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ADDITIONAL HYDROGEOLOGICAL SURVEY OF THE ARCO CHEMICAL PRODUCTS EUROPE PLANT SITE AT RIEME (BELGIUM)

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ARCO CHEMICAL
PRODUCTS EUROPE

ATO ATOCHEM

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1. INTRODUCTION

By its letter of June 15th 1987 ATOCHEM instructed the Laboratory of Applied Geology and Hydrogeology of the State University Ghent to carry out an additional hydrogeological investigation at the Rieme plant site. The test programme was outlined during a meeting held at O.V.A.M. and the State University Ghent.

The hydrogeological investigation was to include

1. Boreholes and lithological description
2. Sampling (ground and water)
3. Pumping tests
4. Mathematical modelling of groundwater flow and quality

The investigation started on June 30th 1987. The present report relates its actions and results. The following subjects are treated successively : geology, drilling, groundwater flow, pumping tests, groundwater quality, mathematical model.

2. GEOLOGY

A detailed description of the geology of the area was given in the 1986 report TGO 86/13(1) "Hydrogeological survey of the ARCO CHEMICAL PRODUCTS EUROPE plant site at Rieme (Belgium)" by the Laboratory of Applied Geology and Hydrogeology (Prof. Dr. W. De Breuck).

The regional geology is given in figure 1.

The subsoil of the northern part of the Province of East-Flanders is characterised by the presence of a thick complex of Tertiary formations monoclinally dipping in a northeastern direction, covered by Quaternary deposits.

The larger part of the Quaternary deposits have been laid down in periglacial conditions during the Pleistocene. Hydrogeologically they consist of a continuous sandy top layer (KZ2) on a semi-pervious silty layer (KL) resting upon a continuous sandy layer (KZ1).

The Tertiary substratum is formed by alternating pervious, semi-pervious and impervious layers. They are indicated on the geological section (fig. 3) as s3, Le-P, Yd (pervious), s2, s1, Plc (semi-pervious), and a3, a2, and a1 (impervious).

The layers to be considered under the Rieme plant are :
KZ2 : unconfined aquifer, sandy
KL : confining layer, silty
KZ1 : semi-confined aquifer, sandy
a3 : impervious substratum, clay

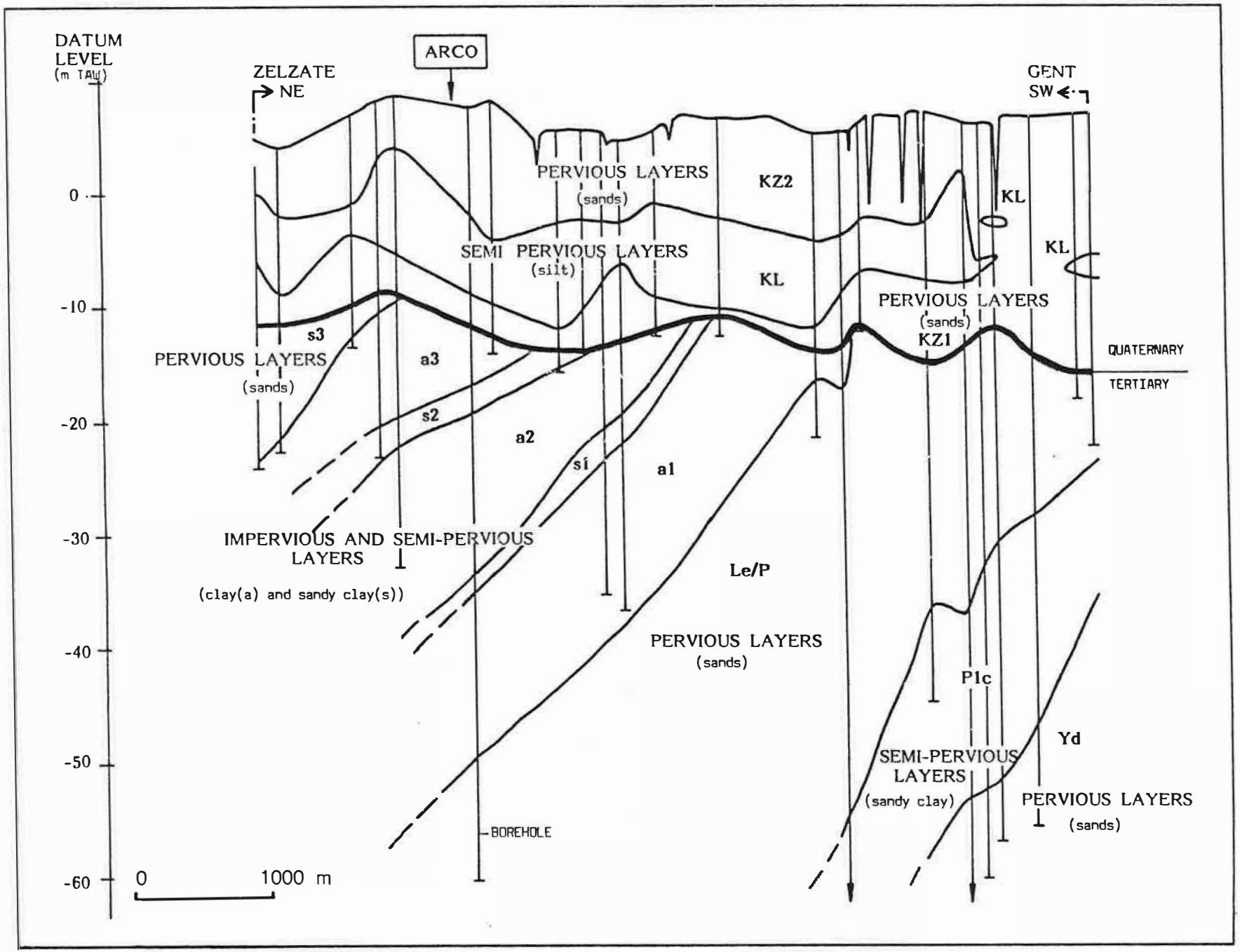

Fig. 1 - Geologic cross section Gent-Zelzate (DE BREUCK, VAN BURM & VAN CAMP, 1983)

3. DRILLING

3.1. General

According to the proposal several boreholes were made :
- seven rotary-drilled holes of variable depth for installation of screens to be used for the pumping tests
- eleven cable-tool drilled ("dry") holes to the bottom of the KZ2 layer
- three special cable-tool drilled holes to the bottom of the KZ1 layer.

The location of every borehole was determined as well as the elevation[1] of the site and the reference points on the observation wells (appendices 1 and 2).

A general lay-out is given in map 1. On this map the formerly drilled holes are also indicated.

The borelogs are given in appendix 1.

3.2. Rotary drilling

In the northern part of the Rieme plant seven holes were rotary drilled (with normal circulation of clean water) to install
- two wells (4D2, 4D3) in KZ1
- three wells (4S1, 4S2, 4S3) in KZ2
- one well (4S4) near the water table (also in KZ2)
- one well (4S5) in KL

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[1] referring to the datum level of the National Geographical Institute (NGI)

The well 4S1 is pumping well in KZ2.
The arrangement is outlined in figure 2 and the construction is shown in the figures 3 and 4.

The wells (except 4S1) consist of a PVC riser pipe (DYKA PVC NBN T42-111 PN10 ϕ 63 mm) and a PVC screen (mostly 2 m) (VAN RYSWYCK - VEGHEL BV HOLLAND ϕ 63 mm NP10). The well-diameter of 4S1 is 125 mm.

The gravel pack around all the screens is made of coarse sand (0,7 - 1,25 mm). The clay seals at the level of the KL layer and above the gravel packs are made of DURANIT or COMPACTONITE clay pellets to prevent downward seepage along the borehole.

3.3. Cable-tool drilling

Eleven holes (1Sbis, 2Sbis, 6S, 7S, 8S, 9S, 10S, 11S, 12S, 13S, 14S) have been made by augering and bailing (figure 5). The holes attained the top of the semi-pervious KL layer. They had a diameter of 168 mm. During the drilling no water was added to ensure uncontaminated sampling and accurate description. During the drilling and in between separate drillings the auger, the bailer and the casing were rinsed with clean water.

During the drilling of the holes 1Sbis and 2Sbis no samples were taken, since this was already done during the drilling of 1Dbis and 2D.

Samples retrieved from the other boreholes were described on the spot. This description included colour, grain size, silt and clay content, inclusions and odour (appendix 1). The description was made according to the classification used by the Laboratory of Applied Geology and Hydrogeology, which is

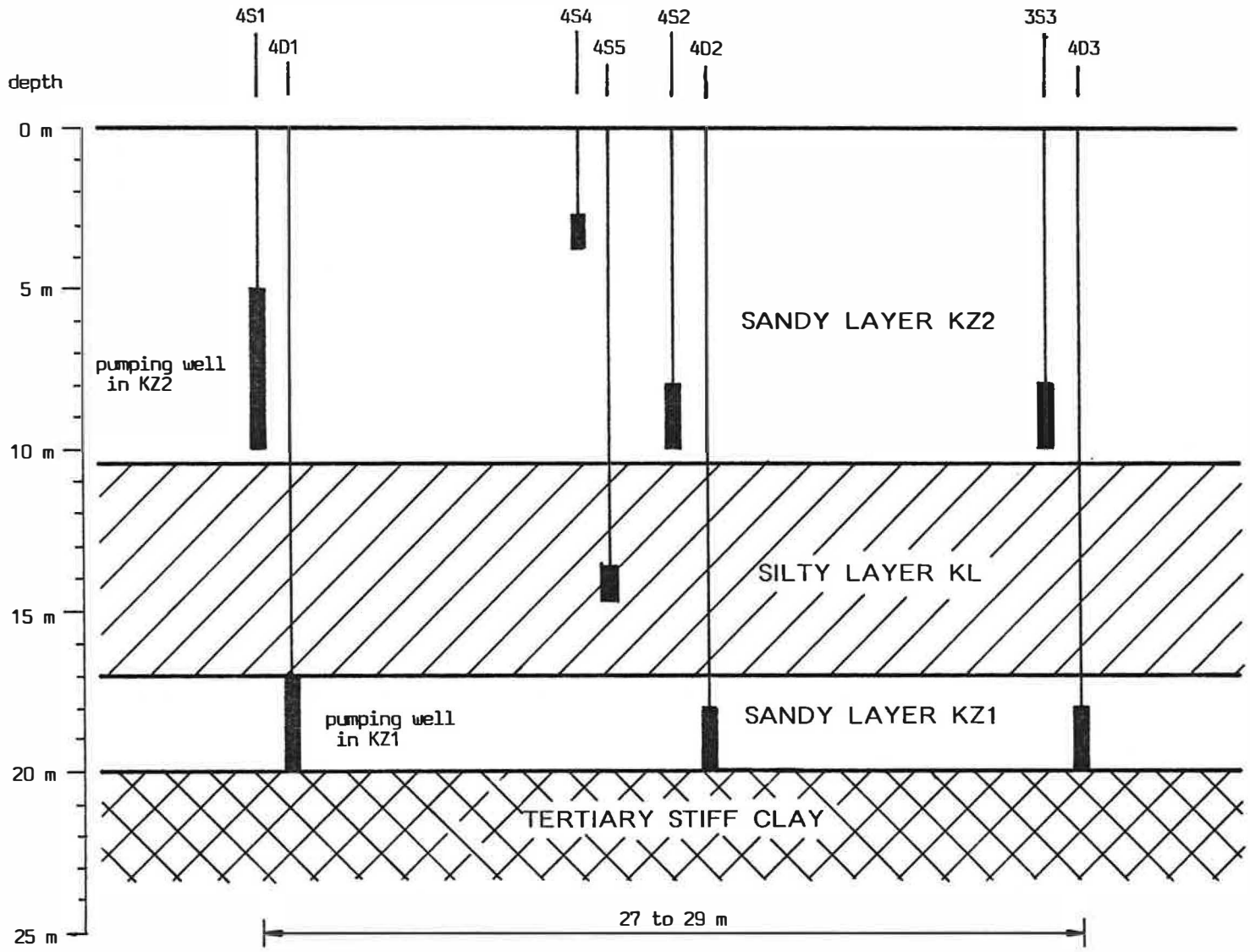

Fig. 2 - Wells for pumping tests.

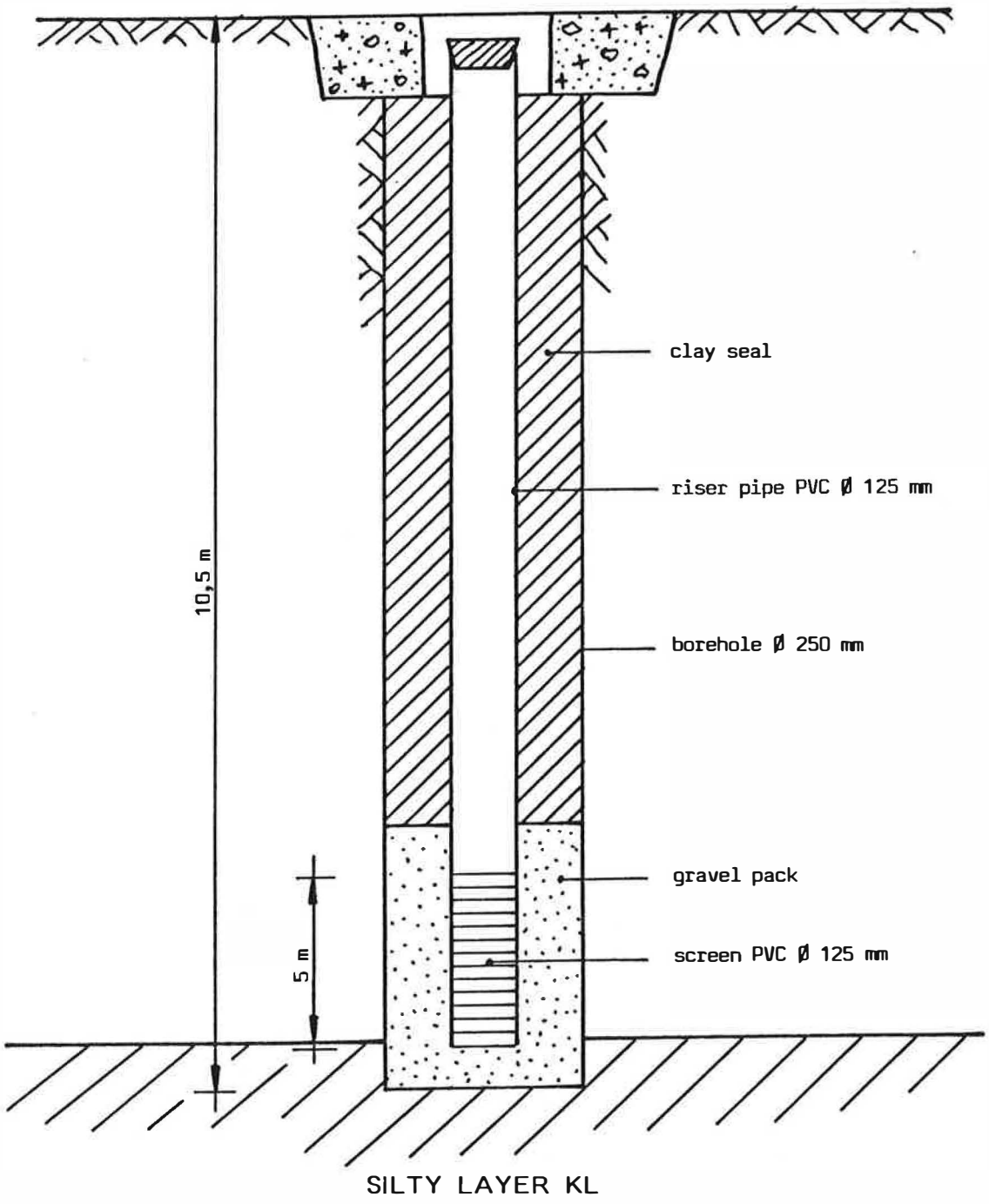

Fig. 3 - Well 4S1

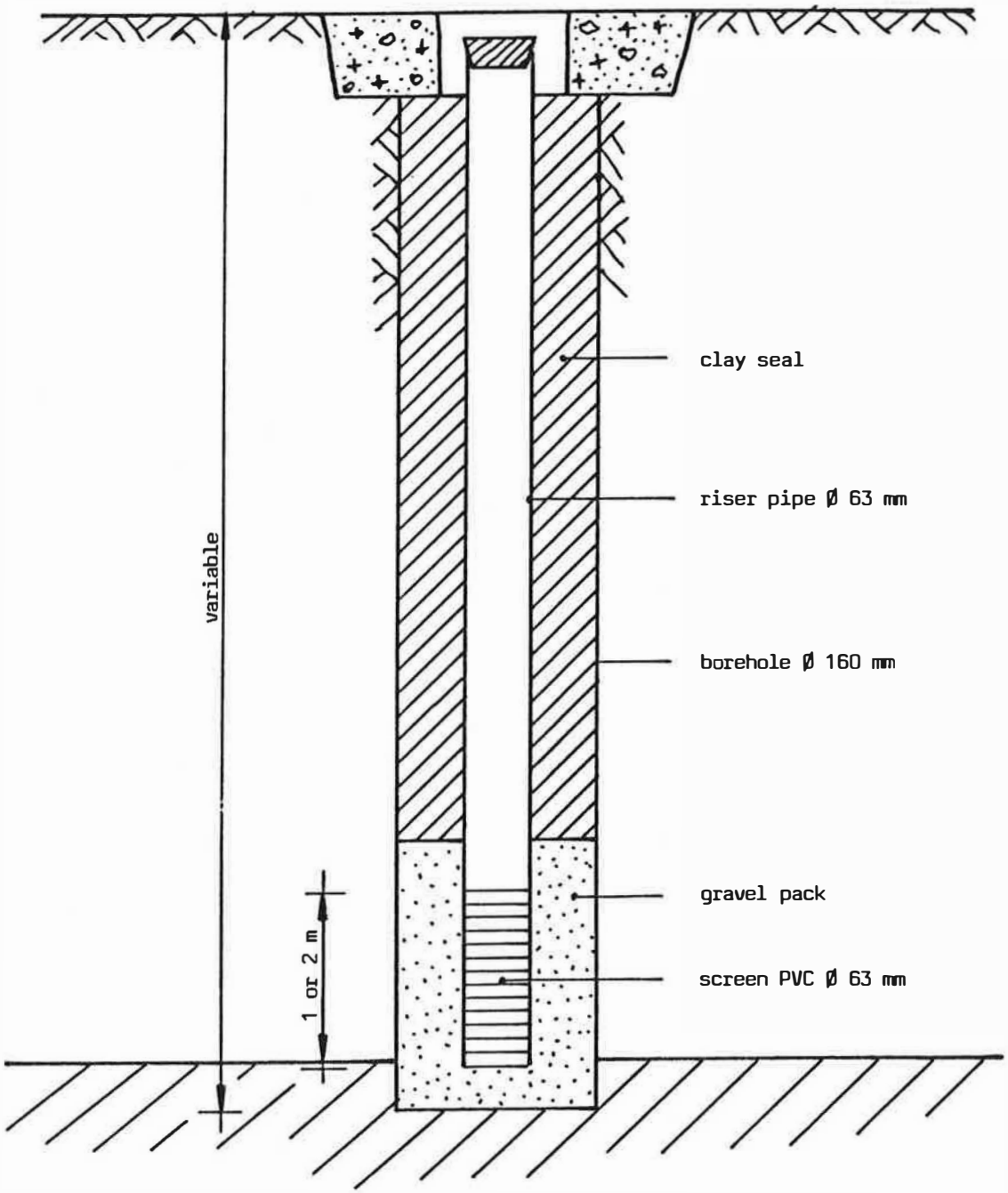

Fig. 4 - Wells 4S2, 4S3, 4S5, 4D2, 4D3

based upon the classification of the Department of Public Works.

Samples, taken every m, have been packed in 1L glass containers. The samples that were not analyzed are still stored at a temperature of 2 to 4 °C.

In each borehole a 2 m PVC screen (ϕ 63 mm) was installed at the bottom of KZ2. The borehole completion is shown in figure 5.

3.4. Special cable-tool drilled holes

Three boreholes (1Dbis, 2D and 4D1) in the KZ1 layer are of a special construction (figures 6 and 7).

First, the holes were drilled with a large diameter (267 mm) into the upper part of the semi-pervious layer KL. Then a protective casing (PVC DYKA-RIOOL 200 x 3,90) was installed and pushed 0,5 to 1 m deeper into the KL layer. Around this casing, bentonite grouting was inserted. The proportion bentonite to cement was about 1/3.

After 1 day stabilisation of the bentonite + cement grout, drilling was continued with smaller diameter (168 mm) trough the inside of the protective casing until the bottom of the pervious layer KZ1 was reached. A screen of ϕ 63 mm (1Dbis, 2D) or a pumping well of ϕ 125 mm (4D1) was installed. Around the screen a gravel pack was placed with a clay seal above it. Before the equipment of the pumping well 4D1 the hole was jetted with clean water to flush the hole and to allow a better screen development.

The installation of a protective casing enclosed in a bentonite-cement seal and filled with a clay seal prevents all

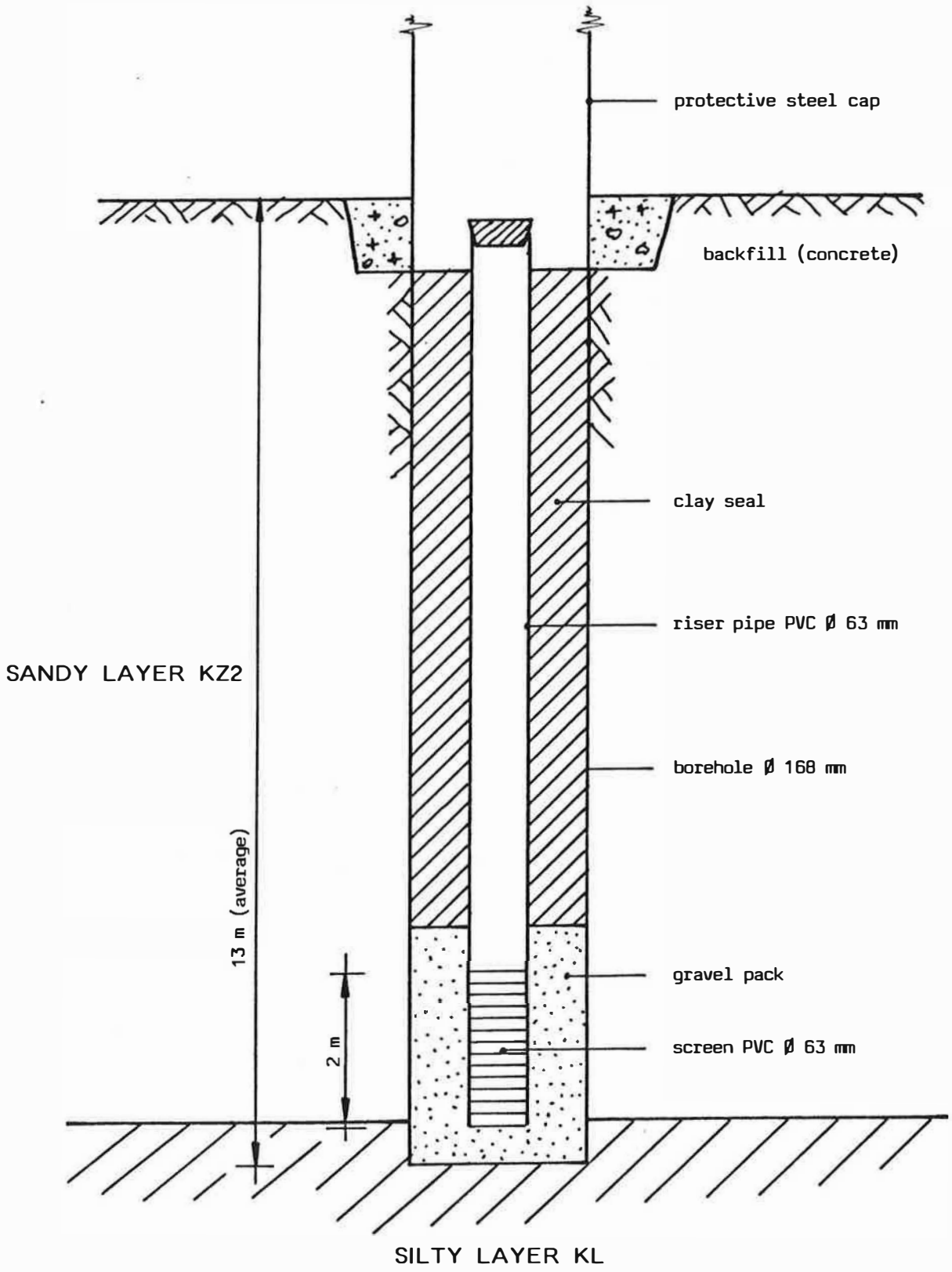

Fig. 5 - Wells 6S → 14S and 2Sbis, 1Sbis

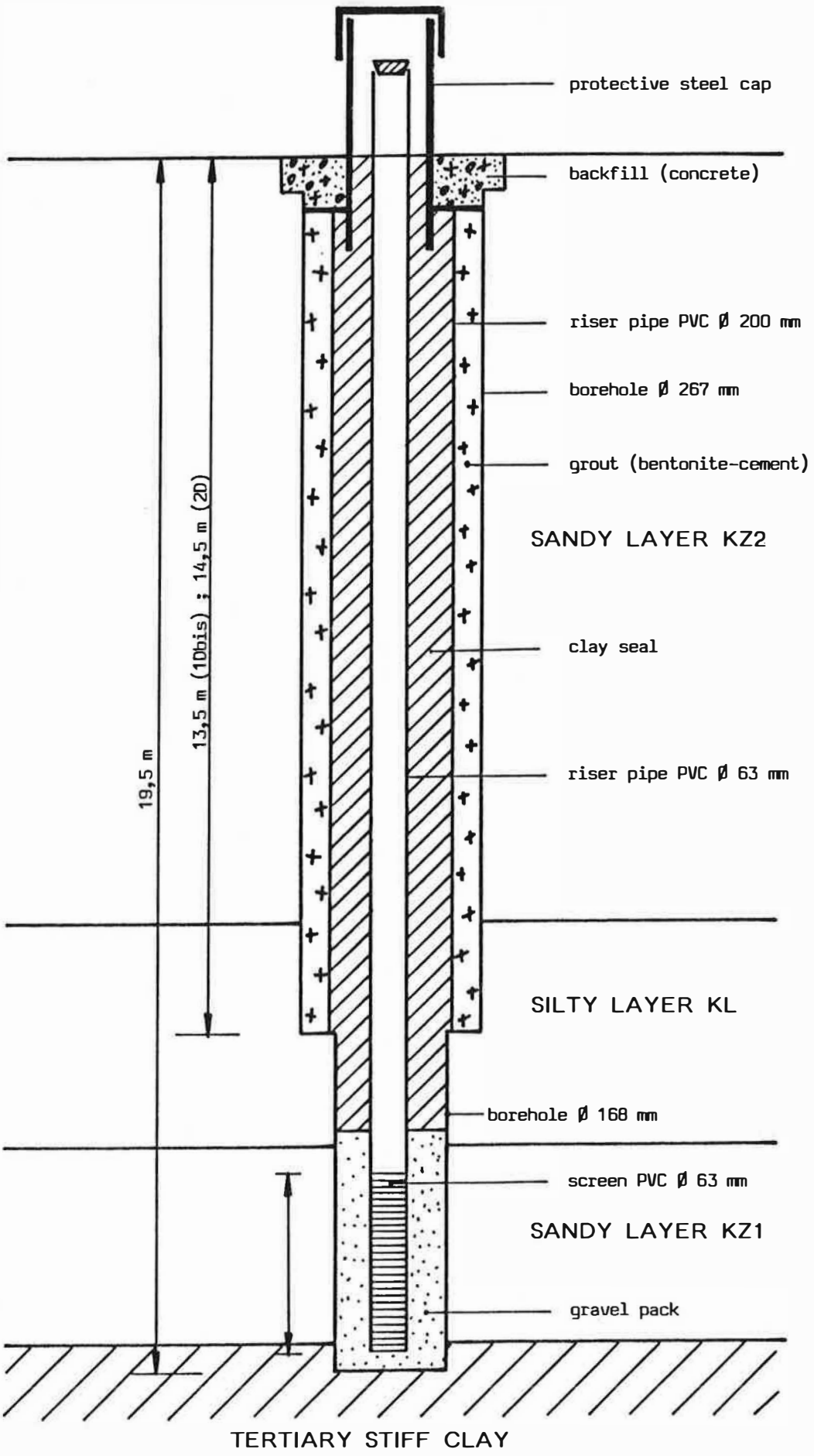

Fig. 6 - Wells 2D and 1Dbis

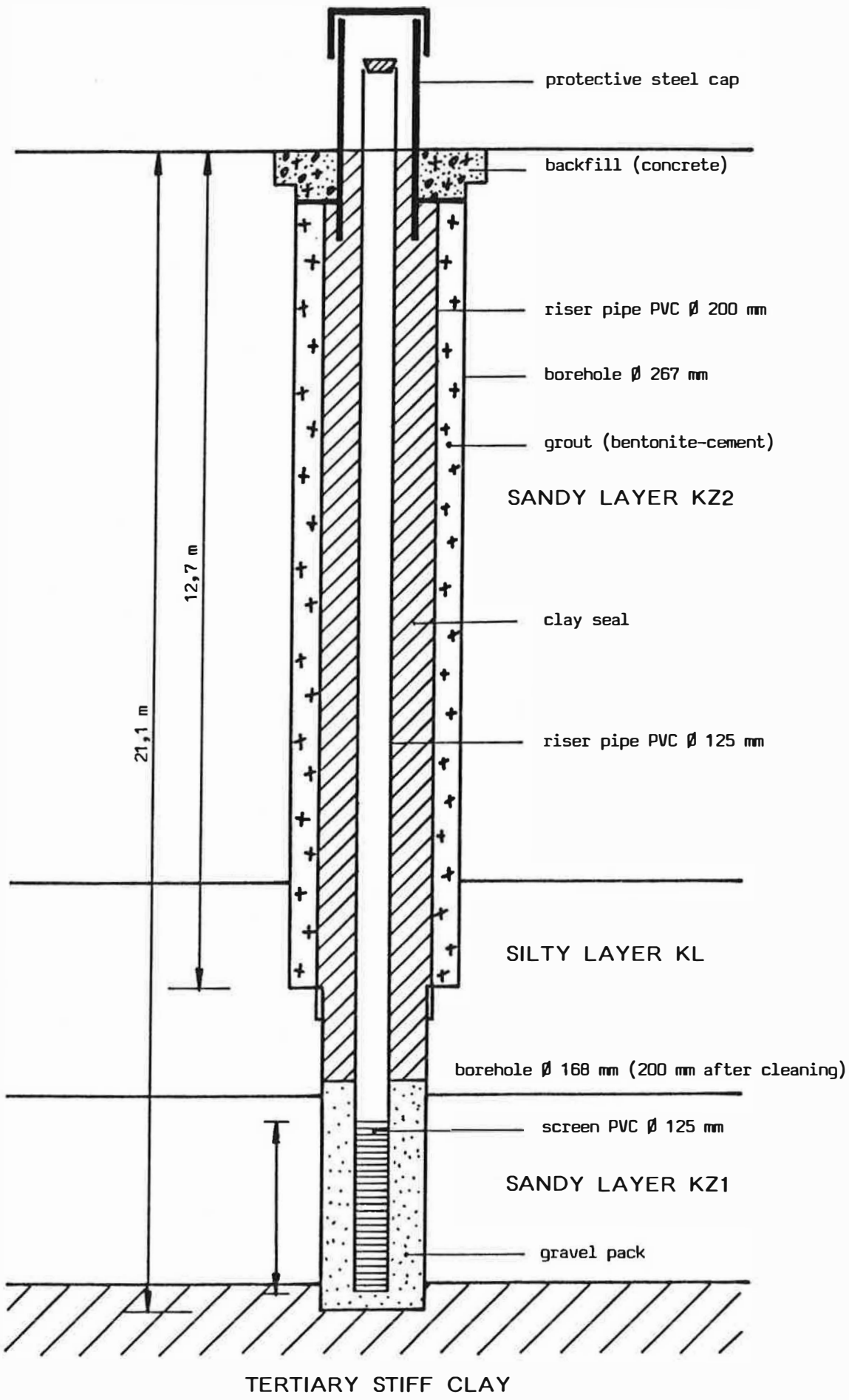

Fig. 7 - Well 4D1

contamination from the KZ2 to the KZ1 and vice versa during drilling and sampling.

3.5. Cross-section B-B'

Based upon the new borelogs a geological cross-section has been drawn. The layers have already been discussed in a previous report of the Laboratory of Applied Geology and Hydrogeology.

4. GROUNDWATER FLOW

4.1. General

The groundwater flow pattern is based on the water level measurements in the previous (1986) and recently (1987) drilled wells. A characterisation of these wells is given in appendix 2.

4.2. Water-level measurements

The water levels were measured on August 5th, 1987 (table 1).

4.3. Head distribution in the KZ2 and the KZ1 aquifers

The figures 8 and 9 are showing the contours of the heads on August 5th, 1987. The flow direction in both aquifers is from north to south and southeast in the southern part of the area and from north to south and southwest in the northern part of the area. The heads are very similar to those of June 1986, but in the contours the bend to the southeast and the southwest is more pronounced. The groundwater flow follows the general pattern from the RHONE-POULENC CHEMIE gypsum pile towards the canal.

The head difference between KZ2 and KZ1 is small and attains a maximum in the northwestern part of the area, which is likely to be influenced by the drainage ditch around the RHONE-POULENC CHEMIE gypsum pile.

Table 1. Heads in the KZ2 and the KZ1 aquifers and in the KL semi-pervious layer on August 5th, 1987.

Well nr.	Head (m versus datum NGI = m TAW)
KZ2 layer	
1S	+ 6,972
1Sbis	+ 6,931
2Sbis	+ 7,195
3S	+ 6,870
4S1	+ 8,059
4S2	+ 8,025
4S3	+ 7,930
4S4	+ 8,056
5S	+ 7,312
6S	+ 7,593
7S	+ 7,426
8S	+ 7,584
9S	+ 7,266
10S	+ 7,257
11S	+ 7,140
12S	+ 7,131
13S	+ 7,067
14S	+ 7,040
KL layer	
4S5	+ 8,079
KZ1 layer	
1D	+ 6,946
1Dbis	+ 6,956
2D	+ 7,161
3D	+ 7,458
4D1	+ 8,071
4D2	+ 8,082
4D3	+ 8,087
5D	+ 7,296

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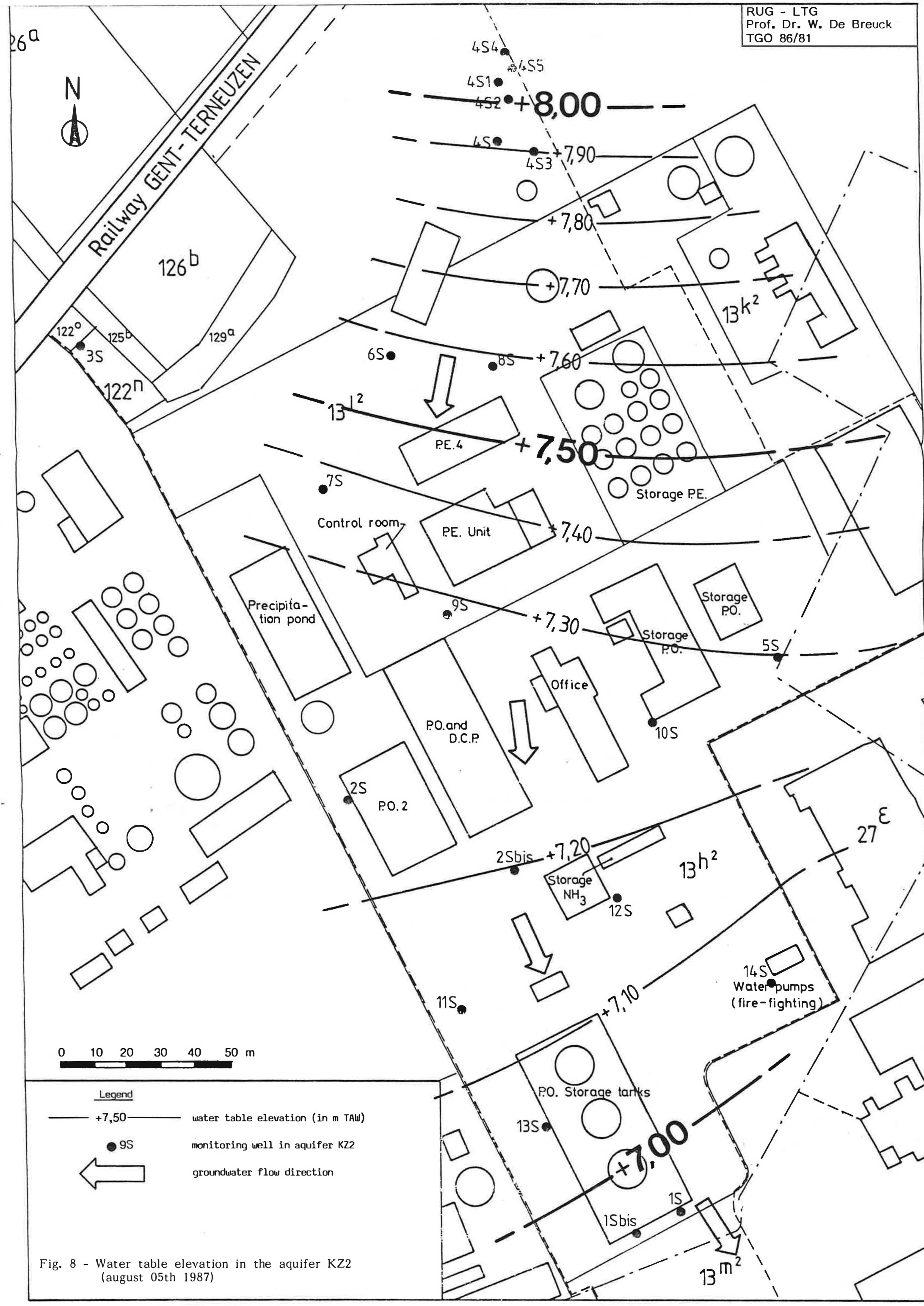

Fig. 8 - Water table elevation in the aquifer KZ2 (august 05th 1987)

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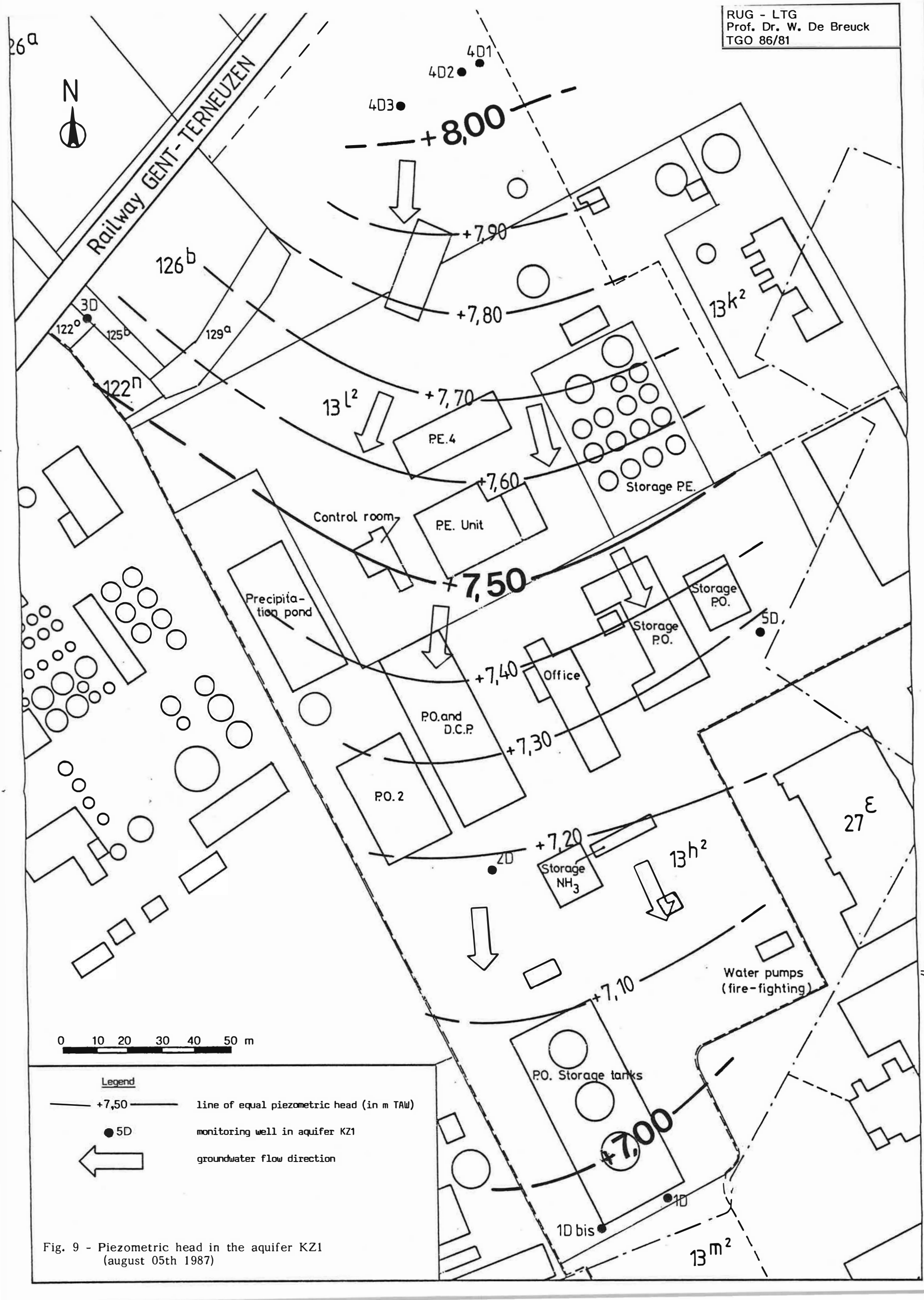

Fig. 9 - Piezometric head in the aquifer KZ1
(august 05th 1987)

5. PUMPING TESTS

5.1. Conduction of the pumping tests

The pumping tests were conducted to determine the hydraulic characteristics of the layers which are used on their turn to calculate the groundwater flow velocity and to elaborate the mathematical model which calculates the distribution of the pollution.

