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NGU Rapport 98.095

Assessment of soil and groundwater contamination at a former Soviet Military Base.
Viestura Prospekts Oil Depot, Riga, Latvia.
APPENDICES

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Assessment of soil and groundwater contamination at a former Soviet Military Base.
Viestura Prospekts Oil Depot, Riga, Latvia. APPENDICEC

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A former Soviet military fuel depot has been subject to site investigation to examine soil and groundwater contamination. Risk assessment techniques have been applied to make a so-called "Tier 2" assessment of risk to human health and risk to water resources from the site. The assessment has concluded that contamination from the site will not reach the nearest surface water body within 35 years, even without taking into account sorption and biodegradation. The risk assessment also concludes that the site can remain in its current usage or be redeveloped for commercial purposes without any risk to human health. The assessment predicts no unacceptable risk to groundwater resources or to the River Daugava from the site.

If the site is redeveloped for residential use or for open public access (parkland), an unacceptable human health risk may be present. If such redevelopment is proposed, either (a) a "Tier 3" risk assessment should be carried out to make a more refined, less conservative assessment of risk or (b) cleanup of selected areas should be carried out to cited risk-based clean-up levels. The investigation has suffered from three main shortcomings:

(i) Lack of reproducibility of analytical data. *Recommendation: that all national laboratories used for contamination assessments should take part in internationally recognised accreditation schemes and international ring tests. Sampling should include adequate provision for spiked samples and blanks.*

(ii) Lack of sensitivity analysis for modelling of groundwater contaminant transport and risk assessment. *Recommendation: no model results or risk assessments should be accepted as the basis for decision-making unless accompanied by a quantitative sensitivity analysis or, at the very least, (i) some quantification of likely margins of error in the results or (ii) a full justification of the conservatism of the approach.*

(iii) Lack of modelling or risk assessment of evolution of LNAPL plume or risk therefrom. *Recommendation: As LNAPL plumes frequently represent the greatest concentrations of contaminants at many former military bases, transport and risk models simulating LNAPL evolution should be assessed and implemented as a matter of urgency.*

Emneord: Hydrogeologi	Geokjemi	Forurensning
Løsmasser	Risikovurdering	Olje
Grunnvannskvalitet	Grunnvann	Geofysikk

APPENDICES

Appendix 1:

Report from 1994 by Levins & Sicovs. "Ecological evaluation of the oil storage facility belonging to Lat-West-East Co. (2 Viestura Prospekts, Riga)", translated from the Latvian.

"URBŠANAS CENTRS" Ltd.
"ĢEO-KONSULTANTS" Ltd.

I. Levins
G. Sičovs

ECOLOGICAL EVALUATION
of the area of the oil storage facility belonging to "Lat-West-East" Co.
(2 Viestura Prosp., Riga)

R. Gavenas, Director, "Urbšanas Centrs" Ltd.
G. Sičovs, Director, "Ģeo-Konsultants" Ltd.

Riga, 19

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Introduction

In compliance with an order from "Lat-West-East", an investigation of the ecological situation at the site of an oil pumping facility (2 Viestura Prosp., Riga; Fig. 1) was carried out. The area of the base is ca 20.5 hectares. The base has been used since 1941. Oil products are stored in underground tanks, their nominal volume is 13,200 cu. m. Potential contamination sources could be as follows: the pumping station, underground pipelines, fuel storage facilities and the railway overpass (Fig. 2).

Based on visual observations, several, contaminated by oil products, areas have been determined (near the pumping station etc.). The general ecological situation was evaluated as favourable. Still, the long-term use of the oil base could lead to hidden (underground) contamination of soil and groundwater. That is why the clarification of this item was one of the main investigation targets. The second main target was the establishment of a network of observation wells to monitor the contamination of groundwater.

The field work was carried out during September 6-17, 1964, the laboratory studies and the data processing took place during 18-28 September. The drilling operations were carried out by "Urbsanas Centrs" Ltd., while other work, including the report compilation - by "Geo-Konsultants" Ltd.

1. Methods of investigations

1.1. Geophysical investigations

Geophysical investigations allow to obtain information about the site, to diminish the amount of drilling. These have been carried out using two methods which complemented one another - radar investigations and vertical electrical sounding.

Radar investigations. Their main task was detailed mapping of the groundwater table, necessary for the compilation of hydroisohypse maps. The analysis of the top of the table allows to determine the directions of local groundwater currents and, due to that, the underground migration of oil products from potential contamination sources. Radar investigations allow to determine the situation of the communication network and to select drilling sites which do not harm underground communications. During the studies, the impulse georadar "Zonde-8" was used; its average emission frequency is 100 MHz, the fixed distance between the transmitter and the receiver is 1.2 m. The total length of radar profiles is 4.2 km. The main results of the radar profiling are summarized in Supplement 3.

Vertical electrical sounding. This method is used to map the zones where the resistivity of water-saturated sand is anomalously low. This phenomenon is usually observed if there is a considerable contamination of groundwater, when the mineralization is heightened and, as a result, its permeability to ions is higher. The vertical electrical sounding (VES) was carried out using A3-72 Compensator. During the first stage of VES, the length of the feeding lines was different (1.5, 3, 5, 9, 15, 25, 50 m). As a result, it was observed that the optimum length of the feeding lines when determining the resistivity of the top of water-saturated sand is 15 m. As a rule, oil products migrate in this layer, their specific gravity being smaller than that of water. During the second stage, VES was carried out using only the above-mentioned length of feeding lines. VES was carried out in 82 points (Fig. 3). The main results of VES are summarized in Supplement 4.

1.2. Drilling

Drilling was conducted using UGB-50M rig. In the boreholes, samples of soil and groundwater were taken. 11 boreholes have been drilled altogether. Their sites are shown in Fig. 5; in Supplements 1 and 2, the information about the construction of the well and the geological section are presented. In all the boreholes, filter columns (ID 50 mm) have been placed down as well as sieve filters (1 m long). They are used for the continuous monitoring of water contamination.

The drilling sites have been selected based on geophysical data. Most wells have been drilled in the zones of anomalously low electrical resistivity, in order to determine the intensity of contamination using geophysical methods. 8 boreholes are situated outside these zones. Their purpose was to determine the background concentrations in the groundwater. In boreholes # 1-8, the filters have been placed in the very top of the aquifer, near the water table; as already mentioned, the migration of oil products occurs, predominantly, in this horizon. In boreholes # 9-10, the filters have been placed at a relatively deep level, in order to monitor the distribution of oil product contamination in depth.

After the drilling, the determination of borehole altitudes took place. For that purpose, DAHLTA 010 A tacheometer was used, together with the determinations of groundwater static levels. The above results, together with georadar profiling data, have been used for the compilation of hydroisohypse maps.

1.3. Sampling of groundwater, soil and subsoil

In order to sample the sand of soil and subsoil (the first subsoil layer, 0.2-0.4m deep), a manual geological drill was used. The sampling was conducted, as far as possible, uniformly all over the base area, paying special attention to the relief lows - possible sites of oil product migration (Fig. 5). Altogether, there were 26 soil and subsoil sampling sites. Each sample, to be representative, consisted of 5 separate samples which had been mixed and divided into 4 parts. 24 samples have been taken from deeper layers of the aeration zone (0.5-4.0 m), using cores. The samples have been placed into double polyethylene bags and stored in a refrigerator prior to laboratory analyses.

The samples of groundwater have been taken using COMET submersible centrifugal pump. The use of such pumps excluded the deterioration of samples due to either degassing or aeration. The pumping was carried out until the pumped water was clear from suspended matter, reaching physical and chemical stabilization (temperature, conductivity, pH). The samples have been taken in view of the above and are representative; their chemical composition fully coincides with that of a relevant water layer.

For the determination of the physical and chemical parameters of the pumped water, microprocessors CONDUCTIVITY METER LP96 and pH METER pH95 have been used. The groundwater samples have been collected in glass containers which were hermetically closed and stored in a refrigerator prior to laboratory analyses.

1.4. Laboratory studies

Infrared spectrophotometry was used for the determination of the content of oil products in soil, subsoil and groundwater, by extraction using carbon tetrachloride. This method is quite accurate: the upper accuracy limit being 0.05 mg/l for water and 30 mg/kg for rocks. At the same time, the method is much cheaper than gas-liquid chromatography.

Besides, in the samples of groundwater, chemical oxygen consumption was determined, characterizing the content of dissolved organic matter, including oil products. The general chemical composition - principal ion content and N compounds. The changes in the general chemical composition of groundwater as regards the content of natural calcium bicarbonate are indirect indicators of the presence of contaminants.

The determinations of the content of oil products were carried out at the laboratory of Hydrometeorological Survey, other analyses - at the laboratory of State Enterprise "Latvijas Geologija".

1.5. Data processing

The results of the processing of data obtained during field studies and laboratory analyses have been summarized in tables and maps, characterizing the degree of contamination of both soil and groundwater. Maps of isolines have been compiled using SURFER software. Radar sounding data have been processed using special software GEOPLUSS 2.0.

2. Geological structure and hydrogeological situation

In order to characterize the geological structure and the hydrogeological conditions, the results of the present study and the information from the Latvian Geological Fund (data about the Riga city water wells) have been used.

