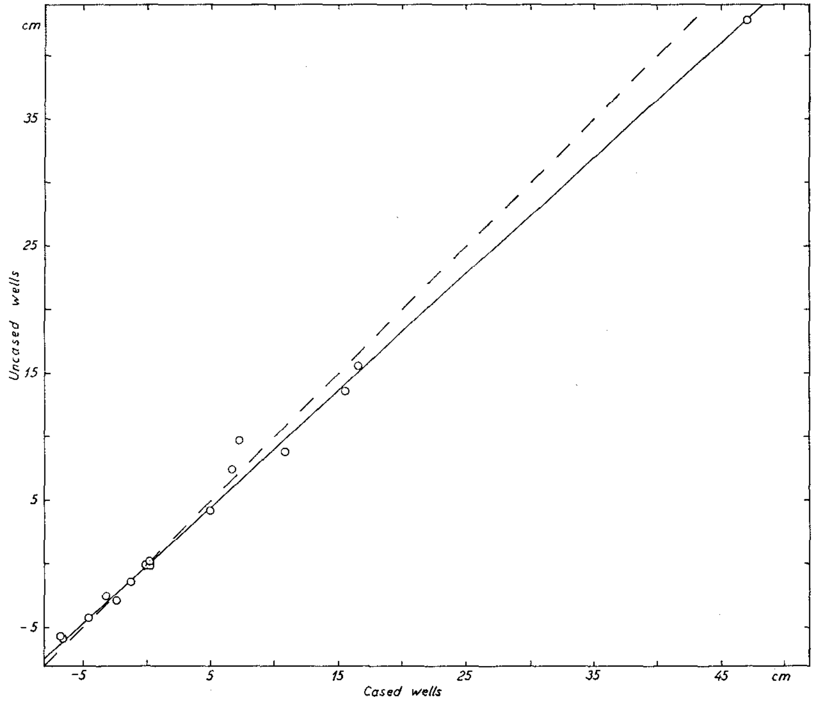


Fig. 6. The average daily change for the 10 uncased wells plotted against the average daily change for the 10 cased wells. November-December figures cf. Table 2.

Fig. 6. Den gennemsnitlige daglige ændring i grundvandstanden for de 10 uforede brønde (ordinat) lagt op over den gennemsnitlige daglige ændring for de 10 forede brønde, november-december. Talværdier fra tabel 2.

Furthermore, this autumn regression coefficient (0.91) was compared with the coefficient of 0.70, which was found on the basis of the spring measurements (see Fig. 5). The two coefficients are significantly different at the 0.1 % level ($t = 8.25$ with $d.f. = 31$).

PERFORMANCE OF THE ONE-METRE DIAMETER WELL AND THE CASED WELLS WITH GLASS WOOL FILL

Neither for the autumn measurements has there been made a statistical analysis of the sensibilities of these two types of well.

The tendencies are like those shown by the May-measurements, but the manifestations are less pronounced (Table 2).

The 2 cased wells with glass wool fill (Column 5, Table 2) show, on an average, the same sensibility as the 10 cased wells (Column 3, Table 2).

The one-metre well (Column 6, Table 2) has, on an average, shown the least sensibility, but the difference from the uncased wells (Column 1, Table 2) is only small. This may be due to the fact that the dug-up earth was not spread. During the summer it was trodden down, so that gradually it formed a funnel-shaped raised edge around the well. Some surface water may have been conducted to the well by this funnel-shaped edge, causing the water-table to rise faster than expected.

CONCLUSIONS

From the preceding it may be concluded that diameter and well type have a significant effect on water levels recorded in observation wells. From the foregoing analyses it appears that the cased 6 cm wells with sand fill can in spring be expected to have changes approximately 1.3 times as great as an uncased 12 cm well, but in autumn only 1.1 times as great. The evidence also indicates that the cased 6 cm diameter wells with glass wool fill reacted similarly to the cased, sand fill wells.

The difference in the magnitude of the effects in the two periods of measurements may — so far as a mere hypothesis — be explained by the physical conditions of the clayey soil. Desiccation makes the clay colloids shrink, and a system of fissures is formed in the soil, allowing the water to pass. The fissures will close up when the soil is soaked, as the colloids will then swell again. This swelling, however, takes some time (cp. *Holstener-Jørgensen et al.*, 1968), so that the passage of water can take place more freely in the autumn and early winter than in spring. It is probable that this circumstance — suggested here as a hypothesis — may explain the weaker manifestation of the tendencies. In that case it must, moreover, be presumed that the wells (both types) show the true position of the ground-water level more precisely in the autumn than in the spring.

Therefore, it seems that in ground-water studies which consider daily or other short-term changes, small-diameter, cased wells will give a more accurate record of the changes in ground-water level than will larger, uncased wells.

Where it is a question of measurements at greater intervals (14 days or more) it is, on the other hand, hardly possible to record essential differences between the type of uncased well used in the present investigation and cased wells with small diameters. For studies of this type there is, therefore, no reason why cheaper, uncased wells should not be used.

DANSK SAMMENFATNING

På svær lerjord med højtstående grundvand kan man måle grundvandspejlets beliggenhed under jordoverfladen i borede huller (grundvandsbrønde), som når ned i den vandmættede jord. Det er nærliggende at *antage*, at man finder vandstandsbevægelser af forskellig størrelse, alt efter hvor stor en diameter brønden har. Grundvandsbrønde er små vandreservoirer. Jo større diameter en brønd har, desto større reservoir danner den. Reservoiret har følgende indflydelse på vandspejlsbevægelserne.