Two pumping tests were executed. The configuration of the pumping and observation wells is indicated on figures 2 and 10 .

During the first pumping test, carried out on July 8-9, 1987, water was extracted from the pumping well 4D1 (layer KZ1) with a constant discharge rate of 188,34 m^3/d. The drawdowns were measured automatically in all the other wells at regular time intervals, following a logarythmic scale. The measuring was done by means of pressure transducers VEGA type 137.01 which can registrate a maximum change of 4 m water pressure head and have an accuracy of 0,1 %. A packer was placed above the pressure transducer to eliminate water flow from the observated well into the groundwater reservoir. Time and pressure drop were registrated on magnetic tape with the use of a measuring- and registration unit MESS & SYSTEMS TECHNIK, logmaster MDL 1000.

During the second pumping test, on July 13-14, 1987, water was extracted with a constant discharge rate of 30,884 m^3/d out of the pumping well 4S1 with the layer KZ2. The drawdowns were measured in the same way as in the first pumping test.

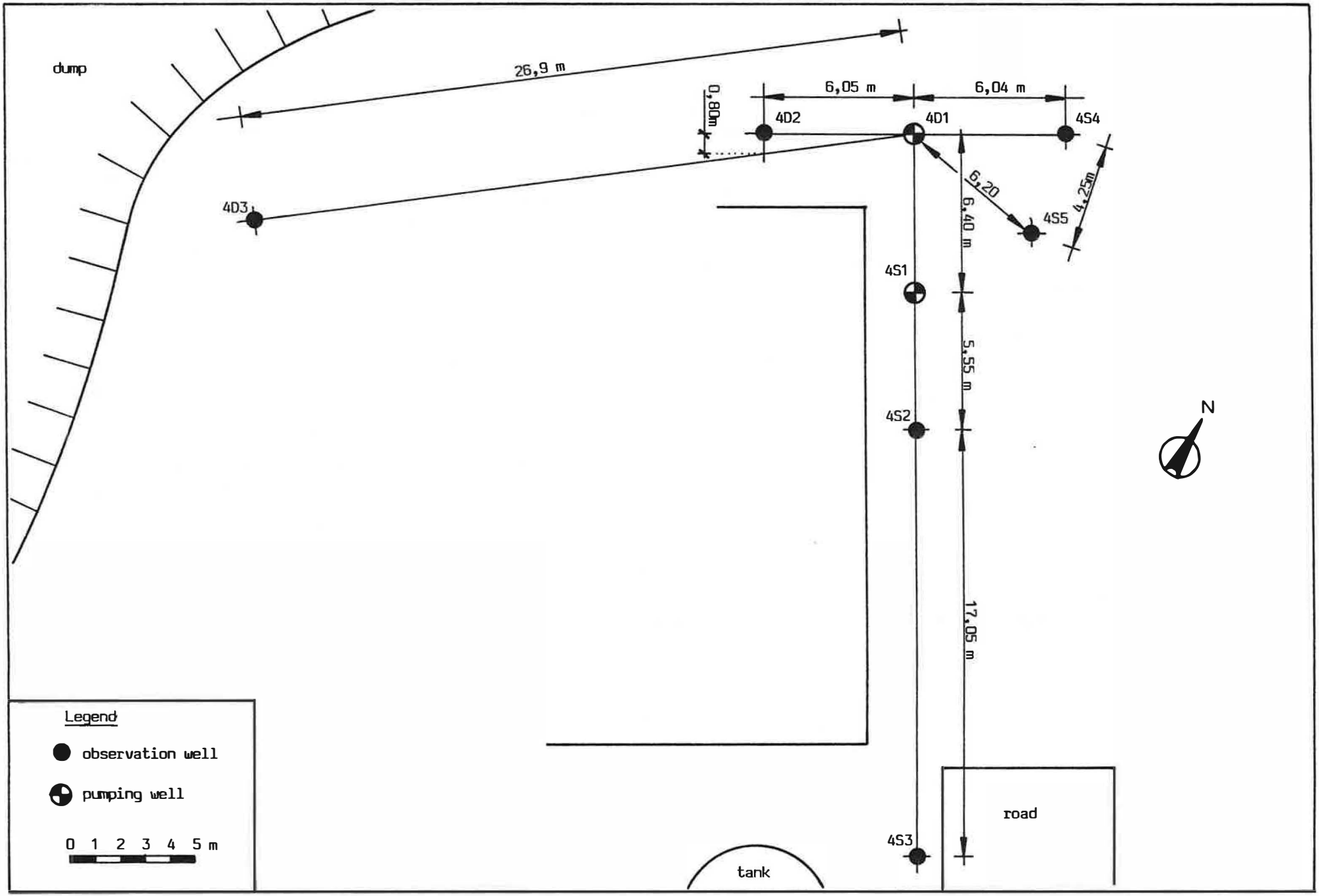

Fig. 10 - Location of wells for pumping tests.

5.2. Interpretation by means of an inverse model

By the application of an inverse model the hydraulic parameters are deduced from the observed drawdowns of the pumping tests. In this model the drawdowns are calculated by a finit-difference axial-symmetric model. By the minimization of the sum of the squares of the deviations between the calculated and the observed drawdowns one can deduce the values of the hydraulic parameters and their accuracies.

In the numerical model the groundwater reservoir is schematized in five different layers as shown in figure 11. The introduction of the thin layer 5 permits a treatment of the groundwater flow from the water table to the groundwater reservoir.

In the model each layer is subdivided in a number of coaxial rings. The axis of the rings coincides with the axis of the pumped well. The outer and inner boundary of two successive rings are formed by the same cylinder. The radii of the coaxial cylinders, that form the boundaries of the rings, increase logarythmically. The number of rings is chosen sufficiently large, so that there can occur no drawdown in all the layers at a corresponding large distance to the pumped well.

Every layer is characterized by a horizontal conductivity k and a specific elastic storage S'_A. Between each two layers a hydraulic resistance c (this is the distance between the middle of the layers, divided by the vertical conductivity) has to be considered. By the introduction of firstly estimated values of these hydraulic parameters the drawdowns are calculated with the help of the numerical model which applies the law of Darcy and the continuity law. The calculated and the observed drawdowns are then compared. With the help of

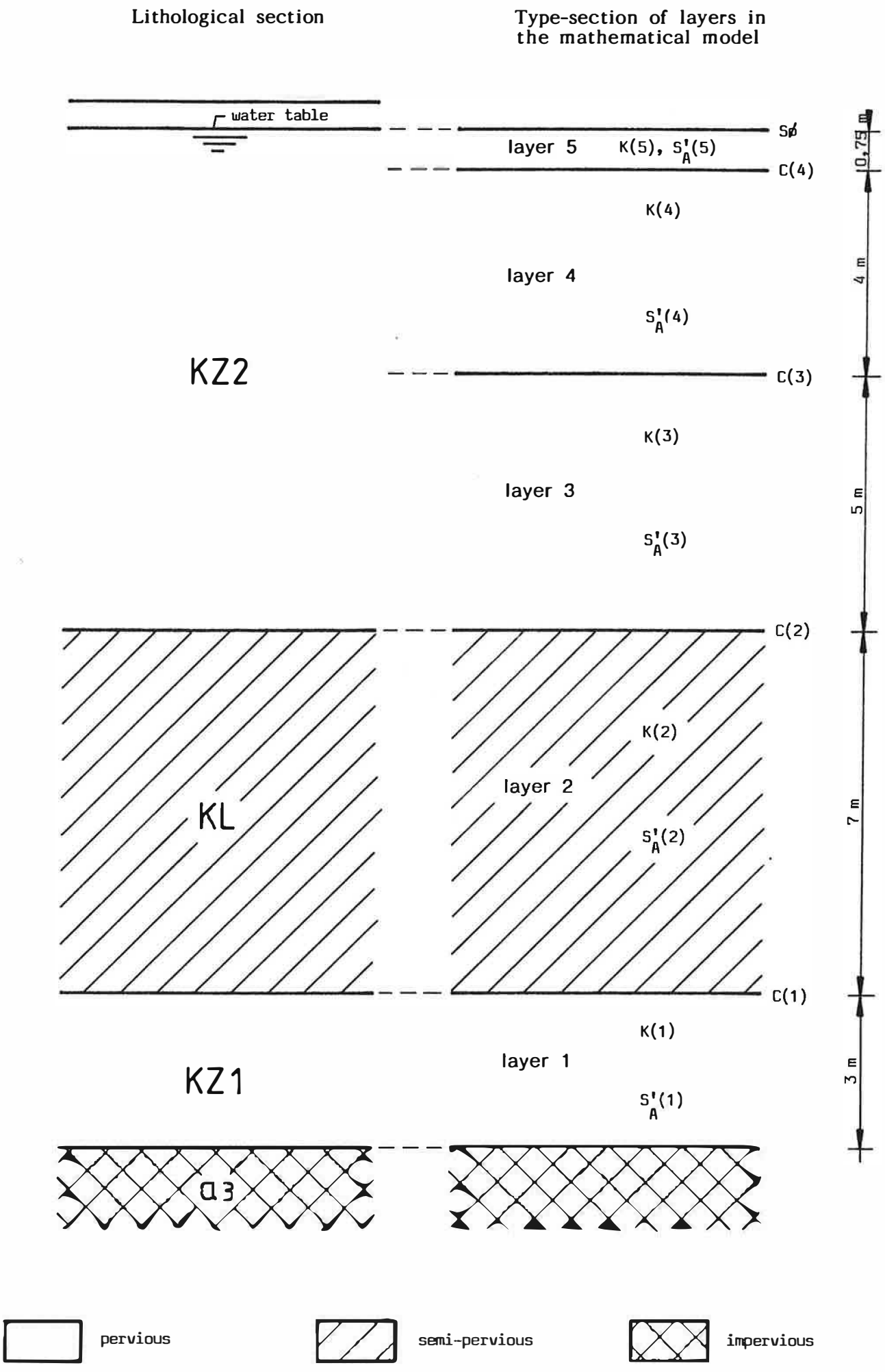

Fig. 11 - Schematization of the groundwater reservoir.

their differences and of the sensitivities of the drawdown to the hydraulic parameters, these paremeters are adjusted in such a way that the difference between observed and calculated drawdowns becomes smaller.

By the repeatedly application of this method the sum of the squares of the deviation between the observed and the calculated values is minimized. Once the minimum value of this sum is reached, one obtains the values of the hydraulic parameters. From the sensitivities and the remaining deviations between calculated and measured drawdowns the accuracy of the obtained values of the hydraulic parameters is deduced.

5.3. Results

The observed drawdowns of the two pumping tests are shown in time-drawdown and distance-drawdown curves by means of crosses (figures 12 and 13). The calculated drawdowns corresponding to the deduced values of the hydraulic parameters are represented in the same figures by the curves.

The deduced values of the hydraulic parameters are given, together with their accuracy factor in table 2. By the multiplication or division of the deduced value of the parameters by the accuracy factor one obtains respectively the upper or the lower limits of the confidence range with a probability of 98 %. The actual values are within this range. The more the accuracy factor approaches a value of 1, the higher the accuracy of the corresponding value.

From this table one can conclude that the horizontal conductivities of the pumped layers, k(1) and k(3) and the hydraulic resistandes c(1) and c(3) are very accurately known. These values, which result in the most important conductivity properties of the aquifers, are followed in accuracy by all

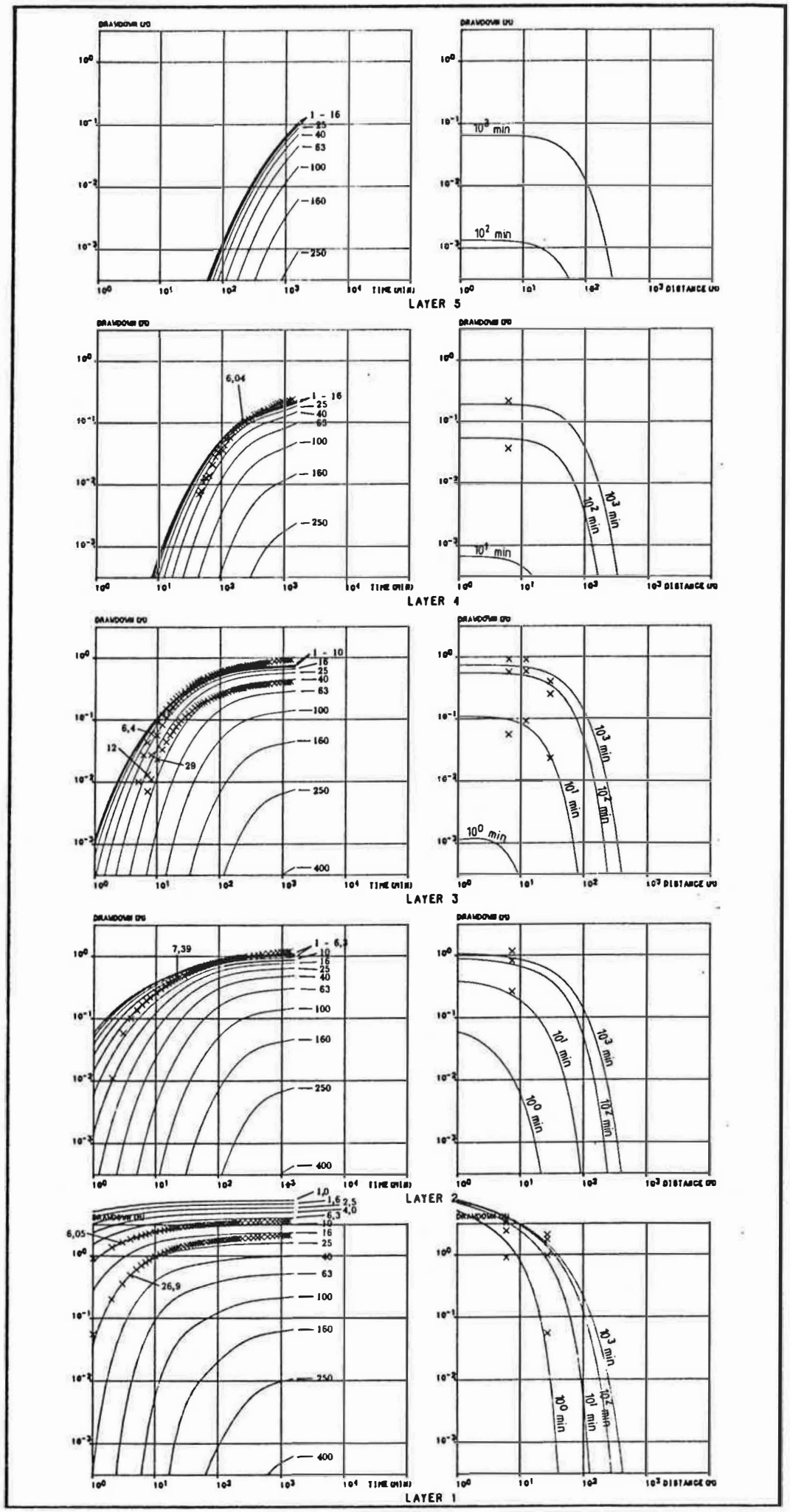

Fig. 12 - Observed (x) and calculated (curves) drawndowns during the pumping test in KZ1

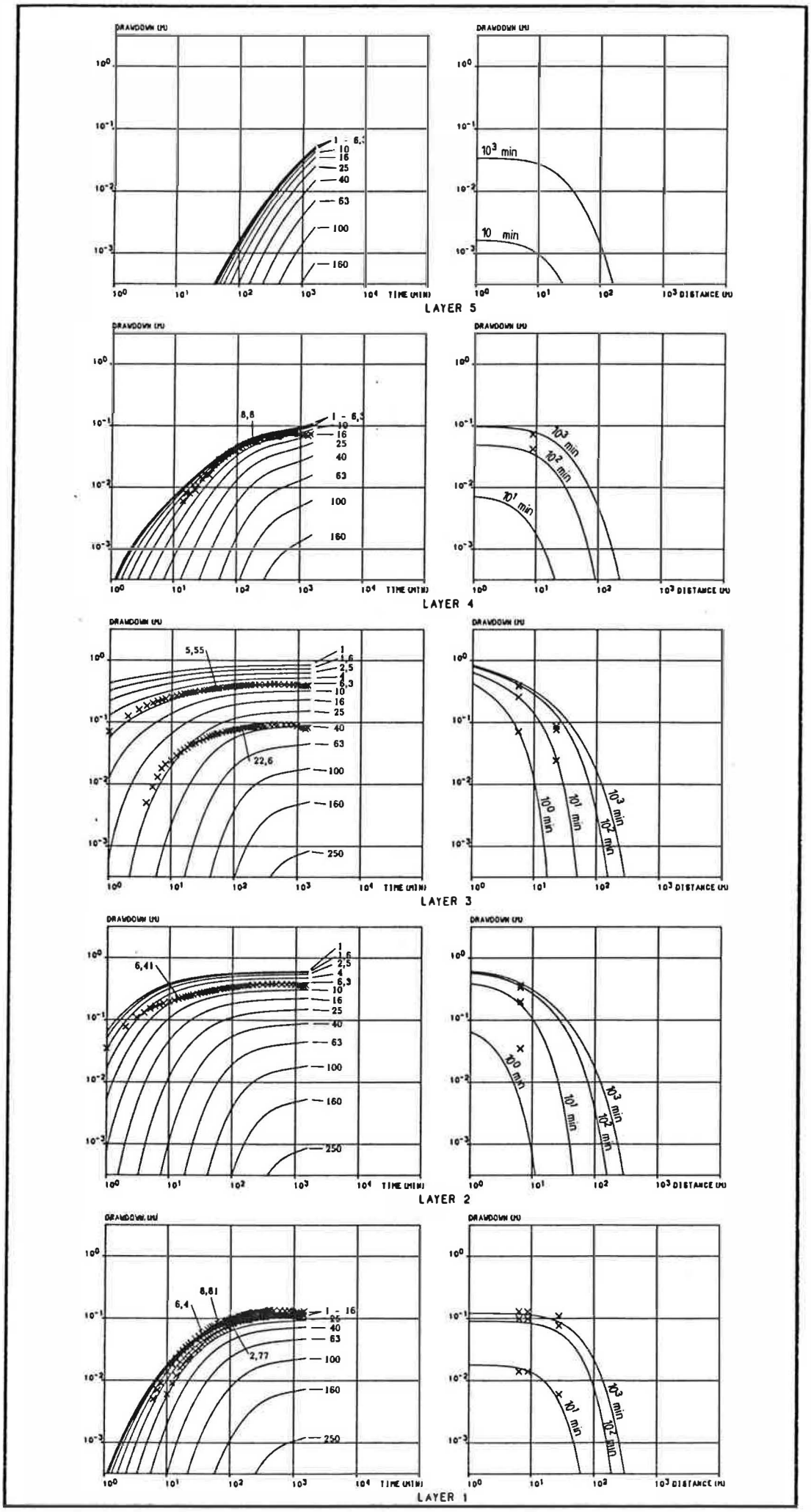

Fig. 13 - Observed (x) and calculated (curves) drawndowns during the pumping test in KZ2

the parameters who determine the elastic properties of the layers, namely $S'_A(3)$, $S'_A(1)$, $S'_A(2)$, $S'_A(4)$ and $S'_A(5)$. The accuracies of c(2) and c(4) are lower and those of the hydraulic conductivities of the two uppermost layers k(4) and k(5) and the storage coefficient near the water table S_Φ are very poor.

Table 2: Deduced values of the hydraulic parameters together with the factors which determine the upper and lower limit of the confidence band with a probability of 98 %.

Hydraulic-parameter	Deduced volues	Accuracy Factor
k(1)	5 m/d	1,0568
k(3)	4,2 m/d	1,0639
c(1)	71 d	1,0659
c(3)	60 d	1,0820
S'A(3)	$1,4.10^{-4}$ m^{-1}	1,1013
S'A(1)	$4,1.10^{-5}$ m^{-1}	1,1251
S'A(2)	$6,2.10^{-5}$ m^{-1}	1,1402
S'A(4) and S'A(5)	$1,3.10^{-3}$ m^{-1}	1,1520
c(4)	18 d	1,1967
c(2)	4,9 d	1,2190
k(4) and k(5)	1,25 m/d	1,6998
S_Φ	0,064	1,9125

The deduced values for these three parameters can only be seen as an estimate. The horizontal conductivity of layer 2, k(2), does not influence enough the measured drawdowns so that its value can not be deduced from these measurements. The introduced value of 0,1 m/d is only a raw estimate.

5.4. Conclusion

The hydraulic properties of the lithostratigraphical units could be derived from the results of the pumping tests.

Layer KZ1 has at the pumping test site a rather small horizontal conductivity of 5m/d and a small specific elastic

storage of 4.1 * 10^{-5} m^{-1}.

The layer KL has a vertical conductivity of 0,092 m/d (D(2)/(c(1)+c(2)) and a specific elastic storage of 6.2 * 10^{-5} m^{-1}. From the observed drawdown the horizontal conductivity of the layer KL can not be deduced .

The lower part of KZ2 has a horizontal conductivity of 4,2 m/d and a specific elastic storage of 1,4 * 10^{-5} m^{-1}. The upper part of KZ2 is less pervious. The horizontal conductivity is rawly deduced from the observed drawdowns. It has a value equal to 1,25 m/d. The vertical conductivity of the upper part of KZ2 is equal to 0,061 m/d (D(4)+D(5)/(c(3)+c(4)). The specific elastic storage of the upper part of KZ2 is rather large: 1,3 * 10^{-3} m^{-1}. The storage coefficient near the watertable is estimated at 0,064.

6. GROUNDWATER QUALITY

6.1. General

The description of the water quality is based upon the new analyses.

The sampling of the groundwater was done by the Laboratory of Applied Geology and Hydrogeology, the analytical work by the Laboratory of Analytical and Agrochemistry and the Laboratory of Organic Chemistry of the Faculty of Agricultural Sciences, State University of Ghent. The analytical procedures are not discussed in this report.

6.2. Sampling

For the purpose of this study groundwater has been sampled from the previous and new observation wells. Samples were taken after purging minimum 10 well volumes. During flushing the resistivity, the temperature and the pH were monitored. In all cases samples were taken after stabilisation of those parameters.

In table 3 field measurements are given.

Table 3: Field measurements

Nr new well	Specific conductance (µS/cm)	temperature (°C)	pH
1Sbis	12.099	12,5	6,46
1Dbis	5.984	14,5	7,39
2Sbis	10.153	13,2	6,50
2D	8.887	13,5	6,50
4S1	15.256	13,1	6,59
4D1	9.071	11,6	6,55
6S	15.336	11,2	6,51
7S	16.645	11,6	6,55
8S	15.020	11,5	6,53
9S	16.902	13,6	6,56
10S	11.203	13,0	6,57
11S	11.854	14,0	6,46
12S	9.555	12,1	6,54
13S	10.248	12,8	6,52
14S	7.384	12,3	6,50
Nr old well	**Specific conductance (µS/cm)**	**temperature (°C)**	**pH**
1S	4.177	11,2	7,08
1D	2.857	12,1	6,65
3S	15.046	11,5	6,59
3D	7.074	11,6	6,60
5S	6.784	12,6	6,59
5D	4,401	13,02	6,58

6.3. Analysis

The samples retrieved during the drilling were mixed ground/ groundwater samples. All those taken from a depth of 6 m, and three samples taken from a depth of 11 m (2D, 4D1, 14S) were analysed for COD, 1,2-dichloropropane (1,2-DCPA) and bischloro-isopropylether (BCIE).

The groundwater samples from the observation wells with the screen at the bottom of the KZ2 aquifer, were analysed for COD, Zn, As, Ba, Se, Hg, Cl, SO_4, F, 1,2-DCPA and BCIE.

The groundwater samples from the deeper KZ1 aquifer were analysed for COD, 1,2-DCPA and BCIE.

The pH and the specific conductance of all samples were determined as well.

The results are shown in tables 4 and 5.

By GC-MS analysis on the groundwater samples 1Dbis, 1Sbis, 2Sbis, 2D, 14S and 10S other minor organic compounds were identified such as chloroform, trichloropropane and two chloropropane isomeres.

6.4. Discussion

The major part of the concentrations of the parameters were plotted on a map of the Rieme plant (figures 14 to 25). Where sufficient data were available, iso-concentration lines were drawn.

Table 4 : Results of the analysis on the mixed ground/groundwater samples

Nr Borehole	Depth (m)	pH	Specific conductance mS/cm	PARAMETER		
				COD mg O2/l	1,2 DCPA mg/l	BCIE mg/l
1Dbis	6,5	7,60	4,91	33	< 1	< 1
2D	6	5,95	9,08	5540	3620	205
4D1	6	6,32	15,08	45	< 1	< 1
6S	6	6,30	23,40	265	< 1	< 1
7S	6	7,15	16,10	310	< 1	< 1
8S	6	6,44	15,90	320	< 1	< 1
9S	6	6,48	13,40	66	< 1	< 1
10S	6	6,66	4,36	123	< 1	< 5*
11S	6	7,20	4,21	156	< 1	12
12S	6	6,23	7,68	4100	753	234
13S	6	7,43	1,81	74	35	64
14S	6	7,20	2,82	90	57	5
2D	11	6,30	10,91	845	2914	266
4D1	9	6,39	15,20	74	< 1	< 1
14S	11	7,40	7,70	490	381	79

* Detected but below limit of quantitative determination

Table 5 : Results of the analysis of the groundwater samples

Nr. Piezo-meter	pH	Specific Conductance mS/cm	COD mgO2/l	1,2 DCPA	BCIE	Zn	As	Ba	Se	Hg	Cl	SO4	F4
						units all in mg/l							
Shallow wells		KZ2 (11 m)											
1Sbis	6,29	12,20	270	650	143	0,06	0,108	220	<0,025	0,0005	4281	2617	<0,20
2Sbis	6,37	10,47	1690	3094	263	0,33	0,271	199	<0,025	<0,0005	2096	4200	<0,20
4S1	6,31	15,20	115	< 1	< 5*	0,89	<0,050	188	<0,025	0,0009	5519	1862	2,63
6S	6,31	15,62	33	< 1	< 5*	0,13	<0,050	218	<0,025	<0,0005	6103	1820	<0,20
7S	6,41	17,08	82	< 1	< 5*	0,19	0,065	210	<0,025	<0,0005	5316	3277	<0,20
8S	6,30	15,60	66	6	< 5*	0,84	<0,050	221	0,065	<0,0005	5908	1912	<0,20
9S	6,40	15,90	66	< 1	< 1	0,04	2,945	249	<0,025	<0,0005	3007	7357	<0,20
10S	6,45	11,18	82	< 1	< 5*	0,21	0,345	195	<0,025	<0,0005	2344	4085	<0,20
11S	6,25	11,84	935	2481	337	0,21	0,212	192	0,028	<0,0005	3538	3450	<0,20
12S	6,45	10,12	675	2834	343	0,09	0,340	186	0,104	<0,0005	2132	4044	<0,20
13S	6,41	10,29	385	1173	240	0,84	0,108	180	<0,025	0,0005	3246	2342	<0,20
14S	6,30	8,21	360	2757	160	0,07	<0,050	171	<0,025	<0,0005	1079	4298	<0,20
Deep wells KZ1													
1Dbis	7,09	6,05	197	167	35								
2D	6,38	9,01	820	3685	321								
4D1	6,41	9,77	41	< 1	< 1								

(*) = detected but below limit for quantitative determination

6.4.1. Quality in the KZ2 aquifer

6.4.1.1. At 6 m depth

The results of the analyses of the ground/groundwater samples are shown in table 4. The conductance is very high in 6S (23.400 µS/cm). Generally the higher values are in the north; they decrease towards the south.

The COD shows very high values at the site of the former P.O.-production plant. Figure 14 shows a plume with an initial concentration of at least 5500 mg O_2/l, decreasing over a short distance to 1000 mg O_2/l. The background for the area seems to be below 100 mg O_2/l, which suggests the presence of another but smaller pollution, directly north of the P.E.-unit, at the border of the local gypsum dump.

The iso-concentration lines of 1,2-DCPA run parallel to those of the first, highest COD-pollution plume (figure 15). They attain at least 3600 mg/l at the former P.O.-production unit and form a very similar plume that extends in a southeasterly direction to the well 14S.

BCIE is found in the same part of the area as 1,2-DCPA (figure 16). It also shows a plume with a maximum concentration of at least 300 mg/l, extending in a southeasterly direction.

6.4.1.2. At 11 m depth

The results of the analyses of the groundwater samples taken at the bottom of the KZ2 aquifer are shown in table 5. Results on the ground/groundwater samples are shown in table 4.

6.4.1.2.1. Groundwater samples

The pH of the groundwater samples is quite normal. The conductance, on the contrary, is extremely high (figure 17). In the northern part of the area, which is clearly influenced by water percolating trough the RPC gypsum pile a value of about 15.000 µS/cm seems to be average for the incoming groundwater. Within this part there is a zone with a higher conductance around wells 7S and 9S. A front zone with values of 15.000 to 12.000 µS/cm separates the northern from the southern part of the area. In the southern zone the conductance decreases from northwest to southeast, to a value of about 8200 µS/cm in well 14S. The conductivities as measured in the field (table 2) are very similar to those measured in the laboratory.
The temperature of the groundwater (figure 18) is relatively high in wells 9S, 10S, 2Sbis and 11S. Higher temperatures may indicate pollution.
The COD of the groundwater samples is lower than those of the ground/groundwater samples (figure 19). The background value on the site seems to be below 100 mg O_2/l. A pollution plume is formed, with a maximal concentration of at least 1690 mg O_2/l (2Sbis). The core of the plume coincides with the one at 6 m depth, but is spread over a larger area. From the high values downstream at the borders of the site, it may be concluded that the plume extends out of the area.
The spreading of the 1,2-DCPA concentration is very similar to the COD concentration (figure 20). Very high values, near the solubility limit, are reached in the same zone, with the same south-southeast extension across the borders of the area.
The BCIE concentration follows the same pattern, although less higher concentrations are attained (figure 21). Traces of BCIE have been found in the wells 4S1, 6S, 7S, 8S and 10S, which might indicate the presence of another pollution source

outside the former P.O.plant.
The distribution of the chloride content shows a pattern very similar to the one of the specific conductance (figure 22) : from a maximum at the border of the local dump it decreases towards the southeast. The concentrations are mostly higher than the average concentration in the canal water. The drinking water standard (200 mg/l) is largely exceeded in every observation well.
The sulphate content (figure 23) also shows a pollution plume with a maximal concentration in the well 9S (7357 mg/l) and a tail in the downstream, south-southeasterly direction. The background of the incoming groundwater appears to be lower than 2000 mg/l.
The Zn concentration is high for groundwater, but does not exceed the Belgian standard for drinking water.
The F and Hg concentration are only exceptionally high in the well 4S1, where F exceeds the drinking water standard (1,5 mg/l).
The barium concentration is extremely high and shows a weak maximum at the border of the local gypsum dump in the wells 6S, 7S and 8S and in the wells 9S and 1Sbis.
High Se contents are encountered in the wells 8S and 12S. Belgian drinking water standards are exceeded for Se (0,01 mg/l).
Arsenicum shows a point source pollution pattern, with the highest concentration in the well 9S and a dispersion in the downgradient direction of the groundwater flow (figure 24). The drinking water standard (0,05 mg/l) is largely exceeded.

6.4.1.2.2. Mixed ground/groundwater samples.

The results of the analysis of the ground/groundwater samples are comparable to the values found for the groundwater of the same depth, except for the COD and the DCPA and BCIE concentrations in well 14S.

6.4.2. Groundwater quality in the KZ1 aquifer

The results are shown in table 5 and in figure 25. The conductance and the COD are high but lower than the one in the KZ2.
The concentrations of 1,2-DCPA and BCIE are extremely high in the well 2D and are still very high downstream in the well 1Dbis.
These facts demonstrate that the pollution has penetrated trough the KL and is moving downstream in the KZ1 aquifer.

6.5. Conclusions

Following samples were analyzed :
- twelve ground/groundwater samples at 6 m depth in KZ2
- three ground/groundwater samples and twelve groundwater samples at 11 m depth at the bottom of KZ2
- three groundwater samples at a depth of approximately 18 m in KZ1.

Based on the results of the analyses some maps with iso-concentration lines have been drawn (figures 14 to 25).
All groundwater in the area is contaminated. The pollution that originates from the plant site area itself consists of an extremely heavy organo-chemical pollution by 1,2-dichloropropane (DCPA) and bischloroisopropylether (BCIE). These chemicals have leached into the ground at the site of the former P.O.-production plant. DCPA is found in concentrations up to the solubility limit.
An important anorganic sulphate and arsenicum pollution probably originates in the area itself in the vicinity of the well 9S : concentrations of respectively 7357 and 2,95 mg/l are found. The high barium content of the groundwater may originate from the percolation out of the local dump.
The present study does not allow to relate the high zinc,

selenium, fluoride and chloride concentrations to any particular source in the area.
The organo-chemical as well as the inorganic pollution plumes migrate downstream in a southward direction and have already passed across the borders of the plant site area.
The organo-chemical pollution has also migrated downward through the KL into the KZ1 aquifer where the same high values and a similar pattern of spreading have been detected.

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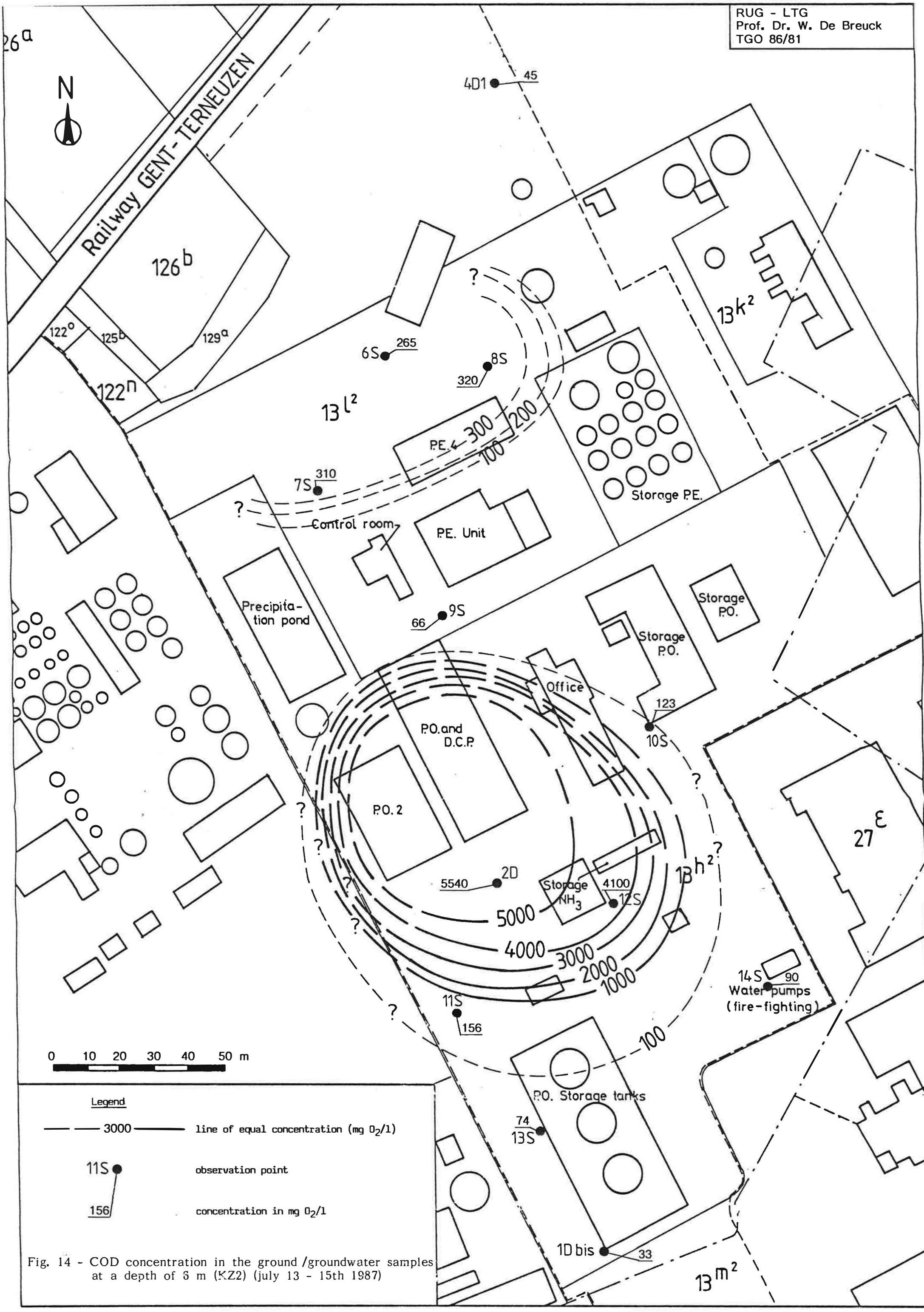

Legend

3000 — line of equal concentration (mg O_2/l)

11S — observation point

156 — concentration in mg O_2/l

Fig. 14 - COD concentration in the ground /groundwater samples at a depth of 6 m (KZ2) (july 13 - 15th 1987)

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N

Railway GENT - TERNEUZEN

126a

126b

122o

125b

129a

122n

4D1 < 1

6S < 1

8S < 1

13l2

P.E.4

7S < 1

Control room

P.E. Unit

Storage P.E.

13k2

Precipitation pond

9S < 1

Storage P.O.

Storage P.O.

Office

P.O. and D.C.P

10S < 1

??P.O.2

?

?

?

2D 3620

3500
3000
2500
2000
1500
1000
500

Storage NH3

12S 753

13h2

27ε

14S 57
Water pumps (fire-fighting)

11S < 1

P.O. Storage tanks

35
13S

50

1D bis < 1

13m2

0 10 20 30 40 50 m

Legend

3000 — line of equal concentration (mg/l)

12S — observation point

753 — concentration in mg/l

Fig. 15 - Concentration of 1,2 DCPA in the ground/groundwater samples at a depth of 6 m (KZ2) (july 13 - 15th 1987)

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TGO 86/81

N

Railway GENT-TERNEUZEN

126a

126b

122o

125b

129a

122n

13l2

13k2

4D1 < 1

6S < 1

8S < 1

7S < 1

9S < 1

P.E.4

Control room

P.E. Unit

Storage P.E.

Precipitation pond

Storage P.O.

Storage P.O.

Office

P.O. and D.C.P.

P.O. 2

< 5* 10S

2D 200

Storage NH_3

228 12S

13h2

27ε

14S < 5* Water pumps (fire-fighting)

11S 12

100

200

P.O. Storage tanks

13S 63

10D bis < 1

13m2

0 10 20 30 40 50 m

Legend

200 — line of equal concentration (mg/l)

12S — observation point

228 — concentration in mg/l

* — detected, but below limit of quantification

Fig. 16 - Concentration of BCIE in the ground/groundwater samples at 6 m depth (KZ2) (july 13 - 15th 1987)

RUG - LTG
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TGO 86/81

N

Railway GENT - TERNEUZEN

126a
126b
122o
125b
129a
122n
13k2
13l2
13h2
27e
13m2

15.20 4S1
6S 15.62
8S 15.60
7S 17.08
9S 15.90
2S bis 10.47
12S 10.12
11S 11.84
10S 11.18
14S 8.21
13S 10.29
15 bis 12.20

P.E.4
Storage P.E.
P.E. Unit
Control room
Precipita-tion pond
Storage P.O.
Storage P.O.
Office
P.O. and D.C.P
P.O. 2
Storage NH_3
Water pumps (fire-fighting)
P.O. Storage tanks

17
16
15
14
13
12
11
10
9
8
7

0 10 20 30 40 50 m

Legend

10 — line of equal specific conductance (mS/cm)

11S — observation well

11.84 — specific conductance (20 °C) in mS/cm

Fig. 17 - Specific conductance (20 °C) of the groundwater at the bottom of the KZ2 aquifer (july 1987)

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N

Railway GENT-TERNEUZEN

126a

126b

122o

125b

129a

122n

3S 11,6

4S1 13,1

6S 11,2

8S 11,5

7S 11,6

9S 13,6

10S 13,0

2Sbis 13,2

12S 12,1

14S 12,3

11S 14,0

13S 12,8

1SBis 12,5

13l2

13k2

13h2

27e

13m2

P.E.4

Storage P.E.

Control room

P.E. Unit

Precipitation pond

Storage P.O.

Storage P.O.

Office

P.O. and D.C.P.

P.O. 2

Storage NH3

Water pumps (fire-fighting)

P.O. Storage tanks

+11,5

+12,0

+13,5

+13,0

+12,5

+11,5

+12,0

?

0 10 20 30 40 50 m

Legend

13,0 line of equal temperature (°C)

11S observation well

14,0 temperature in °C

Fig. 18 - Groundwater temperature at the bottom of the KZ2 aquifer (13 - 15th 1987)

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N

Railway GENT-TERNEUZEN

26a

126b

122o

125b

129a

122n

4S1 115

6S 33

8S 66

13l2

P.E.4

7S 82

Control room

P.E. Unit

Precipitation pond

66 9S

13k2

Storage P.E.

Storage P.O.

Storage P.O.

Office

82 10S

P.O. and D.C.P.

P.O. 2

2S bis 1690

1500

Storage NH3

12S 675

13h2

200

?

14S 360
Water pumps (fire-fighting)

27ε

11S 935

1000

500

400

300

200

P.O. Storage tanks

13S 385

1S bis 270

13m2

-42-

0 10 20 30 40 50 m

Legend

1500 line of equal COD (mg O_2/l)

11S observation well

935 concentration in mg O_2/l

Fig. 19 - Concentration of COD in the groundwater at the bottom of the KZ2 aquifer (july 13 - 15th 1987)

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N

Railway GENT - TERNEUZEN

126a

126b

122o

125b

129a

122n

13l2

13k2

13m2

27ε

4S1 < 1

6S < 1

8S < 1

7S < 1

P.E.4

Control room

P.E. Unit

Storage P.E.

Precipitation pond

6 9S

Storage P.O.

Storage P.O.

Office

P.O. and D.C.P.

P.O. 2

< 1 10S

2S bis 3094

Storage NH_3

2834 12S

2757 14S

Water pumps (fire-fighting)

11S 2481

1173 13S

1S bis 650

500

1000

1500

2000

2500

3000

?