The total thickness of the Quaternary deposits in the oil base area is ca 50 m. In the cemetery area, fine-grained eolic sand occurs, its thickness being up to 3 m. The most important part of the geological section consists of the Baltic Ice Lake sand, its thickness being ca 30-40 m. The sand is, predominantly, fine-grained, in some places, medium coarse and fine sand interlayers occur (see Supplement 1). Lower Quaternary deposits consist of limnoglacial ones - silt and clay. Glacial deposits (morainic sandy clay and clayey sand), unlike the above-mentioned, do not occur all over the area. The total thickness of limnoglacial and glacial rocks is between 10 and 20 m. Their permeability is low.

The first aquifer is composed of the Baltic Ice Lake sand. The level of groundwater table varies from 2.8 m in the relief lows to 5.4 m in the SW part of the base. The absolute altitude of the water table varies from 3.25 to 2.65 m (Fig. 6). It is lower in the southern and in the western parts of the area under study. Due to that, a radial groundwater flow has been observed. It is possible that the structure of that flow is determined by buried river valleys and artificial draining in the Mezaparks area, situated to NW of the base.

The bedrock is formed by upper Devonian (Gauja formation) sandstone with siltstone interlayers. The Gauja horizon is widely used for the water supply of Riga.

3. Criteria for the evaluation of the degree of contamination of soil and groundwater

Today in Latvia there are no regulations determining maximum contamination of soil, subsoil and groundwater. The only exception concerns surface water, where the maximum permissible oil product content is 0.05 mg/l (Standard of the Environmental Protection Committee of the Republic of Latvia, approved 1/11/91). Taking into consideration the fact that there is no similar standard for soil and groundwater, we had to rely on personal experience obtained during the studies at similar sites as well as on the use of foreign standards. At the same time, the accuracy of the analytical methods used and the background content of oil products in urban areas had to be taken into account.

As already mentioned, in order to determine the content of oil products, infrared spectrophotometry was used. This method allows to identify the presence of oil products in water and soil if their content is > 0.05 mg/l in groundwater and 30 mg/kg in soils. If the content of oil products exceeds the above values, we consider, based on the experience from similar sites, that groundwater or soil are contaminated. Lower levels of contamination cannot be unambiguously identified as oil product contamination as weakly polarized hydrocarbons found in the samples could have been formed under natural conditions.

The criteria for the evaluation of the contamination of groundwater and subsoil have been worked out, in detail, in Germany in 1993 (Richt und Grenzwerte fur Nutz und Kulturboden, Richtwerte fur Grund und Sickerwasser-Kontaminationen). The degree of contamination by oil products was evaluated determining 3 different concentrations: A - background, in urban areas; B - heightened, if they are exceeded, additional studies are necessary; C- heavy, if these are exceeded, special studies are carried out for remedial purposes. These concentrations are as follows: for subsoil - 50; 1,000; 5,000 mg/kg; for groundwater - 0.05; 0.20; 0.60 mg/l. It should be mentioned that these correspond to the background values in Latvia (50 mg/kg and 0.05 mg/l).

Oil products in groundwater (non-polar and weakly polar hydrocarbons) disintegrate during chemical oxidation and biodegradation. As a result, different polar destruction products are formed: acids, phenols, etc. These compounds are not determined during the determination of general oil product content. That is why we used an additional value - chemical oxygen consumption units (COC) , ozidizability by bichromate, in order to determine the amount of destroyed organic matter, including oil products. If, in the Baltic Ice Lake sediments, COC exceeds 20 mg of O2/l, we, taking into account our experience, can make the conclusion about the existence of contamination.

In view of the above, groundwater and soil samples have been classified based on their contamination by oil products (see Fig. 7,8,10). The following degrees of contamination have been singled out:
- weak;
- considerable;
- strong and very strong.

The degrees of contaminations have been singled out based on the above-mentioned German criteria A, B and C. The "very strong" degree has been singled out as a single value in order to describe the most polluted soil areas, to achieve more representative information.

4. Soil and subsoil contamination by oil products

The content of oil products in soil and subsoil varies from 20 to 950 mg/kg (Table 1). Oil contamination (concentrations >50 mg/kg) has been observed in 11 from 26 sampling sites. They occur, predominantly, near the underground tank, the pumping station and the railway overpass (Fig. 7,8). Quite strong contamination (>100 mg/kg, smell) was observed at 3 sites near the pumping station and the northern underground tank. It should be mentioned that in 2 cases (the sites correspond to boreholes 2 & 5), the samples have been taken from technogenous deposits. There is no undisturbed soil and subsoil there.

The content of oil products does not exceed 1,000 mg/kg either in soil or subsoil, although the range of concentrations is wide. It was concluded that no additional investigations of the layer contamination problems are necessary.

In the deepest layers of the aeration zone, oil contamination in the geological section from the surface to the groundwater table was observed in all the boreholes, excluding # 3. The content of oil products varies from 30 to 690 mg/kg (Table 2). Boreholes # 5 and 6, i.e. the area in the vicinity of the northern oil tank, have displayed considerable contamination. Oil contamination does not end in the aeration zone and is observed, although to a lesser degree, in the cores (smell) as far as the borehole bottom (Supplement 1).

Table 1
The content of oil products in soil and subsoil

Sampling site #	The content of oil products, mg/kg	
	In soil	In subsoil
1 (borehole # 1)	30	26
2 (borehole # 2)	950	480
3 (borehole # 3)	28	52
4 (borehole # 4)	30	30
5 (borehole # 5)	85	280
6 (borehole # 6)	62	40
7 (borehole # 7)	39	30
8 (borehole # 8)	47	32
12	27	51
13	32	28
14	30	34
15	35	69
16	31	28
17	64	57
18	28	67
19	29	32
20	27	30
21	32	28
22	34	25
23	25	67
24	65	32
25	28	67
26	180	25
27	30	25
28	20	24
29	20	60

Table 2
The content of oil products in sand in the aeration zone

Borehole #	Sampling depth, m	The content of oil products, mg/kg
1	0.5	80
1	1.5	70
1	3.5	96
1	5.5	60
2	0.5	40
2	1.5	30
2	3.5	75
3	0.5	45
3	1.5	30
3	4.5	50
4	0.5	70
4	1.5	75
4	3	35
5	1	850
5	5.5	90
6	0.5	580
6	1.5	690
6	2.5	340
7	0.5	120
7	1.5	80
8	0.5	50
8	1.5	98
8	4	70

The occurrence of oil products of oil products almost in all the boreholes drilled within the base shows that its whole area is contaminated. As already mentioned, the boreholes were been drilled, predominantly, in the contaminated areas where, earlier, anomalously low electrical resistivity in sand had been observed. It should also be mentioned that the content of oil products does not exceed 1,000 mg/kg at the site.

5. Chemical composition and contamination of groundwater

Unpolluted groundwater in the sediments of the Baltic Ice Lake is characterized by low mineralization (normally below 0.4 mg/l). This is a calcium bicarbonate water. The content of nitrogen compounds does not exceed tenths of mg, the total organic content (TOC) is up to 20 mg O2/l. The reaction of the environment is alkaline, pH background value is 7.2-7.6.

At the base site, such composition of groundwater was observed only in borehole # 8. The concentration of dissolved and emulsified oil products is 0.05 mg/l there, corresponding to the background value in the urban areas (Table 3). Borehole # 8 was drilled in the groundwater flow area above the potential contamination sources. The chemical composition observed in borehole # 8 is considered as the background one for groundwater flow entering the oil base area.

The chemical composition of groundwater in other boreholes differs, to a greater or lesser degree, from the natural background composition. The content of oil products exceeds 0.05 mg/l in all the boreholes. The differences in chemical composition are typical for oil contamination. Chemical oxygen consumption rises considerably - up to 225 mg O2/l, demonstrating the presence of disintegrated oil products in groundwater. Weak organic acids are some of the products of oil product destruction; their presence explains the acidic reaction of the environment (pH - up to 6.2) and the big growth of the content of apparent bicarbonate (up to 677 mg/l). These acids define the alkalinity of the water, on which bicarbonate ion concentration depends. The high concentration of ammonia (up to 13 mg/l) is characteristic of "old" oil contamination, as this component is formed during the destruction of oil hydrocarbons.

Table 3
Chemical analyses of groundwater in situ and in the laboratory

Parameter	Measur. units	BOREHOLES										
		1	2	3	4	5	6	7	8	9	10	11
Filter depth	m	6.1-7.1	3.5-4.5	6.0-7.0	3.7-4.7	6.0-7.0	4.4-5.2	6.0-7.0	4.7-5.6	9.4-10.4	8.2-9.2	8.4-9.4
Oil product smell		Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Colour	Grad.	80	80	100	90	90	70	120	15	80	35	130
pH		6.42	6.25	6.87	6.45	6.56	6.39	6.45	7.26	7.11	6.96	7.03
Conductivity	uS/cm	726	881	780	913	708	758	950	459	688	569	640
Residue	mg/l	432	554	452	519	402	477	554	296	424	357	351
Na^+	mg/l	14	1	7	18	10	8	16	5	17	8	2
Ca_2^+	mg/l	122	180	126	144	124	156	158	86	120	100	112
Mg_2^+	mg/l	22	22	30	27	13	16	23	15	17	18	13
HCO_3^-	mg/l	518	677	561	628	482	580	671	281	464	342	415
Cl^-	mg/l	10	5	4	9	7	4	8	8	9	8	9
SO_4^{2-}	mg/l*	NO	NO	NO	NO	NO	NO	NO	42	25	51	NO
NO_3^-	mg/l	NO	NO	NO	NO	NO	NO	2	NO	NO	NO	NO
NO_2^-	mg/l	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

cont.