Når grundvandet er vigende (forår og sommer) vil det tage nogen tid, før brøndens vand trænger ud i den omgivende, svært gennemtrængelige lerjord. Det vandspejl, som man finder i brønden, er derfor noget højere end det „rigtige“ vandspejl i jorden. „Fejlen“ stiger med brønddiameteren, det vil sige reservoirets størrelse.

Når grundvandet er stigende (efterår og vinter), virker brøndene som dræn for de omgivende jordlag. Lerjordens grovporevolumen er lille, så brønden fyldes langsomt. I denne situation vil brønden derfor vise et vandspejl, som ligger noget dybere end vandspejlet i jorden. „Fejlen“ stiger også i dette tilfælde med brønddiameteren.

For at undersøge denne antagelses rigtighed begyndtes i foråret 1966 en undersøgelse i en 90-årig bøgebevoksning på Vallø. Figur 1 viser, hvilke brøndtyper der er anvendt, og deres indbyrdes placering på arealet. Vandspejlets afstand fra jordoverfladen måltes i alle brønde en gang daglig (samme klokkeslet) i perioden fra 4. maj til 22. maj og i perioden fra 23. november til 10. december.

Terrænet på undersøgelsesarealet er plant; men der er dog små koteforskelle. Brøndene blev placeret helt tilfældigt på arealet. Der blev kun taget det hensyn, at de skulle ligge mindst 10 m fra nærmeste grøft. Brøndene har derfor forskellig afstand fra træer. Figur 2 viser, at der ikke er nogen klar sammenhæng mellem koter og gennemsnitlig daglig vandstandsbevægelse i perioden 12.—19. maj (nedbørsfri periode). Figur 3 viser, at der heller ikke er nogen klar sammenhæng mellem afstand til træer og den gennemsnitlige daglige vandstandsbevægelse i den samme periode. Endelig kunne det tænkes, at der var tale om en opsummeret effekt, således at afstanden til grundvandspejlet ved periodens begyndelse havde indflydelse på vandspejlsbevægelserne. Figur 4 tyder ikke på en sådan indflydelse.

Figurerne 5 og 6 viser, hvilke sammenhænge der er mellem vandstandsændringerne i uforede brønde (ca. 12 cm indvendig diameter) og vandstandsændringerne i forede brønde (6 cm indvendig diameter). Der er anvendt gennemsnitlige, daglige ændringer med hensyntagen til fortegn (stigninger = positive, fald = negative). Figur 5 dækker maj-målingerne, figur 6 november-december målingerne. På begge figurerne er vinkelhalveringslinien tegnet ind. Det fremgår, at de uforede brønde i begge perioder viser mindre stigninger eller fald end de forede brønde. Forskellene mellem de to brøndtyper er dog væsentlig større i forårsmånederne end i efterårsmånederne.

Forskellen i „udslag“ mellem de to måleperioder kan — foreløbig rent hypotetisk — sættes i forbindelse med lerjordens fysiske forhold. Ved udtørring skrumper lerkolloiderne, og der dannes i jorden et sprækkesystem, som vandet kan bevæge sig i. Sprækkerne lukker sig, når jorden gennemfugtes, idet lerkolloiderne påny kvælder. Denne kvældning tager imidlertid nogen tid (jfr. *Holstener-Jørgensen et al.*, 1968), således at vandbevægelsesmulighederne i efterårsmånederne og de tidlige vintermåneder er større end i forårsmånederne. Det er sandsynligt, at dette — hypotetiske — forhold kan forklare udjævningen af udslaget. Om så er, må man i øvrigt antage, at brøndene (begge typer) om efteråret bedre end om foråret viser det sande grundvandspejls beliggenhed.

Sprækkesystemets eksistens kan man i øvrigt let overtyde sig om i naturen. Hvis man tager en frisk lerklump og bryder den mellem hænderne, så vil den bryde efter mere eller mindre regelmæssige flader. Disse flader har et brunt overtræk af veliltede jernforbindelser (Ferriforbindelser). Brydes klumpen på tværs af sådanne flader, kan man se, at resten af materialet har en grå til gråblå farve, fordi jernforbindelserne her er mindre iltede (Ferroforbindelser). Sprækkesystemets veliltede, brune overtræk viser, at systemet, når det er åbent, er velgennemluftet. Meget ofte kan man konstatere, at rødder følger sprækkesystemer.

På undersøgelsesarealet blev der også anbragt en brønd med en indvendig diameter på 1.0 m (jfr. figur 1). Denne brønd viste sig som ventet at være mindst følsom (tabel 1 og tabel 2). Forskellen mellem den og de øvrige brønde er størst i maj måned og lille ved efterårsmålingerne. Hvad denne brønd angår, kan man ikke se bort fra den mulighed, at der sidst på året er sket en overfladetilstrømning. Den opgravede jord blev ikke spredt, og den dannede sidst på sommeren en fasttrampet tragt omkring brønden.

En bevilling fra Statens teknisk-videnskabelige Fond har gjort det muligt at gennemføre undersøgelsen. Vi vil gerne her bringe Fondet vor varmeste tak.

Endvidere er det os en kær pligt at takke Vallø skovdistrikt, fordi arealet beredvilligt blev stillet til rådighed for undersøgelsen, ligesom vi gerne vil takke skovfoged *Hjerrild*, fordi han påtog sig arbejdet med målingerne i november-december.

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