0 10 20 30 40 50 m

Legend

1000 line of equal concentration (mg/l)

11S observation well

2481 concentration in mg/l

Fig. 20 - Concentration of 1,2 - DCPA in the groundwater at the bottom of the KZ2 aquifer (july 13 - 15th 1987)

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N

Railway GENT - TERNEUZEN

126b

122o

125b

129a

122n

13l2

4S1 < 5*

6S < 5*

8S < 5*

7S < 5*

9S ≤ 1

P.E.4

P.E. Unit

Control room

Precipitation pond

13k2

Storage P.E.

Storage P.O.

Storage P.O.

Office

10S < 5*

100

P.O. and D.C.P.

P.O. 2

2Sbis 257

Storage NH_3

335 12S

13h2

27e

14S 156 Water pumps (fire-fighting)

11S 329

300

200

P.O. Storage tanks

13S 234

1Sbis 139

13m2

0 10 20 30 40 50 m

Legend

300 line of equal concentration (mg/l)

11S observation well

329 concentration in mg/l

* detected, but below limit of quantification

Fig. 21 - Concentration of BCIE in the groundwater at the bottom of the KZ2 aquifer (july 13 - 15th 1987)

RUG - LTG
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N

Railway GENT-TERNEUZEN

126a
126b
122o
125b
129a
122n
13k2
13l2
13h2
27e
13m2

4S1 5519
6S 6103
8S 5908
7S 5316
9S
10S 2344
2S bis 2096
12S 2132
11S 3538
13S 3246
1S bis 4281
14S 1079

6000
5000
4000
3000
2000
1000

P.E.4
Storage P.E.
Control room
P.E. Unit
Precipitation pond
Storage P.O.
Storage P.O.
Office
P.O. and D.C.P.
P.O. 2
Storage NH_3
Water pumps (fire-fighting)
P.O. Storage tanks

?

0 10 20 30 40 50 m

Legend

2000 — line of equal concentration (mg/l)

11S — observation well

3538 — concentration in mg/l

Fig. 22 - Concentration of Cl^- in the groundwater at the bottom of the KZ2 aquifer (july 13 - 15th 1987)

RUG - LTG
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TGO 86/81

N

Railway GENT - TERNEUZEN

126a

126b

122o

125b

129a

122n

13k2

4S1
1862

6S
1820

8S
1912

13l2

PE.4

7S
3277

Control room

P.E. Unit

Storage P.E.

Precipitation pond

9S
7357

Storage P.O.

Storage P.O.

Office

7000

6000

5000

4000

3000

P.O. and D.C.P.

4085
10S

P.O. 2

2S bis
4200

Storage NH_3

12S
4044

13h2

14S
4298
Water pumps
(fire-fighting)

11S
3450

P.O. Storage tanks

13S
2342

1S bis
2617

27e

13m2

0 10 20 30 40 50 m

Legend

5000 — line of equal concentration (mg/l)

11S — observation well

3450 — concentration in mg/l

Fig. 23 - Concentration of SO_4^{2-} in the groundwater at the bottom of the KZ2 aquifer (july 13 - 15th 1987)

RUG - LTG
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N

Railway GENT - TERNEUZEN

126 a

126 b

122 o

125 b

129 a

122 n

13 l 2

13 k 2

13 h 2

27 ε

4S1 < 0,050

6S < 0,050

8S < 0,050

7S 0,065

9S 2,945

10S 0,345

2S bis 0,271

12S 0,340

14S < 0,050

11S 0,212

13S 0,108

1S bis 0,108

P.E.4

Storage P.E.

Control room

P.E. unit

Precipitation pond

?

2,500
2,000
1,500
1,000
0,500

P.O. and D.G.P.

Office

0,100

Storage P.O.

Storage P.O.

P.O. 2

Storage NH_3

Water pumps (fire-fighting)

P.O. Storage tanks

0 10 20 30 40 50 m

Legend

— — 1,000 — — line of equal concentration (mg/l)

11S observation well

0,212 concentration in mg/l

Fig. 24 - Concentration of As in the groundwater at the bottom of the KZ2 aquifer (july 13 - 15th 1987)

RUG - LTG
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N

Railway GENT-TERNEUZEN

26a

4D1
DCPA : < 1 mg/l
BCIE : < 5 mg/l *
Spec. Cond. : 9.77 mS/cm
t° : 11.6 °C

126b

3D
Spec. Cond. : 6.18 mS/cm
t° : 11.6 °C

122o

125b

129a

122n

13k2

13l2

P.E.4

Storage P.E.

Control room

P.E. Unit

Precipita-
tion pond

Spec. Cond. : 4.41 mS/cm
t° : 13.0 °C

Storage P.O.

5D

Storage P.O.

Office

P.O.and D.C.P.

P.O. 2

27e

2D
DCPA : 3685 mg/l
BCIE : 409 mg/l
Spec. Cond. : 9.01 mS/cm
t° : 13.5 °C

Storage NH_3

13h2

Water pumps
(fire-fighting)

P.O. Storage tanks

1D
Spec. Cond. : 2.83 mS/cm
t° : 12.1 °C

1D bis
DCPA : 167 mg/l
BCIE : 45 mg/l
Spec. Cond. : 6.05 mS/cm
t ° : 14.5 °C

0 10 20 30 40 50 m

Legend

* detected but below limit of quantification

Fig. 25 - Groundwater quality in the KZ1 layer
(july 13 - 15th 1987)

7. MATHEMATICAL MODEL

7.1. General

To obtain more information about the evolution of the groundwater quality and the occurence of contamination a mathematical model has been applied. The purpose of a mathematical model is to simulate the real hydrogeological situation. Herefore the area is subdivided in a grid of cells. In each cell the hydraulic parameters of the aquifer and the boundary conditions must be entered.

In this study two different options of one model are applied. The first simulates the groundwater flow in a horizontal plane. This implies that the properties of the aquifer remain the same over the whole thickness. This model calculates the areal average groundwater quality distribution, but gives no information over quality changes in depth.

With the second option of the model the groundwater flow in a vertical cross-section is simulated. Information is obtained about the contaminant distribution in the different layers.

Combining the results of the two models, an idea of the spatial distribution in the groundwater reservoir is obtained.

7.2. Applied model

The mathematical model of solute transport and dispersion in groundwater of KONIKOW & BREDEHOEFT has been applied. This model calculates the transient changes in concentration of a non-reactive solute in flowing groundwater. The computer program solves simultaneously two partial differential equa-

tions. One equation is the groundwater flow equation, which describes the head distribution in the aquifer. The second is the solute-transport equation, which describes the chemical concentrations in the system. A particle-tracking procedure is used to solve the solute-transport equation.

Each simulation is subdivided in a small number of time steps. Each time step corresponds with a period of 1,25 year. For every time step the piezometric head, the groundwater flow velocities and the chemical concentration are obtained. The output data are presented in the form of plots. On each plot the piezometric head during the time step is presented by lines of equal water level. The groundwater flow velocities are indicated by vectors. The concentrations are represented by lines of equal percentage of contamination. A saturated solution of the organic chemical DCPA is concidered as 100 % . Lines of 1 % , 5 % , 16 % , 50 % , 84 % , 95 % and 99 % contamination are plotted.

7.3. Simulations in a horizontal plane

7.3.1. Location-boundaries-input data

In the horizontal model the groundwater flow is simulated in a rectangular area of approx. 640 by 720 m, bordered to the west by the railway Gent-Terneuzen, and to the east by the canal Gent-Terneuzen (fig. 26).

The finite-difference grid is subdivided in 40 rows and 40 columns, corresponding with 1600 cells. Each cel measures about 15 by 20 m. The aquifer is bounded below by the semi-pervious layer KL. The model calculates the groundwater flow in the pervious layer KZ2.

The aquifer has a thickness of 12 m. The applied horizontal hydraulic conductivity is 1,25 m/d in the whole area, the longitudinal dispersivity 0,30 m, the ratio of transverse to longitudinal dispersivity 0,30.

The model has constant head boundaries in the north, south, west and east. The east boundary is the canal (level : + 4,45), the values in the cells near the other boundaries are derived from piezometric level measurements.

The mean natural infiltration rate is 300 mm/year, which is the normal value for this area. In the cell representing the spill area an amount of 900 m^3/year of polluted water is injected (approx. 3,2 tons DCPA). This value is a rough estimation. In some simulations an amount of 90 'm³/year/cel of polluted water was assumed to have leaked from a sewer (approx. 4,2 tons/year DCPA) (figure 27).

An overview of the different simulations in the horizontal plane is given in table 6.

7.3.2. Discussion of results

Six different simulations in the horizontal plane are given (see table 6).

In the first two simulations (figures 28 and 29) there is assumed that infiltration of polluted water occurs at only one place (spill area between the former P.O.-installation and the precipitation pond). In the corresponding cel 900 m^3/year is injected. The injected water is considered as a saturated solution (100 %).

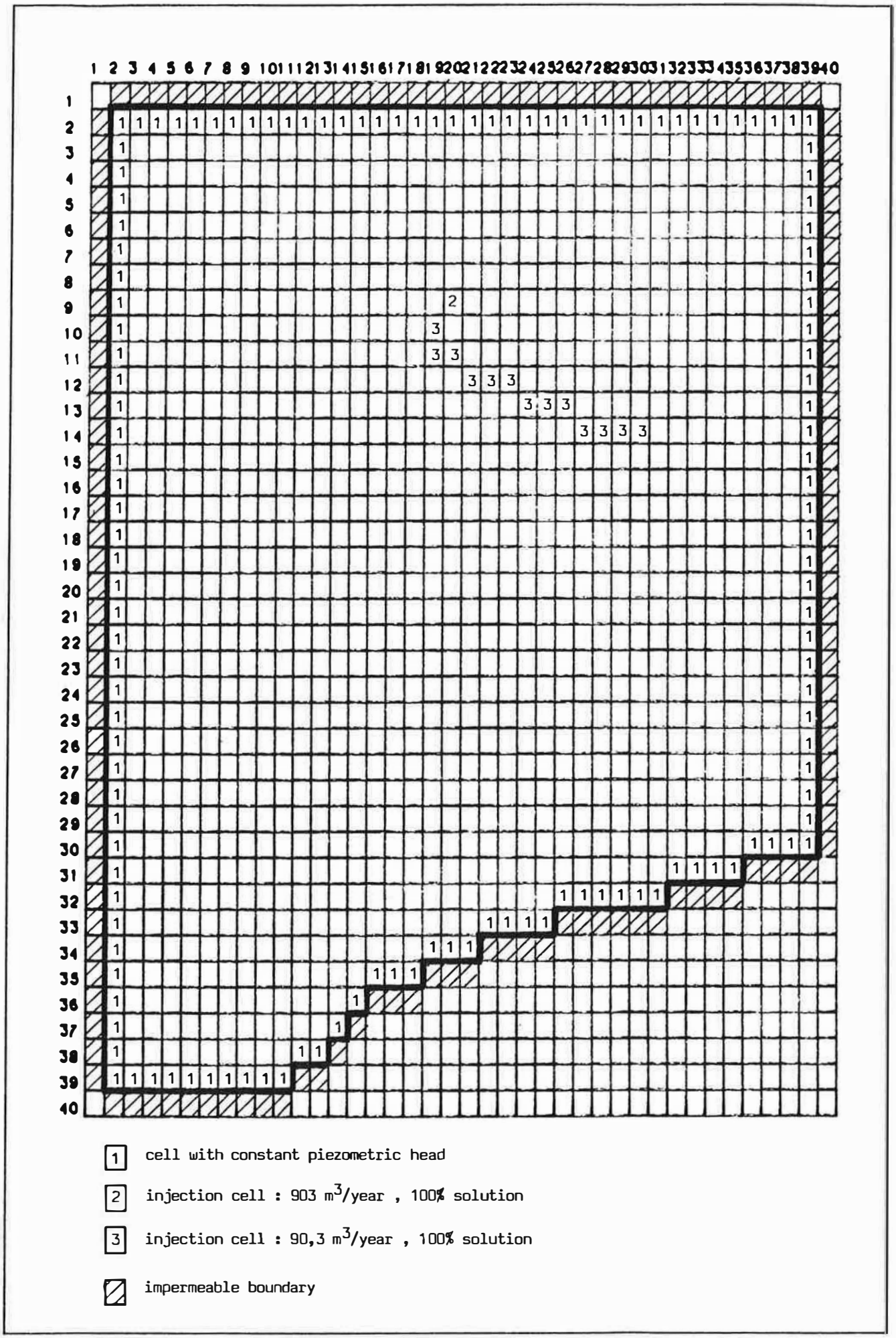


Fig. 27 - Boundary conditions (for the simulations in the horizontal plane)

Table 6 : The different simulations in the horizontal plane

	1972-1979,5	place of infiltration spill sewer area	1979,5-1987	place of infiltration spill sewer area	1987-2002	place of infiltration spill sewer area
SIMULATION H1	infiltration of saturated solution (100 %)	x	no further solution of organic compounds			
SIMULATION H2	infiltration of oversaturated solution (>100%)	x	further solution of organic compounds	x		
SIMULATION H3	infiltration of saturated solution (100 %)	x x	no further solution of organic compounds			
SIMULATION H4	infiltration of oversaturated solution (>100%)	x x	further solution of organic compounds	x x		
SIMULATION H5	infiltration of oversaturated solution (>100%)	x x	further solution of organic compounds	x x	no further solution of organic compounds	
SIMULATION H6	infiltration of oversaturated solution (>100%)	x x	further solution of organic compounds	x x	further solution of organic compounds	x x

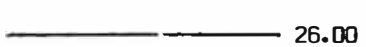
In the first simulation (figure 28) the pollution source exists only during the period 1972-1979,5. After 1979,5 there is only natural infiltration (300 mm/year). In the second simulation (figure 29) the pollution source exists during the whole period, from 1972 until present. This can be explained by the assumption that the infiltrating solution in the first 7,5 years was oversaturated (> 100 %), so that an amount of non-dissolved organic halogens leaked into the aquifer, and the process of dissolving could continue years after the polluting infiltration.

In both cases the pollution front has moved approx. 200 m to the east, and the zone of contamination has a long, small form in the groundwater flow direction.

Fitting the results of the chemical analyses, an evolution like this seems unlikely. It can not explain the high values of organic compounds in boreholes 2Sbis, 12S and 14S. These high values can be explained by a leakage from a sewer (figure 27), which captured the effluent of the P.O.plant. This situation is calculated in simulations 3 and 4 (figures 30 and 31). In these simulations in each cell representing the sewer (see figure 27) 90 m^3/year of saturated solution is injected. In simulation H3 the leakage ended in 1979, while in simulation H4, the dissolving of organic compounds continues due to the previous leakage of an oversaturated solution. In both cases the calculated pollution front has reached the canal. Unfortunately there are no observation points to confirm this. In simulation H3 the concentrations of the contamination zone become smaller, due to the effects of mixing and dispersion. The results of simulation H4 fit best with the observed concentrations. In the adjacent downstream part of the sewer, almost saturated water is found. This is confirmed by observation wells 2Sbis, 12S en 14S.
Simulations H5 and H6 (figures 32 and 33) give a probable

LEGEND

Line of equal percentage of saturated solution



Line of equal piëzometric head (m TAW)

Fig. 28 - Simulation H1 - situation after 15 years (1987) (one spill area during 1972 - 1979,5 only normal infiltration during 1979,5 - 1987)

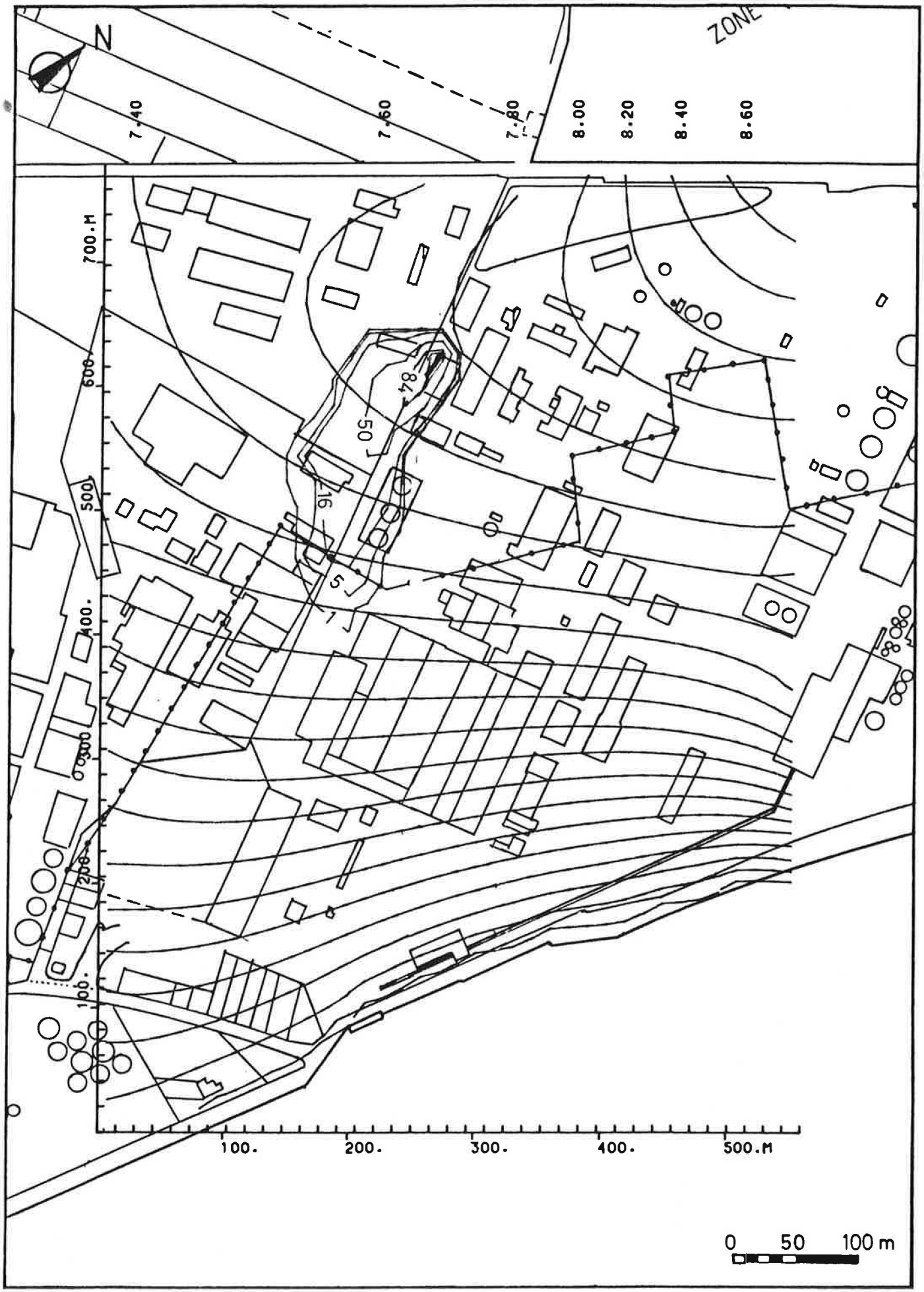


Fig. 29 - Simulation H2 - situation after 15 years (1987) (one spill area during 1972 - 1987)

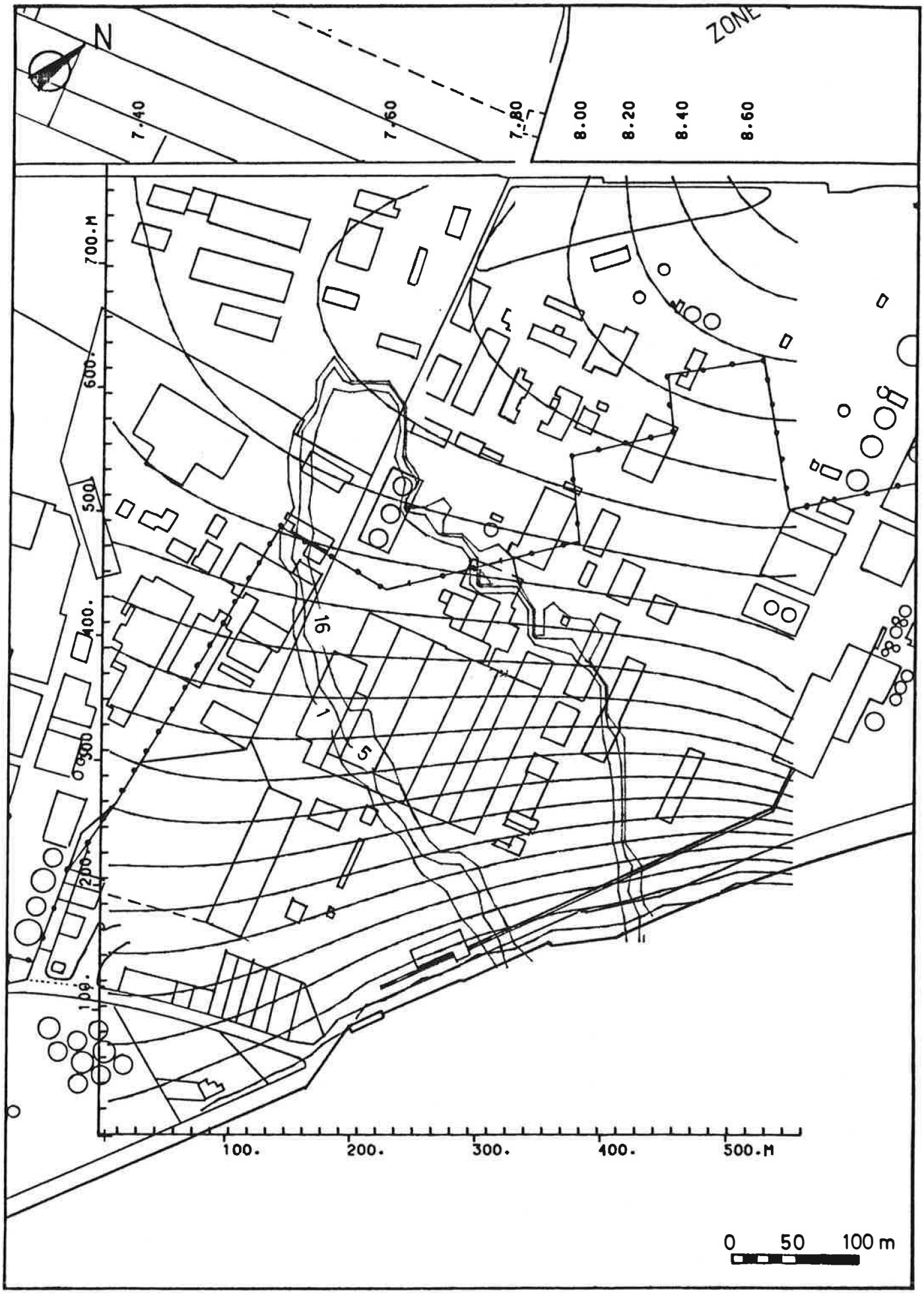


Fig. 30 - Simulation H3 - situation after 15 years (1987) (spill area + infiltrating sewer during 1972 - 1979,5 , only normal infiltration during 1979,5 - 1987)

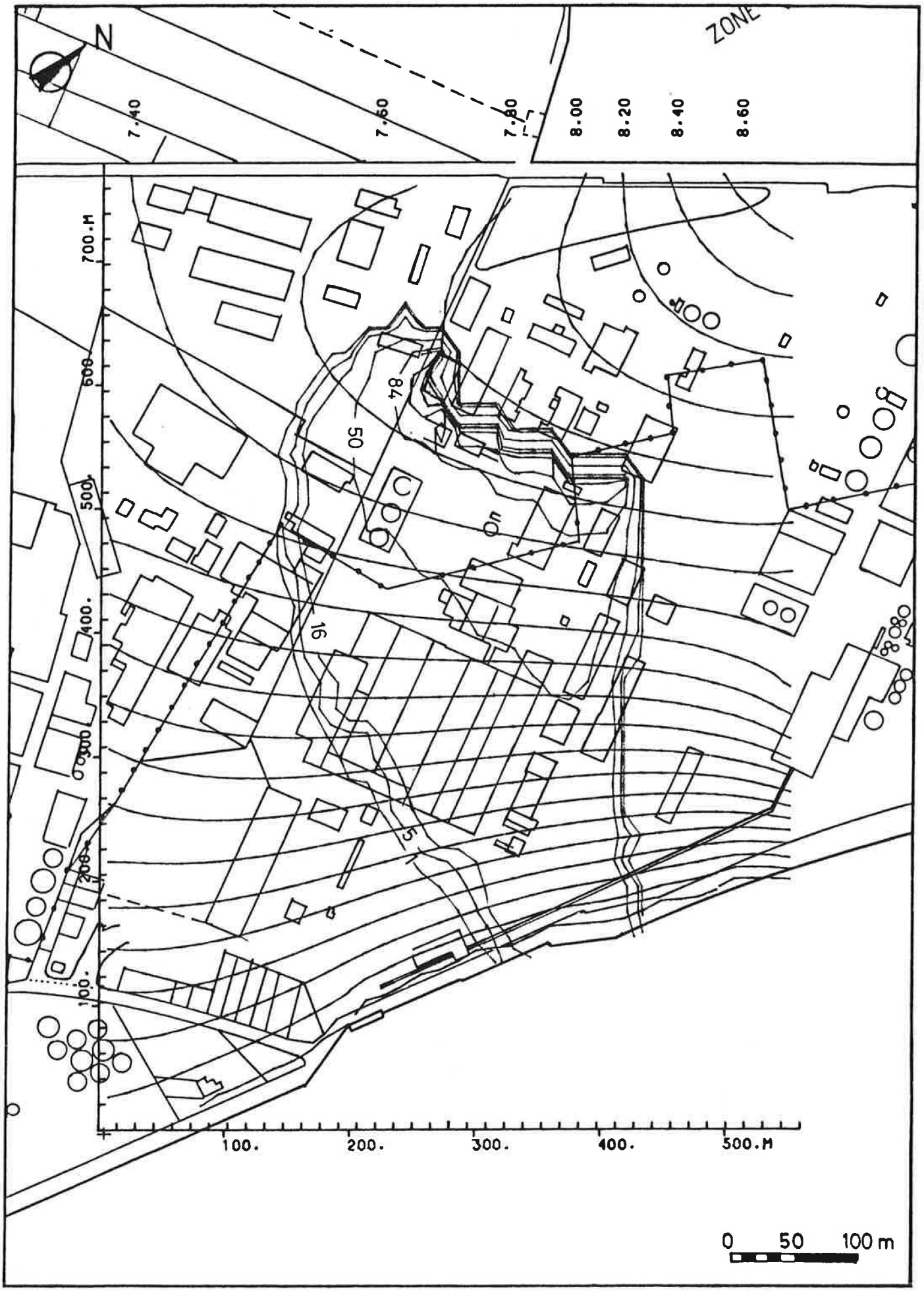


Fig. 31 - Simulation H4 - situation after 15 years (1987) (spill area + infiltrating sewer during 1972 - 1987)

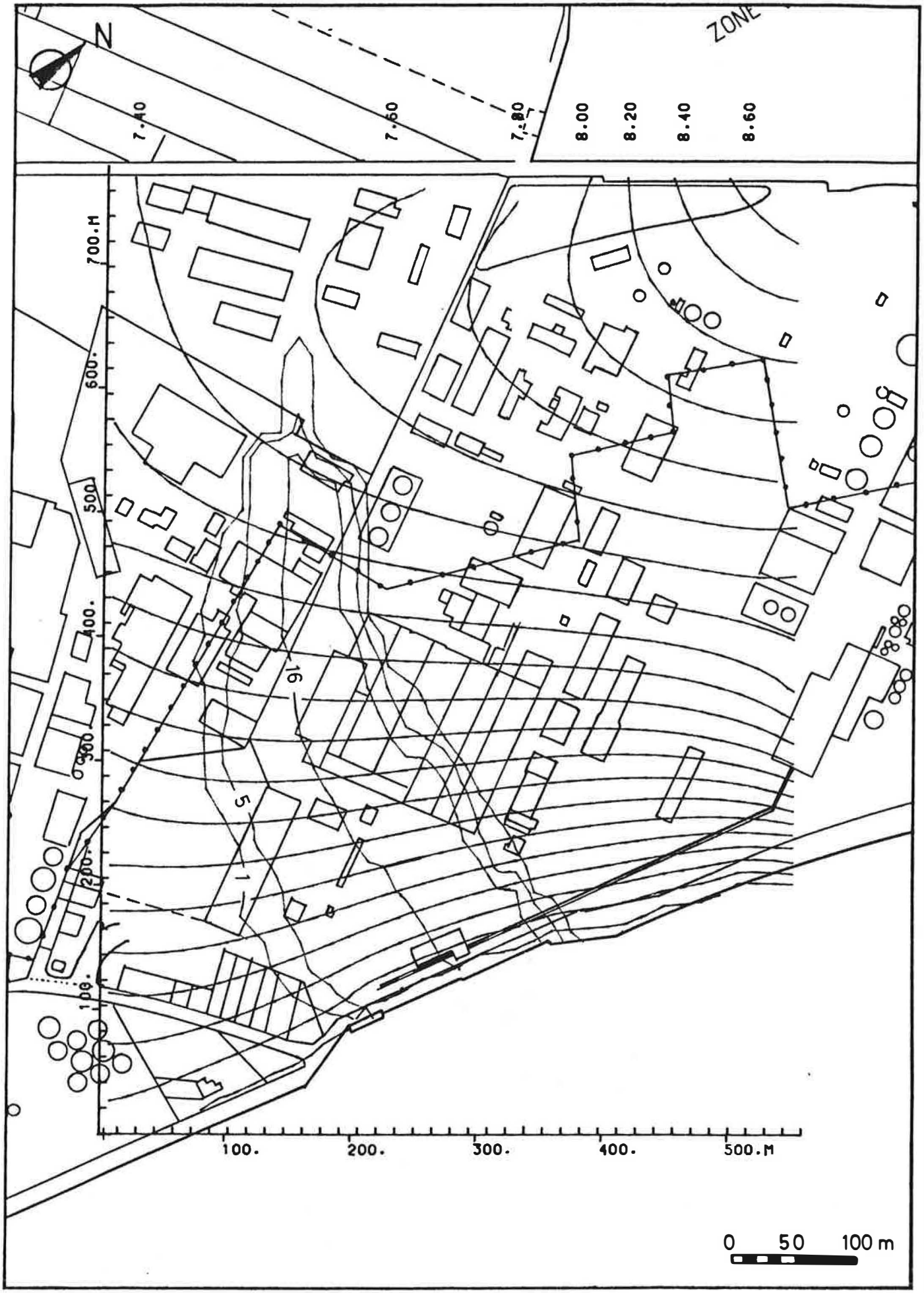


Fig. 32 - Simulation H5 - situation after 30 years (2002) (spill area + infiltrating sewer during 1972 - 1987, only normal infiltration during 1987 - 2002)

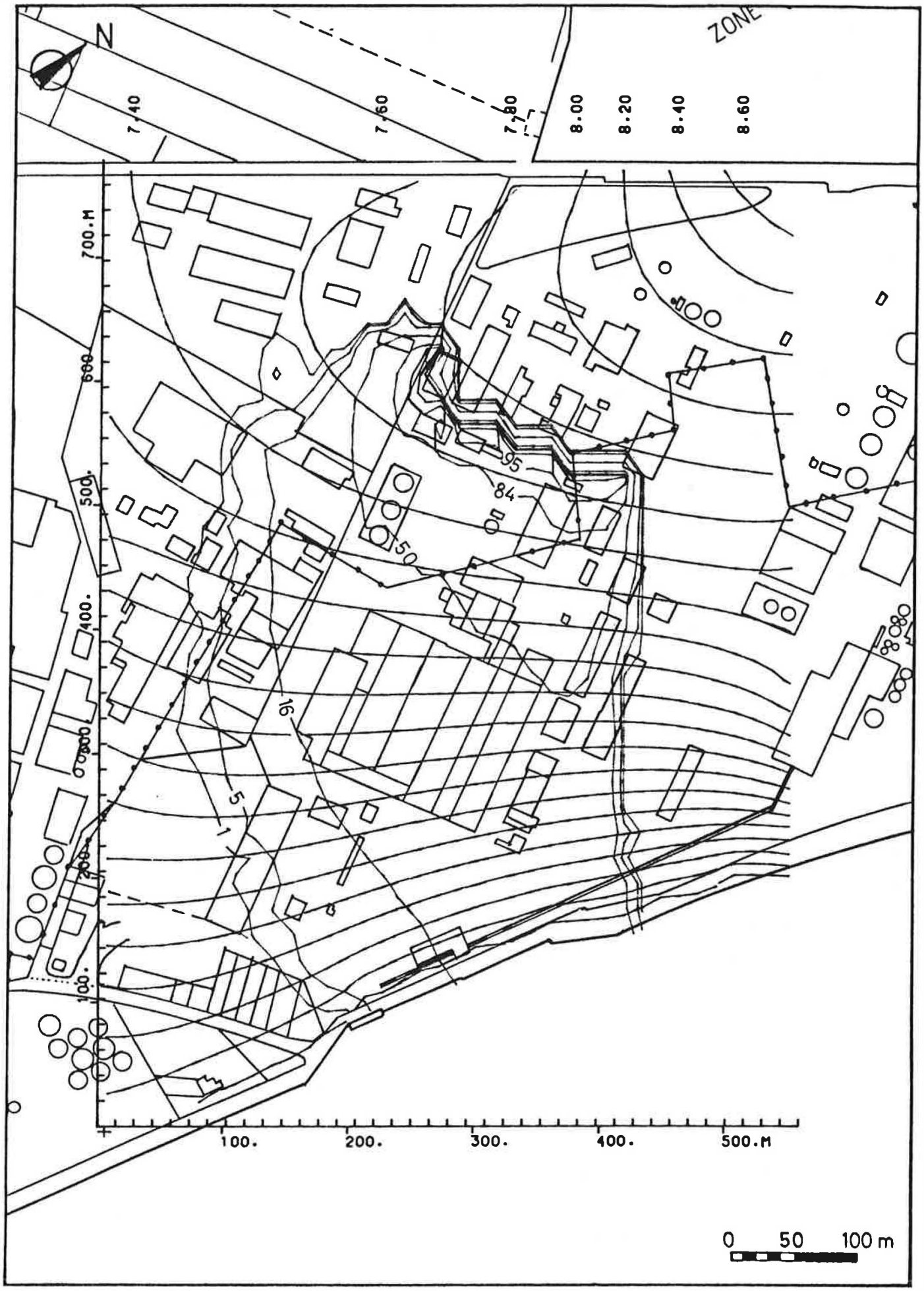


Fig. 33 - Simulation H6 - situation after 30 years (2002) (spill area + infiltrating sewer during 1987 - 2002)

evolution in the next future (1987 - 2002). The situation with a future continuous dissolution of pollutant shows a similar pattern as compared with the present, except for a further broad southerly extension.

7.4. Simulations in a vertical cross-section

7.4.1. Location-boundaries-input data

The groundwater flow and the evolution of the groundwater quality is simulated in a cross-section of approx. 1770 m length, along a straight line, beginning at the top of the gypsum pile, and ending in the canal Gent-Terneuzen (figure 26). A vertical model permits to evaluate the change in groundwater quality in different layers.

The finite difference grid is subdivided in 16 rows and 40 columns. Each cel is approx. 46,5 meters long and has a thickness of 3 meters. The aquifer is bounded below by the impermeable layer of the a3 clay. The different horizontal hydraulic conductivities are derived from the results of the pumping tests. The assumed longitudinal dispersivity is 0,30 m. The ratio of transversal to longitudinal dispersivity is 0,30.

The left boundary of the cross-section is the water-divide under the gypsum pile, the right boundary is a constant head boundary (sea canal : + 4.45). The natural infiltration rate is 300 mm/year. On the gypsum pile the infiltration rate is 1500 mm/year. In the cel corresponding with the spill area, the infiltration rate of polluted water is equal to the quantity of water injected in the horizontal model.
A schematisation of the input data is shown in figure 34.

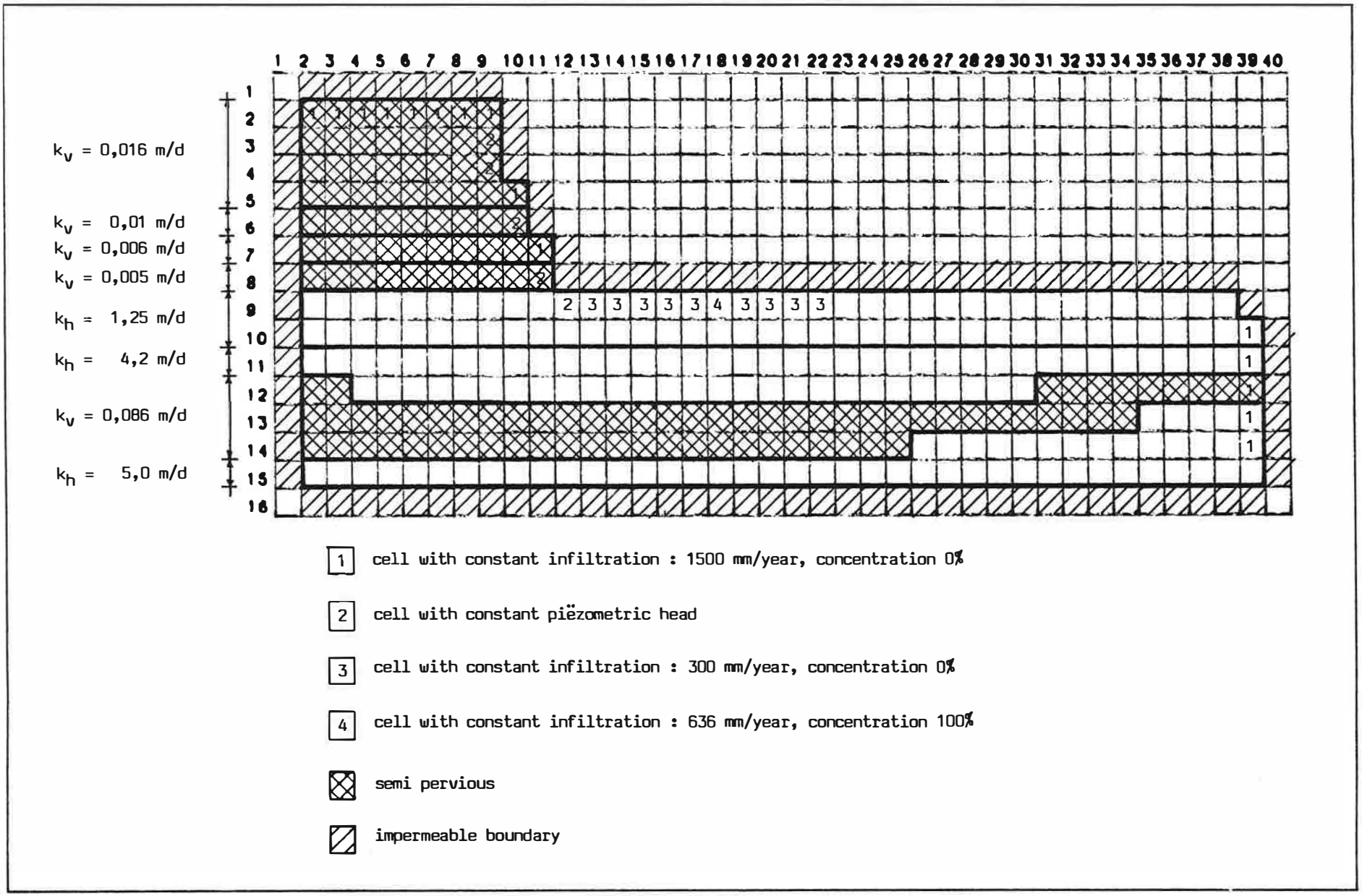


Fig. 34 - Boundary conditions and permeabilities (for the conditions in the vertical cross-section)

7.4.2. Discussion of results

It is assumed that in the period 1972-1979,5 , the infiltrating solution was oversaturated. The next 7,5 years, dissolution continues and the pollution source remains. The calculated situation after 15 years (1987) is shown in the figures 35 and 36 (simulations V1 and V2).

The contamination moves downstream in the direction of the canal. The pollution front had advanced mostly in the lower part of the KZ2 layer, where the horizontal conductivity (4,2 m/d) is higher than in the upper part (1,25 m/d). The concentrations increase towards the bottom of the KZ2 layer. Concentrations of 10 - 20 % may be expected 250 m downstream the spill area, and within a range of 150 m the concentrations may exceed 50 % of a saturated solution. This is confirmed by the water analyses in wells 1Sbis, 13S and 11S. Lower concentrations may be found in the KZ1 aquifer (well 1Dbis), around the spill area the concentrations may be greater.

7.5. Conclusions

With the mathematical model the occurence of the contamination was calculated. Most likely the leakage of organic halogens took not only place around the P.O.-installation, but also along the sewer. The infiltrating polluted water was an oversaturated solution, so that the dissolution process could continue after 1979 in the aquifer. The pollution front moves downstream, where it has probably reached the canal. There are no observation wells to confirm this. In the south the pollution front moves more slowly. The evolution in the next future depends on the amount of non-dissolved organic halogens that is left in the aquifer, which is not known.