Para- meter	Measur. units	BOREHOLES										
		1	2	3	4	5	6	7	8	9	10	11
NH_4^+	mg/l	4.9	7.2	3.8	6.4	6.8	2.9	13	NO	3.6	0.5	4.9
COD	mg O_2/l	62	225	56	101	95	103	193	12	73	14	75
Oil products	mg/l	0.42	0.35	0.10	0.40	1.20	1.35	0.45	0.05	0.08	0.10	0.43

* NO - not observed

The increase of the concentrations of the above components leads to the increase in the ionic conduction in the groundwater which is demonstrated by an anomalously high electric conductivity - up to 950 μS/cm (background value - 459). As a result, the resistivity of water-saturated sand has greatly diminished.The results of vertical electrical sounding have allowed to single out 3 zones where the resistivity in sand is >200 Ohmm (Fig. 9). In the boreholes (# 2,5,6,7) drilled in such zones, the most contaminated groundwater has been observed (Fig. 10). As already mentioned, in boreholes # 5 and 6, the maximum content of oil products in the sand of the aeration zone has been observed.

The configuration of the heavily contaminated zone and the direction of groundwater flow have demonstrated that the main source of contamination is pipeline leakage (Fig. 10). It is possible that the fuel storage has also contributed in the formation of the SW contaminated zone (No. 4, Fig. 2).

The features of the groundwater chemical composition have allowed, although roughly, make conclusions about the time of existence of contamination. High concentrations of oil products in boreholes # 5 and 6 (1.2-1.35 mg/l) point at a recent contamination in the nearest pipeline zone; that pipeline is connected to the northern underground tank.

In boreholes # 2 and 7, the content of oil products was relatively low (0.35-0.45 mg/l) while the degree of oil product destruction was anomalously high (COD - up to 225 mgO2/l), HCO3 - up to 677 mg/l, ammonia - up to 13 mg/l).

Characterizing contamination by oil product products, it should be mentioned that its degree is not the greatest in the Northern District of Riga. Earlier investigations in the area of the Milgravis oil base (Tvaiku St.) have shown that the content of oil products in groundwater was up to 950 mg/l there, besides, most of the hydrocarbons were in the free phase, up to 0.5 m thick, "swimming" above the groundwater table. Today the ecological situation at the object under study is much better - the content of hydrocarbons in groundwater does not exceed 1.35 mg/l; besides, they have been observed in dissolved or emulsified condition only.

The geophysical data show that the zone of heavily contaminated groundwater does not continue beyond the oil base area (Fig. 9, 10). The configuration of isohypses shows that the migration of oil products with the groundwater flow may occur towards NE, i.e. to Mezaparks (Fig. 10).

The contamination of groundwater diminishes further down the section. That has been observed in the following well pairs: 7-9, 4-10, 2-11 (Fig. 5, Table 3); the explanation is that, due to small density of oil products, their sorption in the soils takes place. More detailed investigations in the Milgravis oil pumping base have demonstrated that already at the depth of 15 m the content of hydrocarbons in groundwater is low. The existence of tight silt in the bottom of the geological section excludes the possibility of oil contamination from the site entering the Devonian sandstone horizon used for the water supply purposes.

Conclusions and recommendations

The geological investigations carried out at the oil pumping base area have led to the following conclusions:

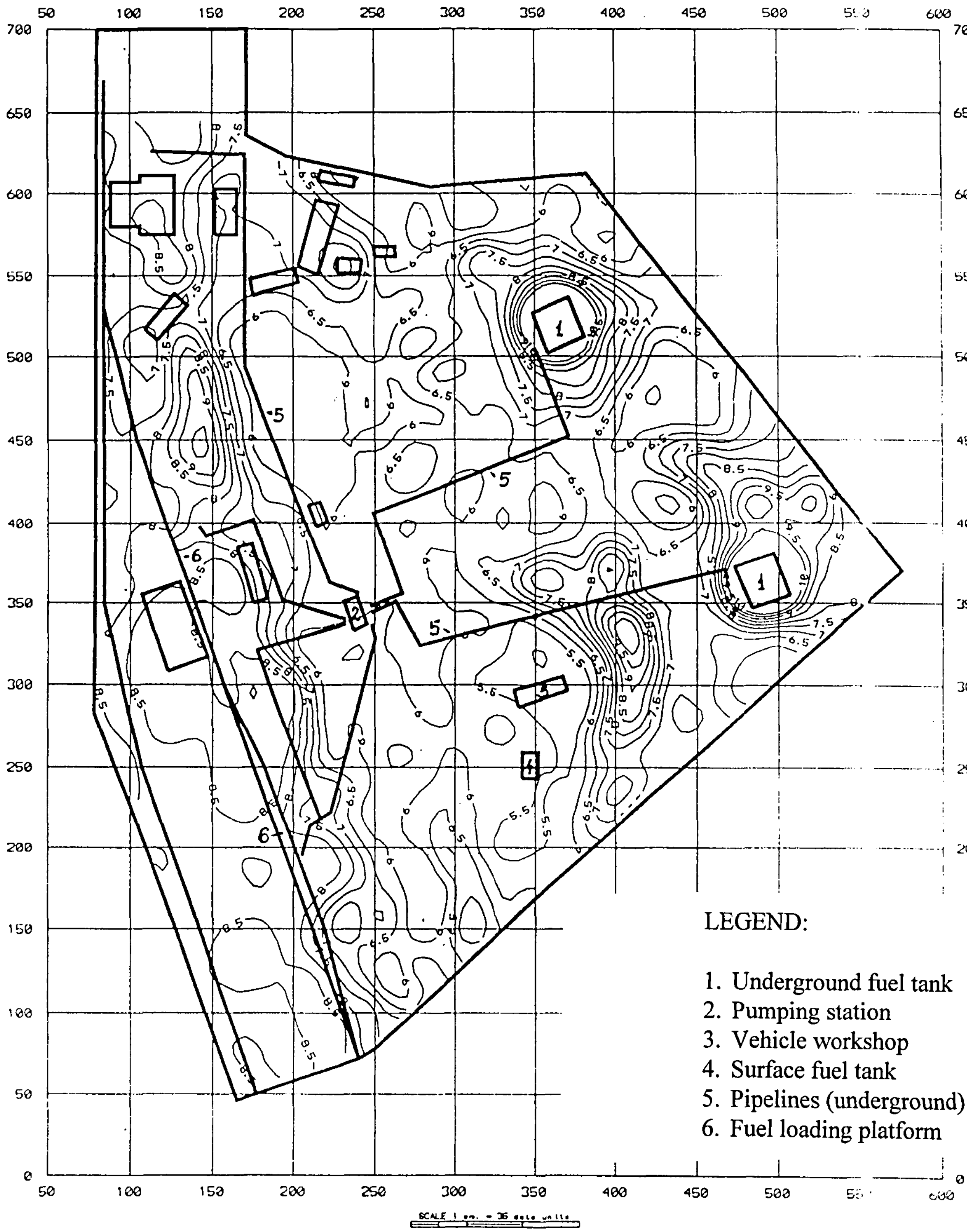
- The content of oil products in soil, subsoil and the sand of the aeration zone varies from 20 to 950 mg/kg. In compliance with the German standard, there is no need to carry out additional investigations or remedial actions regarding the soil.
- The concentration of oil products in groundwater is 0.05-1.35 mg/l. Heavily contaminated groundwater which should be investigated in view of remedial actions, is localized within the base area. The leakages from underground pipelines are, probably, the sources of contamination. The high COD (up to 225 mg O_2/l) and considerable changes in the chemical composition of groundwater are also due to that.
- The contamination, taking into account the direction of groundwater flow, may migrate towards NE - to Mezaparks. The possibility of contamination entering the Devonian deposits (used for water supply purposes) is remote.

Within the base area, 11 observation wells have been established for the monitoring of groundwater contamination.

Taking into consideration the obtained information, the recommendations are as follows: the most urgent and important task is to determine the sites of oil product leakages from the pipelines. This can be done by the use of vertical electrical sounding, by the establishment of a denser observation grid and by drilling a few additional boreholes to check the earlier obtained results.