LEGEND

——— 50 ———	Line of equal percentage of saturated solution
——— 26.00	Line of equal piëzometric head (m TAW)
→	Velocity vector

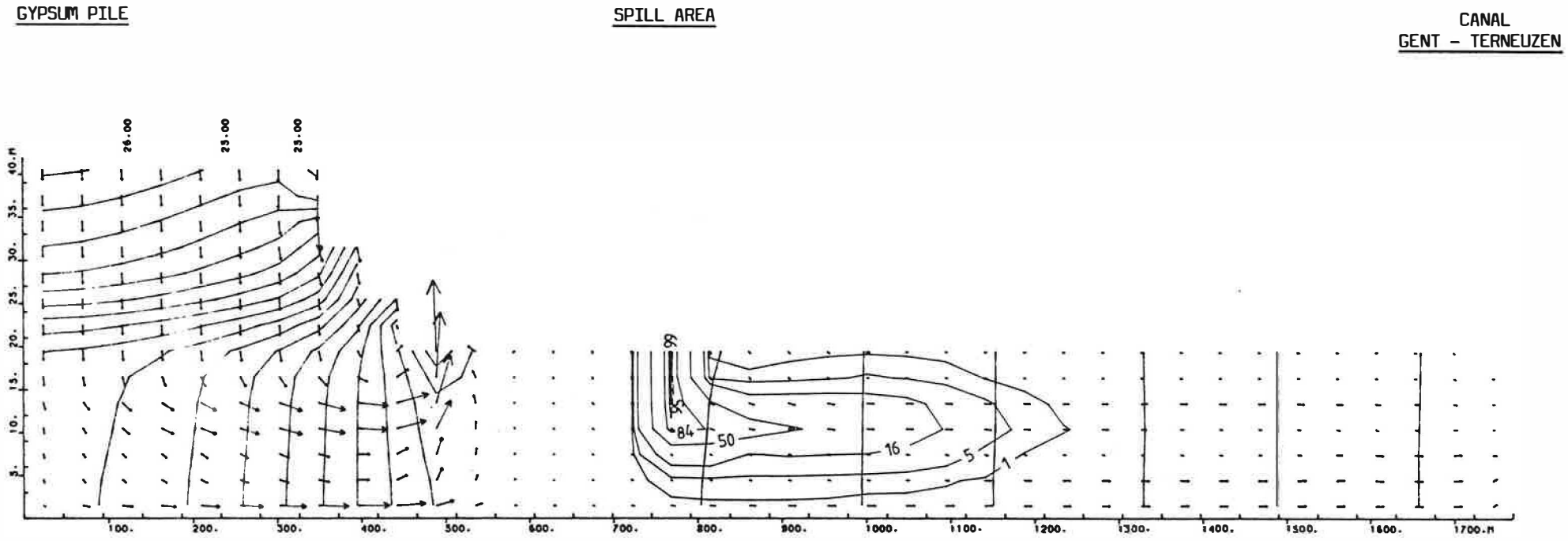


Fig. 35 - Simulation V1 - situation after 15 years (1987)

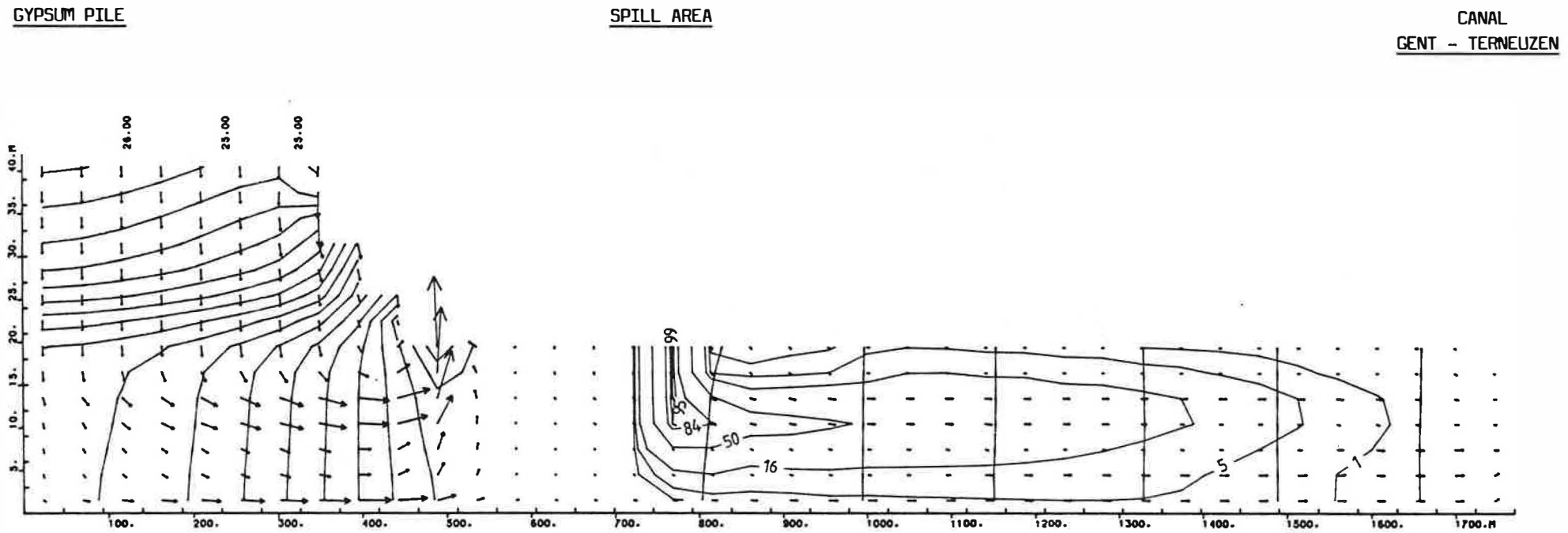


Fig. 36 - Simulation V2 - situation after 30 years (2002)

APPENDIX 1
BOREHOLE RECORDS
SITUATION PLANS

Rijksuniversiteit Gent
Laboratorium voor Toegepaste Geologie en Hydrogeologie
Laboratory of Applied Geology and Hydrogeology
Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 1S bis

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 14th 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Nordmeyer DRILLER :
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/5 GEOL./PEDOL. MAP Nr. : 40E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = Y = ZMV = 8,322 (m TAW)
  (LAMBERT-COORDINATES) ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Anger	168	0 - 2				
Bailer	135	2 - 13				
Casing	168	0 - 12,5				

- DRILLING MUD : - CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		10,5	12,5	8,791			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : yes/no
- Characteristics - riser pipes : Ø 63 x 1,8 PN10 PVC DYKA NBN T42-111
  - screens : PVC Ø 63 VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) :
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7 - 1,25 m
  - volume (l.) : 9,5 - 13 m depth
- Seals-type and characteristics : clay pellets Duranit
  - volume (l.) : from 0 to 9,5 m depth
- Borehole backfill material : -
- Development - method :
  - date - duration (h) : July 14th 1987; 15 min
  - discharge (m^3/h) : ± 1 ; see also sampling
- Finishing : steel cap

LITHOLOGIC LOG - DATE : July 14th 1987

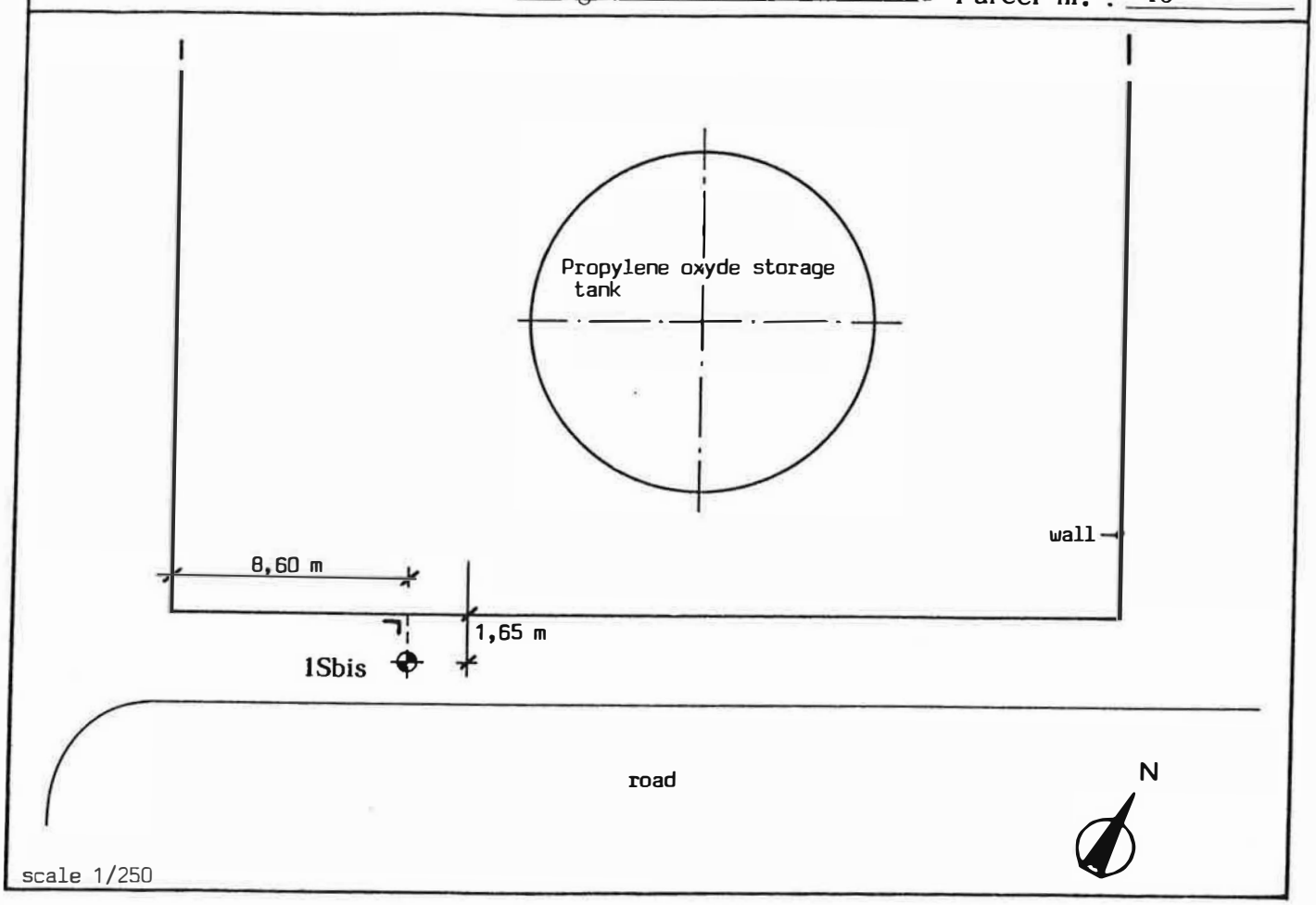
Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Cable tool drilling with use of pure water		
	Description of cuttings : see Drilling nr 1D bis		

Sample nr.	Description of the cuttings	Depth (m)	
		from	to

Geological interpretation and remarks

0 - 12,50 : KZ2
12,50 : KL

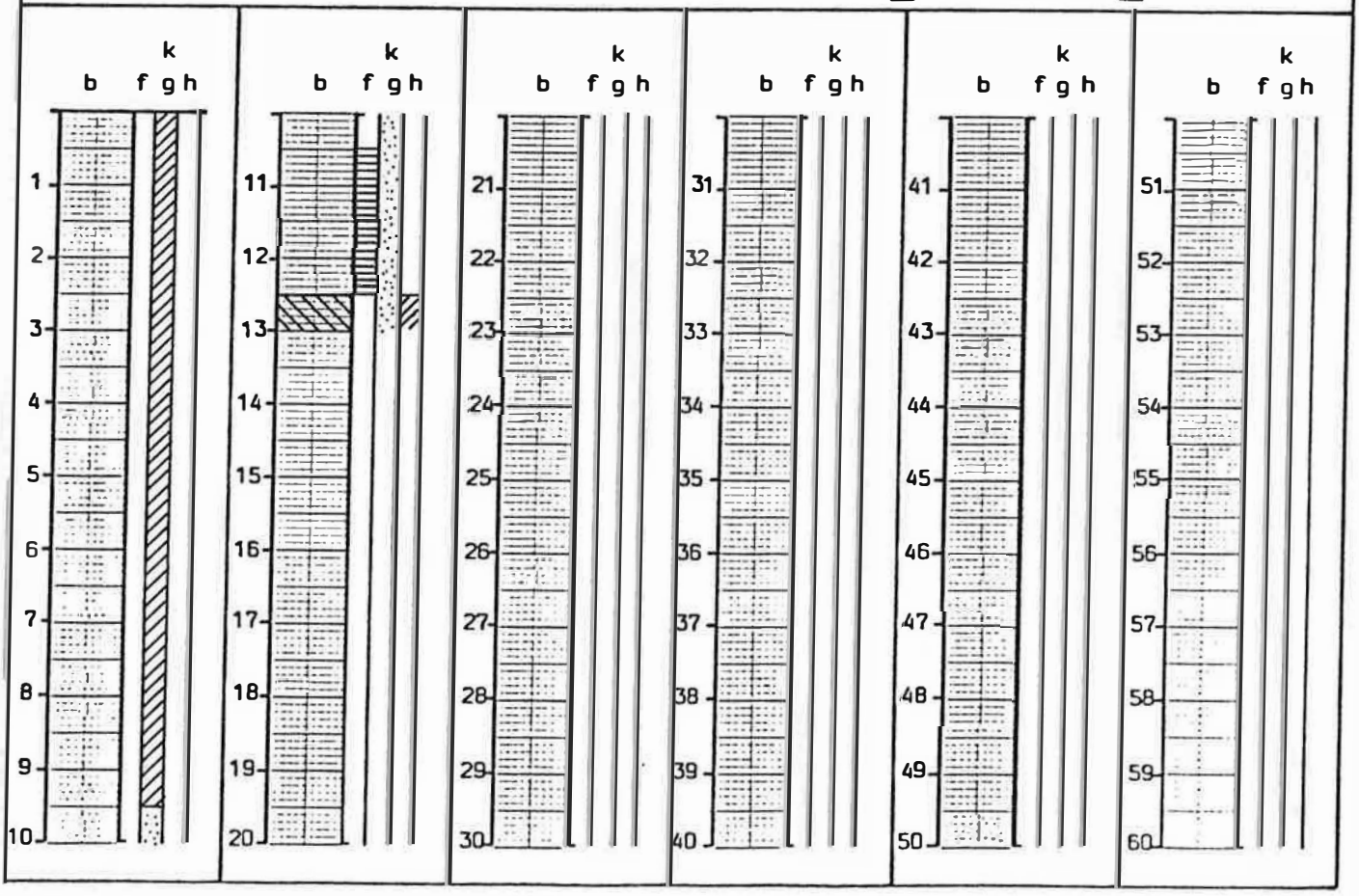
LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13^{h2}



lithologic log screen (s) filter pack seal(s) grout

(b) (f) (g) (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



Rijksuniversiteit Gent
Laboratorium voor Toegepaste Geologie en Hydrogeologie
Laboratory of Applied Geology and Hydrogeology
Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 1 D bis

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 6th 1987 - July 7th 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Nordmeyer DRILLER :
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/5 GEOL./PEDOL. MAP Nr. : 40E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = Y = ZMV = 8,434 (m TAW)
  (LAMBERT-COORDINATES) ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Auger	220	0 - 5,5				
Bailer	220	5,5-14,0				
Casing	267	0 -14,0				
Bailer	135	14,0-19,0				
Casing	168	0 -19,0				

- DRILLING MUD : - CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		17,25	19,25	9,011			2	11	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NBN T42-111
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) :
  - open area (%) :
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7 - 1,25 mm;
  - volume (l.) : from 16,0 - 19,5 m
- Seals-type and characteristics : Clay pellets "compactonite"
  - volume (l.) : from 16,0 to 0 m
- Borehole backfill material :
- Development - method : see sampling
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing : steel cap

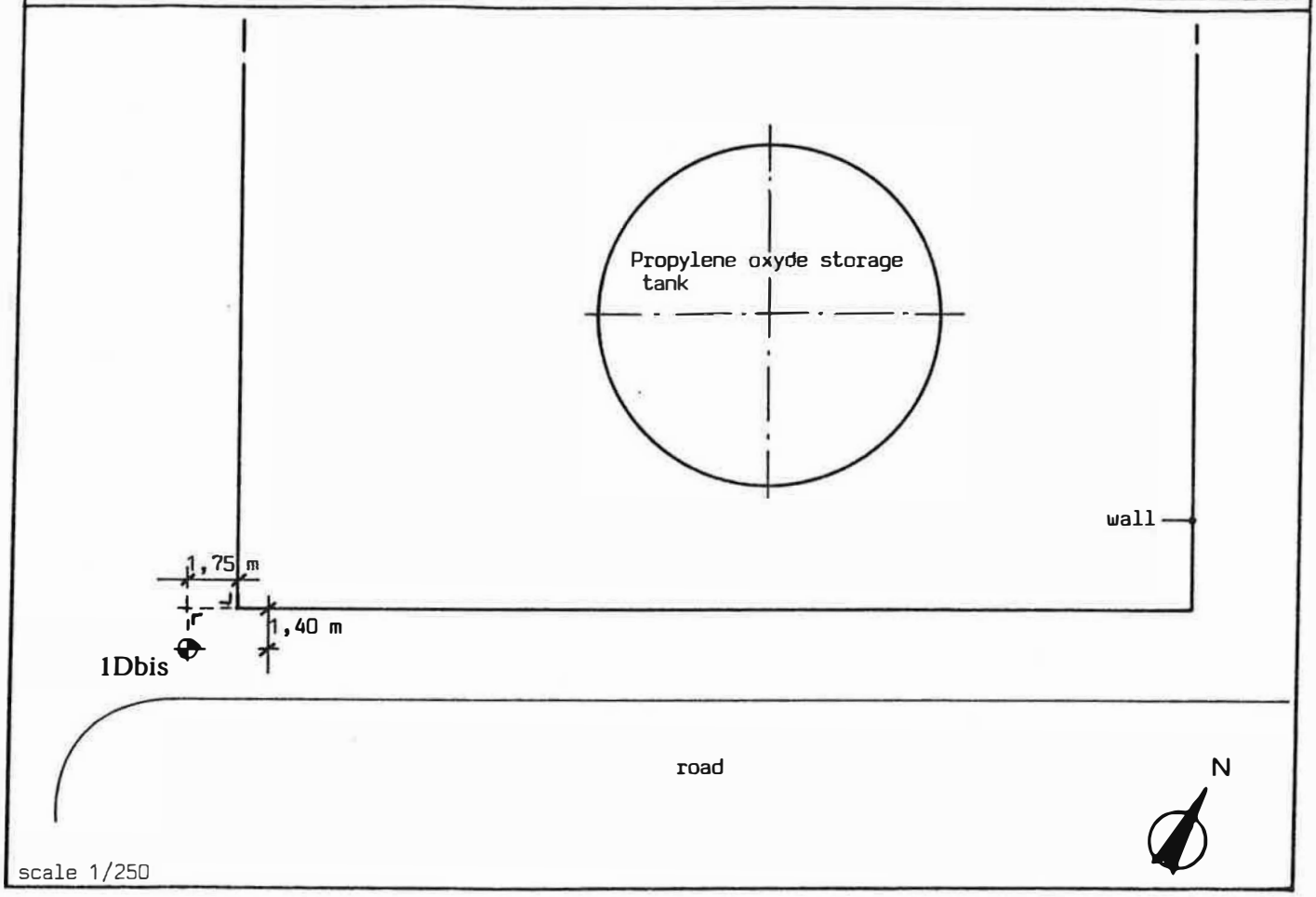
LITHOLOGIC LOG - DATE : 06-07-1987

Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Brown sand with stones and stone fragments	0	0,3
	Brown fine sand	0,3	1,5
	Greyish brown fine sand	1,5	2,0
	Greyish brown fine sand with thin layers of peat and plant fibres	2,0	2,5
	Greyish brown fine sand with many wood fragments	2,5	3,5
	Dark brown fine sand	3,5	4,0
	Grey silty fine sand	4,0	4,5
	Grey slightly sandy silt	4,5	5,1
	Grey slightly silty fine sand	5,1	5,3
	Grey slightly sandy silt	5,3	5,5
	Grey fine sand	5,5	6,5
	Greenish grey fine sand	6,5	8,5
	Grey fine sand	8,5	9,5
	Greenish grey fine sand with few fine shell fragments	9,5	10,5
	Grey fine sand with silt lumps	10,5	11,0
	Grey slightly silty fine sand with very few fine shell fragments	11,0	12,5
	Grey silt	12,5	12,6
	Grey silt with few fine gravel	12,6	13,5
	Greenish grey slightly sandy silt with thin black layers and few fine gravel		
	- Placement of protective casing (Ø 200 mm NP 7,5 VAN RYS-WYCK-VEGHEL BV HOLLAND Ø 200 x 5,1 Polva PVC 7,5 bar), pressed to a depth of 14,55 m.		
	Inserting of bentonite-cement grout from 0 to 13,5 m around this casing		

Sample nr.	Description of the cuttings	Depth (m) from	to
	July 7th 1987		
	Greenish grey slightly sandy silt	13,5	14,5
	Greenish grey silt	14,5	15,5
	Greenish grey slightly sandy silt	15,5	16,0
	Greyish green sandy silt	16,0	16,5
	Greyish green slightly silty fine sand	16,5	17,0
	Grey sandy silt	17,0	17,25
	Greyish green fine sand	17,25	17,5
	Greyish green fine sand with small silt lumps	17,5	18,25
	Greyish green fine sand with few fine wood fragments	18,25	18,75
	Greyish green fine sand with few fine gravel	18,75	19,0
	Greyish green fine sand with lumps of sandy clay	19,0	19,3
	Green stiff slightly sandy clay with few coarse and fine gravel	19,3	19,5
	During installation of the observation well, the inside of the protective casing has been filled up with clay pellets		
	From 2 - 9 m : slight odour (same as 2D) 9 - 17,5 m : strong penetrating odour (2D) 17,5-19,5m : slight odour (2D)		

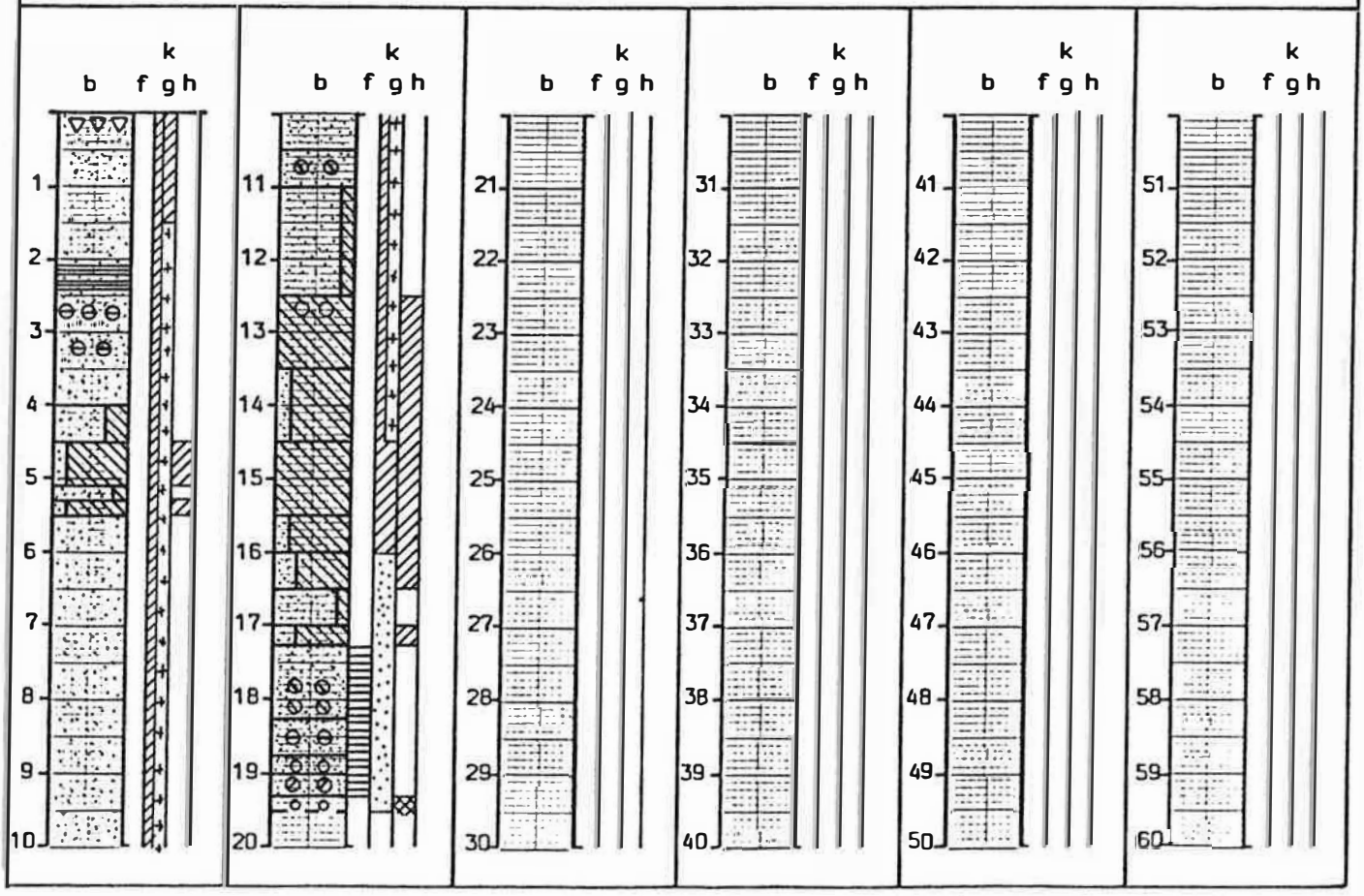
Geological interpretation and remarks	
0 - 0,3 m	Fill (disturbed soil)
0,3 - 12,5 m	KZ2 (pervious layer)
12,5 - 17,25 m	KL (semi pervious layer)
17,25 - 19,25 m	KZ1 (pervious layer)
19,25 -	a3 (Tertiary clay substratum)

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13h2



lithologic log screen (s) filter pack seal(s) grout
(b) (f) (g) (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



Rijksuniversiteit Gent
Laboratorium voor Toegepaste Geologie en Hydrogeologie
Laboratory of Applied Geology and Hydrogeology
Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 2S bis

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 15th 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Nordmeyer DRILLER :
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/5 GEOL./PEDOL. MAP Nr. : 40E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = Y = ZMV = 8,151 (m TAW)
  (LAMBERT-COORDINATES) ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Auger	168	0 - 2				
Bailer	135	2 - 12				
Casing	168	0 - 12				

- DRILLING MUD : - CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		10	12	8,640			1	10	2
F2									
F3									

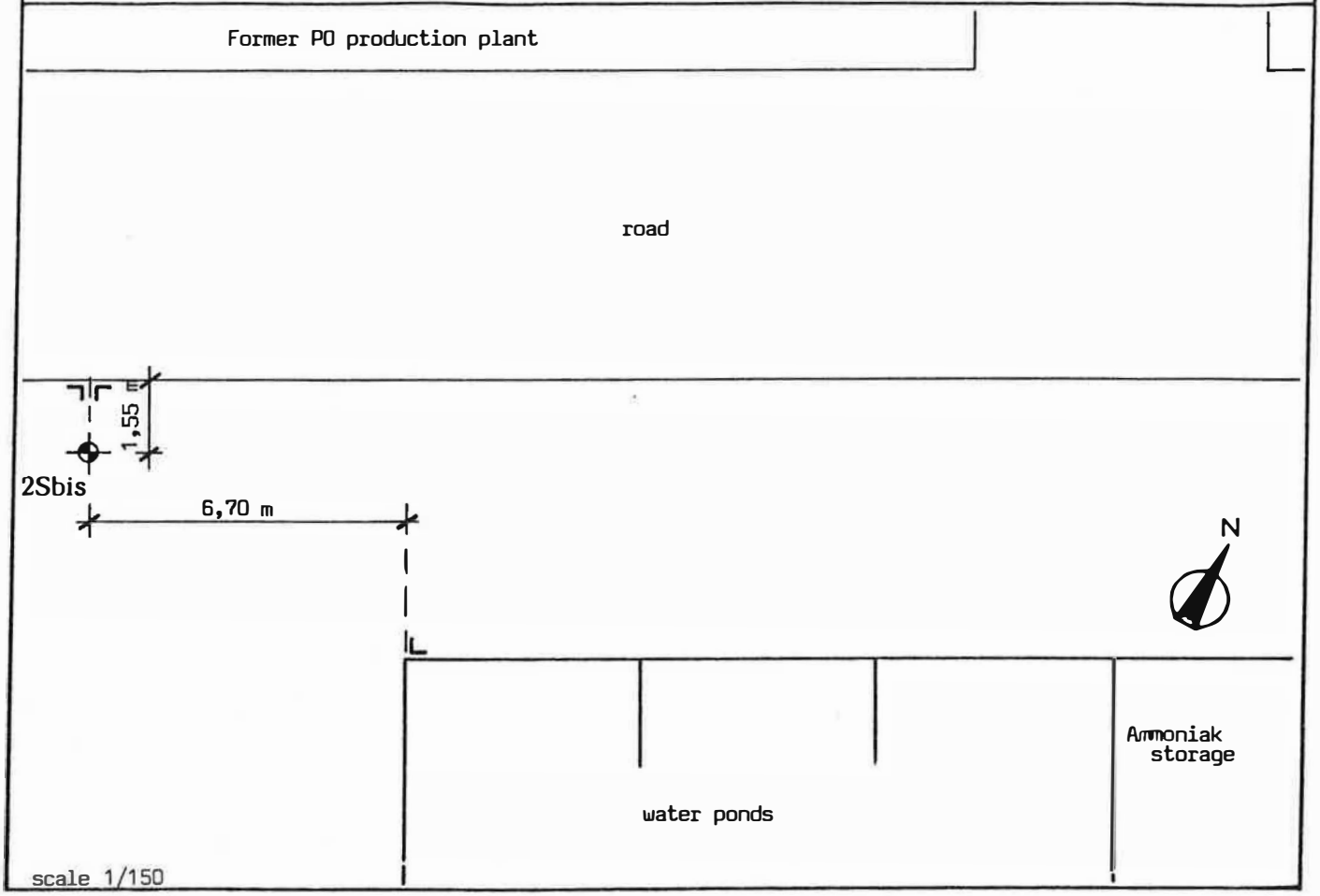
NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

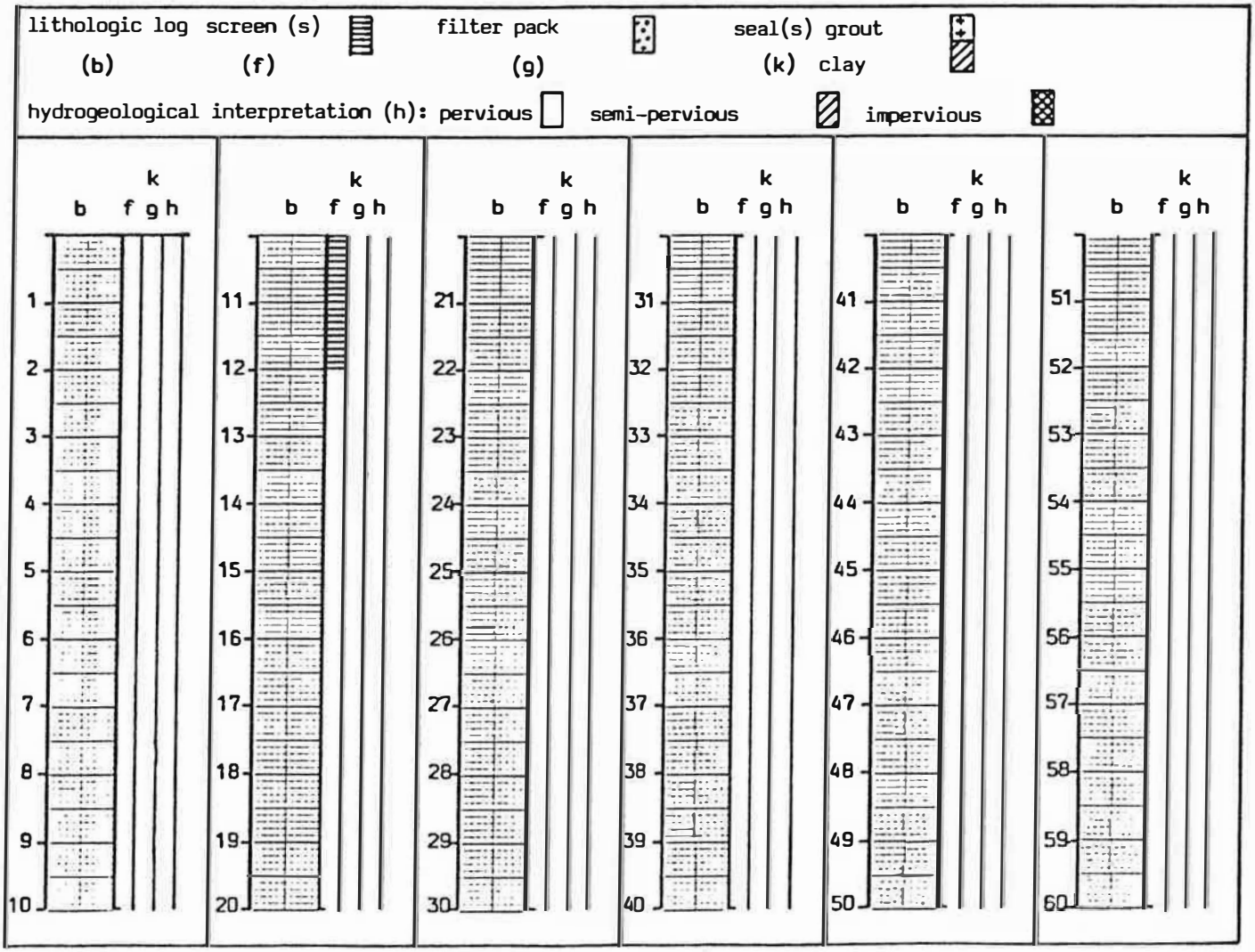
- Several screens in one borehole : yes/no
- Characteristics - riser pipes : Ø 63 x 1,8 PN10 PVC DYKA NBN T42-111
  - screens : PVC Ø 63 VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) :
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7 - 1,25 m
  - volume (l.) : 9,5 - 12 m depth
- Seals-type and characteristics : clay pellets Duranit
  - volume (l.) : from 0 to 9,5 m depth
- Borehole backfill material : -
- Development - method : see sampling
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing : steel cap

LITHOLOGIC LOG - DATE : July 15th 1987

Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Cable tool drilling with use of pure water		
	Description of cuttings : see Drilling nr 2D bis		

LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13^{h2}





Rijksuniversiteit Gent
Laboratorium voor Toegepaste Geologie en Hydrogeologie
Laboratory of Applied Geology and Hydrogeology
Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 2 D

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 02 nd 1987 - July 03 rd 1987
- DRILLING CY. : Geolab
- DRILLING RIG Nordmeyer DRILLER :
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/5 GEOL./PEDOL. MAP Nr. : 40E
- MUNICIPALITY : Evergem NIS-CODE :
- X = Y = ZMV = 8,124 (m TAW)
  (LAMBERT-COORDINATES) ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Auger	220	0 - 2				
Bailer	220	2 -14,5				
Casing	250	0 -14,5				
Bailer	135	14,5-19,5				
Casing	168	0 -19,0				

- DRILLING MUD : CONSUMPTION (l) :
- BOREHOLE LOG(S) :

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		17,5	19,5	8,711			2	11	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm x 1,8 PN 10 DYKA PVC NBN T42-111
  - screens : PVC Ø 63 NP 10 VAN RYSWYCK-VEGHEL BV HOLLAND
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) :
- Centralizer(s) - place (m) : 17,0 ; 19,0
- Filter-pack type and characteristics : coarse sand 0,7 - 1,25 mm
  - volume (l.) : from 16,0 to 19,5 m
- Seals-type and characteristics : Clay pellets Duranit
  - volume (l.) :
- Borehole backfill material : -
- Development - method : see sampling
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing :

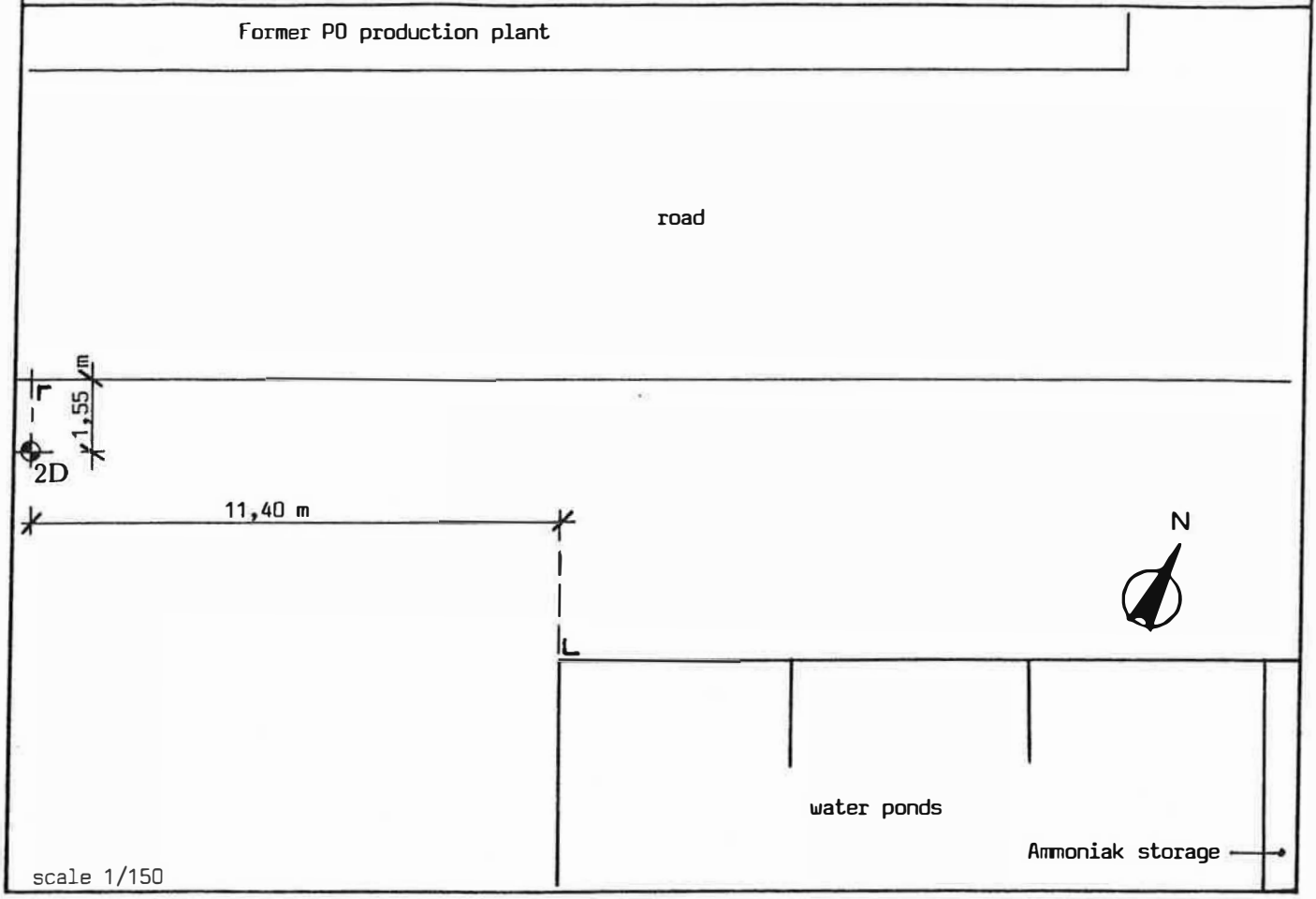
LITHOLOGIC LOG 2D - DATE : July 02nd 1987

Sample nr.	Description of the cuttings	Depth (m) from	to
M1	Dark brown fine sand	0,0	1,0
M2	Idem Brown fine sand	1,0	2,5
M3	Greyish brown fine sand	2,5	3,0
	Brown fine sand	3,0	3,5
M4	Greenish grey fine sand with wood fragments	3,5	4,0
M5	Greenish grey fine sand with small sandstone fragments	4,0	5,5
M6	Greenish grey fine sand	5,5	6,0
M7	Greenish grey fine sand	6,0	7,0
M8	Greenish grey silty fine sand with very few fine shell fragments	7,0	8,5
M9	Greenish grey slightly silty fine sand with very few fine shell fragments	8,5	9,0
M10	Idem	9,0	10,0
	Greenish grey silty fine sand with very few fine shell fragments	10,0	10,6
M11	Greenish grey sandy silt and silty sand	10,6	11,0
M12	Greenish grey slightly silty fine sand with very few fine shell fragments	11,0	12,0
	Idem	12,0	12,5
M13	Grey silt	12,5	13,0
	Grey slightly sandy silt with black spots	13,0	13,5
M14	Grey slightly sandy silt	13,5	14,5
	Placement of protective casing to a depth of 15,0 m, pressed into the silt layer KL the last half a meter (PVC VAN RYSWYCK EN VEGHEL BV HOLLAND Ø 200 mm x 5,9 Polva PVC 7,5 bar)		
	Placement of bentonite grout around the protective casing, from 14,5 to 0 m		

Sample nr.	Description of the cuttings	Depth (m) from	to
	Drilling continued on July 3rd 1987		
M15	Greenish grey slightly sandy silt	14,5	15,0
	Greenish grey sandy silt with black spots	15,0	15,5
M16	Greenish grey slightly sandy silt with fine black inter-layers	15,5	16,5
M17	Greenish grey slightly silty sand	16,5	17,0
M18	Greenish grey silty sand	17,0	18,5
	Greenish grey fine sand		
M19	Greenish grey fine sand with few small silt lumps	18,5	19,1
	Greyish green sandy stiff clay with few gravel and shell fragments	19,1	19,4
	Greyish green sandy stiff clay	19,4	19,5
	During installation of observation well the inside of the protective casing has been filled up with clay pellets		
	from 1,5 - 6,5 m slight odour		
	6,5 - 12,5 m strong penetrating odour		
	12,5 - 13,5 m slight odour		
	13,5 - 19,5 m strong penetrating odour		
	During the drilling, from 1,5 to 19,5 m : all the same, solvent like odour, which is referred to in the other drillings as "odour 2D"		