Topogrāfiskā karte

Mērogs: 1 : 3 500



——8—— zemes virsmas izolīnija, m abs. atz

2. zīmējums

Table 2. Details of wells

Urbums	Absolūtā atzīme, m		Gruntsūdens līmenis urbumā, m		
	urbuma atvere	caurules gals	no zemes virsmas (m bgl)	no caurules gala (bwt)	absolūtajās atzīmēs (m asl)
1	8.60	8.97	5.37	5.74	3.23
2	5.78	6.05	2.51	2.78	3.27
11	5.69	5.95	2.55	2.81	3.14
3	6.42	7.00	3.42	4.00	3.00
4	5.50	5.85	2.90	3.25	2.60
10	4.84 ?	5.23	2.83	3.22	2.01
5	6.10	6.64	3.43	3.97	2.67
6	6.20	6.57	3.43	3.80	2.77
7	5.59	6.17	2.74	3.32	2.85
9	5.58	5.79	2.71	2.92	2.87
8	5.99	6.47	3.08	3.56	2.91
	Ground level m.a.s.l	Well top m.a.s.l.	Water level m.b.g.l.	Water level m.b.w.t.	Water level m.a.s.l.

b.g.l. = below ground level
b.w.t. = below well top
a.s.l. = above sea level

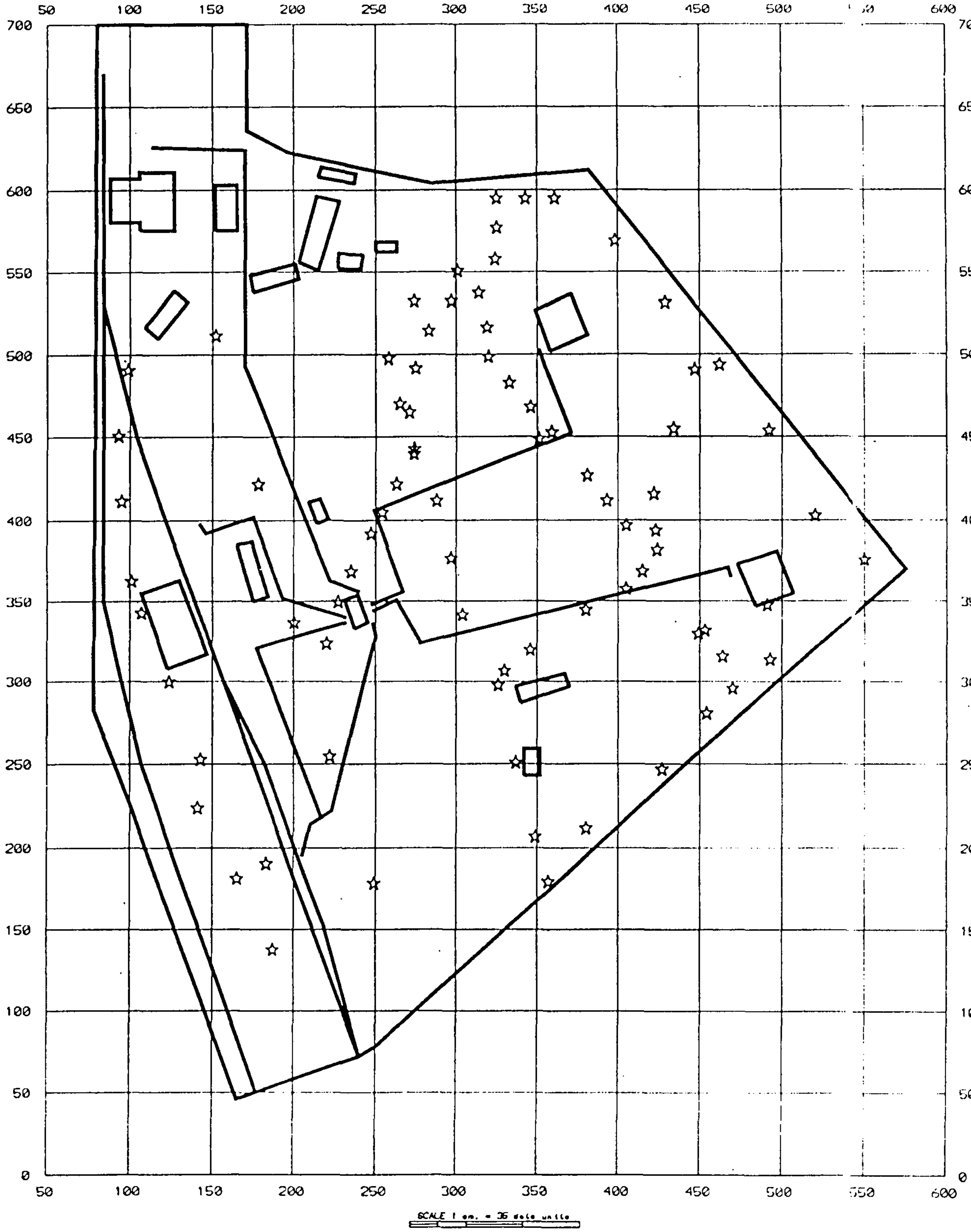
Table 3. Analytical results

Gruntsūdens lauku un laboratorijas ķīmiskās analīzes

Para-metri	Mēr-vienī-bas	URBUMI										
		1	2	3	4	5	6	7	8	9	10	11
Filtra dziļums (Filter depth)	m	6,1 - 7,1	3,5 - 4,5	6,0 - 7,0	3,7 - 4,7	6,0 - 7,0	4,4 - 5,2	6,0 - 7,0	4,7 - 5,6	9,4 - 10,4	8 2 - 9 2	8,4 - 9,4
Naftas produktu smaka		Ir	Ir	Ir	Ir	Ir	Ir	Ir	Nav	Ir	Ir	Ir
Krāsa	Grad.	80	80	100	90	90	70	120	15	80	35	130
pH		6,42	6,25	6,87	6,45	6,56	6,39	6,45	7,26	7,11	6 96	7,03
Elektro-vadīt-spēja	µS / cm	728	881	780	913	708	758	950	459	688	5 9	640
Sausne (izsk.)	mg/l	432	554	452	519	402	477	554	296	424	3 7	351
Na +	mg/l	14	1	7	18	10	8	16	5	17	8	2
Ca2 +	mg/l	122	180	126	144	124	156	158	86	120	1 0	112
Mg2 +	mg/l	22	22	30	27	13	16	23	15	17	8	13
HCO3 -	mg/l	518	677	561	628	482	580	671	281	464	3 2	415
Cl -	mg/l	10	5	4	9	7	4	8	8	9	8	9
SO4 2-	mg/l	N. k.	N. k.	N. k.	N. k.	N. k.	N. k.	N. k.	42	25	51	N. k.
NO3 -	mg/l	N. k.	N. k.	N. k.	N. k.	N. k.	N. k.	2	N. k.	N. k.	N. k.	N. k.
NO2 -	mg/l	N. k.	N. k.	N. k.	N. k.	N. k.	N. k.	N. k.	N. k.	N. k.	N. k.	N. k.
NH4 +	mg/l	4,9	7,2	3,8	6,4	6,8	2,9	13	N. k.	3,6	.5	4,9
ĶSP	mg O2/l	62	225	56	101	95	103	193	12	73	14	75
Naftas produkti	mg/l	0,42	0,35	0,10	0,40	1,20	1,35	0,45	0,05	0,08	0.10	0,43