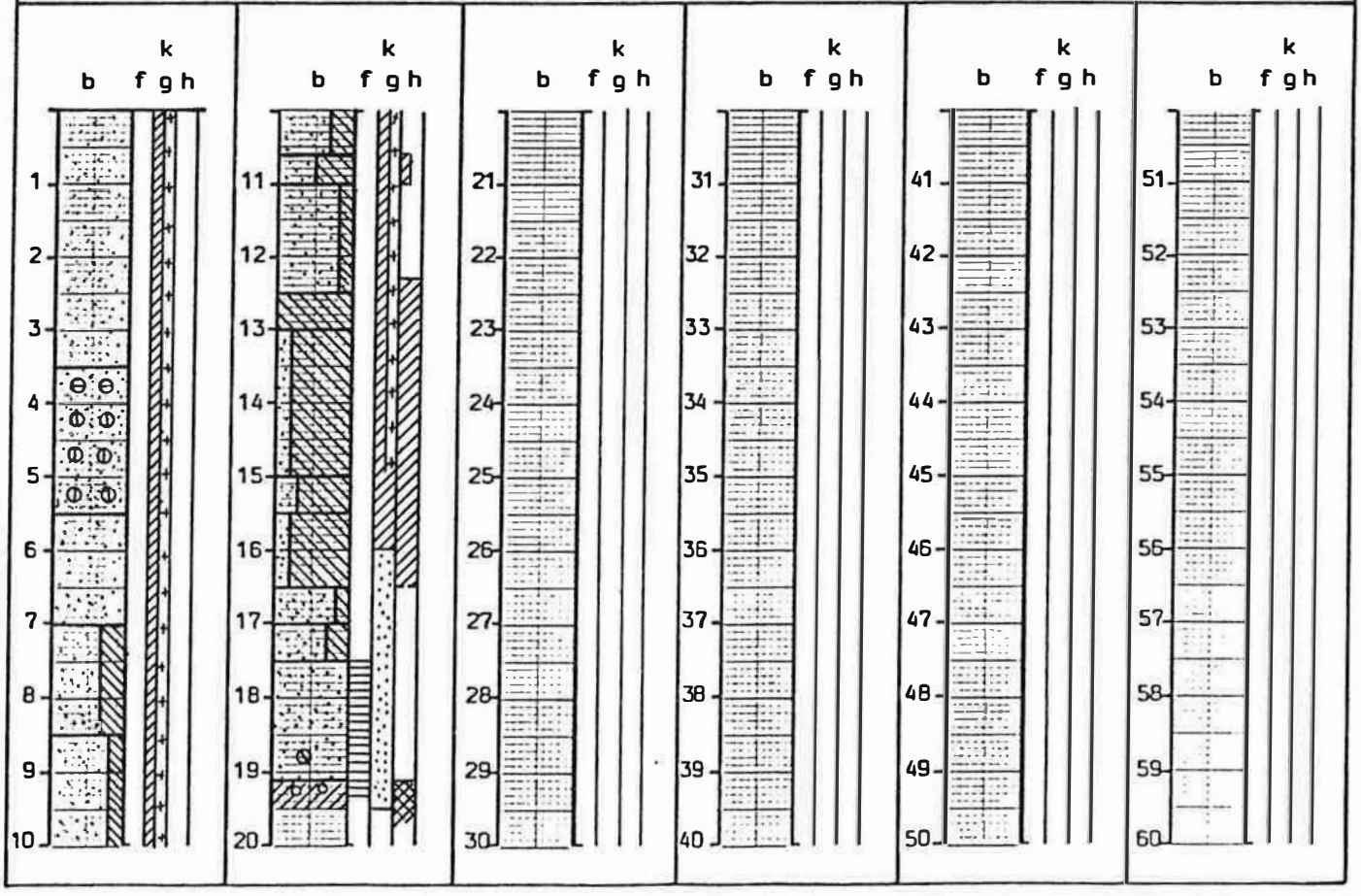
Geological interpretation and remarks
0 - 12,25 m : KZ2
12,25 - 17,5 m : KL
17,5 - 19,1 m : KZ1
19,1 - A3

LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13h2



lithologic log screen (s) filter pack seal(s) grout
(b) (f) (g) (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Laboratorium voor Toegepaste Geologie en Hydrogeologie
Laboratory of Applied Geology and Hydrogeology
Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 4S1

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 3rd 1987
- DRILLING CY. : Geolab
- DRILLING RIG Geolab DRILLER :
- DESCRIPTION OF CUTTINGS BY : no description
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = Y = ZMV = 8,798 (m TAW)
  (LAMBERT-COORDINATES) ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø	DEPTH (in m)				
	(mm)	from - to	from - to	from - to	from - to	from - to
rotary	160	0 - 10				

- DRILLING MUD : pure water CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		5,0	10,0	9,394			1	10	2
F2									
F3									

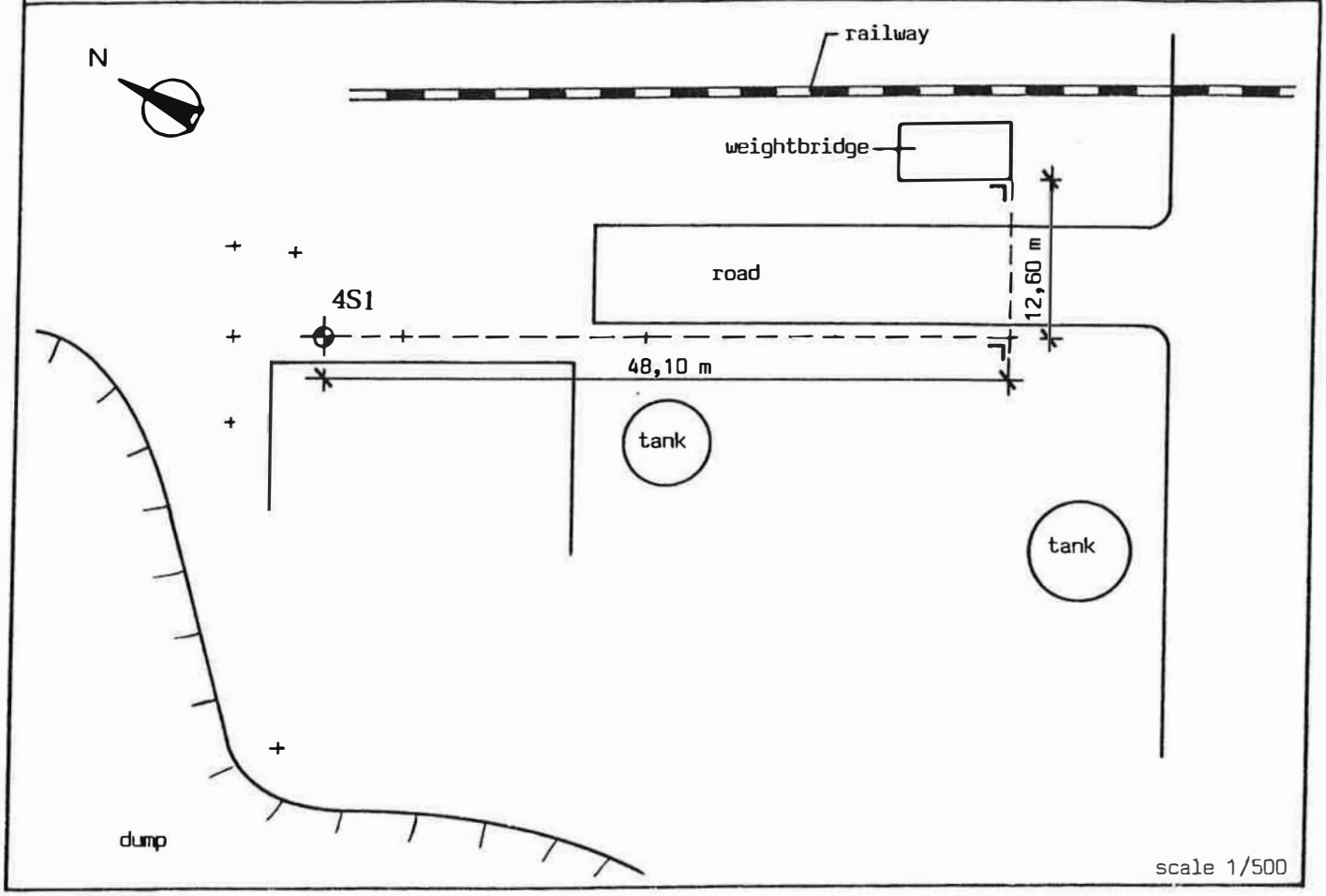
NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : yes/no
- Characteristics - riser pipes : PVC Ø 125 omniplast KL10 KIWA 6110/87-11
  - screens : PVC Ø 125 x 4,8 WIKA
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,10
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,4
  - open area (%) :
- Centralizer(s) - place (m) : 10,0 and 5,0
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 10-6 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 0 to 6 m
- Borehole backfill material : -
- Development - method : see pumping test
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing : steel cap

LITHOLOGIC LOG - DATE : _____

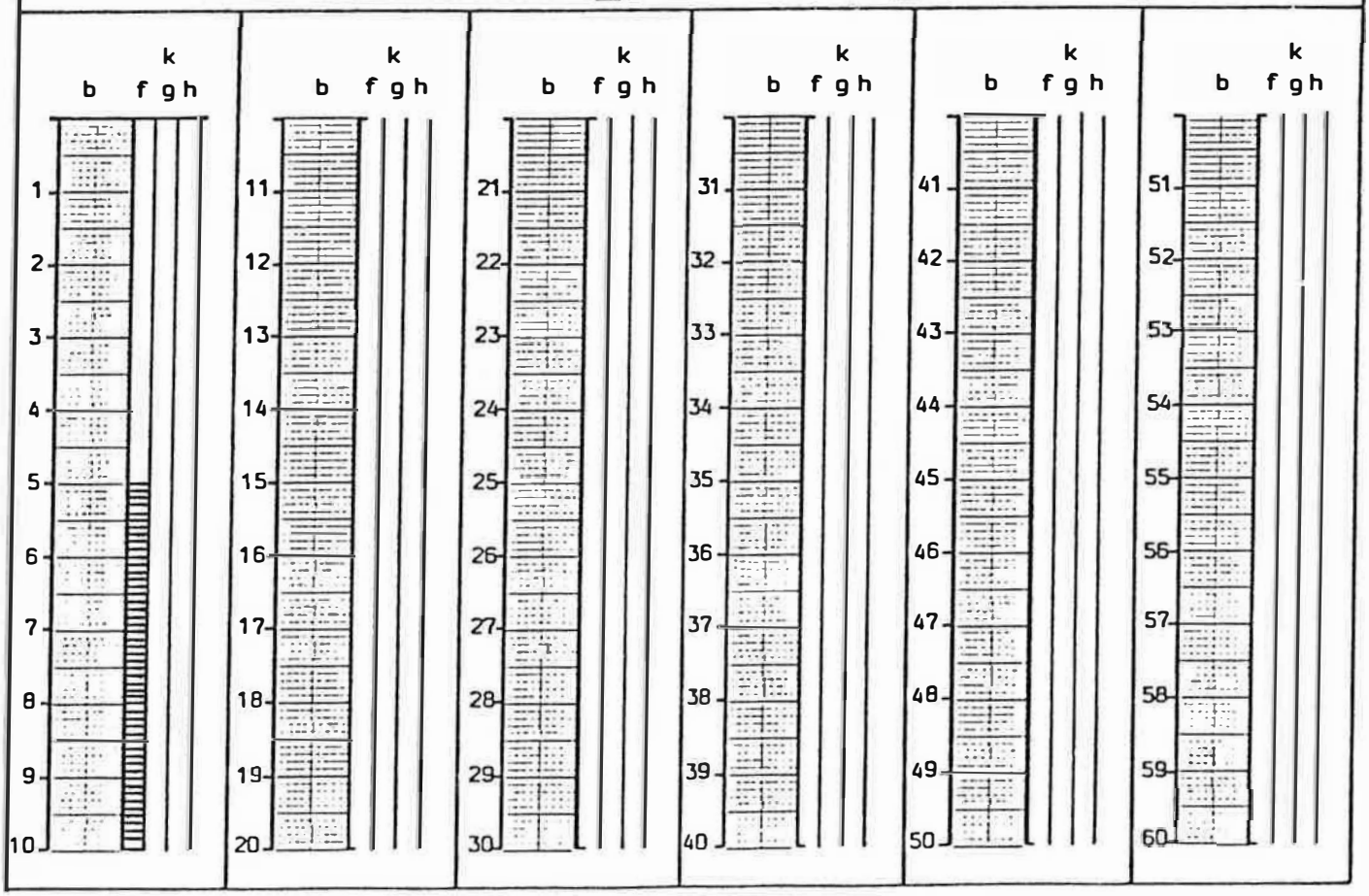
Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	See description 4D1		

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13r2



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 4S2

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 3rd 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Geolab DRILLER : -
- DESCRIPTION OF CUTTINGS BY : -
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = _____ Y = _____ (LAMBERT-COORDINATES) ZMV = 8,655 (m TAW) ZMV* = _____ (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø	DEPTH (in m)				
	(mm)	from - to	from - to	from - to	from - to	from - to
rotary	160	0 - 10				

- DRILLING MUD : pure water CONSUMPTION (l) : -
- BOREHOLE LOG(S) : _____

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		8,0	10,0	9,200			1	10	2
F2									
F3									

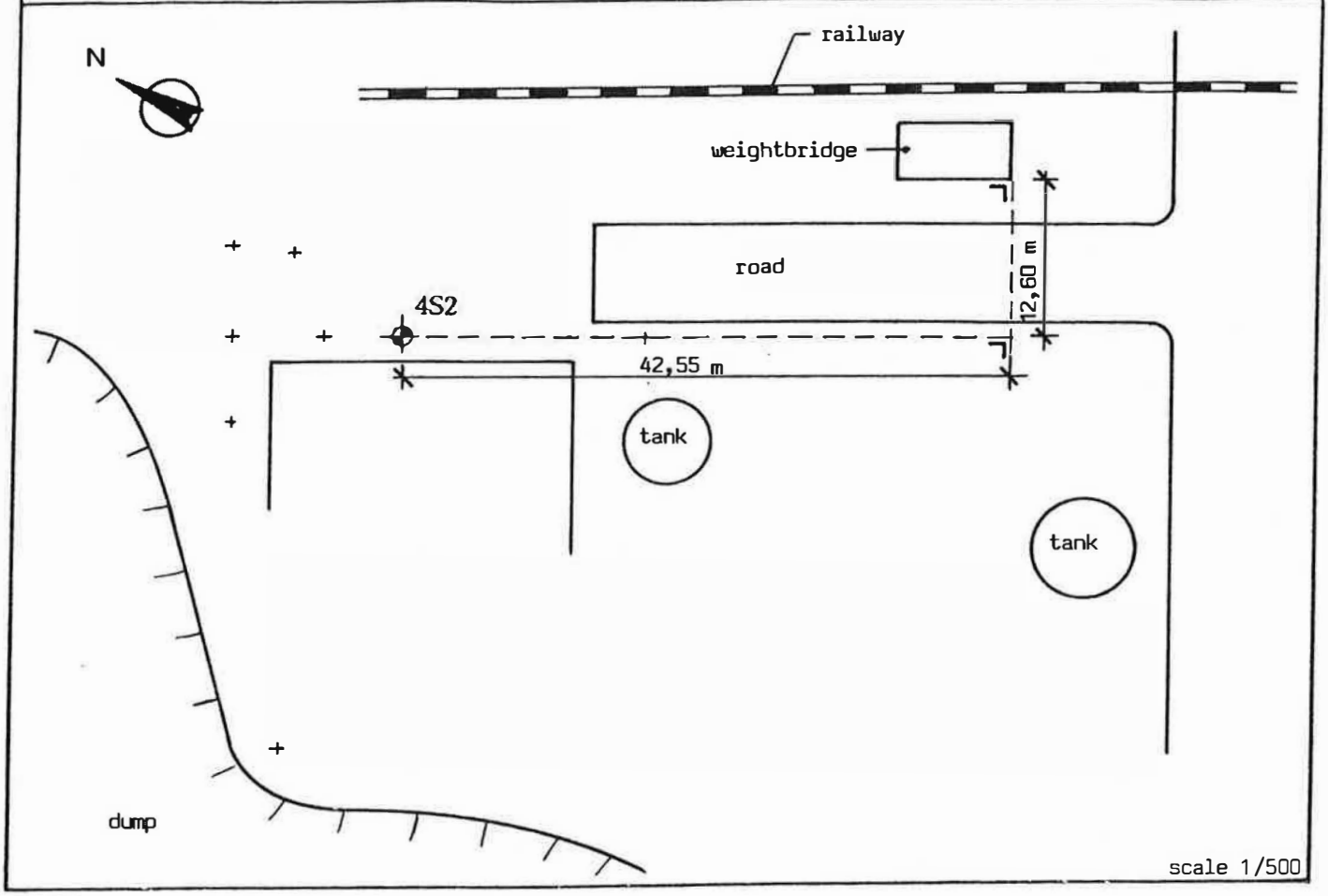
NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NBN T42-111 PN20
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) : _____
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 7 to 10 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 0 to 7 m
- Borehole backfill material : -
- Development - method : _____
  - date - duration (h) : _____
  - discharge (m^3/h) : _____
- Finishing : _____

LITHOLOGIC LOG - DATE : ____________

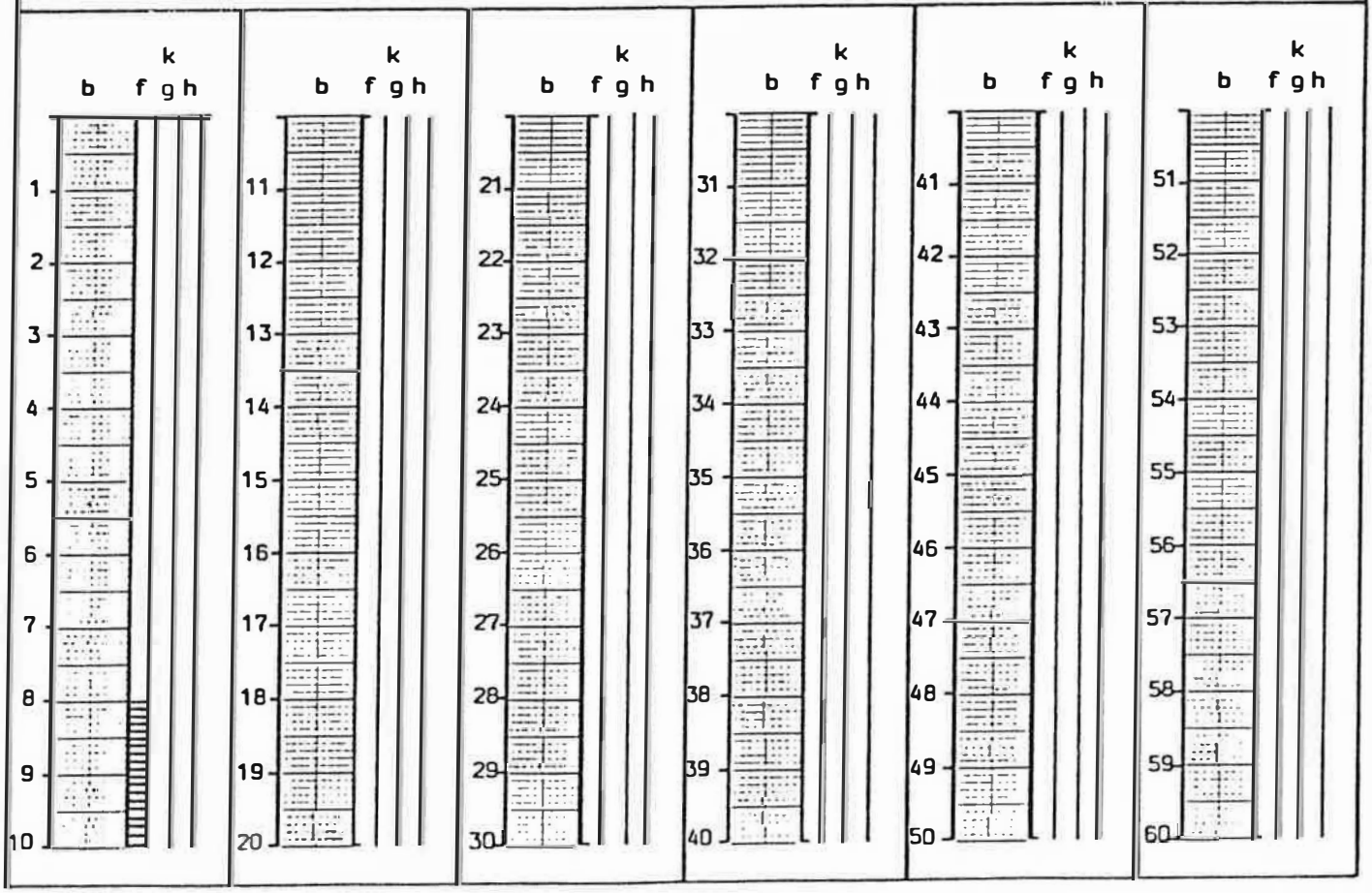
Sample nr.	Description of the cuttings	Depth (m)	
		from	to
	See description 4D1		

LOCATION - CADASTRAL MAP :Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13r2



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Research nr. : TGO 86/81

Well nr. : 4S3

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 3rd 1987
- DRILLING CY. : Geolab
- DRILLING RIG Geolab DRILLER :
- DESCRIPTION OF CUTTINGS BY :
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. :
- MUNICIPALITY : Evergem NIS-CODE :
- X = Y = ZMV = 8,468 (m TAW)
  (LAMBERT-COORDINATES) ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø	DEPTH (in m)				
	(mm)	from - to	from - to	from - to	from - to	from - to
ROTARY	160	0 - 10				

- DRILLING MUD : pure water CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		8,0	10,0	9,165			1	10	2
F2									
F3									

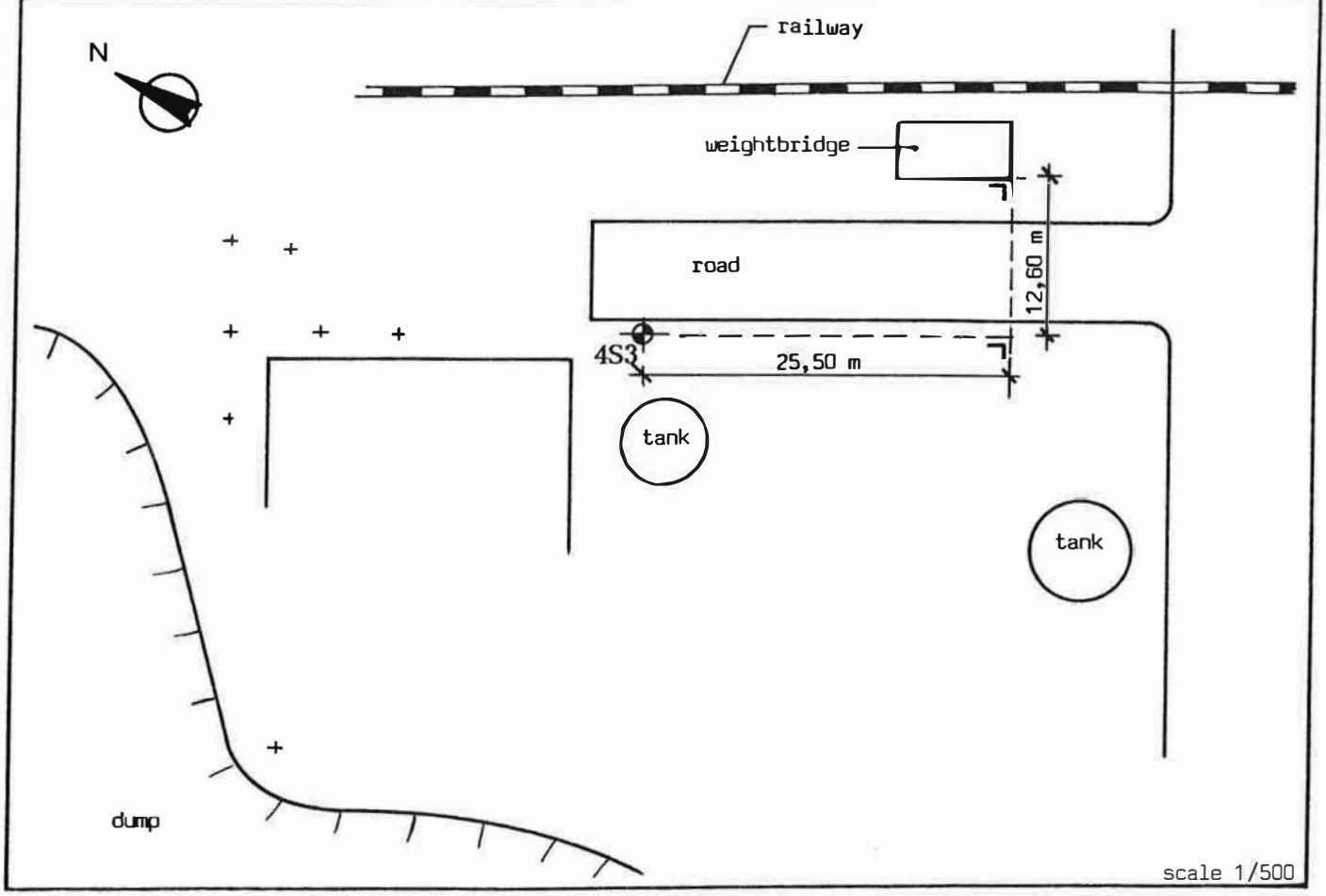
NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NBN T42-111 PN10
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) :
- Centralizer(s) - place (m) : 10,0 and 5,0 m
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 10 to 7 m
- Seals-type and characteristics : Clay pellets "compactonite"
  - volume (l.) : from 0 to 7 m
- Borehole backfill material : -
- Development - method :
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing :

LITHOLOGIC LOG - DATE : _____

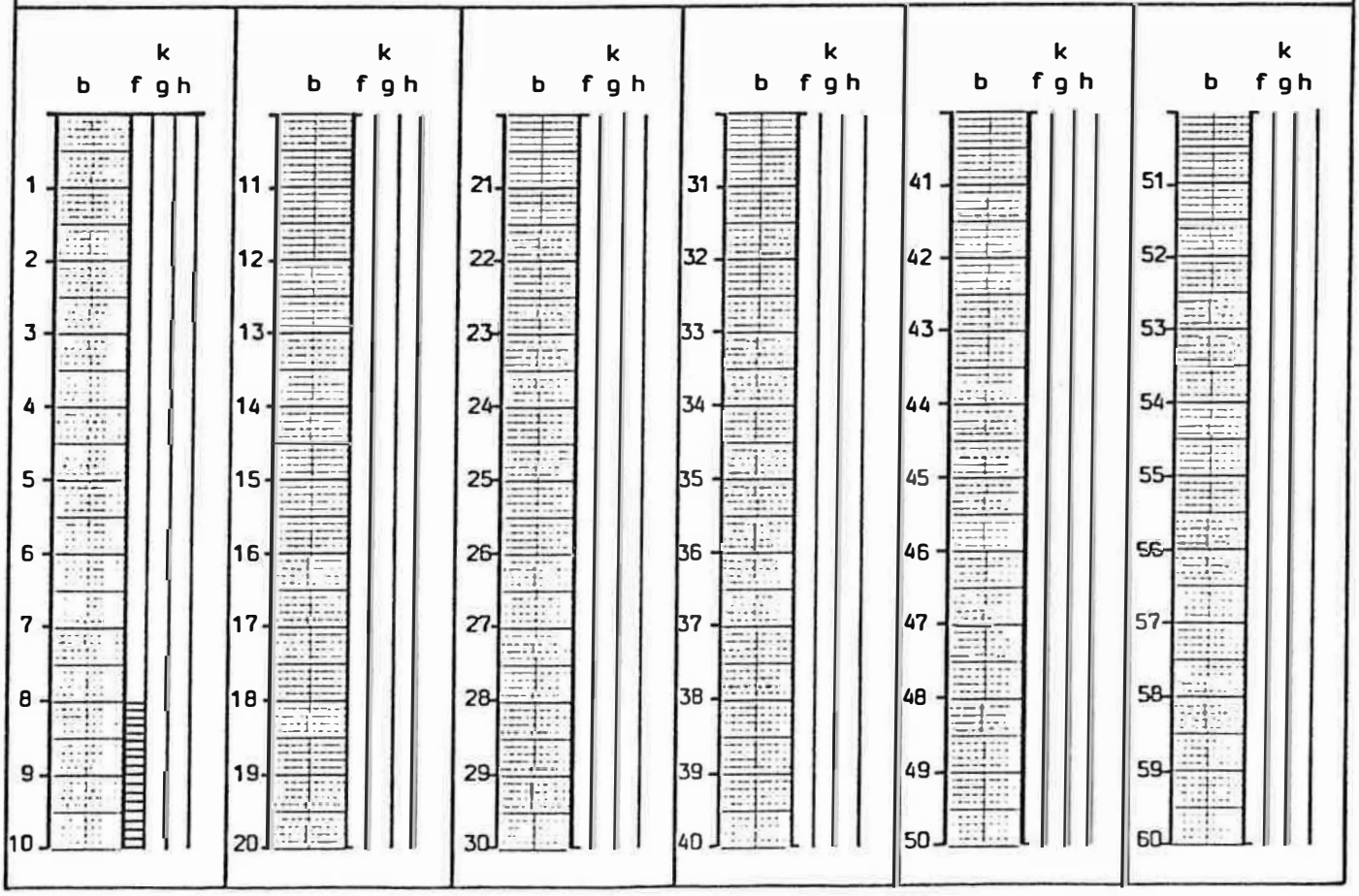
Sample nr.	Description of the cuttings	Depth (m)	
		from	to
	See description 4D1		

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13r2



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Research nr. : TGO 86/81

Well nr. : 4S4

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 4th 1987
- DRILLING CY. : Geolab
- DRILLING RIG Geolab DRILLER : _____
- DESCRIPTION OF CUTTINGS BY : _____
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = _____ Y = _____ (LAMBERT-COORDINATES) ZMV = 8,750 (m TAW) ZMV* = _____ (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
rotary	160	0 - 3,5				

- DRILLING MUD : _____ CONSUMPTION (l) : _____
- BOREHOLE LOG(S) : _____

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		2,5	3,5	9,046			1	10	2
F2									
F3									

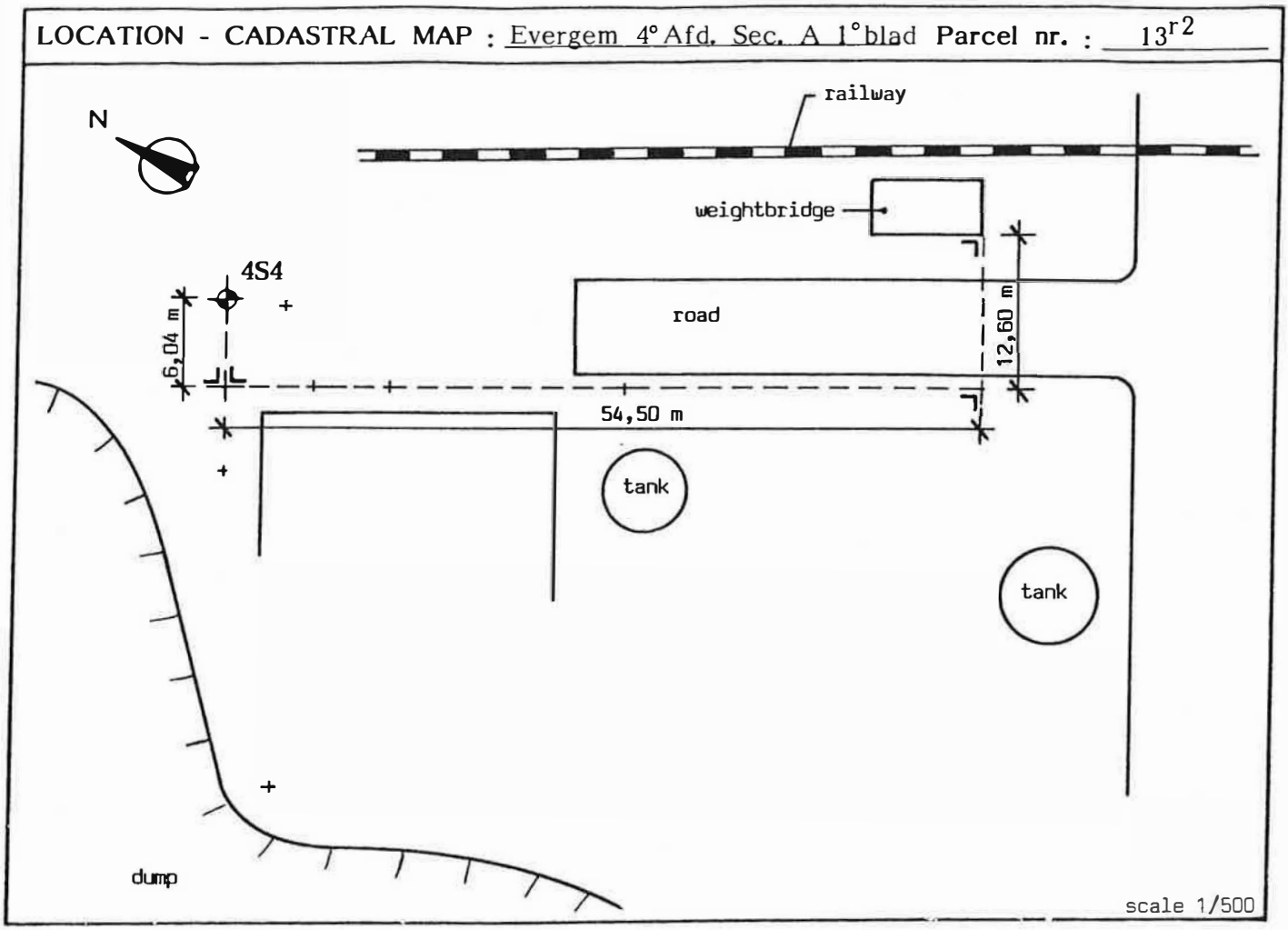
NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NBN T42-111 PN10
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) : _____
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 1 to 3,5 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 0 to 1 m
- Borehole backfill material : -
- Development - method : _____
  - date - duration (h) : _____
  - discharge (m^3/h) : _____
- Finishing : _____

LITHOLOGIC LOG - DATE : _____

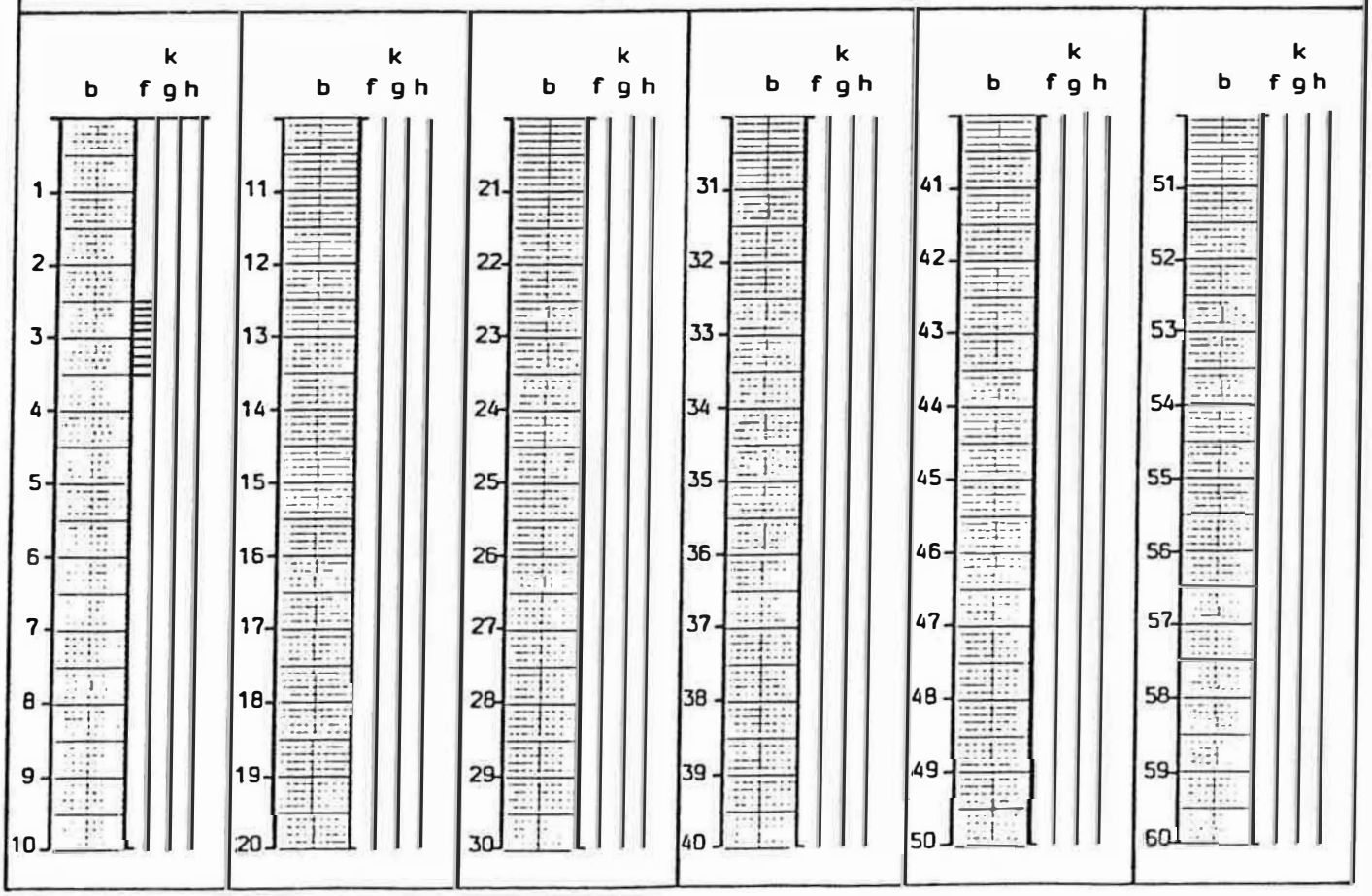
Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	See description 4D1		

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13r2



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Research nr. : TGO 86/81

Well nr. : 4S5

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 4th 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Geolab DRILLER : -
- DESCRIPTION OF CUTTINGS BY : -
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = _____ Y = _____ (LAMBERT-COORDINATES) ZMV = 8,784 (m TAW) ZMV* = _____ (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø	DEPTH (in m)				
	(mm)	from - to	from - to	from - to	from - to	from - to
rotary	160	0 - 14,6				

- DRILLING MUD : _____ CONSUMPTION (l) : _____
- BOREHOLE LOG(S) : _____

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		13,6	14,6	9,234			2	9	2
F2									
F3									

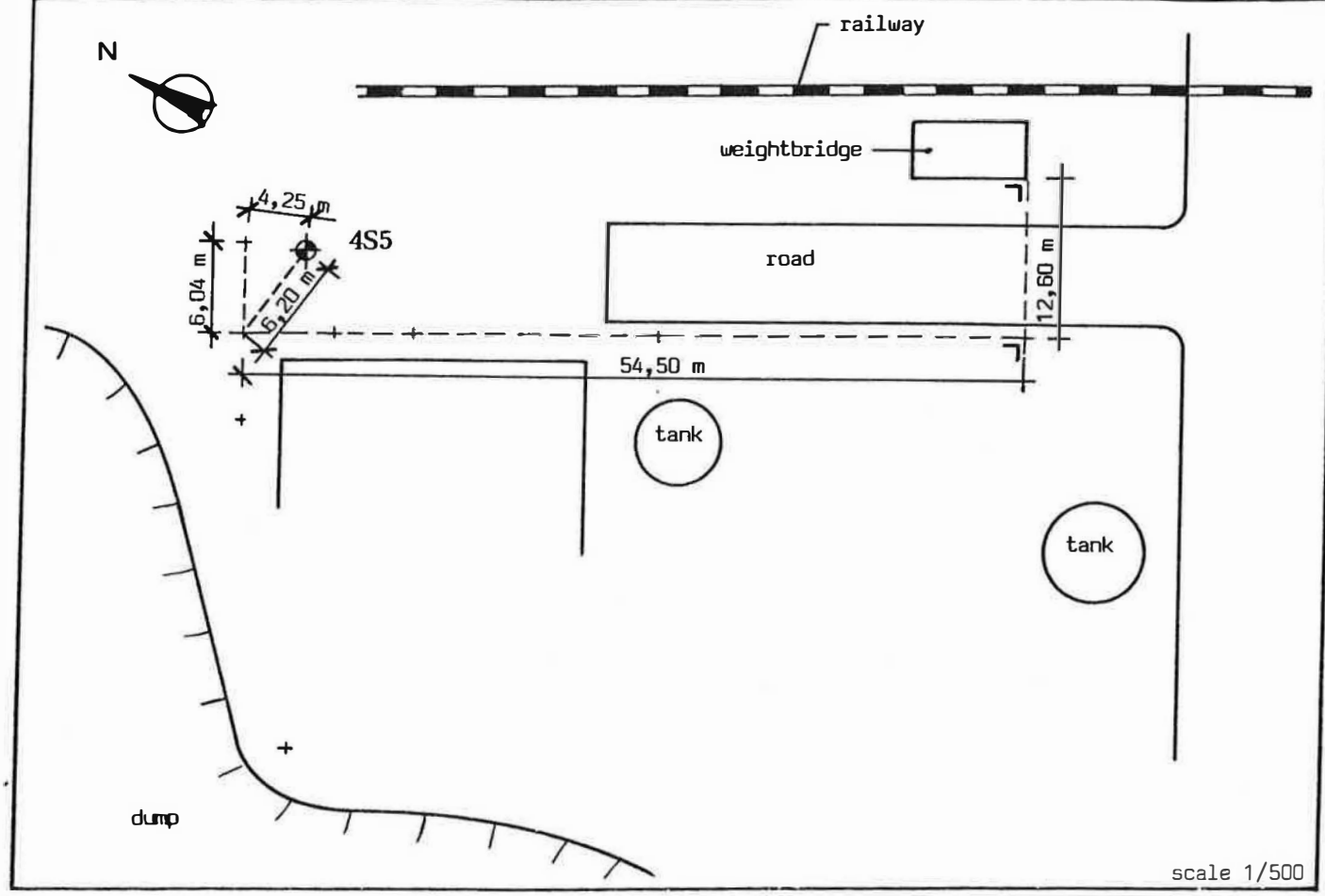
NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NBN T42-111 PN10
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) : _____
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 13 to 14,6 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 0 to 13 m
- Borehole backfill material : -
- Development - method : _____
  - date - duration (h) : _____
  - discharge (m^3/h) : _____
- Finishing : _____