Vertikālās elektrozondēšanas punktu karte

Mērogs: 1 : 3 500

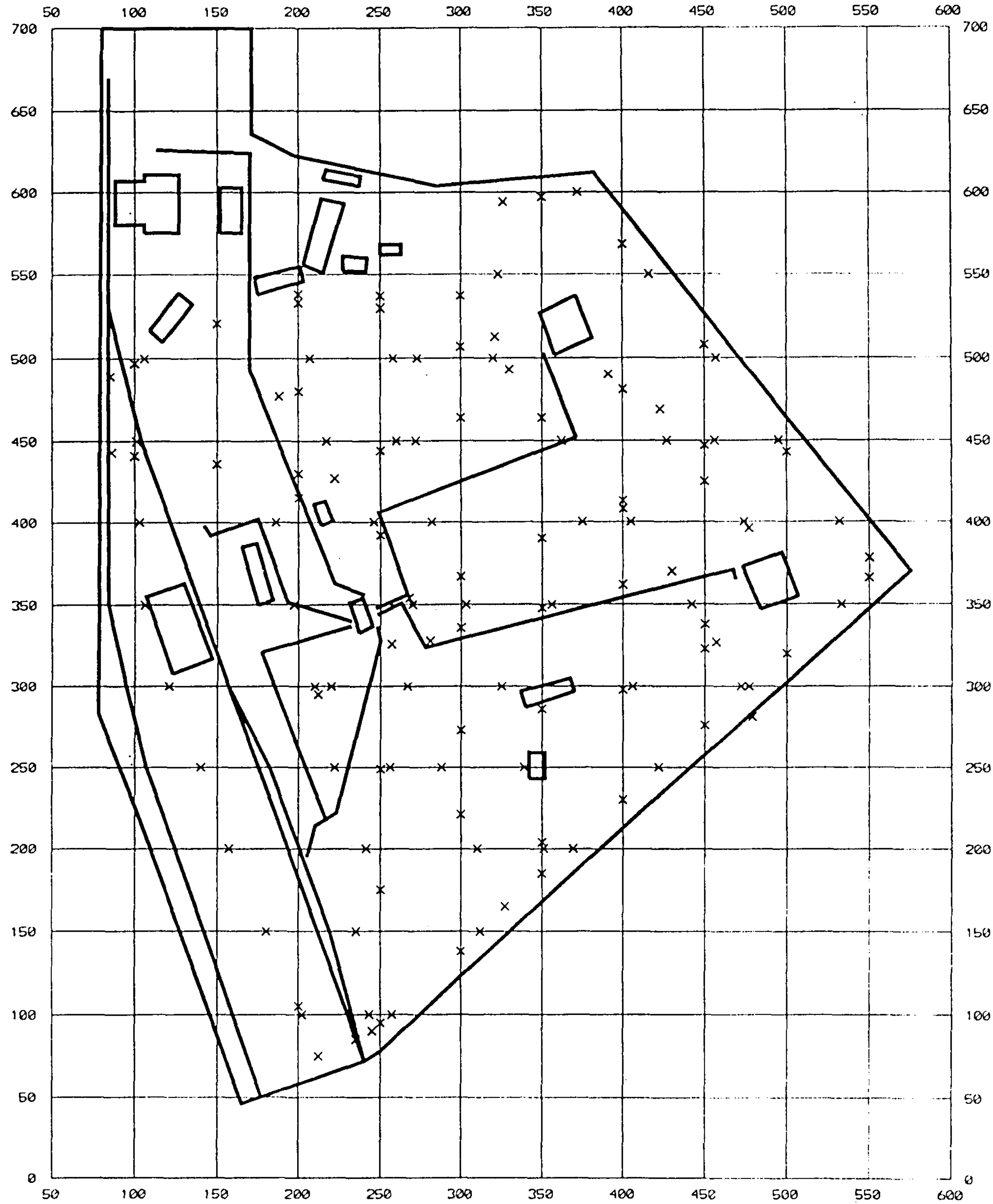


Points for vertical electrical profiling

3. zīmējums

Radiolokācijas punktu zondēšanas karte

Mērogs: 1 : 3 500

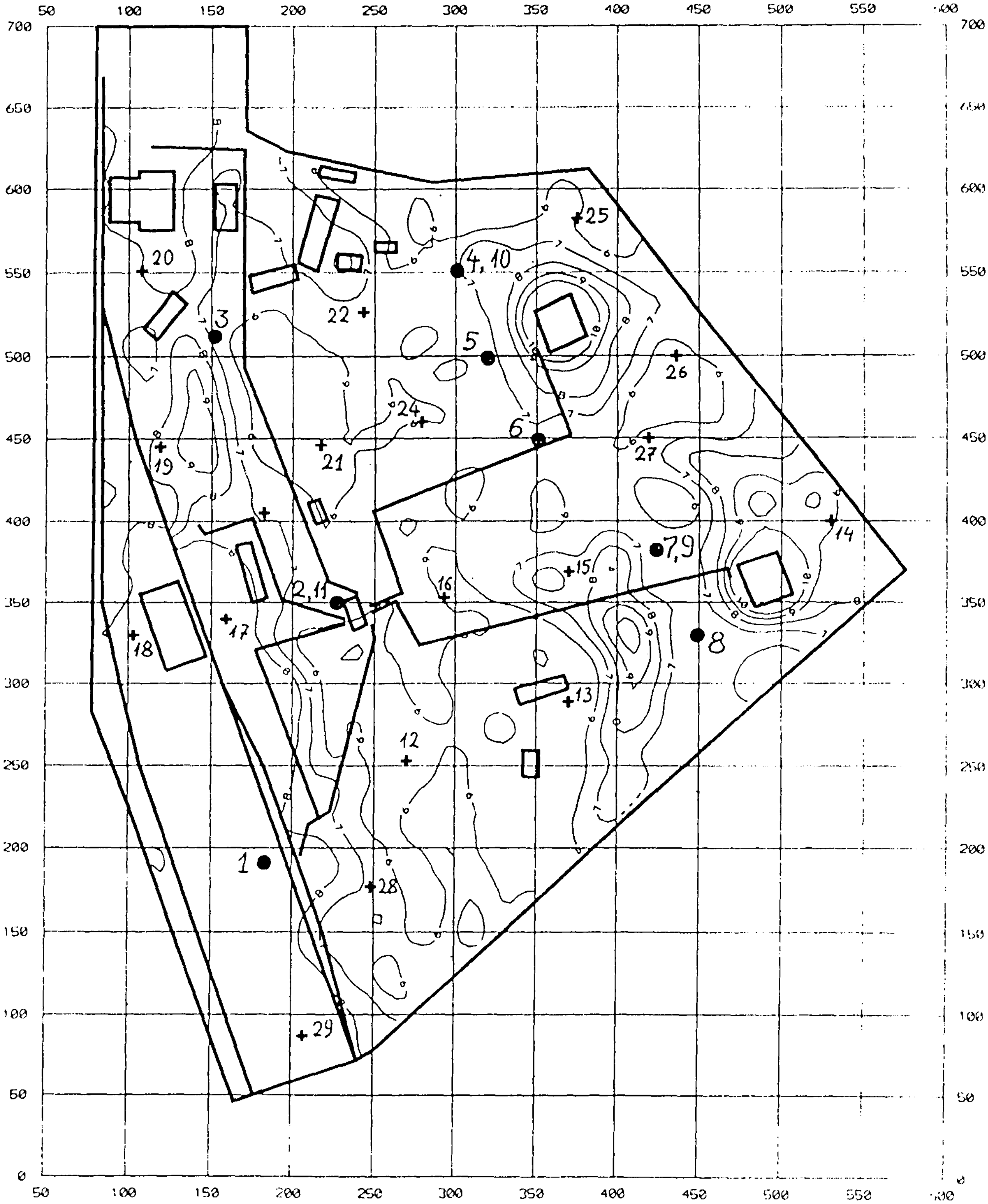


Points for Georadar surveying

4. zīmējums

Urbumu, grunšu un augsnes paraugošanas punktu karte

Mērogs: 1 : 35 00



—— 8 —— zemes virsmas izolīnija, m abs. atz.; **3** ● - augsnes un grunts paraugošanas punkts; + augsnes un cilmieža paraugošanas punkts

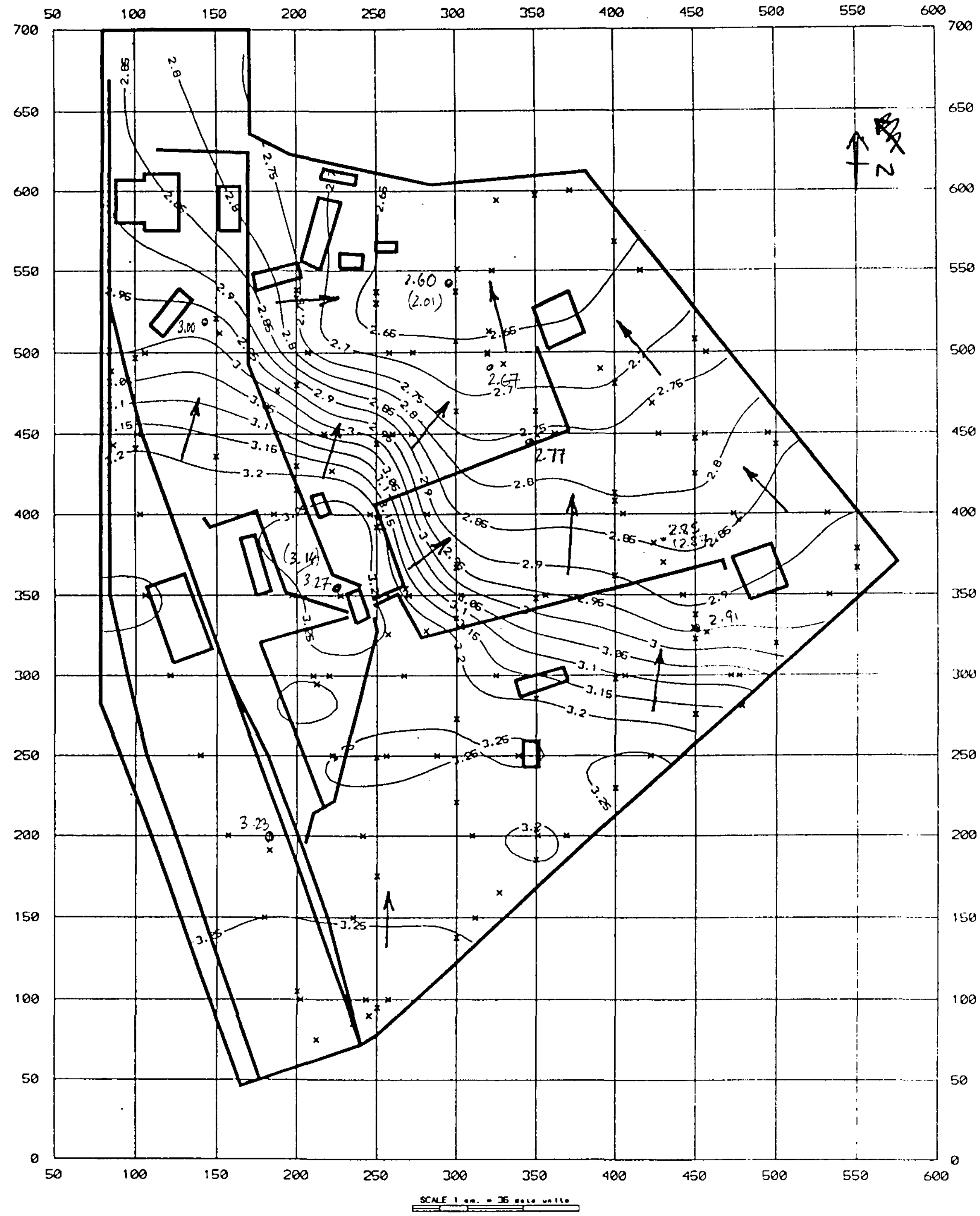
soil sampling points (~~50~~ 20-40 cm ~~...~~)

sampling points for Quaternary at groundwater level ~~(0.2 0.~~ (0.5 - 4 m)