LITHOLOGIC LOG - DATE : _____

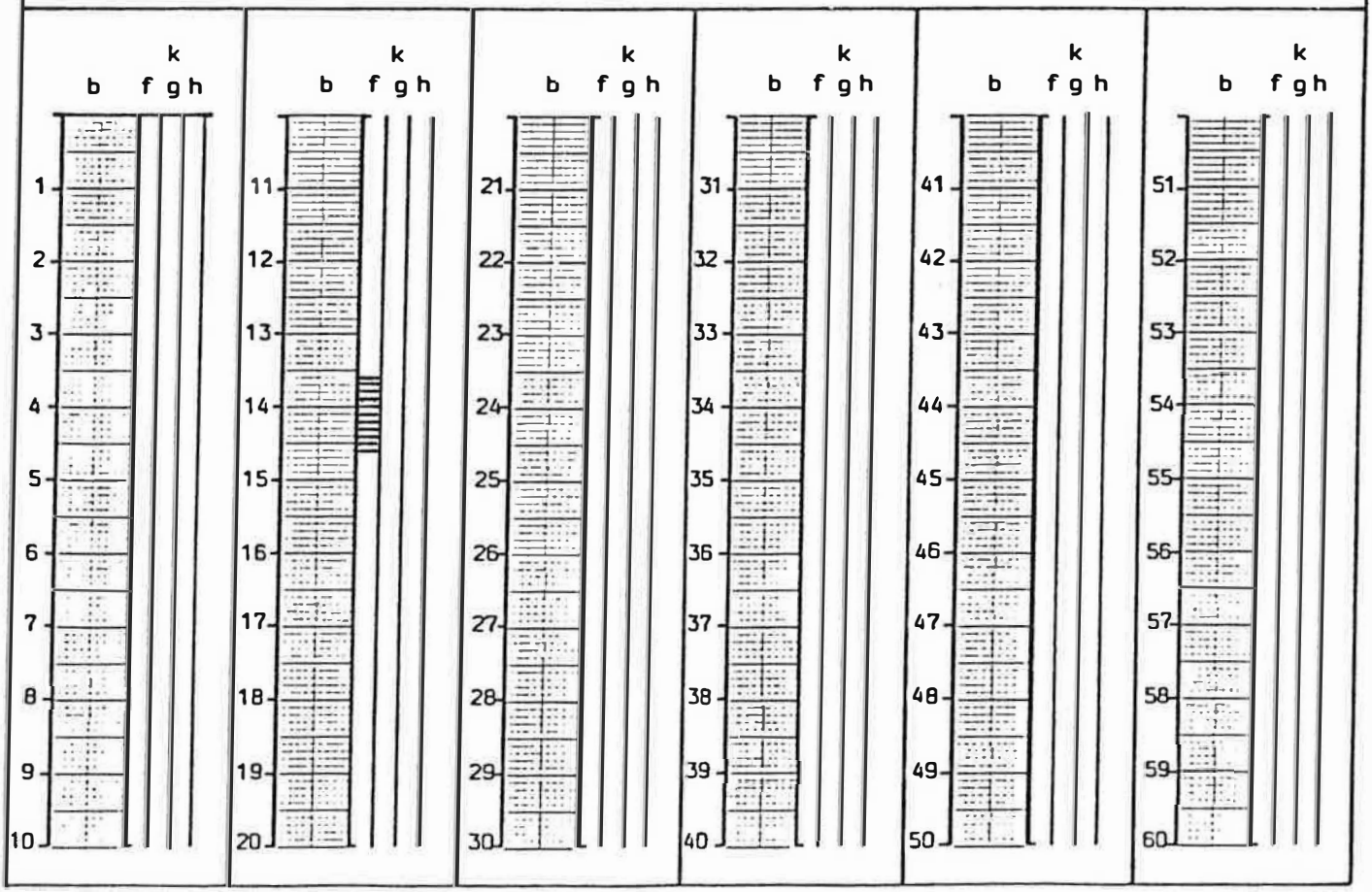
Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Description has been made during drilling 4D1		

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13^{r2}



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 4D1

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : June 30, 1987 - July 01, 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Nordmeyer DRILLER : _____
- DESCRIPTION OF CUTTINGS BY : E. Van Dyck - A. De Bruyn
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : _____
- X = _____ Y = _____ (LAMBERT-COORDINATES) ZMV = 8,801 (m TAW) ZMV* = _____ (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Auger	250	0,0- 1,5				
Auger	220	1,5- 2,5				
Bailer	220	2,5-12,0				
Casing	267	0,0-11,6				
Bailer	135	12,0-21,1				
Casing	168	0,0-21,2				

- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		17,0	20,0	9,391			2	11	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC OMNIPLAST Ø 125 x 4,8 KL10 KIWA 6190 / 87-11
  - screens : PVC Ø 125 x 4,8 WIKA
  - connections : GLUED AND SCREWED JOINTS
- Bottom pipe (m) : 0,10
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,4
  - open area (%) : _____
- Centralizer(s) - place (m) : 17,0 ; 20,0
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : _____
- Seals-type and characteristics : Clay pellets Duranit
  - volume (l.) : _____
- Borehole backfill material : -
- Development - method : see pumping test
  - date - duration (h) : _____
  - discharge (m^3/h) : _____
- Finishing : steel cap

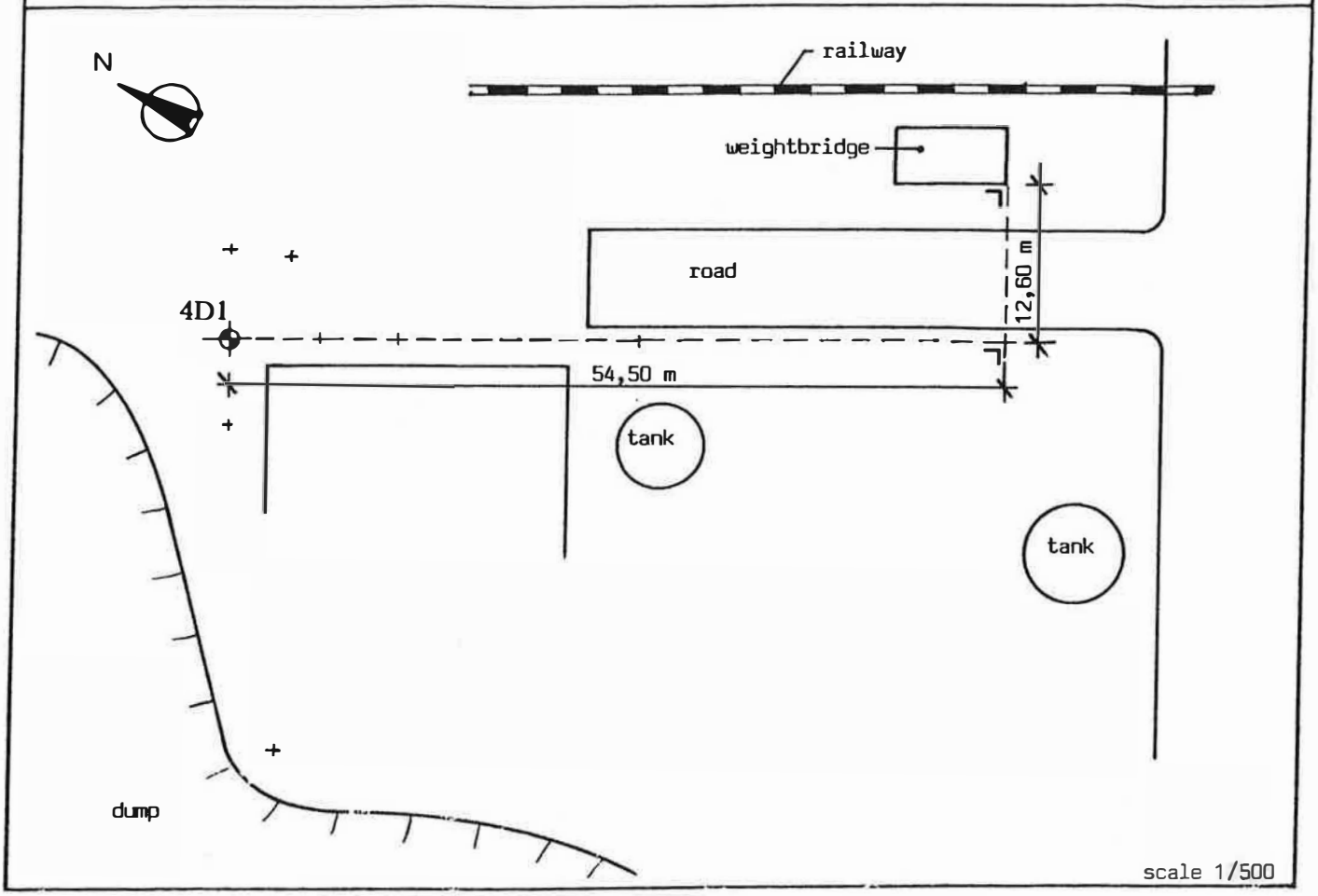
LITHOLOGIC LOG 4D1 - DATE : June 30th 1987

Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Greyish brown fine sand	0,0	0,4
	Black humic fine sand	0,4	0,5
M1	Black humic fine sand with wood and stone fragments	0,5	1,4
M2	Brown fine sand	1,4	2,0
M3	Idem	2,0	3,0
M4	Greyish brown fine sand with peat fragments	3,0	4,5
M5	Idem, with wood fragments	4,5	5,0
M6	Grey to greenish grey fine sand with peat and wood fragments	5,0	6,0
M7	Idem	6,0	7,0
M8	Grey fine sand with very few peat fragments	7,0	8,0
	Grey fine sand	8,0	8,5
M9	Idem, with grey sandy silt lumps	8,5	9,0
M10	Grey fine sand	9,0	10,5
M11	Grey very silty fine sand to sandy silt	10,5	11,0
M12	Idem, with very few fine shell fragments	11,0	12,0
	Installation of protective casing to a depth of 12,65 m. Around this casing bentonite-cement grout was inserted from 12,1 to 0,5 m depth. From 0,5 to 0 m clay pellets have been used to fill up around the protective casing which is made of PVC (Ø 200 mm DYKA-RIOOL 200 x 3,90 86-33)		
	Drilling continued on July 1st 1987		
M13	Grey slightly silty fine sand	12,0	13,0
	Grey sandy silt	13.0	13,5
M14	Grey slightly sandy silt	13,5	14,0
M15	Idem	14,0	15,8
M16	Grey very sandy silt	15,8	16,0

Sample nr.	Description of the cuttings	Depth (m) from	to
	Grey slightly sandy silt	16,0	16,5
M17	Idem, with very few fine wood fragments	16,5	17,0
	Grey very silty fine sand with very few fine wood fragments	17,0	17,5
M18	Idem, with very few fine shell fragments	17,5	18,0
	Grey silty fine sand with few fine shell fragments	18,0	18,5
M19	Grey slightly silty fine sand with few fine shell and wood fragments	18,5	19,0
M20	Grey sand with few silt lumps	19,0	20,0
	Greyish green and brown stiff clay with shell fragments, few wood fragments and few fine gravel	20,0	20,3
	Grey clayey fine sand with few clay lumps	20,3	20,5
M21	Idem, with sandstone fragments and pyrite	20,5	21,0
	Grey stiff clay with pyritisized sandstone fragments	21,0	21,1
	After cable tool drilling, cleaning of the borehole with pure water, from 12,6 to 21,0 m (Ø 160 mm). Inside of protective casing has been filled up with clay pellets.		
	Odour : 0,5 - 1 m : strong; different from 2D 7,5 - 14 m : same, but slight odour; different from 2D		
	During jetting : ammonia odour		

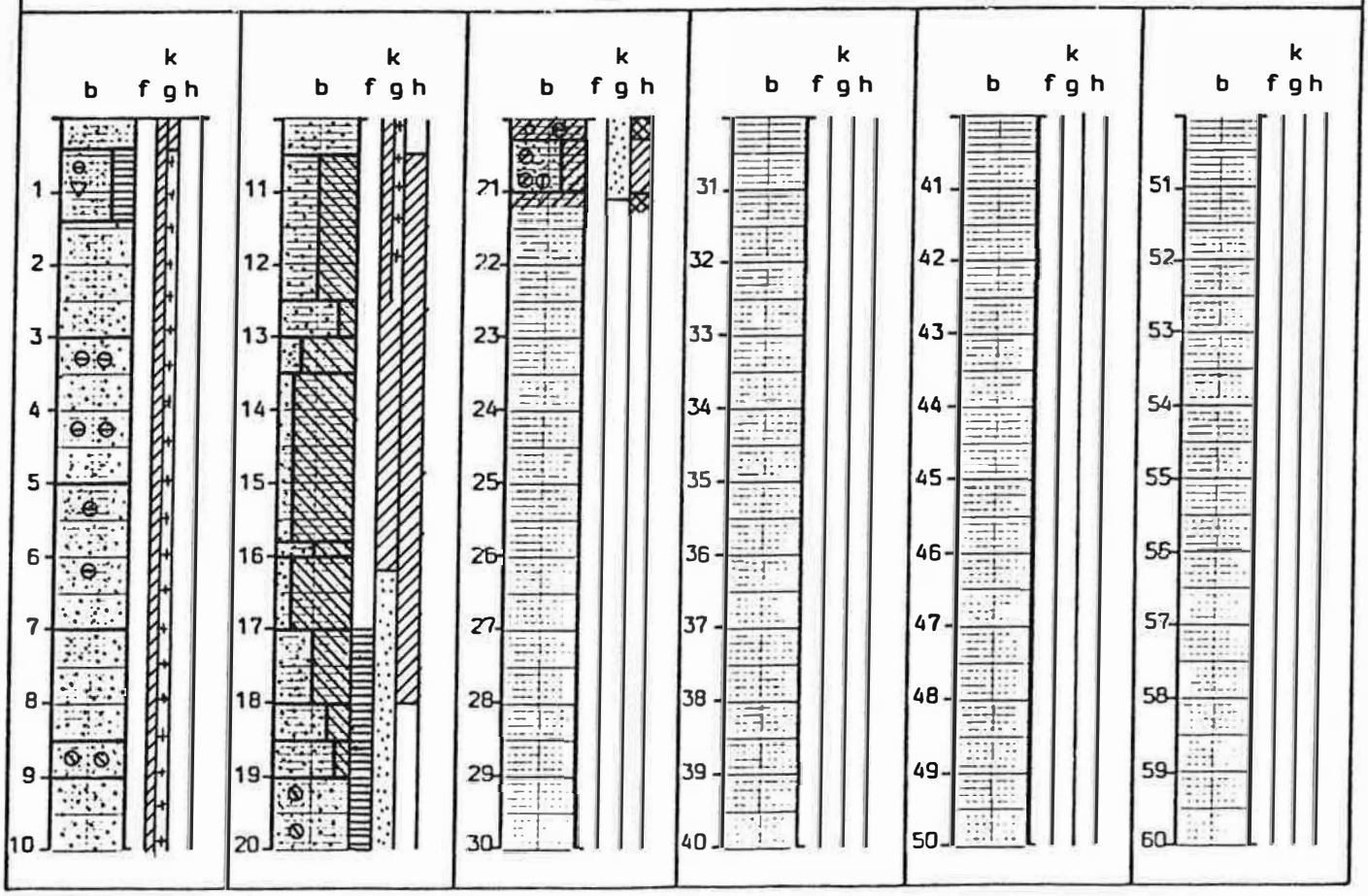
Geological interpretation and remarks
0 - 10,5 m KZ2
10,5 - 17,0 m KL
17,0 - 20,0 m KZ1
20,0 - a3

LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13r2



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 4D2

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 1st , 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Geolab DRILLER : -
- DESCRIPTION OF CUTTINGS BY : -
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = _____ Y = _____ (LAMBERT-COORDINATES) ZMV = 8,935 (m TAW) ZMV* = _____ (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
ROTARY	160	0 - 20				

- DRILLING MUD : pure water CONSUMPTION (l) : _____
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		18,0	20,0	9,627			2	11	2
F2									
F3									

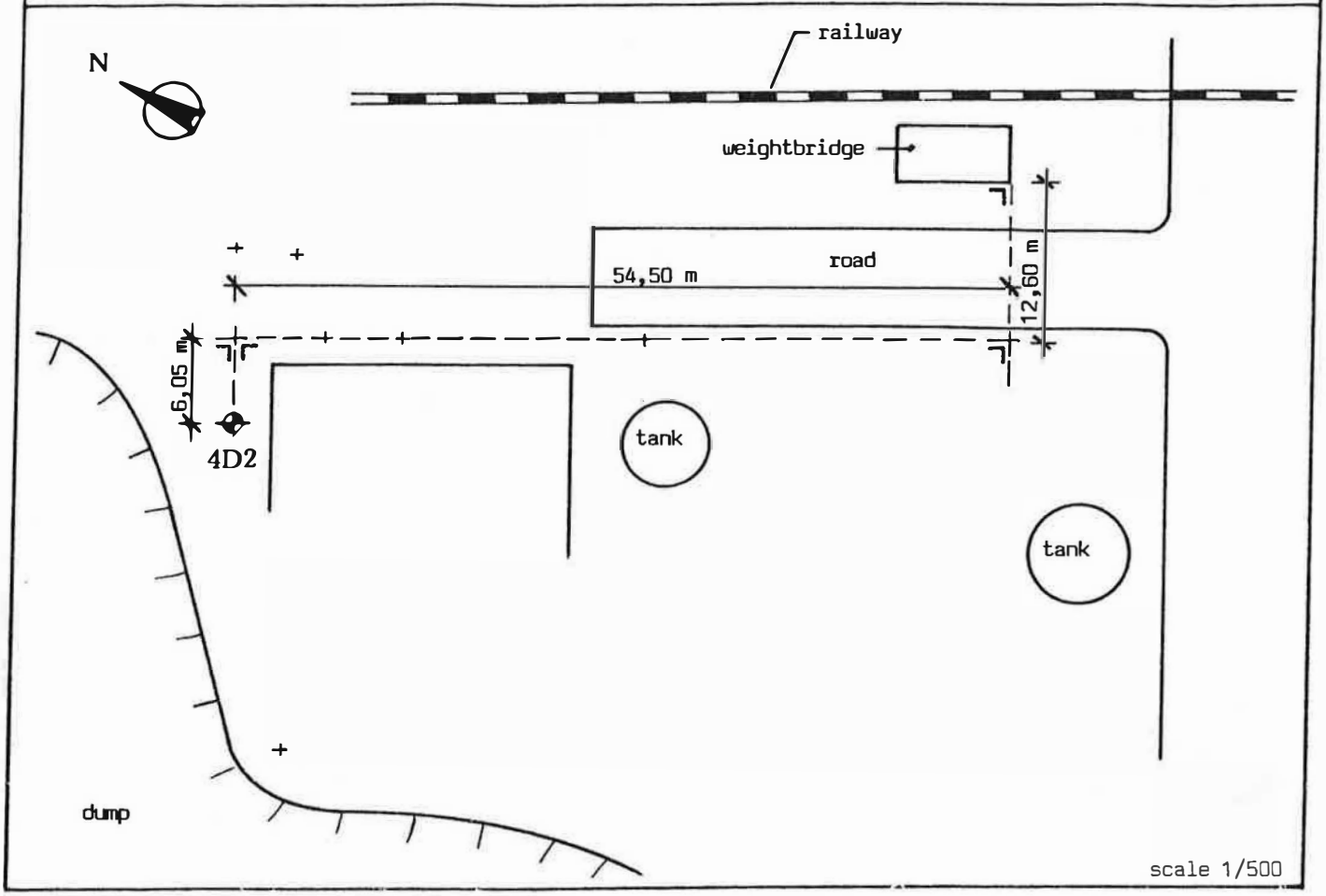
NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NP10 NBN T42-11
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND PN10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) : _____
- Centralizer(s) - place (m) : 20,0 and 10,0
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 17 to 20 m
- Seals-type and characteristics : Clay pellets compactonite/duranite
  - volume (l.) : from 0 to 17 m
- Borehole backfill material : -
- Development - method : _____
  - date - duration (h) : _____
  - discharge (m^3/h) : _____
- Finishing : _____

LITHOLOGIC LOG - DATE : _____

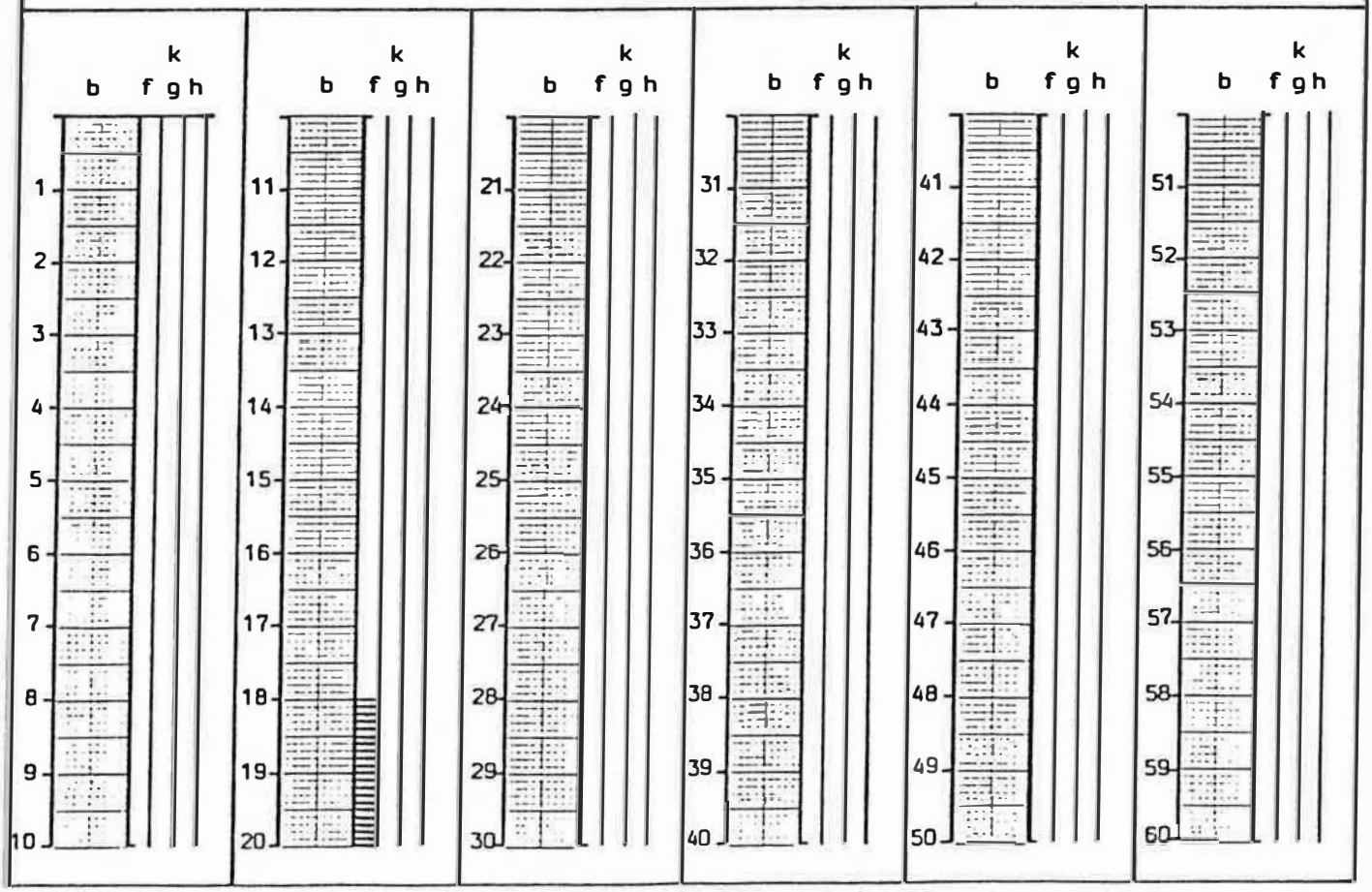
Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Description has been made during drilling 4D1		

LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13r2



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Research nr. : TGO 86/81

Well nr. : 4D3

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 2nd, 1987
- DRILLING CY. : Geolab
- DRILLING RIG Geolab DRILLER : -
- DESCRIPTION OF CUTTINGS BY : -
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = ____ Y = ____ ZMV = 9,192 (m TAW)
  (LAMBERT-COORDINATES) ZMV* = ____ (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø	DEPTH (in m)				
	(mm)	from - to	from - to	from - to	from - to	from - to
Jetting	160	0 - 20,0				

- DRILLING MUD : pure water CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		18,0	20,0	9,217			2	11	2
F2									
F3									

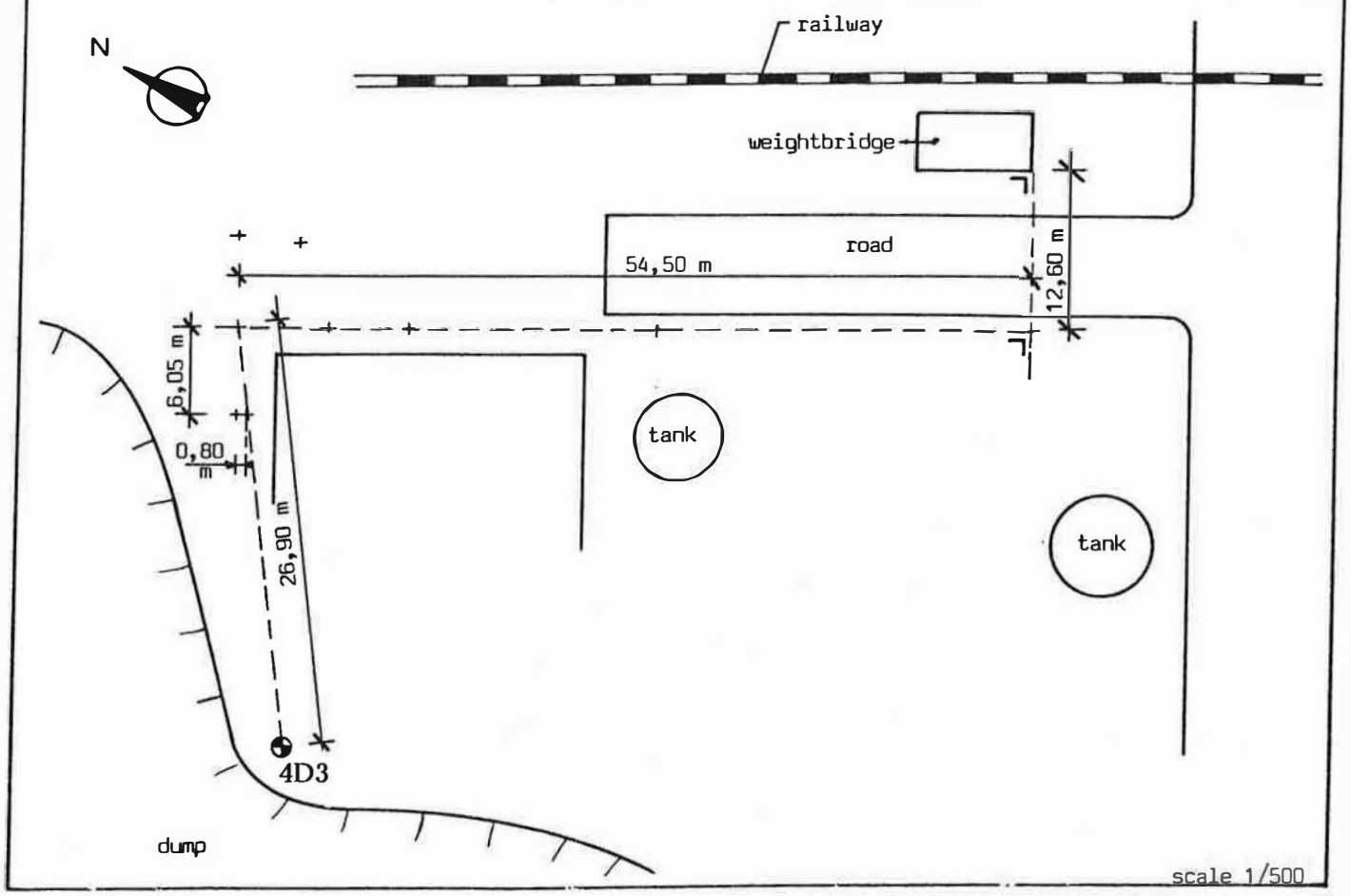
NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : DYKA PVC Ø 63 mm NBN T42-111 PN10
  - screens : VAN RYSWYCK-VEGHEL BV HOLLAND PVC Ø 63 mm NP 10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 20,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) : ____
- Centralizer(s) - place (m) : 20 m and 10 m
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 20 to 17 m
- Seals-type and characteristics : Clay pellets Duranit
  - volume (l.) : from 0 to 17 m
- Borehole backfill material : -
- Development - method : ____
  - date - duration (h) : ____
  - discharge (m^3/h) : ____
- Finishing : ____

LITHOLOGIC LOG - DATE : _____

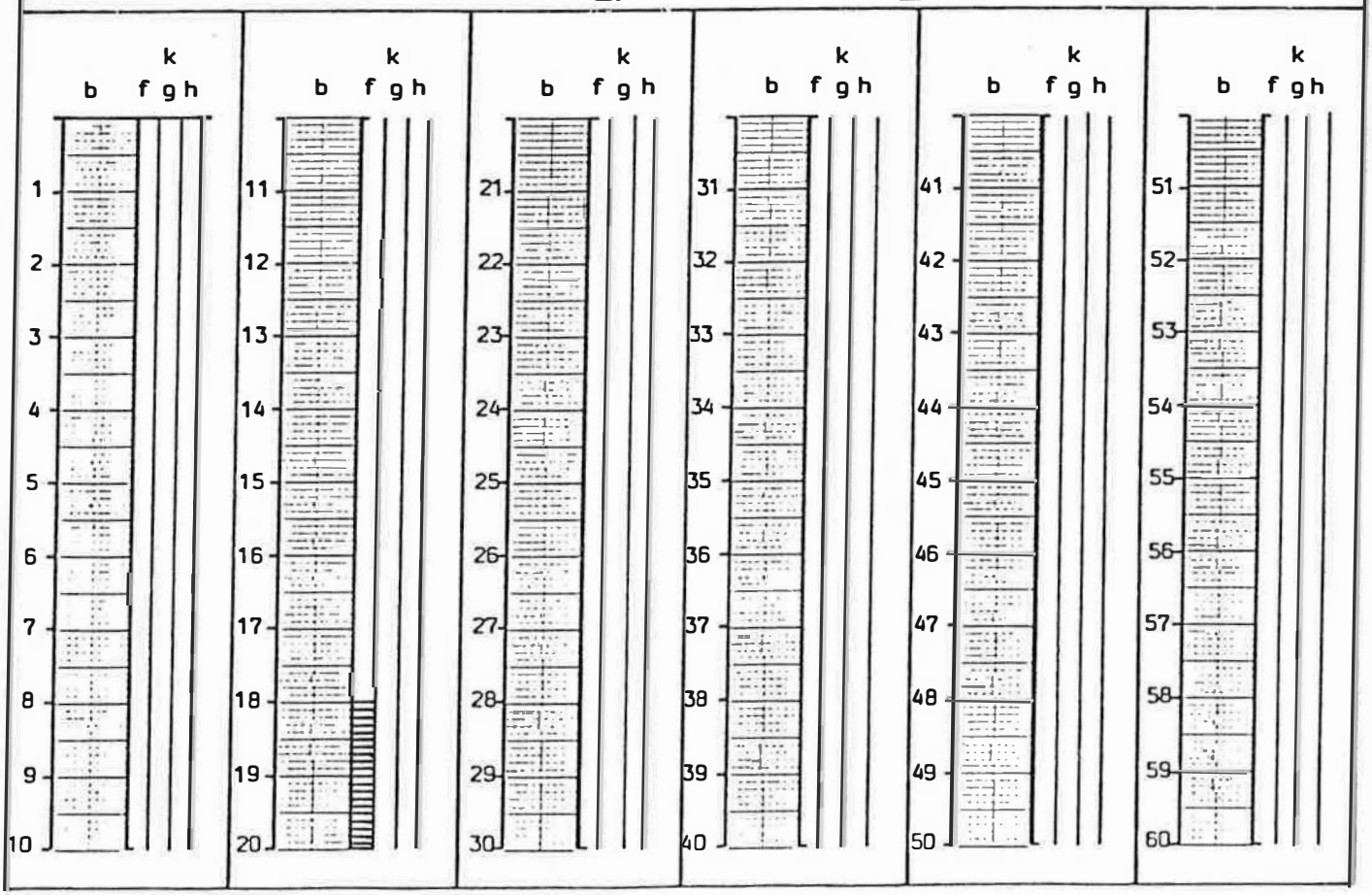
Sample nr.	Description of the cuttings	Depth (m) from	to
	Description see drilling 4D1		

LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13r2



lithologic log screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Research nr. : TGO 86/81

Well nr. : 6S

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 9th 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Nordmeyer DRILLER :
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = Y = (LAMBERT-COORDINATES)
- ZMV = 8,869 (m TAW)
- ZMV* = - (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Dugged	-	0 - 0,7				
Auger	168	0 - 2,0				
Auger	125	2,0- 5,0				
Bailer	135	5,0-14,3				
Casing	168	0 -14,1				

- DRILLING MUD : CONSUMPTION (l) :
- BOREHOLE LOG(S) :

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		12,0	14,0	9,398			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : Ø 63 mm PVC DYKA PVC NBN T42-111 PN10
  - screens : Ø 63 mm PVC VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) :
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 14,25 - 11 m
- Seals-type and characteristics : Clay pellets
  - volume (l.) : from 0 - 11 m
- Borehole backfill material : -
- Development - method : see sampling
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing : steel cap

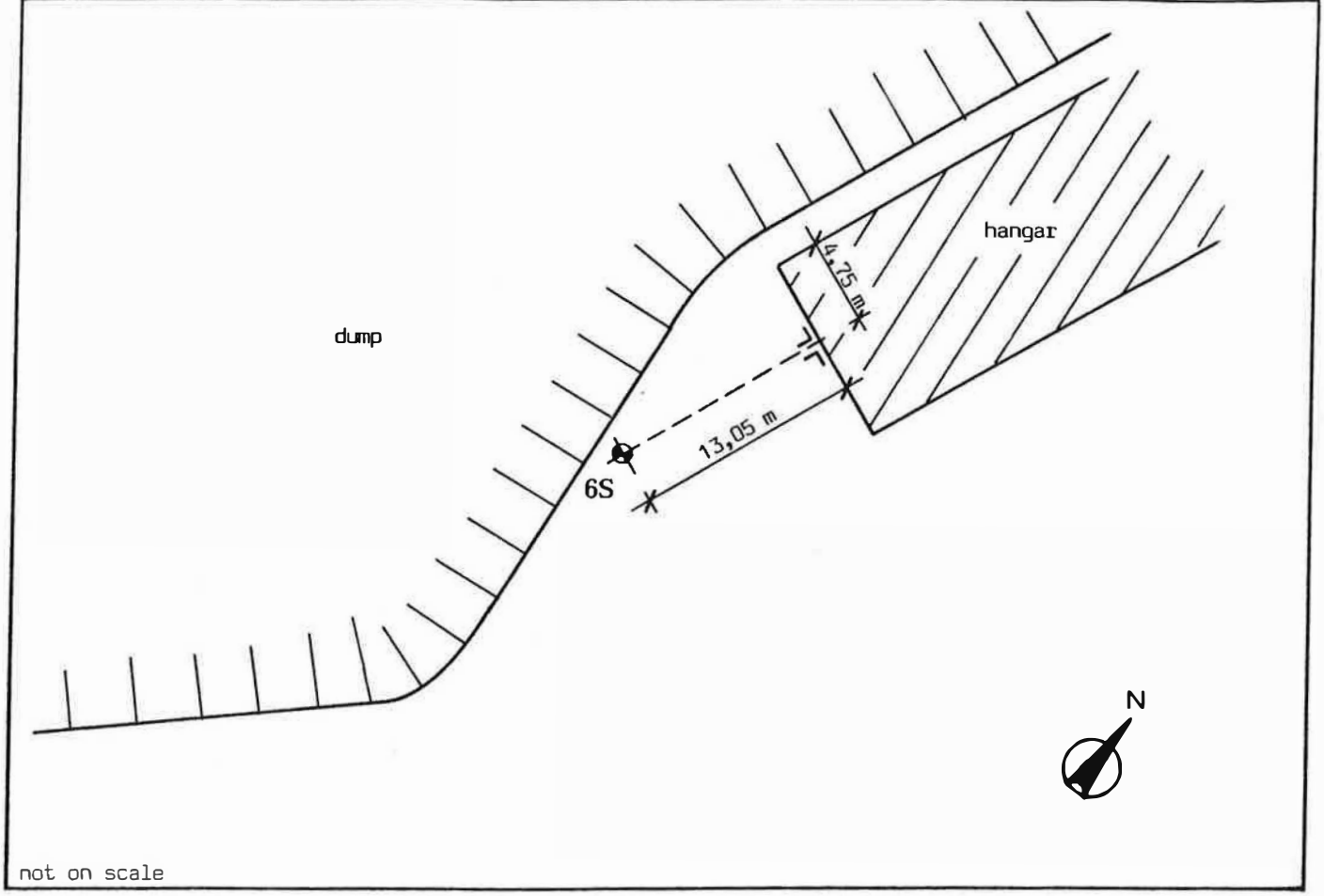
LITHOLOGIC LOG - DATE : July 09 1987

Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Brown sand with stones and store fragments	0,0	0,7
M1	Brown fine sand with gypsum and stones	0,7	1,0
	Brownish black fine sand	1,0	1,3
	Dark brown fine sand	1,3	1,5
M2	Brown sand	1,5	2,0
M3	Brown to greyish brown fine sand	2,0	3,0
	Grey fine sand	3,0	3,5
M4	Brown fine sand with very much peat and wood fragments	3,5	4,0
	Greyish brown slightly silty fine sand with sandstone fragments	4,0	4,7
M5	Idem, without sandstone fragments	4,7	5,0
M6	Grey silty fine sand with sandstore fragments	5,0	6,0
	Grey very silty fine sand to sandy silt	6,0	6,5
M7	Grey sandy silt	6,5	7,0
	Grey silty fine sand	7,0	7,5
M8	Grey slightly silty fine sand	7.5	8.0
M9	Grey silty fine sand	8,0	9,0
M10	Grey slightly silty fine sand	9,0	10,0
M11	Grey fine sand with very few fine shell fragments	10,0	11,0
M12	Idem	11,0	12,0
M13	Idem	12,0	13,5
M14	Grey silty fine sand with very few fine shell fragments	13,5	14,1
	Grey sandy silt	14,1	14,3

Sample nr.	Description of the cuttings	Depth (m) from	to
	Odour : from 1,5 to 3,0 m, same odour as during drilling 4D		
	from 3,0 to at least 7,0 m slight odour (2D)		

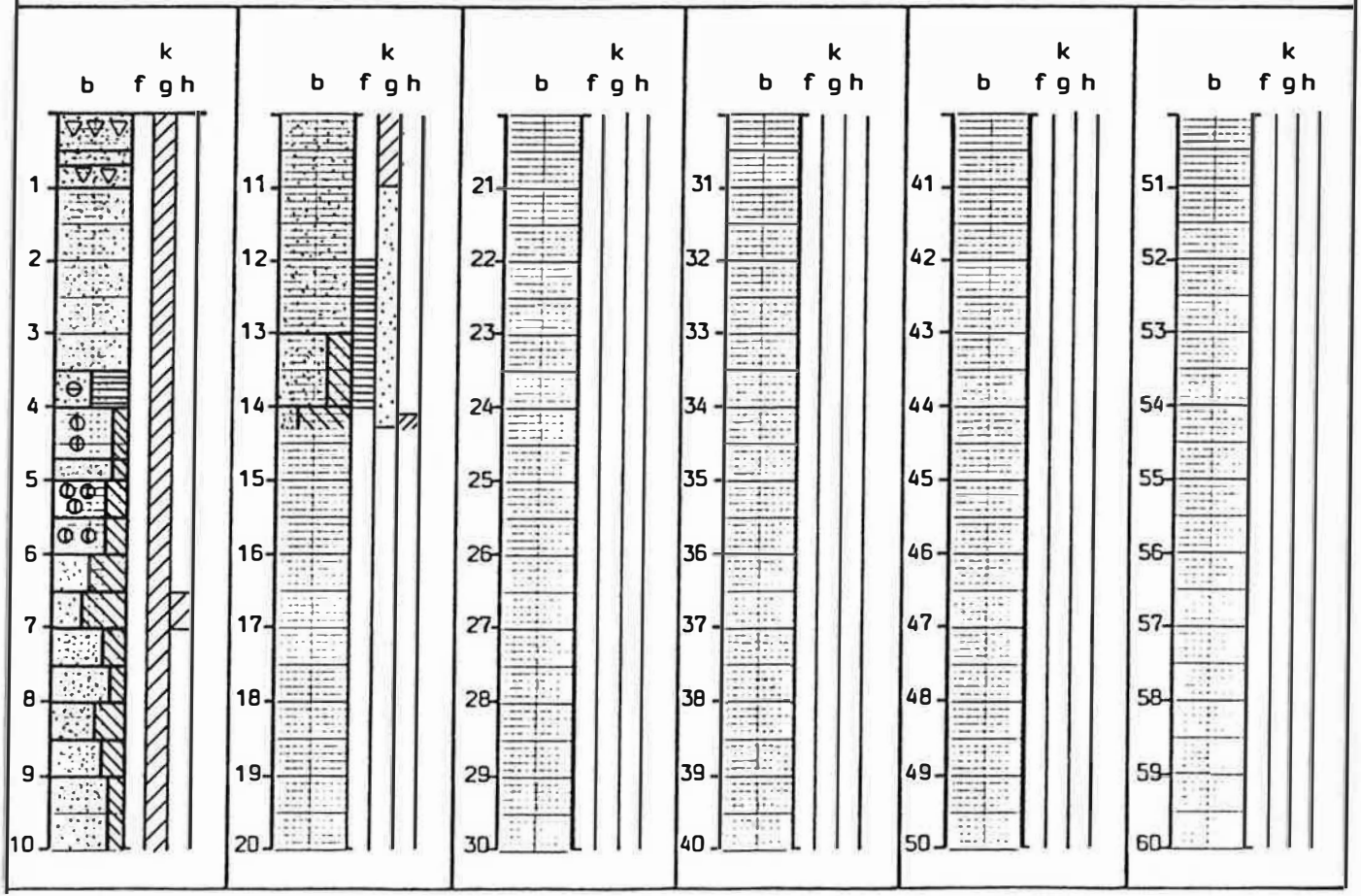
Geological interpretation and remarks	
0,0 - 1,0 m	Disturbed soil
1,0 - 14,1 m	KZ2
14,1	KL

LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13/2



lithologic log screen (s) (f) filter pack (g) seal(s) grout (k) clay (b)

hydrogeological interpretation (h): pervious semi-pervious impervious



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Research nr. : TGO 86/81

Well nr. : 7S

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 08, 1987
- DRILLING CY. : Geolab
- DRILLING RIG Nordmeyer DRILLER : -
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = - Y = - ZMV = 8,479 (m TAW)
  (LAMBERT-COORDINATES) ZMV* = - (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø	DEPTH (in m)				
	(mm)	from - to	from - to	from - to	from - to	from - to
Auger	165	0 - 2,0				
Auger	125	2,0- 6,0				
Bailer	135	6,0-12,9				
Casing	168	0 -13,2				

- DRILLING MUD : - CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		10,5	12,5	9,001			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm "Viplex beregening" PN10
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) : -
- Centralizer(s) - place (m) : 10,5 and 12,5
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 12,9 - 9,5 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 9,5 to 0,0 m
- Borehole backfill material : -
- Development - method : see sampling
  - date - duration (h) : -
  - discharge (m^3/h) : -
- Finishing : steel cap

LITHOLOGIC LOG - DATE : July 08, 1987

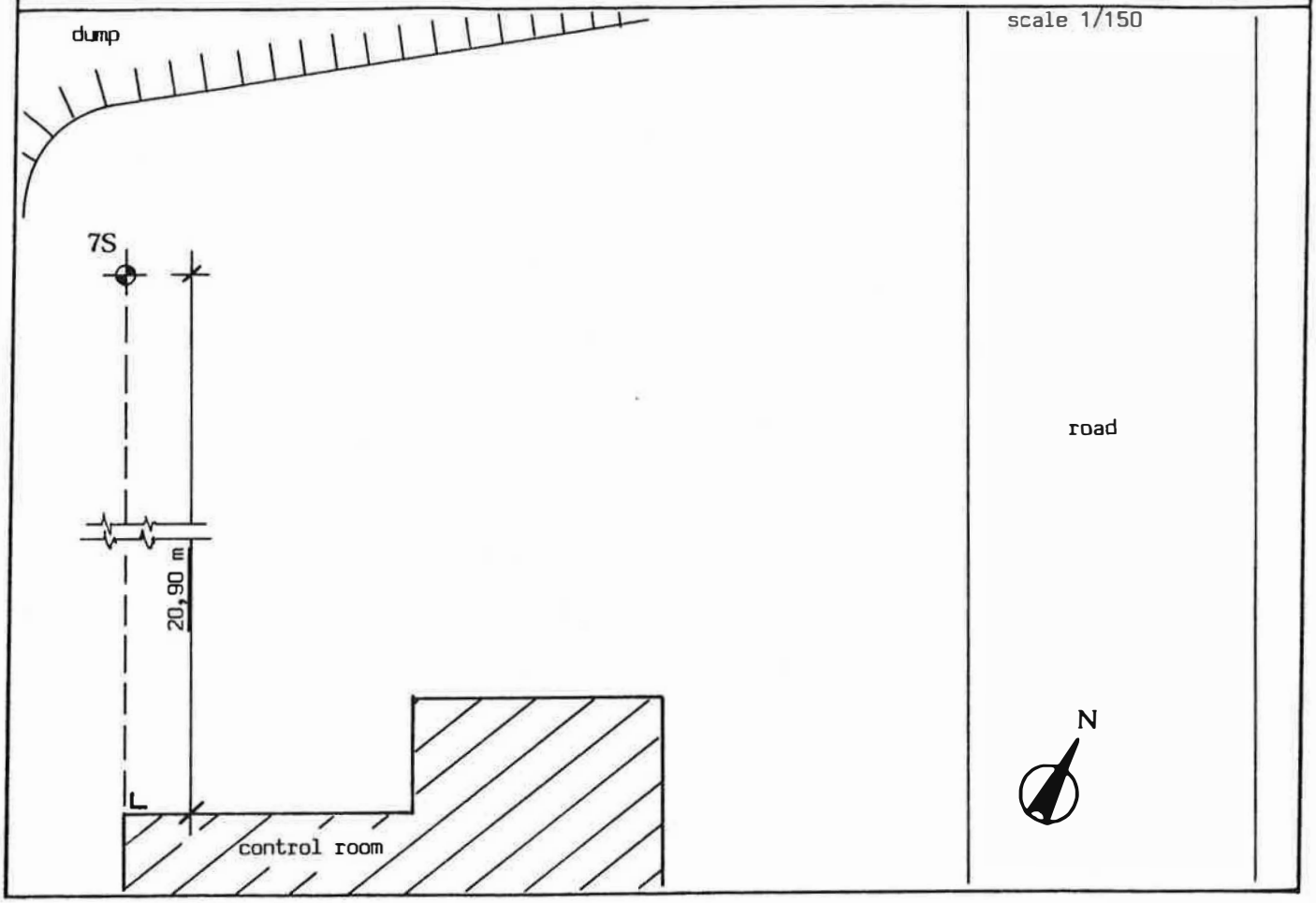
Sample nr.	Description of the cuttings	Depth (m) from	to
	Brown fine sand with many stones and gravel	0,0	0,2
	Dark brown fine sand	0,2	0,5
M1	Brown fine sand	0,5	1,0
M2	Idem	1,0	2,0
M3	Idem	2,0	3,0
	Brown fine sand with very much peat	3,0	3,5
M4	Grey fine sand	3,5	4,5
M5	Grey sandy silt	4,5	5,0
	Grey very silty fine sand	5,0	5,5
M6	Grey silty fine sand	5,5	6,0
M7	Grey slightly silty fine sand with very few fine shell fragments	6,0	7,0
M8	Grey fine sand with very few fine shell fragments	7,0	8,0
M9	Idem	8,0	9,0
	Grey slightly silty fine sand with very few fine shell fragments	9,0	9,5
M10	Idem, silty	9,5	10,0
M11	Grey slightly silty, idem	10,0	11,5
	Grey silty fine sand with very few fine shell fragments	11,5	12,5
	Grey silt	12,5	12,9
	Odour : - from 3,5 to 4,5 and 5,5 to 12,9 m : slight odour same as 2D - from 4,5 to 5,5 : strong to very strong same odour		

Sample nr.	Description of the cuttings	Depth (m)	
		from	to

Geological interpretation and remarks

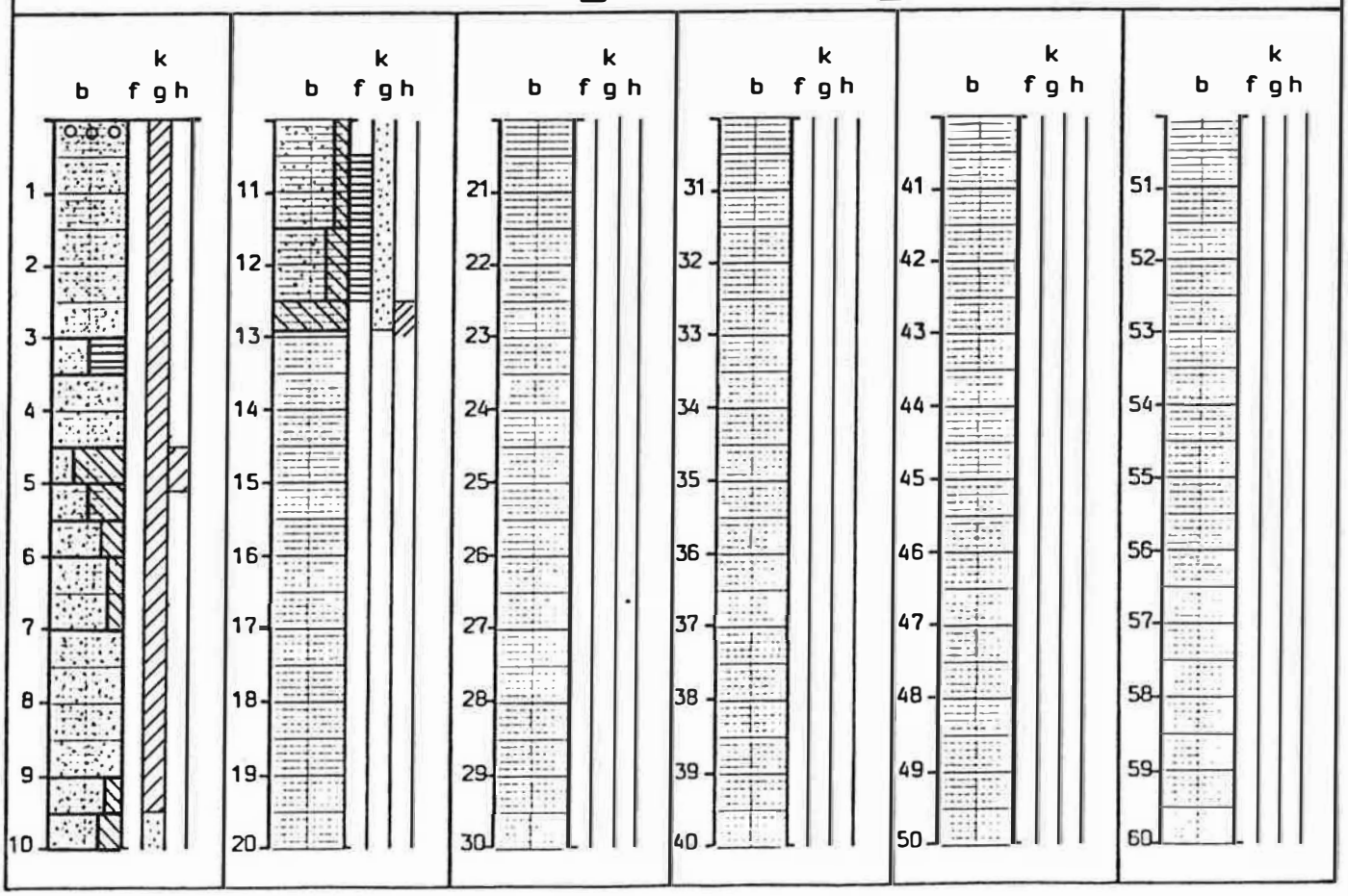
0,0 - 0,2 m : disturbed soil
0,2 - 12,5 m : KZ2
12,5 - : KL

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13/12



lithologic log screen (s) filter pack seal(s) grout
(b) (f) (g) (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 8S

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 08, 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Nordmeyer DRILLER : _____
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = _____ Y = _____ (LAMBERT-COORDINATES)
- ZMV = 8,387 (m TAW)
- ZMV* = _____ (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Auger	168	0 - 2,0				
Auger	125	2,0- 8,0				
Bailer	135	8,0-13,0				
Casing	168	0 -13,0				

- DRILLING MUD : - CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		10,4	12,4	8,914			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : yes/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA NBN T42-111
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND PN10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) : _____
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 12,4 to 9,3 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 9,3 to 0 m
- Borehole backfill material : -
- Development - method : see sampling
  - date - duration (h) : _____
  - discharge (m^3/h) : _____
- Finishing : steel cap

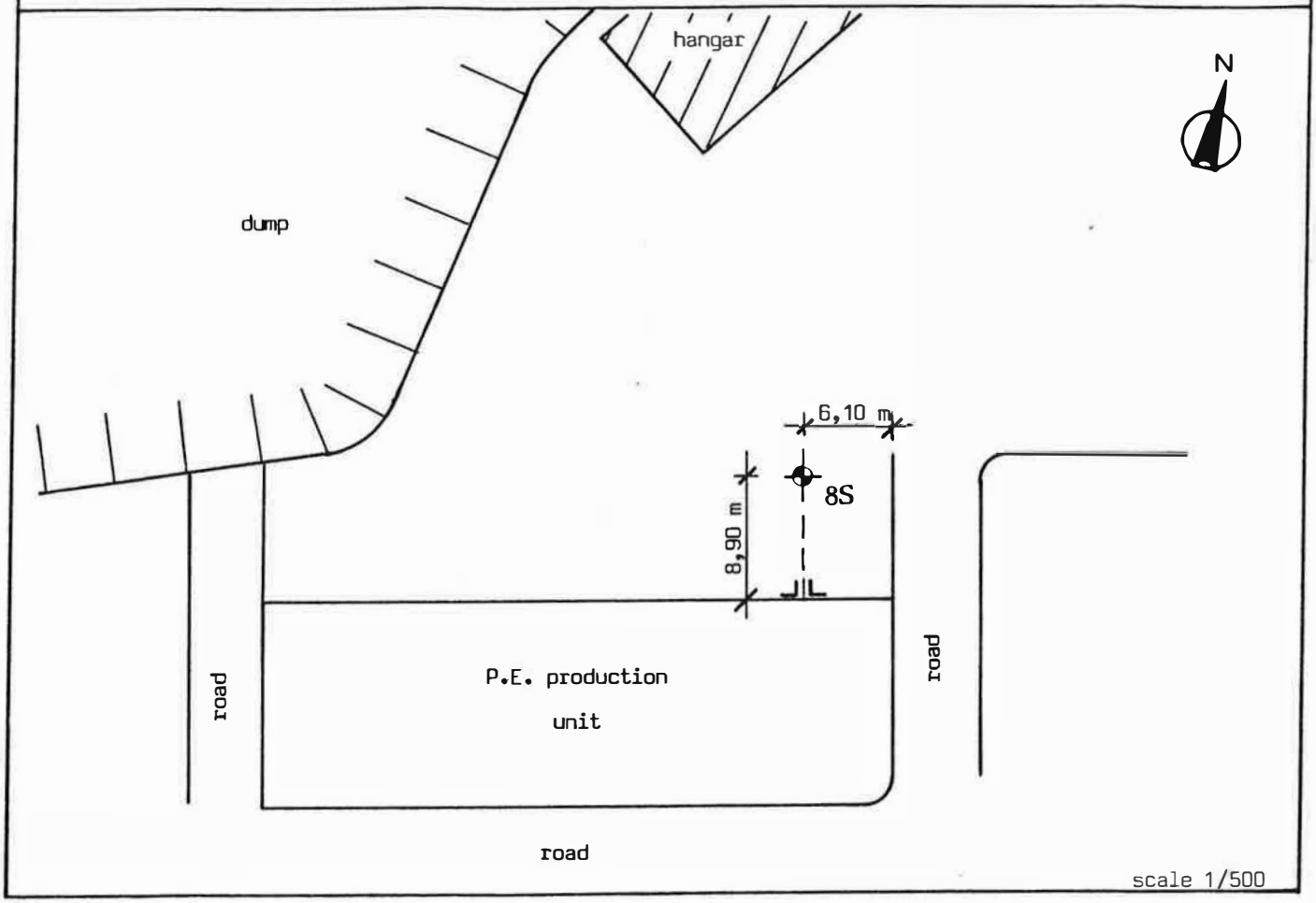
LITHOLOGIC LOG 8S - DATE : July 08, 1987

Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Brown fine sand with stones and stone fragments	0,0	0,4
	Dark brown fine sand with very much peat and wood fragments	0,4	0,5
M1	Dark brown fine sand	0,5	1,0
	Greenish grey fine sand	1,0	1,5
	Light Brown fine sand	1.5	1,7
M2	Greenish grey fine sand	1,7	1,9
	Brown fine sand with black spots and humic material	1,9	2,0
M3	Brown fine sand	2,0	3,5
	Brown humic material and peat	3,5	3,7
M4	Brown fine sand with much peat	3,7	4,1
	Grey fine sand	4,1	4,5
M5	Grey slightly sandy silt	4,5	5,0
	Grey silty sand	5,0	5,5
M6	Grey fine sand	5,5	6,5
M7	Grey slightly silty fine sand	6,5	7,0
	Idem, with very few fine shell fragments	7,0	7,5
M8	Grey fine sand with very few fine shell fragments	7,5	8,0
	Grey fine sand	8,0	8,5
M9	Grey silty fine sand	8,5	9,5
M10	Grey silty fine sand with very few fine shell and wood fragments	9,5	10,5
M11	Grey very silty fine sand, idem	10,5	11,0
M12	Grey silty fine sand, idem	11,0	12,4
	Grey silty fine sand with silt lumps	12,4	12,5
	Grey silt with few fine gravel and very few fine shell fragments	12,5	13,0

Sample nr.	Description of the cuttings	Depth (m) from	to
	Odour : - from 0,4 to 0,5 m : strong odour of rotten material		
	- from 1,0 to 4,1 m : slight odour, different of odour at 2D		
	- from 10,5 to 12,5 : slight odour, same as at 2D		

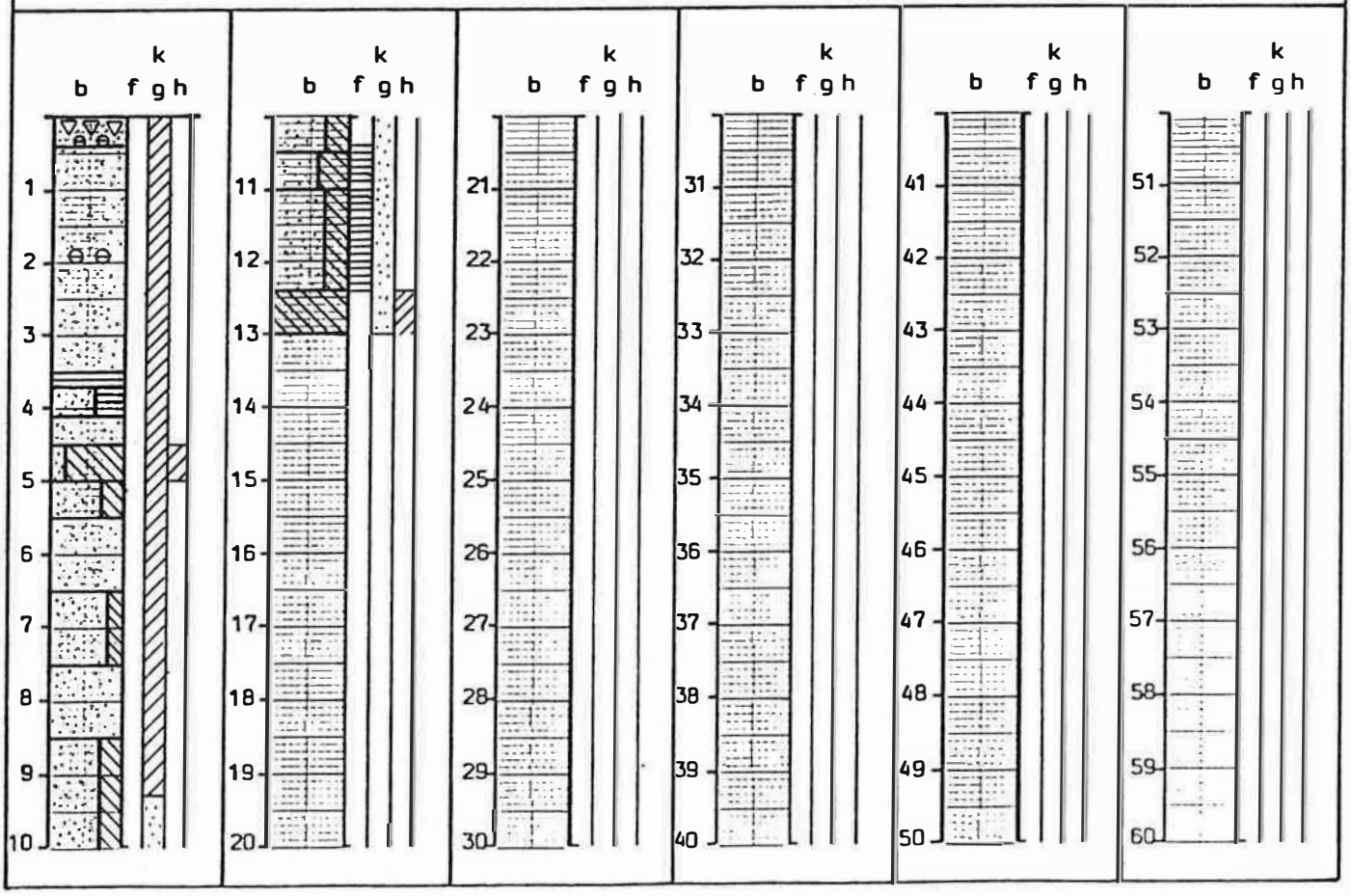
Geological interpretation and remarks
0 - 0,5 m : Disturbed soil
0,5 - 12,4 m : KZ2
12,4 - : KL

LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13[12]



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Laboratory of Applied Geology and Hydrogeology
Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 9S

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 15th, 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Nordmeyer DRILLER : _____
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = _____ Y = _____ (LAMBERT-COORDINATES) ZMV = 8,237 (m TAW) ZMV* = _____ (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Dugged	400	0- 1				
Auger	168	1- 2				
Bailer	135	2-13,0				
Casing	168	0-12,5				

- DRILLING MUD : - CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		10,6	12,6	8,781			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NP10 NBN T42-111
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND PN10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) : _____
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 9,5 to 13,0 m
- Seals-type and characteristics : Clay pallets Duranit
  - volume (l.) : from 0 - 9,5 m
- Borehole backfill material : -
- Development - method : see sampling
  - date - duration (h) : _____
  - discharge (m^3/h) : _____
- Finishing : steel cap

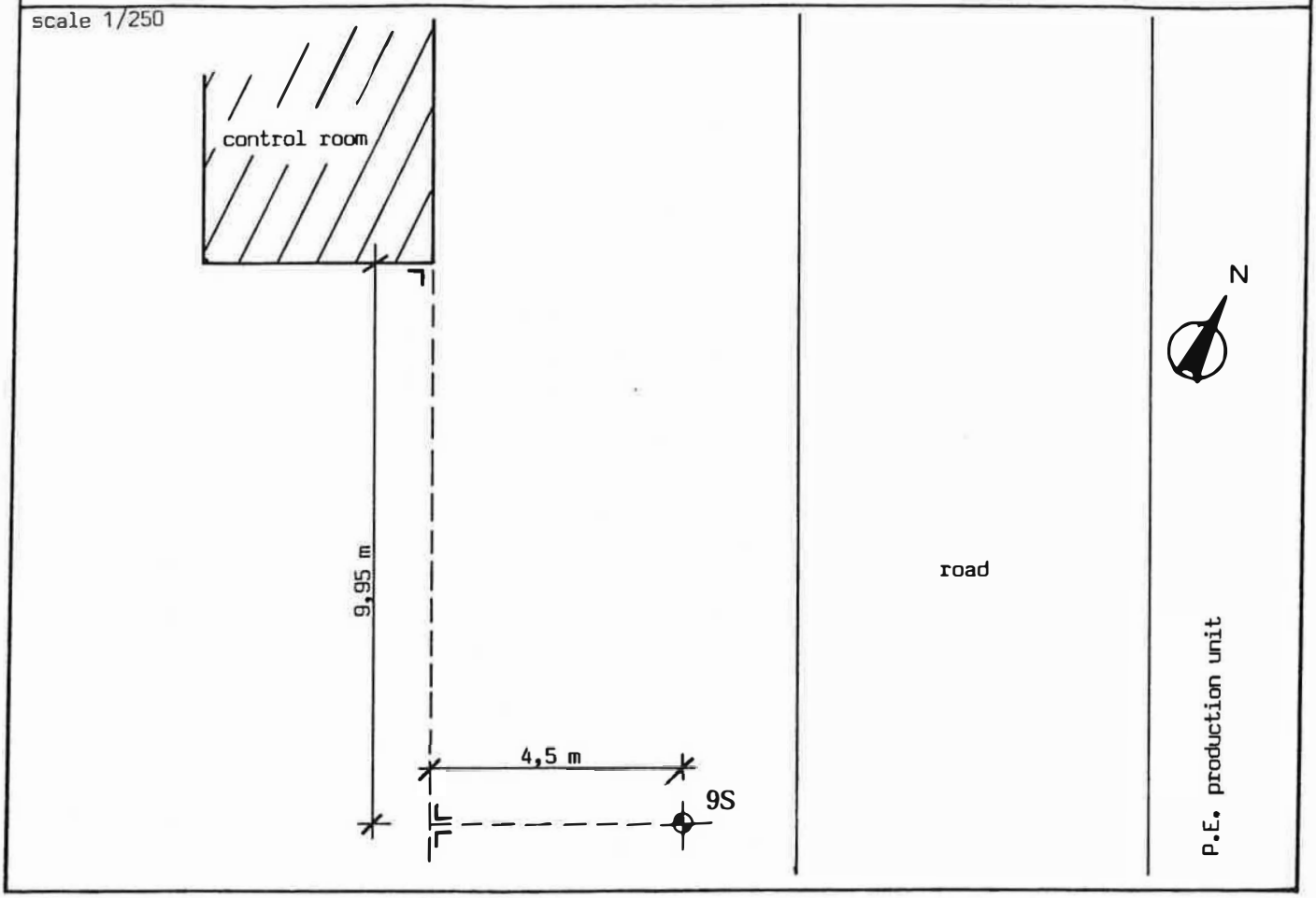
LITHOLOGIC LOG 9S - DATE : July 15th, 1987

Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Brown sand with stones and stone fragments, brick fragments and porcelane	0,0	0,5
M1	Brown fine sand	0,5	1,0
M2	Brown fine sand with wood fragments	1,0	2,5
M3	Grey fine sand	2,5	3,0
	Greyish brown silty fine sand with wood fragments	3,0	3,3
	Peat and greyish brown silty fine sand with very much wood fragments	3,3	3,5
M4	Grey fine sand with few wood fragments and very few fine shell fragments	3,5	4,0
	Idem, but silty	4,0	4,3
	Grey silt	4,3	4,5
M5	Grey sandy silt	4,5	5,0
	Grey silty fine sand	5,0	5,5
M6	Grey fine sand with very few fine shell fragments	5,5	6,0
M7	Idem	6,0	7,0
	Grey slightly silty fine sand with very few fine shell fragments	7,0	7,5
M8	Grey fine sand with very few fine shell fragments	7,5	8,5
M9	Idem	8,5	9,5
M10	Grey fine sand	9,5	10,5
M11	Grey silty fine sand	10,5	11,5
	Grey slightly silty fine sand	11,5	11,6
	Grey fine sand with few fine shell fragments	11,6	12,3
	Idem, with sandstone fragments	12,3	12,6
	Grey fine sand with many silt lumps	12,6	13,0

Sample nr.	Description of the cuttings	Depth (m) from	to
	Odour : - from 0,5 - 5,0 m : very strong odour, same as at 2D		
	- from 5,0 - 13,0 m : same strong odour		

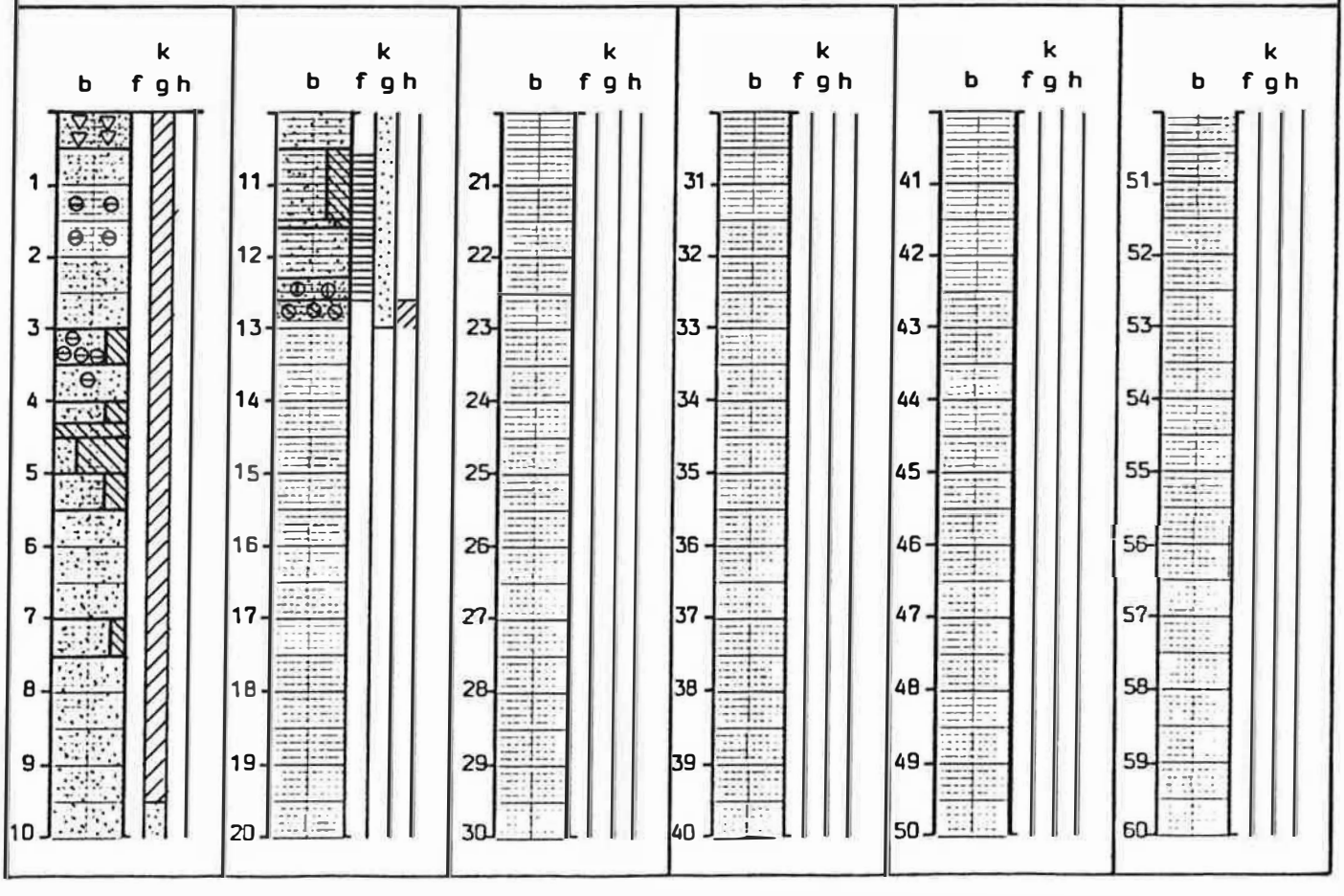
Geological interpretation and remarks
0 - 0,5 m : disturbed soil
0,5 - 12,6 m : KZ2
12,6 - : KL

LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13[12]



lithologic log screen (s) filter pack seal(s) grout
(b) (f) (g) (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 10S

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 9th 1987 - July 10th 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Nordmeyer DRILLER : _____
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. : 25E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = _____ Y = _____ (LAMBERT-COORDINATES) ZMV = 8,217 (m TAW)
  ZMV* = _____ (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Auger	168	0 - 2,0				
Auger	125	2,0- 7,0				
Bailer	135	7,0-13,5				
Casing	168	0 -13,0				

- DRILLING MUD : - CONSUMPTION (l) : -
- BOREHOLE LOG(S) : -

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		11,0	13,0	8,827			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NP10 NBN T42-111
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND PN10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) : _____
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 1,25/0,7
  - volume (l.) : from 10 to 13,5 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 0 - 10 m
- Borehole backfill material : -
- Development - method : see sampling
  - date - duration (h) : _____
  - discharge (m^3/h) : _____
- Finishing : steel cap

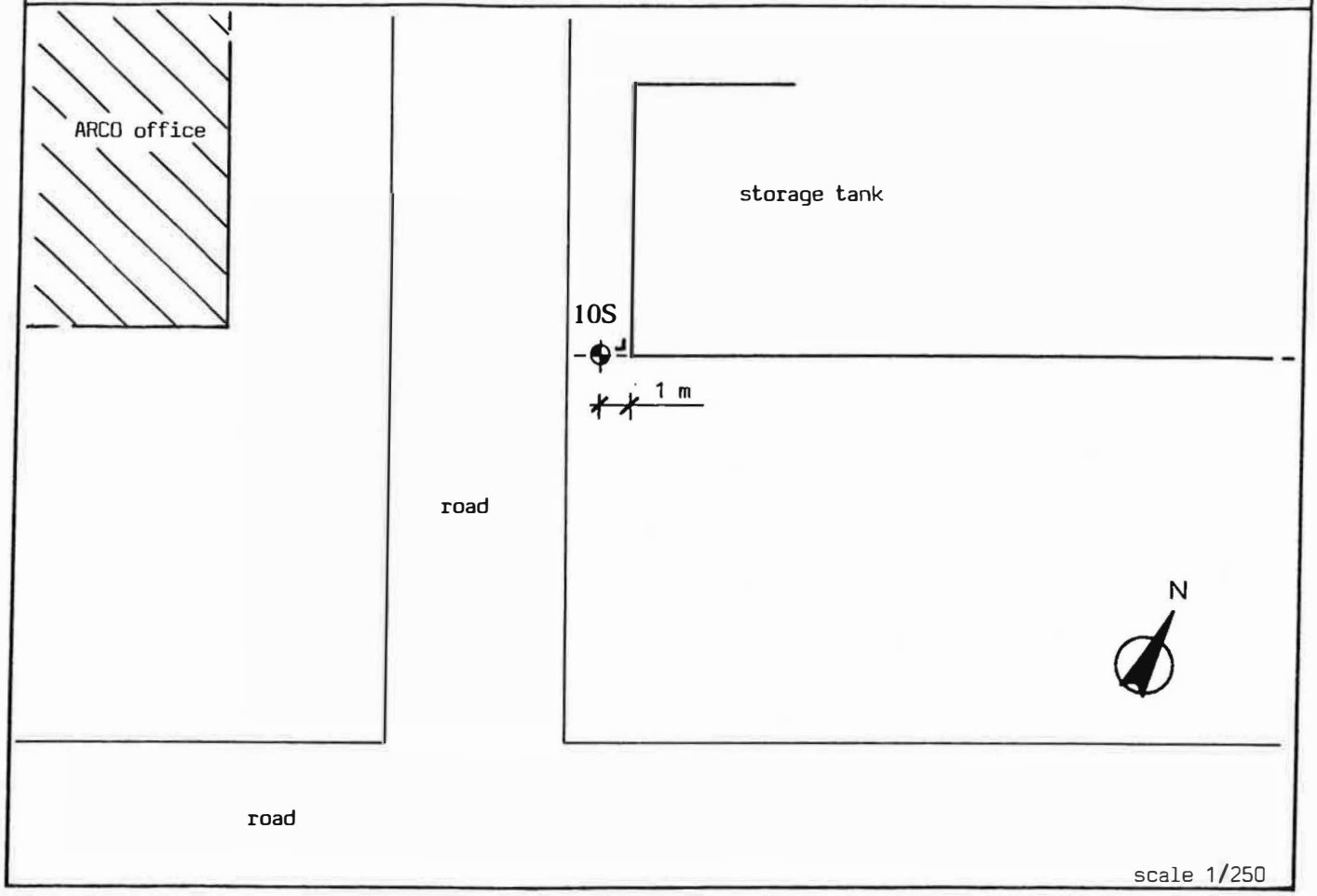
LITHOLOGIC LOG 10S - DATE : July 9th 1987

Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Dark brown fine sand with stones	0	0,1
M1	Brown fine sand	0,1	1,0
M2	Greenish brown fine sand	1,0	2,0
M3	Brown fine sand	2.0	3,0
	Brown fine sand with much humic material	3,0	3,2
	Brownish black peat	3,2	3,6
M4	Grey fine sand	3.6	4,0
	Grey silt	4,0	4,2
	Grey very silty fine sand	4,2	4,8
M5	Grey fine sand	4,8	5,0
M6	Idem, with very few fine shell fragments	5,0	6,0
	Grey sandy silt	6,0	6,5
M7	Grey silty fine sand	6,5	7,0
M8	Grey slightly silty fine sand	7,0	8,0
	Drilling continued on July 10th, 1987		
M9	Grey fine sand with very few fine shell fragments	8,0	9,0
M10	Idem	9,0	10,5
	Idem, with lumps of silty sand	10,5	10,6
M11	Grey slightly silty fine sand with few fine sandstore fragments and very few fine wood fragments	10,6	11,0
M12	Grey silty fine sand, idem	11,0	11,5
	Grey slightly silty fine sand, idem	11,5	12,5
M13	Idem	12,5	13,0
	Grey fine sand with many silt lumps and very few fine shell fragments	13,0	13,5

Sample nr.	Description of the cuttings	Depth (m) from	to
	Odour : - from 1 to 8 m very strong odour, same as at 2D		
	- from 8 to at least 12 m, same but slight odour		
	Because of repeated strongly uprising of sand in the		
	casing, two buckets of pure water had to be poured in		
	the borehole, at a drilling depth of 7,0 m		

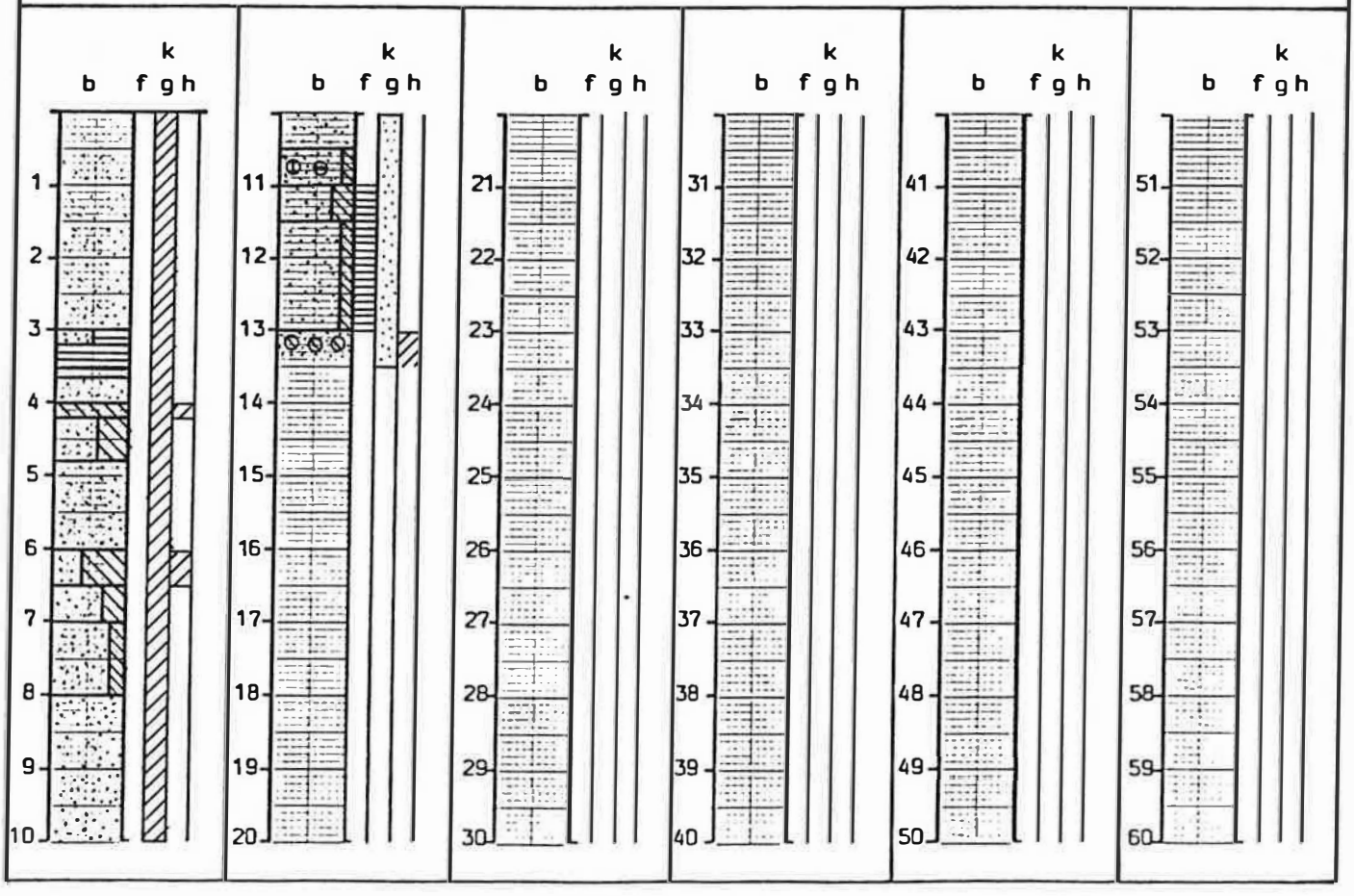
Geological interpretation and remarks
0 - 0,1 : disturbed soil
0,1 - 13,0 : KZ2
13,0 : KL

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13h2



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Research nr. : TGO 86/81

Well nr. : 11S

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 14th, 1987
- DRILLING CY. : Geolab
- DRILLING RIG : Nordmeyer DRILLER :
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/5 GEOL./PEDOL. MAP Nr. : 40E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = Y = ZMV = 8,197 (m TAW)
  (LAMBERT-COORDINATES) ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Auger	125	0 - 2,0				
Bailer	135	2,0-11,8				
Casing	168	0 -11,5				

- DRILLING MUD : CONSUMPTION (l) :
- BOREHOLE LOG(S) :

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		9,5	11,5	8,675			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : yes/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA NBN T42-111 NP10
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 X 0,3
  - open area (%) :
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 8,5 to 11,8 m
- Seals-type and characteristics : Clay pellets Duranit
  - volume (l.) : from 0 to 8,5 m
- Borehole backfill material : -
- Development - method : see sampling
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing : steel cap