5. zīmējums

Hidroizoģipsu karte

Mērogs: 1 : 35 00

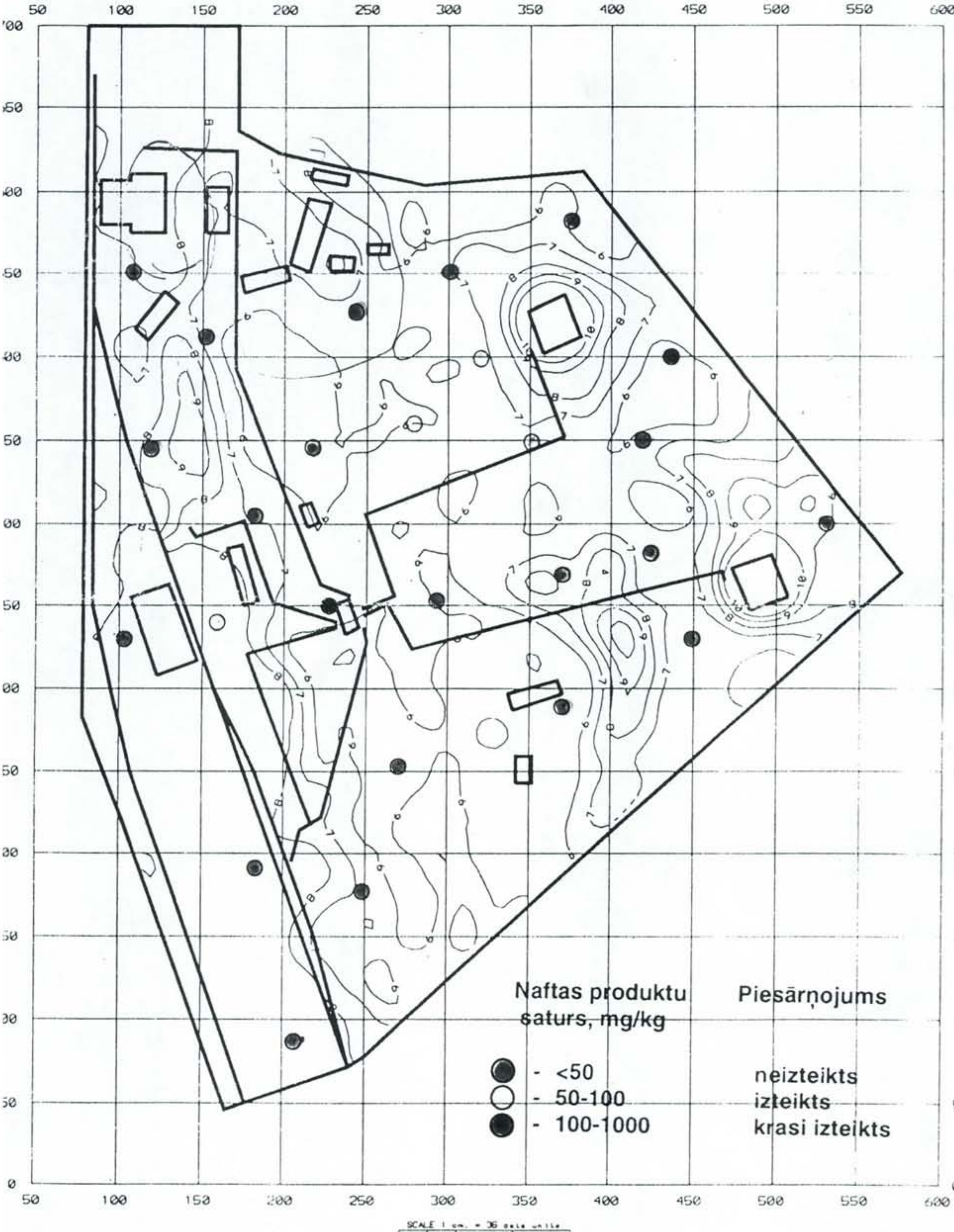


—— 3.25 —— hidroizoģipsa, m; ——→ gruntsūdens plūsmas virziens; X radiolokācijas zondēšanas punkts, kur noteikts gruntsūdens līmenis

6. zīm

Naftas produktu saturs augsnē

Mērogs: 1 : 3 500



—8— zemes virsmas izolīnija, m abs. atz.

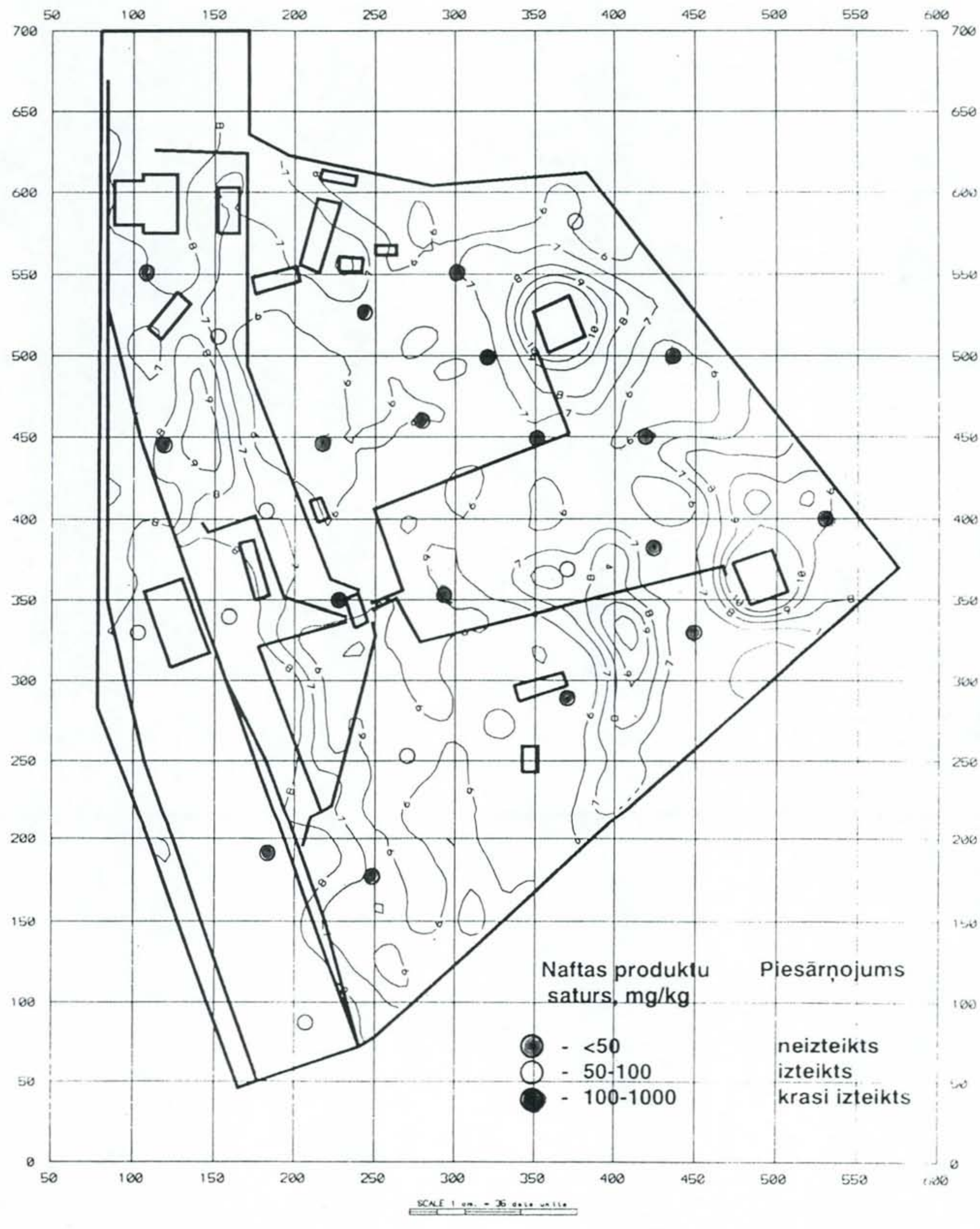
Total mineral oil by IR on soil samples (on < 2mm grain fraction)

7. zīmējums

Quaternary

Naftas produktu saturs cilmiezī

Mērogs: 1 : 3 500



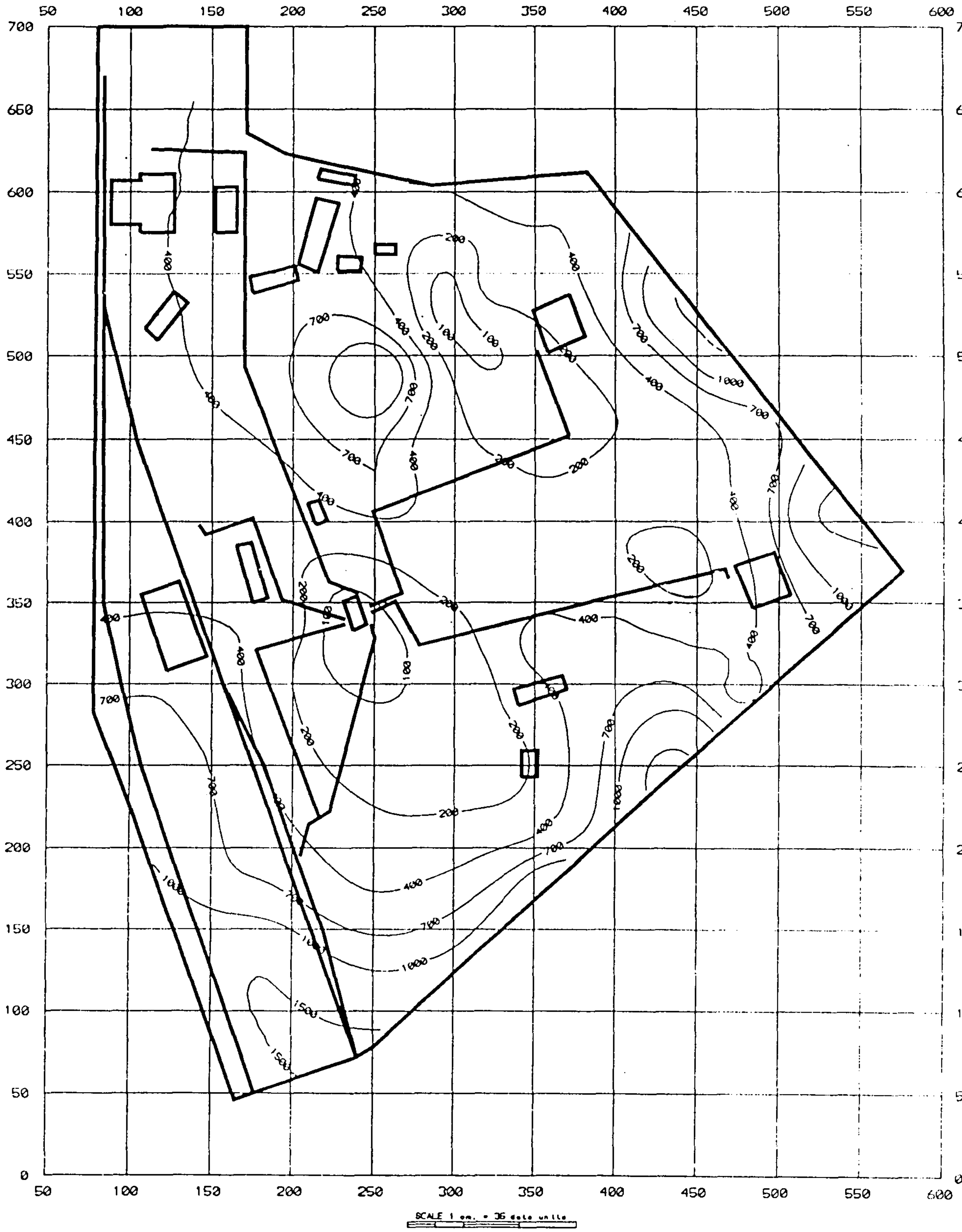
—8— zemes virsmas izolīnija, m abs. atz.

8. zīmējums

Total mineral oil in Quaternary sand (< 2m)

Ūdeni saturošo smilšu elektriskās pretestības vērtību karte

Mērogs: 1 : 35 00



—— 400 —— Elektriskās pretestības vērtību izolinija, om/m

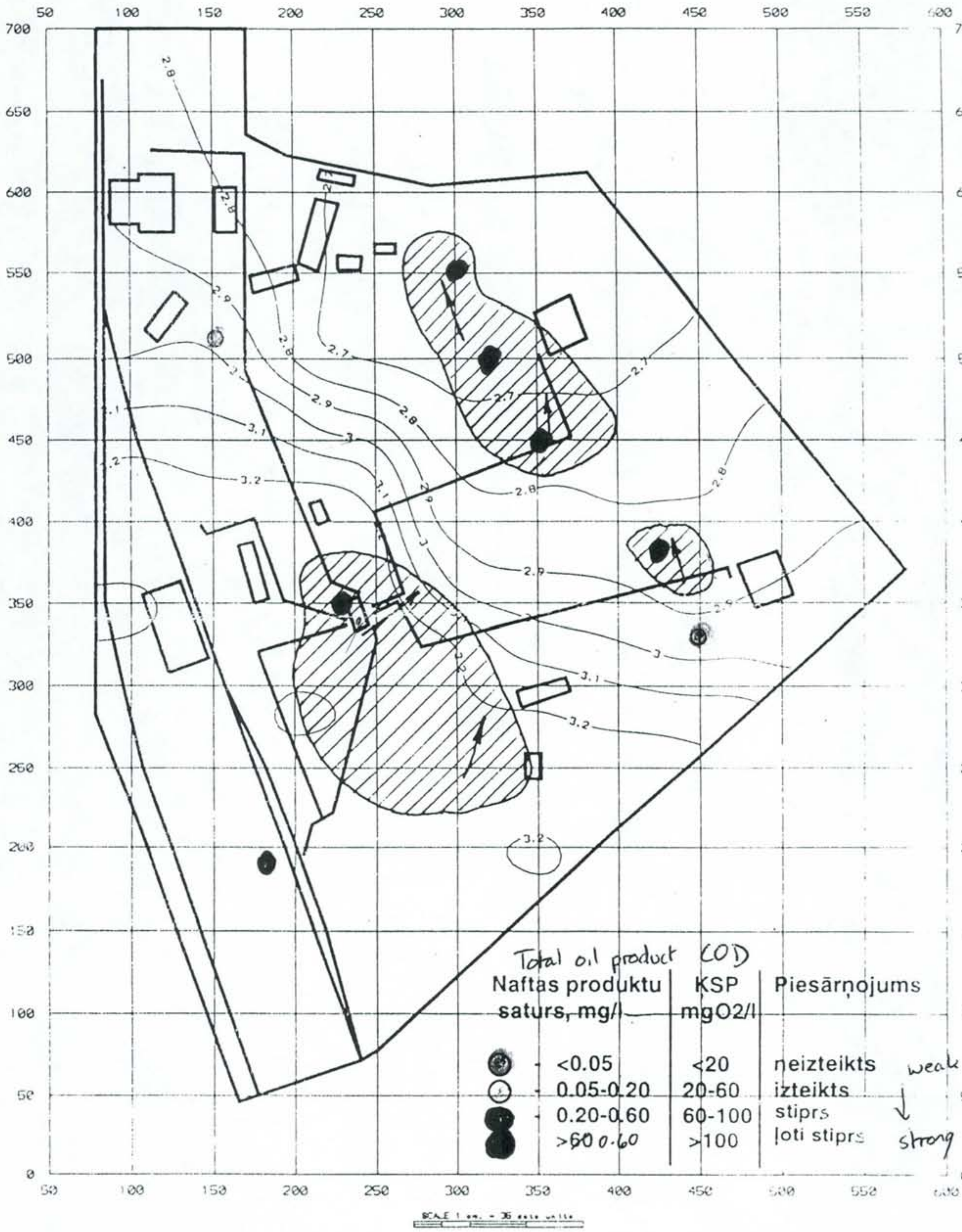
9. zīmējums

Apparent electrical resistivity of sand Ωm

5-10 m depth

Gruntsūdeņu piesārņojuma karte

Mērogs: 1 : 3 500



— 2.9 — hidroizogipsa; ——▸ gruntsūdens plūsmas virziens; (hatched) stipra gruntsūdens piesārņojuma kontūrs (pēc VEZ datiem)

(determined on basis of VES

10. zīmējums

Groundwater contam

Appendix 2:

Analyses carried out in Latvia in 1996 on soil and groundwater samples from Viestura Prospekts site.

SEDIMENTS / SOILS

Results of determination of metals using atomic - adsorption spectrophotometry

Viestura avenue

Nº	Sample Nr.		Zn	Cn	Pb	Cd	Hg
			µg/g				
1.	31		5	1	3	0,05	0,01
2.	32-1		35	6	15	0,13	0,07
3.	32-2		7	1	2	0,02	0,01
4.	33		6	2	2	0,02	0,01
5.	34		7	1	2	0,03	0,01
6.	35		4	1	2	0,03	0,01
7.	36		15	2	8	0,05	0,02
8.	Well	12. 5-6 m	4	2	1	0,02	0,02
9.	Well	13. 5 m	5	4	1	0,02	0,01
10.	Well	13. 7 m	6	1	1	0,02	0,01
11.	Well	14. 3-5 m	4	2	2	0,02	0,01
12.	Well	14. 7 m	3	1	1	0,02	0,02
13.	Well	15. 4-5 m	7	1	1	0,05	0,01
14.	Well	15. 6 m	3	2	1	0,05	0,01

Grain size distribution, %

Viostura avonue

Sample Nr.	5 mm	5-2 mm	2-1 mm	1-0.5 mm	0.5-0,25 mm	0,25-0,10 mm	0,10-0,05 mm	0,05 mm
31		0,01	0,03	0,09	5,68	82,51	10,04	1,64
32-1		1,99	3,94	8,12	23.30	58,57	2,87	0,07
32-2		0,29	0.33	0.41	6,85	86,96	4,92	0,24
33	0,09	0,09	0,14	0,18	3,01	87.44	8,29	0,76
34			0,02	0.06	4,12	90,04	5,20	0,56
35	0,04	0.21	0,36	0,75	16,73	76,16	5,08	0,67
36	3.26	1,96	2,17	2.30	8.99	69,72	10.44	1,16
Well 12. 5-6 m			0,11	0,45	28,26	59,93	4,00	7,25
Well 13. 7 m				0,02	3,01	89,51	5,98	1,48
Well 13. 5 m				0,60	18,78	69,76	5,23	5,63
Well 14. 7 m				0,03	3,97	87,05	7,95	1,00
Well 14. 3-5 m				1,10	33,41	60,88	2,40	2,14
Well 15. 4-5 m			0,02	0,03	1,58	84,05	10,22	4,10
Well 15. 6 m				0,05	14,40	76,36	4,00	5,19

WATERS.