LITHOLOGIC LOG 11S - DATE : July 14th, 1987

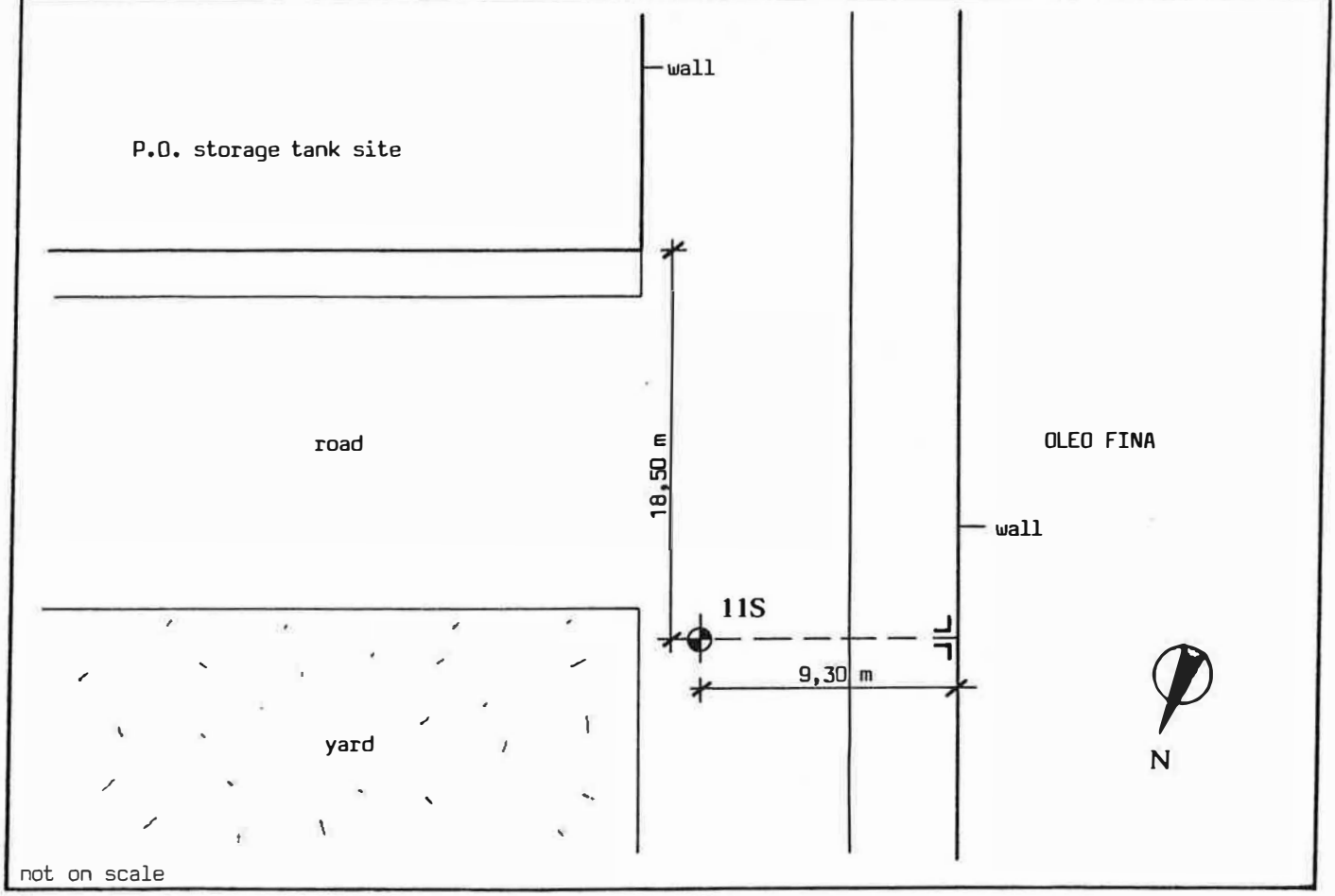
Sample nr.	Description of the cuttings	Depth (m) from	to
	Brown fine sand with few stones and store fragments	0	0,3
	Brown fine sand	0,3	0,8
M1	Grey fine sand	0,8	1,5
M2	Idem	1,5	2,5
M3	Idem	2,5	3,5
	Dark grey slightly silty fine sand	3,5	3,6
M4	Dark grey very silty fine sand with wood fragments	3,6	4,0
	Grey slightly silty fine sand	4,0	4,5
M5	Grey fine sand	4,5	5,5
M6	Idem, with very few fine shell fragments	5,5	6,5
M7	Grey silty sand	6,5	7,8
M8	Grey, slightly silty fine sand	7,8	8,5
	Idem, with very few fine shell fragments	8,5	8,8
M10	Grey fine sand with very few fine shell fragments	8,8	10,0
	Idem	10,0	10,5
M11	Idem	10,5	11,0
	Idem, with fine silt lumps	11,0	11,5
	Grey fine sand with many silt lumps	11,5	11,8
	Odour : from 1,0 to 2,5 : slight odour, different from odour 2D		
	from 3,5 to 11,5 : slight odour same odour as at 2D		

Sample nr.	Description of the cuttings	Depth (m) from	to

Geological interpretation and remarks

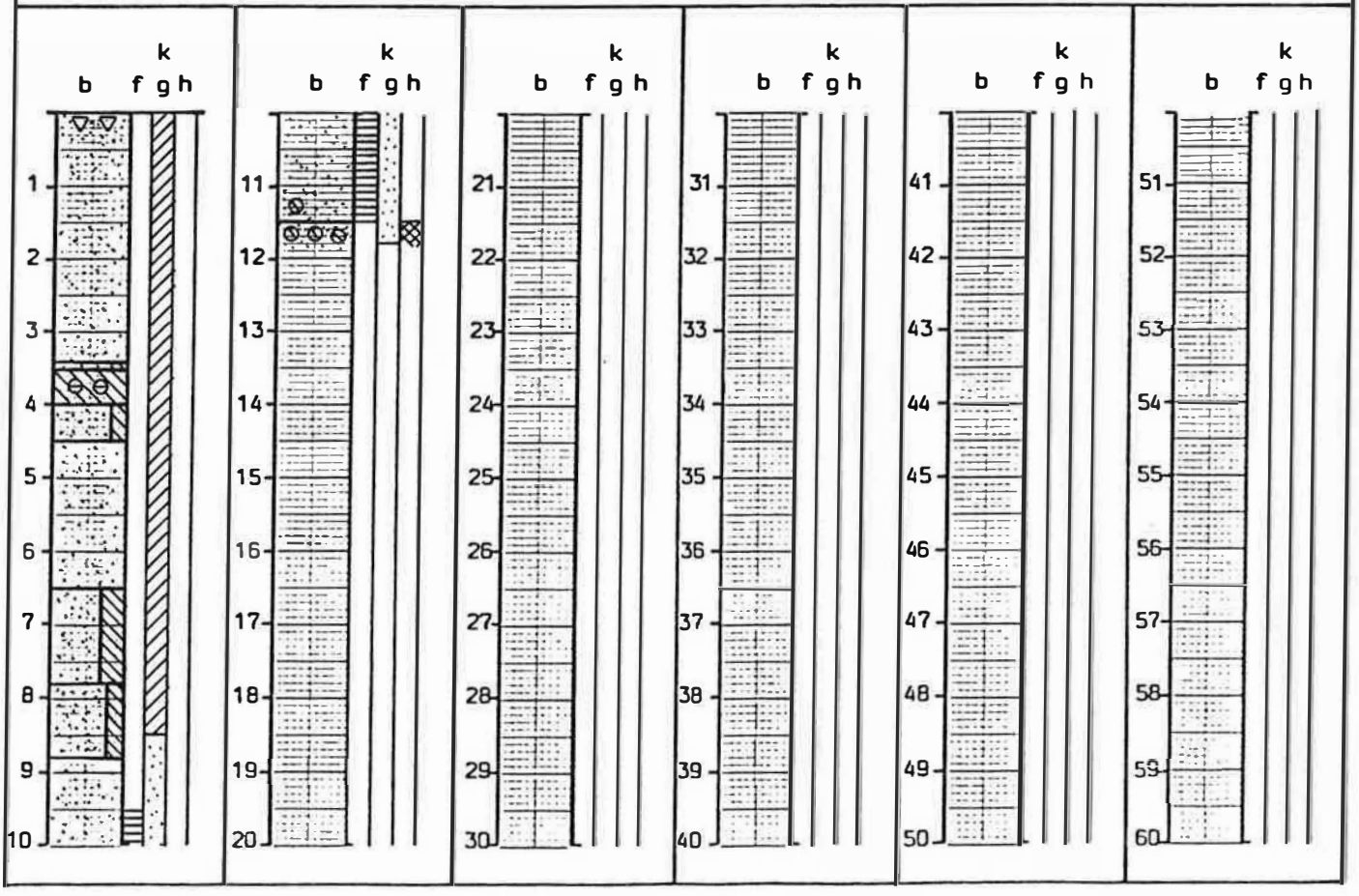
0 - 0,3 : disturbed soil
0,3 - 11,5 : KZ2
11,5 - : KL

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13h2



lithologic log screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Research nr. : TGO 86/81

Well nr. : 12S

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 13th, 1987
- DRILLING CY. : Geolab
- DRILLING RIG Nordmeyer DRILLER :
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/5 GEOL./PEDOL. MAP Nr. : 40E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = Y = (LAMBERT-COORDINATES) ZMV = 8,321 (m TAW) ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø	DEPTH (in m)				
	(mm)	from - to	from - to	from - to	from - to	from - to
Auger	168	0 - 2				
Bailer	135	2 - 13,0				
Casing	168	0 - 13,3				

- DRILLING MUD : CONSUMPTION (l) :
- BOREHOLE LOG(S) :

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		10,5	12,5	8,931			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : yes/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NBN T42-111 PN10
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) :
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 2,5 - 13,0 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 0 - 9,5 m
- Borehole backfill material :
- Development - method : see sampling
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing : steel cap

LITHOLOGIC LOG 12S - DATE : July 13th 1987

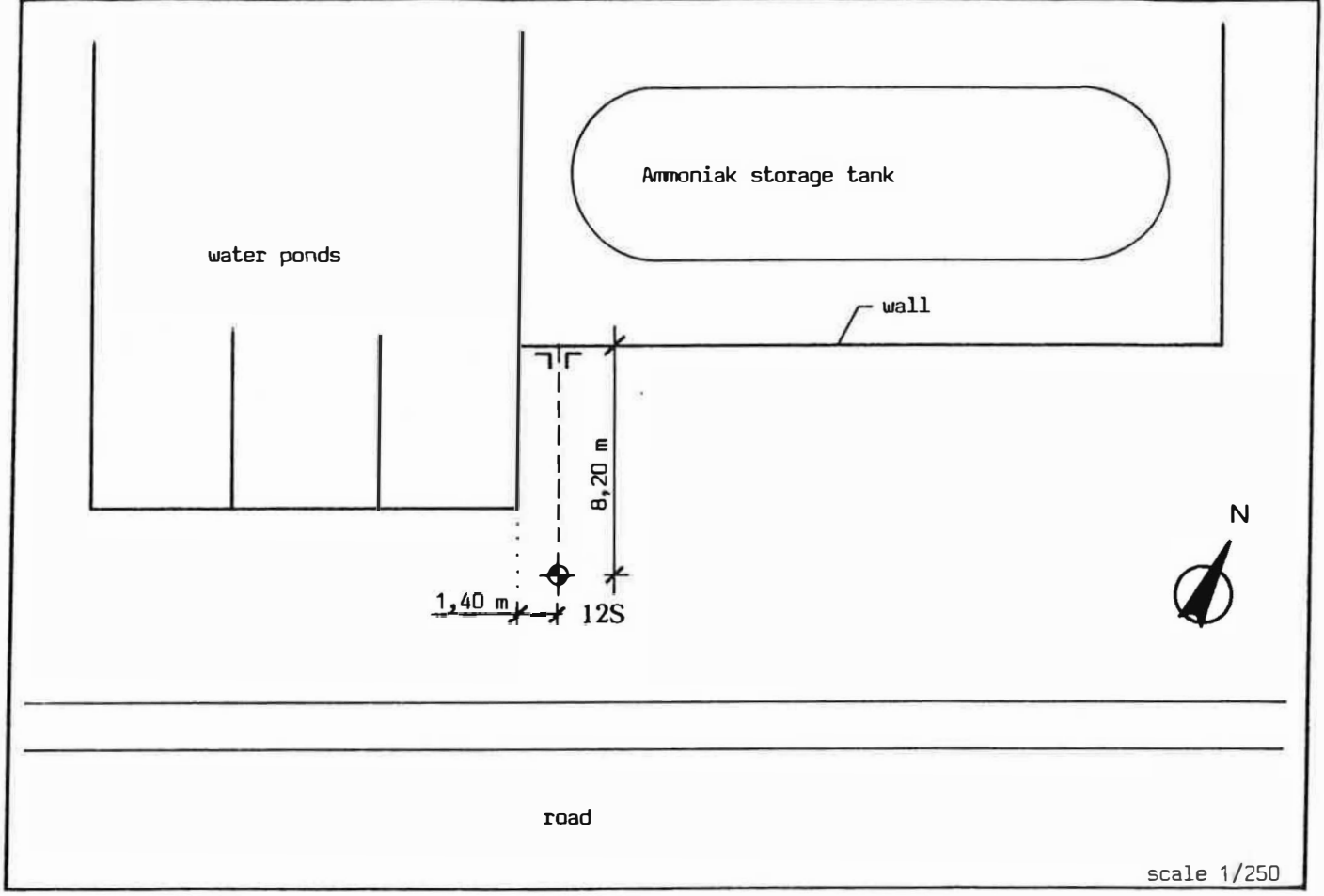
Sample nr.	Description of the cuttings	Depth (m) from	Depth (m) to
	Dark brown fine sand	0	0,4
	Reddish brown fine sand	0,4	0,5
M1	Brown fine sand	0,5	1,5
M2	Idem	1,5	2,8
M3	Brown fine sand with few wood fragments	2,8	3,5
M4	Dark brown silty fine sand with few peat fragments	3,5	4,0
	Grey silty fine sand	4,0	4,3
	Grey very silty fine sand	4,3	4,5
M5	Grey fine sand with very few fine shell fragments	4,5	5,0
M6	Grey slightly silty fine sand, idem	5,0	6,0
M7	Grey silty fine sand, idem	6,0	7,5
M8	Grey slightly silty fine sand with very few fine shell fragments	7,5	8,0
M9	Idem	8,0	9,5
M10	Grey silty fine sand, idem	9,5	10,0
M11	Grey very silty fine sand, idem	10,0	11,0
	Grey fine sand with very few fine shell fragments	11,0	12,4
	Idem, with silt lumps en few fine gravel	12,4	12,9
	Greenish grey silt	12,9	13,0
	Odour : from 2,8 to 11 m : strong to very strong odour (2D) from 11 m to at least 12,4 m : same, slighter odour		

Sample nr.	Description of the cuttings	Depth (m)	
		from	to

Geological interpretation and remarks

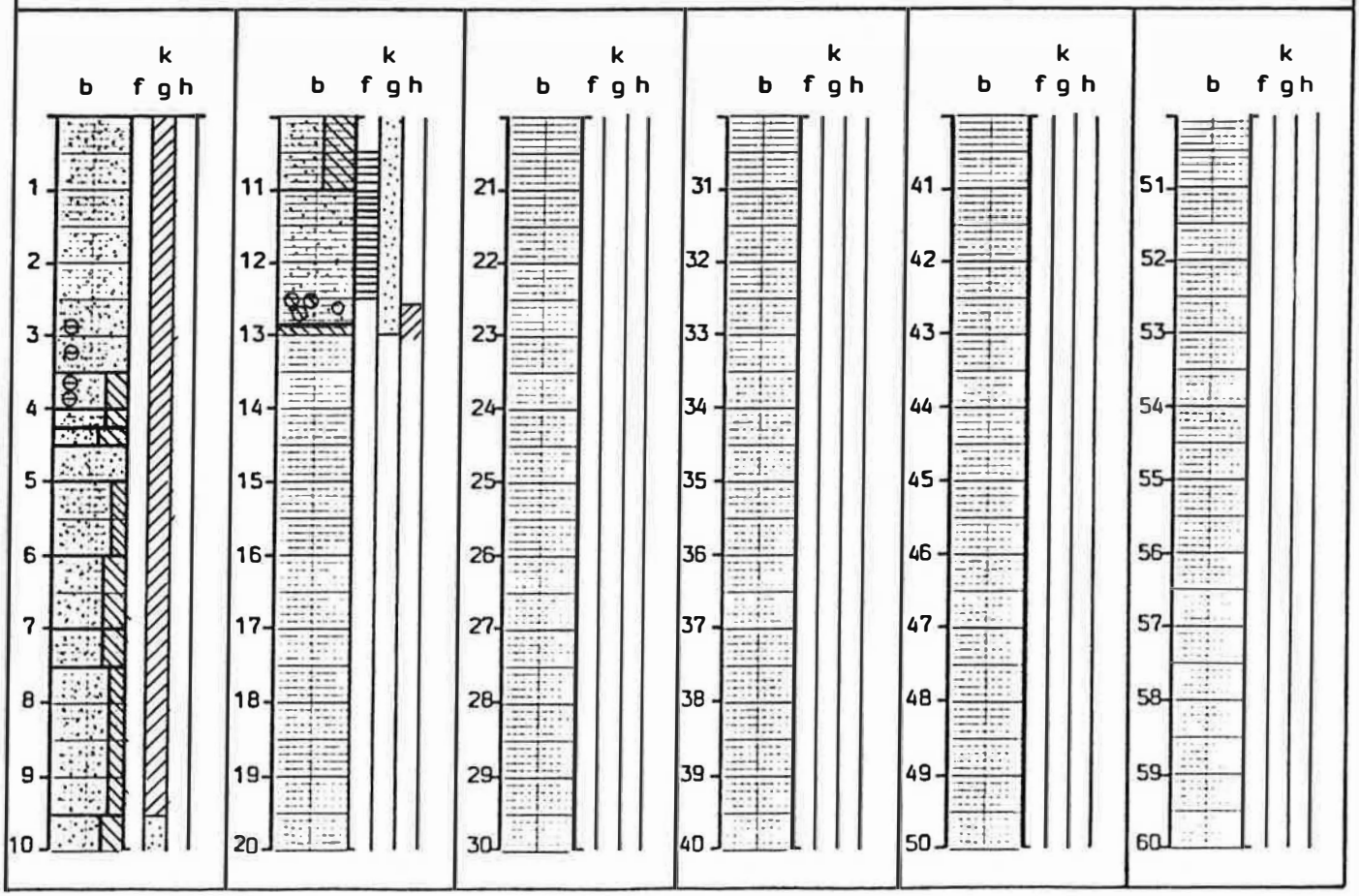
0 - 12,4 : KZ2
12,4 : KL

LOCATION - CADASTRAL MAP : Evergem 4°Afd. Sec. A 1°blad Parcel nr. : 13^{h2}



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



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Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 13S

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 13th, 1987
- DRILLING CY. : Geolab
- DRILLING RIG Nordmeyer DRILLER :
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/2 GEOL./PEDOL. MAP Nr. :
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = Y = (LAMBERT-COORDINATES) ZMV = 8,535 (m TAW) ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø	DEPTH (in m)				
	(mm)	from - to	from - to	from - to	from - to	from - to
Auger	168	0 - 2				
Bailer	135	2 - 12,5				
Casing	168	0 - 12,3				

- DRILLING MUD : CONSUMPTION (l) :
- BOREHOLE LOG(S) :

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		10,0	12,0	9,122			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NBN T42-111 NP10
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND PN10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) :
- Centralizer(s) - place (m) : 10,0 and 12,0
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 8,5 to 12,5 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 0 to 8,5 m
- Borehole backfill material : -
- Development - method : see sampling
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing : steel cap

LITHOLOGIC LOG - DATE : July 13th, 1987

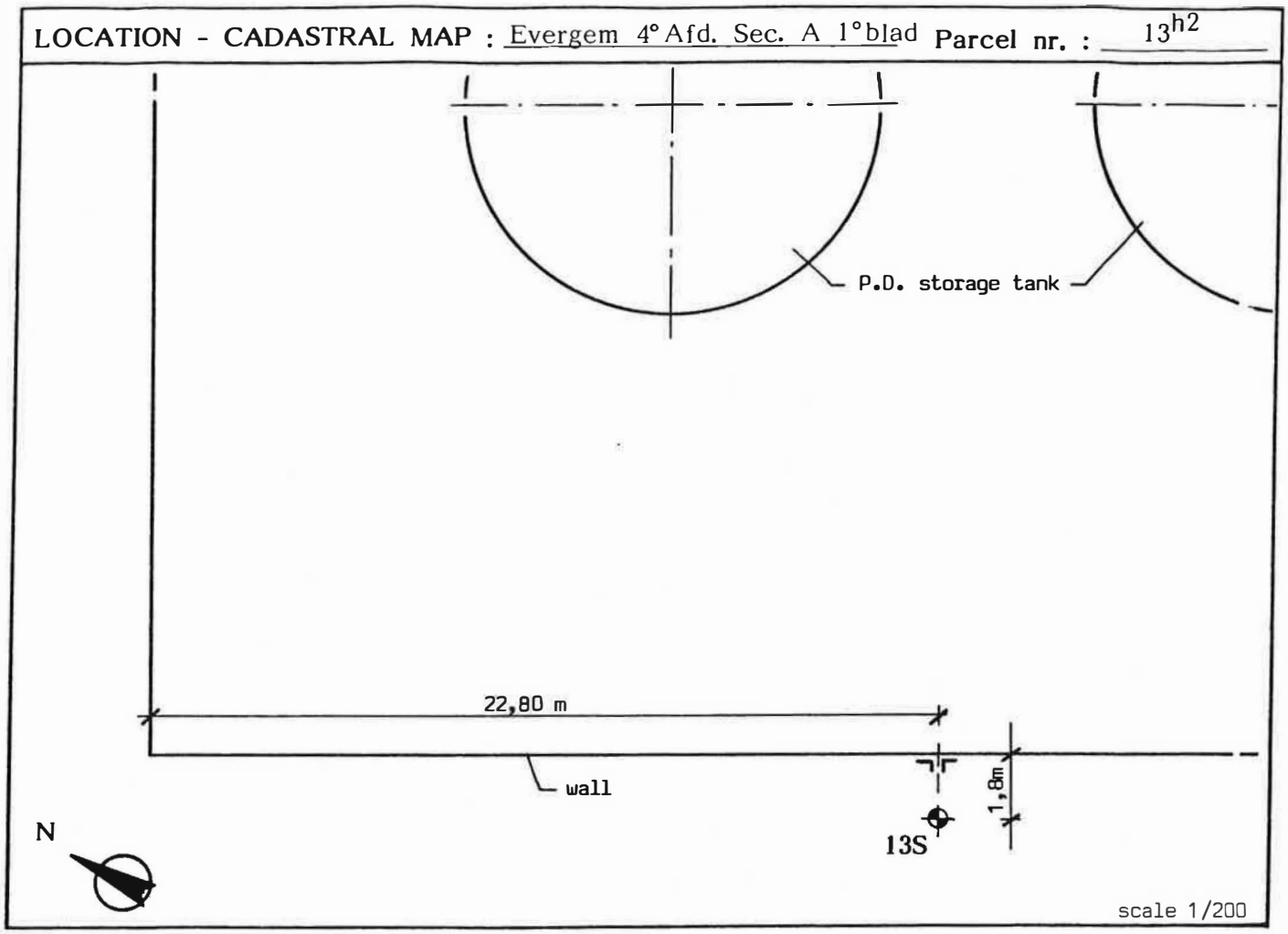
Sample nr.	Description of the cuttings	Depth (m) from	to
	Stones, stone fragments and gravel	0	0,2
M1	Dark brown fine sand	0,2	1,0
	Brown fine sand	1,0	1,5
M2	Grey fine sand	1,5	2,5
M3	Brownish grey fine sand	2,5	3,0
	Greyish brown slightly silty fine sand with peat	3,0	3,5
M4	Idem, with very much peat and wood fragments	3,5	4,0
	Grey fine sand with few wood fragments	4,0	4,5
M5	Grey fine sand	4,5	5,5
M6	Idem	5,5	6,0
M7	Grey slightly silty fine sand with few fine wood fragments	6,0	7,0
M8	Grey slightly silty fine sand	7,0	8,0
M9	Idem	8,0	9,0
	Grey fine sand	9,0	9,5
M10	Idem, with very few fine shell fragments	9,5	10,5
M11	Idem	10,5	11,0
	Grey fine sand with very few fine shell fragments and few fine silt lumps	11,0	11,5
M12	Grey slightly silty fine sand, idem	11,5	12,0
	Grey silt with few fine gravel	12,0	12,5
	Odour : from 6,5 to 8,0 m : slight odour, same as at 2D from 8,0 to 12,5 m : same strong odour		

Sample nr.	Description of the cuttings	Depth (m) from	to

Geological interpretation and remarks

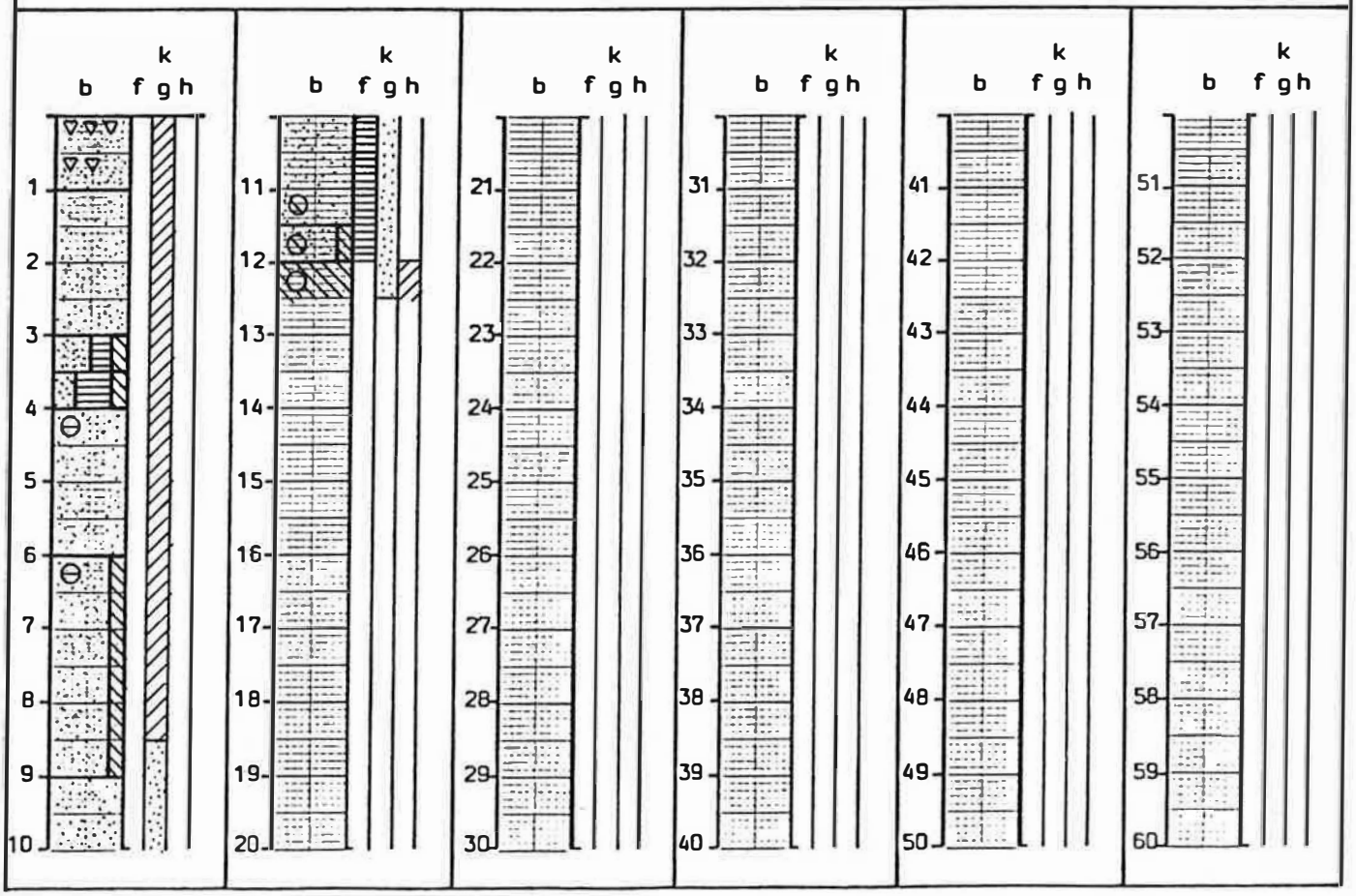
0 - 1,0 m : disturbed soil
1,0 - 12,0 m : KZ2
12,0 - : KI.

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13^{h2}



lithologic log screen (s) (f) filter pack (g) seal(s) grout (k) clay (b)

hydrogeological interpretation (h): pervious semi-pervious impervious



Rijksuniversiteit Gent
Laboratorium voor Toegepaste Geologie en Hydrogeologie
Laboratory of Applied Geology and Hydrogeology
Prof. Dr. W. De Breuck

Research nr. : TGO 86/81

Well nr. : 14S

RESEARCH : Additional hydrogeological Survey of the Arco Chemical Products Europe plant site at Rieme (Belgium)

OWNER : ARCO-ATOCHEM

- DATE : July 10th, 1987
- DRILLING CY. : Geolab
- DRILLING RIG Nordmeyer DRILLER :
- DESCRIPTION OF CUTTINGS BY : A. De Bruyn
- MAP N.G.I. Nr. : 14/5 GEOL./PEDOL. MAP Nr. : 40E
- MUNICIPALITY : Evergem NIS-CODE : 44019
- X = Y = (LAMBERT-COORDINATES)
- ZMV = 8,243 (m TAW)
- ZMV* = (m TAW)

(ZMV = ground level (measured); ZMV* = ground level (estimated))

DRILLING METHOD	Ø (mm)	DEPTH (in m) from - to	from - to	from - to	from - to	from - to
Auger	168	0 - 2,0				
Bailer	135	2 - 13,0				
Casing	168	0 - 12,8				

- DRILLING MUD : CONSUMPTION (l) :
- BOREHOLE LOG(S) :

screen nr.	NR.	DFB	DFO	ZMP	ZMP*	GWDP	L	ST	P
F1		10,5	12,5	8,830			1	10	2
F2									
F3									

NR = Number
DFB = Depth to top of screen (m)
DFO = Depth to bottom of screen (m)
ZMP = Level measuring point (m TAW)
ZMP* = Estimated level of mark (m TAW)
GWDP = Groundwater depth below mark
L = Type of aquifer : 1 = phreatic; 2 = non phreatic
ST = Stratigraphy (conform to legend LTG)
P = 1=Piezometer; 2=Observation well; 3=Dugged well; 4=Pumping well

- Several screens in one borehole : ~~yes~~/no
- Characteristics - riser pipes : PVC Ø 63 mm DYKA PVC NBN T42-111 PN10
  - screens : PVC Ø 63 mm VAN RYSWYCK-VEGHEL BV HOLLAND NP10
  - connections : GLUED JOINTS
- Bottom pipe (m) : 0,05
- Screen slot openings - type : vertical sawed slots
  - size (mm) : 60 x 0,3
  - open area (%) :
- Centralizer(s) - place (m) : -
- Filter-pack type and characteristics : coarse sand 0,7/1,25
  - volume (l.) : from 9,5 to 13,0 m
- Seals-type and characteristics : Clay pellets compactonite
  - volume (l.) : from 0 to 9,5 m
- Borehole backfill material :
- Development - method : see sampling
  - date - duration (h) :
  - discharge (m^3/h) :
- Finishing : steel cap

LITHOLOGIC LOG 14S - DATE : July 10th, 1987

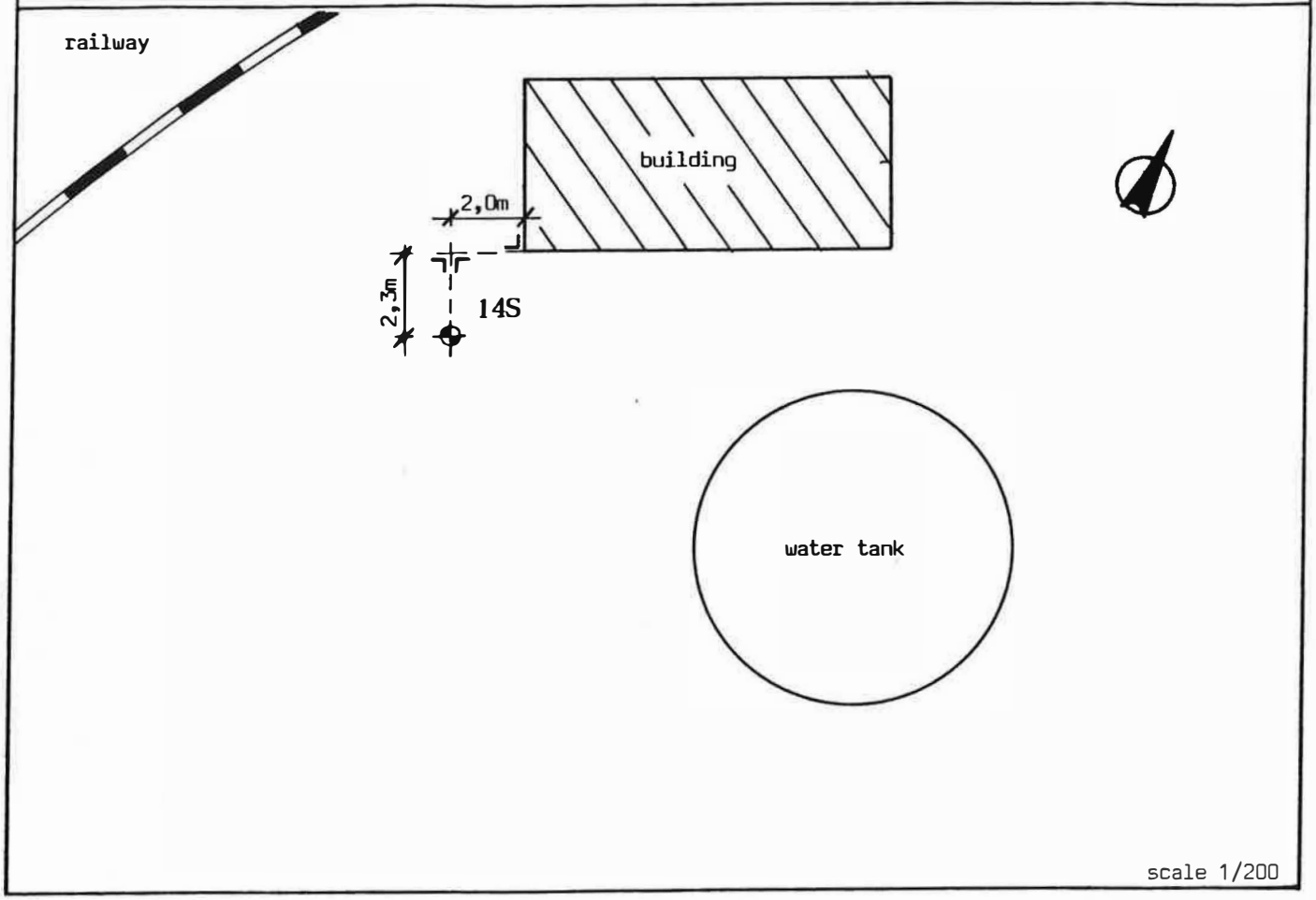
Sample nr.	Description of the cuttings	Depth (m) from	to
	Brown fine sand with stones and store fragments and brick fragments	0	0,5
M1	Brown fine sand	0,5	1,5
M2	Idem	1,5	2,0
M3	Idem	2,0	3,0
	Greyish brown fine sand	3,0	3,5
	Dark brown silty fine sand with many wood fragments	3,5	3,8
M4	Dark brown silty fine sand with wood fragments	3,8	4,0
	Greyish brown fine sand with few wood fragments	4,0	4,5
M5	Greyish brown fine sand	4,5	5,0
M6	Greyish brown silty fine sand	5,0	6,0
	Grey slightly silty fine sand	6,0	6,5
M7	Grey fine sand	6,5	7,5
M8	Idem	7,5	8,0
M9	Grey fine sand with very few fine shell fragments	8,0	9,0
M10	Idem	9,0	10,0
M11	Idem	10,0	11,0
M12	Idem	11,0	12,5
	Idem, with silt lumps	12,5	12,9
	Odour : from 4,0 to 12,9 m : slight odour 2D		

Sample nr.	Description of the cuttings	Depth (m)	
		from	to

Geological interpretation and remarks

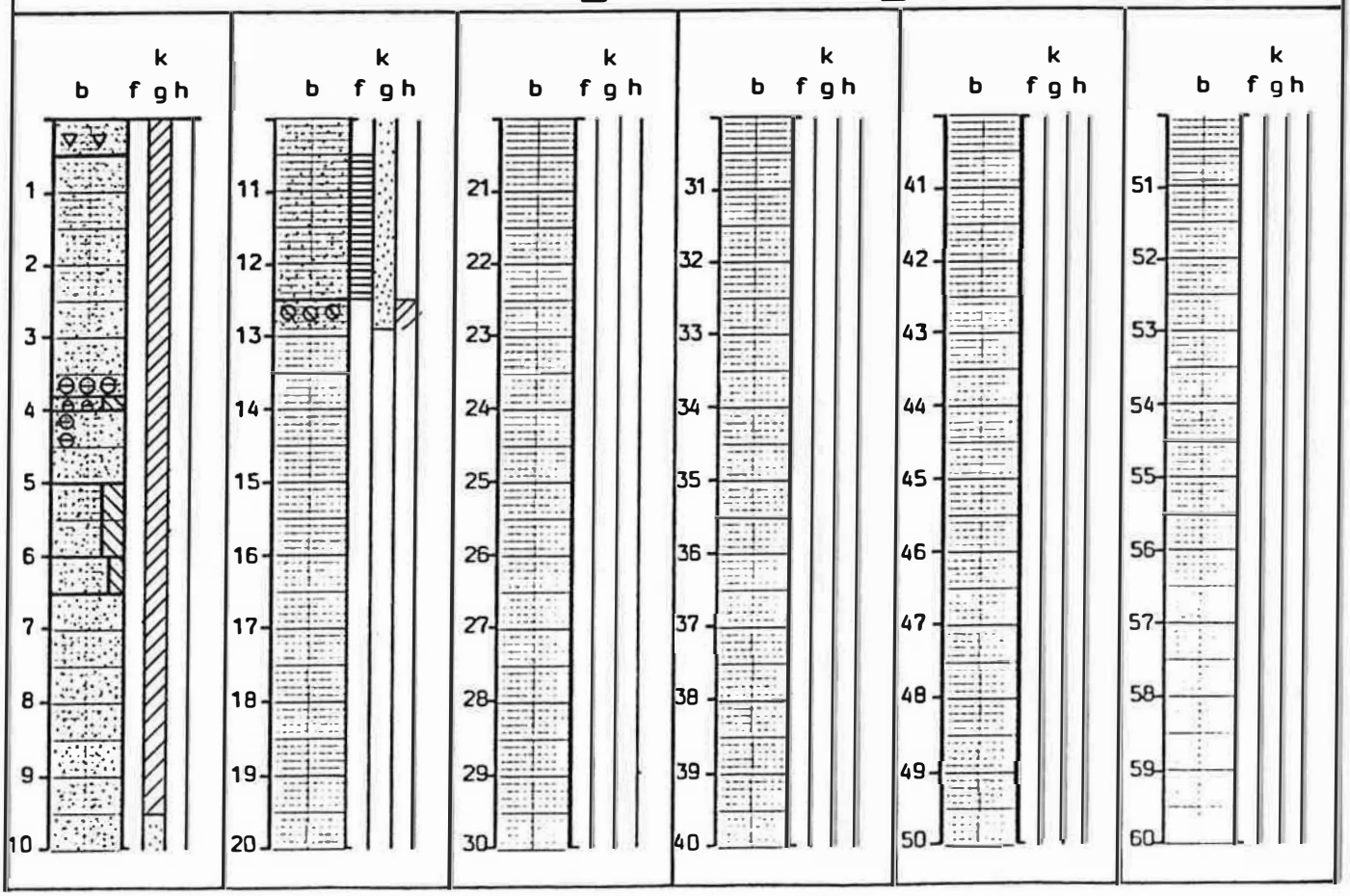
0 - 0,5 m : disturbed soil
0,5 - 12,5 m : KZ2
12,5 : KL

LOCATION - CADASTRAL MAP : Evergem 4° Afd. Sec. A 1° blad Parcel nr. : 13^{h2}



lithologic log (b) screen (s) (f) filter pack (g) seal(s) grout (k) clay

hydrogeological interpretation (h): pervious semi-pervious impervious



APPENDIX 2

GEOMETRIC CHARACTERISTICS OF THE OBSERVATION WELLS

borehole nr.	screen nr.	Co-ordinates		Ground elevation (m TAW)	Elevation measuring point	Screen		length (m)	ø (mm)
		x	y			depth (m) TOP - BASIS	level (m TAW) TOP - BASIS		
		FORMERLY DRILLED ARCO WELLS							
1S	1S	SEE MAP 1		+8,2	+8,907	7,0 - 9,0	+1,2/-0,8	2,0	63
1D	1D			+8,2	+8,816	17,5 - 19,5	-9,3/-11,3	2,0	63
2S	2S			+8,2	+8,900	7,0 - 9,0	+1,2/-0,8	2,0	63
3S	3S			+8,7	+9,360	8,5 - 10,5	+0,2/-1,8	2,0	63
3D	3D			+8,7	+9,348	18,0 - 20,0	-9,3/-11,3	2,0	63
4S	4S			+8,7	+9,337	7,5 - 9,5	+1,2/-0,8	2,0	63
5S	5S			+8,2	+8,909	8,4 - 10,4	-0,2/-2,2	2,0	63
5D	5D			+8,2	+8,918	16,5 - 18,5	-8,3/-10,3	2,0	63
		NEWLY DRILLED OBSERVATION WELLS							
1Sbis	1Sbis	SEE MAP 1		+8,3	+8,791	10,5 - 12,5	-2,1/-4,1	2,0	63
1Dbis	1Dbis			+8,4	+9,011	17,3 - 19,3	-9,0/-11,0	2,0	63
2Sbis	2Sbis			+8,2	+8,640	10,0 - 12,0	-1,8/-3,8	2,0	63
2D	2D			+8,1	+8,711	17,5 - 19,5	-9,4/-11,4	2,0	63
4S1	4S1			+8,8	+9,394	5,0 - 10,0	+3,8/-1,2	5,0	125
4S2	4S2			+8,7	+9,200	8,0 - 10,0	+0,7/-1,3	2,0	63
4S3	4S3			+8,5	+9,165	8,0 - 10,0	+0,5/-1,5	2,0	63
4S4	4S4			+8,8	+9,046	2,5 - 3,5	+6,3/+5,3	1,0	63
4S5	4S5			+8,8	+9,234	13,6 - 14,6	-4,8/-5,8	1,0	63
4D1	4D1			+8,8	+9,391	17,0 - 20,0	-8,2/-11,2	3,0	125
4D2	4D2			+8,9	+9,626	18,0 - 20,0	-9,1/-11,1	2,0	63
4D3	4D3			+9,2	+9,217	18,0 - 20,0	-8,8/-10,8	2,0	63
6S	6S			+9,4	+9,231	12,0 - 14,0	-2,6/-4,6	2,0	63
7S	7S			+9,0	+8,822	10,5 - 12,5	-1,5/-3,5	2,0	63
8S	8S			+8,9	+8,821	10,4 - 12,4	-1,5/-3,5	2,0	63
9S	9S			+8,8	+8,541	10,6 - 12,6	-1,8/-3,8	2,0	63
10S	10S			+8,8	+8,701	11,0 - 13,0	-2,2/-4,2	2,0	63
11S	11S			+8,7	+8,465	9,5 - 11,5	-0,8/-2,8	2,0	63
12S	12S			+8,9	+8,757	10,5 - 12,5	-1,6/-3,6	2,0	63
13S	13S			+9,1	+8,904	10,0 - 12,0	-0,9/-2,9	2,0	63
14S	14S			+8,8	+8,653	10,5 - 12,5	-1,7/-2,7	2,0	63