Results of chemical analyses
Viestura prospekts

Well		1	2	3	4	6	7	7 - 2	8
pH		6.38	6.37	7.10	6.71	6.53	6.27	6.11	7.00
Conductivity	µS/cm	670	881	622	833	856	843	873	391
Dry residue		410	690	390	501	562	538	530	240
Na	mg/l	70	4.6	4.1	18	1.8	2.8	2.8	1.8
K		3.9	2	1.6	3.9	1.6	2	2	1.2
Ca		59	161	95	117	147	140	137	61
Mg		15	40	27	33	42	40	37	17
Cl		8.3	6.4	4.5	6.9	4.6	6.2	6.7	4.3
SO4		29	37	35	33	37	35.5	37.5	36.5
HCO3		390	629	400	540	590	571	560	220
N/NH4		0.86	2.86	0.43	1.2	0.64	0.89	1	0.35
N/NO2		0.010	0.030	0.012	0.025	0.015	0.025	0.030	0.016
N/NO3		0.50	0.90	0.70	0.60	0.65	0.59	0.70	0.15
N min.		1.37	3.78	1.14	1.83	1.31	1.61	1.73	0.52
N tot.		1.9	6.02	2.03	4.02	3.48	4.96	4.7	0.93
N org.		0.53	2.23	0.89	2.20	2.18	3.46	2.97	0.42
Colority	degree	76	42	70	86	60	80	62	74
P/PO4		0.30	0.42	0.37	0.38	0.44	0.37	0.04	0.04
Oil		0.16	0.27	0.12	0.12	0.36	0.28	1.24	0.09
Phenol		0.075	0.201	0.013	0.035	0.03	0.148	0.088	0.008
SSAS		0.07	0.1	0.02	0.02	0.02	0.05	0.03	0.02
COD-Cr	mg O2/l	38	68	20	38	32	56	28	13
BOD5		1.96	3.9	0.76	5.7	1.4	4.05	7.48	0.24
Cr	µg/l	<2	<2	<2	<2	<2	<2	<2	<2
Cd		0.1	0.4	0.2	0.1	0.4	0.4	0.6	10.7
Pb		<2	<2	<1	<1	<2	<2	<2	<2
Cu		0.8	1.3	1	1.2	1.9	1.2	0.8	1.3
Hg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ni		0.8	1	0.8	0.6	0.8	0.8	0.9	1.9

Well		9	10	11	14	15	222a	p-1	p-2
pH		7.20	7.58	7.41	6.14	6.56	7.81	7.60	7.27
Conductivity	µS/cm	463	472	372	558	527	323	387	587
Dry residue		280	320	206	330	343	201	250	391
Na	mg/l	1.8	1.8	3.2	3	1.6	2.8	3.5	11.5
K		1.6	1.6	2	1.6	3	2	3.1	3.9
Ca		66	78	49	82	84	49	55	84
Mg		18	20	14	22	24	13	16	25
Cl		4.5	6	7.6	6.4	6.7	6.4	8.9	26.6
SO4		49.5	82	34	35	35.5	33	48	71.4
HCO3		240	220	170	325	339	168	203	293
N/NH4		0.46	0.35	0.61	0.43	1.03	0.11	0.05	0.34
N/NO2		0.015	0.010	0.020	0.030	0.028	0.018	0.010	0.018
N/NO3		0.70	0.25	0.24	1.30	0.70	0.20	0.18	0.38
N min.		1.18	0.61	0.87	1.76	1.76	0.33	0.24	0.74
N tot.		3.94	0.87	1.14	3.7	4.1	0.48	0.8	2.9
N org.		2.77	0.26	0.27	1.94	2.34	0.15	0.56	2.16
Colority	degree	58	40	35	41	83	6		
P/PO4		0.07	0.02	0.03	0.31	0.31	0.37	0.08	0.10
Oil		0.24	0.09	0.09	0.45	0.67	0.03	0.04	0.13
Phenol		0.021	0.009	0.003	0.018	0.58	<0.003	0.003	0.013
SSAS		0.01	0.01	0.02	0.03	0.02	0.01	0.01	0.04
COD-Cr	mg O2/l	18	8	12	18	24	7.8	16.8	24.8
BOD5		0.97	0.34	0.38	6.9	6.2	0.38	0.86	1.3
Cr	µg/l	<2	<2	<2	<2	<2	<2	<2	<2
Cd		3.9	0.8	2.8	0.6	0.4	12.5	0.2	0.2
Pb		<2	<2	<2	<2	<2	<2	<2	<2
Cu		1.3	0.8	1.2	1	1.2	1.9	1	1
Hg		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ni		1.4	0.8	1.2	1	0.8	3.4	1	0.9

Legende:

p-1 and p-2 = Cemetry wells

p-1 = SW cemetry

p-2 = SE cemetry

Appendix 3:

Analyses carried out in Latvia in 1997 on soil and groundwater samples from Viestura Prospekts site.

Appendix 3

Soil Samples
– Taken May 1997
Analysed in Latvia May '97

Oil analysis in soil samples

Number of sample	Oil mg/kg	Number of sample	Oil mg/kg
Viestura prospect			
31	26	34	46
32	83	35	38
32^A	320	36	92
33	24		
Valmieras street			
1	72	11	68
2	60	12	52
3	38	13	72
4	64	14	60
5	24	15	60
6	38	16	190
7	250	17	140
8	128	18	103
9	84	19	74
10	60	20	38

FIELD MEASUREMENTS

below well top

Viestura prospekts

Borhole	date	water level	temp	pH	EC 20	EC 25
1	17-Jūn	6.16	10.4	6.45	*Broken device*	
2	17-Jūn	2.28	8.4	6.20	*Broken device*	
3	17-Jūn	4.17	8.0	7.12	*Broken device*	
4	16-Jūn	3.42	8.4	6.47	*Broken device*	
5	16-Jūn	4.17	8.3	6.64	470	
6	17-Jūn	4.01		6.43	*Broken device*	
7	16-Jūn	3.58	9.6	6.39	646	
8	16-Jūn	3.80	6.8	7.58	339	
9	16-Jūn	3.16	9.7	7.20	403	
10	16-Jūn	3.40	8.9	7.35	*Broken device*	
11	17-Jūn	3.02	8.4	7.30	*Broken device*	
12	16-Jūn	5.22	9.1	6.32	*Broken device*	
13	17-Jūn	5.73		*don't pumping*		
14	17-Jūn	3.31	7.8	6.37	*Broken device*	
15	16-Jūn	4.50	9.1	6.86	507	
222A	18-Jūn	3.79	7.3	8.17		368

Valmieras iela

Borhole	date	water level	temp	pH	EC 20	EC 25
1	19-Jūn	4.12	9.8	7.81		855
2	19-Jūn	4.22	11.0	7.04		718
3	19-Jūn	4.81	8.8	6.56		1250
4	19-Jūn	3.71	8.8	6.92		879
5	19-Jūn	3.98	9.3	6.83		1390

STATE GEOLOGICAL SURVEY OF LATVIA

5, Eksporta Street, Riga LV-1010, Latvia Phone: (371) 7320379 Fax: (371) 7333218

Date: Our ref. Your ref.

August 1, 1997

To: fax +47 73 92 16 20
NGU
Trondheim, Norway

Attn: Mr David Banks

Dear David,

Sorry for the delay in answering your fax.

Thank you for the software diskettes and the analytical results. Please find enclosed the analytical results for the water samples taken at Viestura Pros. and Valmieras St. (2 pages).

The collection of samples within the framework of the Baltic Soil Survey continues. It takes place parallel to the sampling within the framework of the Latvian geochemical mapping, scale 1:500,000. It is planned to complete the sampling till the end of August. The samples will be sent to Norway in mid-September.

I will send the information necessary for modelling next week.

Best regards,

Agris

Results of water chemical analyses **(Viestura prospekts)**

Well		1	2	3	4	5	6	7	8	9	10	11	12	14	15	222A
Ca^{2+}	mg/l	131	155	94.2	169	162	178	128	69.7	77.8	83.2	62.3	218	124	121	61.5
Mg^{2+}	mg/l	40.9	44.3	27.2	50.5	48.5	51.0	41.8	19.1	22.1	20.2	18.6	59.6	38.5	36.2	17.1
Na^{+}	mg/l	1.8	2.3	3.0	1.4	2.8	2.1	2.8	4.6	1.8	1.8	2.8	1.6	2.3	2.3	4.6
K^{+}	mg/l	1.2	1.2	2.0	1.2	2.0	1.6	2.3	2.7	2.0	1.6	2.0	1.2	2.0	2.0	2.7
HCO_3^-	mg/l	519	665	366	604	635	732	555	244	293	232	244	781	421	433	223
SO_4^{2-}	mg/l	57.6	43.2	44.7	111	65.8	41.8	32.2	40.8	38.9	86.5	33.6	125	98.0	86.5	40.8
Cl^-	mg/l	4.6	3.5	2.5	1.8	6.4	3.2	5.3	10.6	5.3	5.7	6.7	3.5	6.0	4.3	12.4
Dry residue	mg/l	526	612	374	688	639	688	523	282	315	334	266	855	503	282	261
N/NH_4	mg/l	0.70	1.90	0.60	0.47	0.34	0.68	1.10	0.24	0.40	0.30	0.20	0.90	0.70	0.62	0.94
N/NO_2	mg/l	0.014	0.034	0.010	0.030	0.018	0.020	0.030	0.013	0.017	0.018	0.015	0.017	0.035	0.040	0.016
N/NO_3	mg/l	0.43	0.74	0.62	0.71	0.80	0.84	1.03	0.40	0.70	0.30	0.20	1.07	0.90	0.50	0.30
N total	mg/l	1.40	5.40	1.98	3.70	3.07	4.50	5.00	1.03	2.98	1.41	1.90	5.70	3.00	4.20	2.49
P/PO_4	mg/l	0.230	0.340	0.290	0.128	0.110	0.184	0.070	0.030	0.050	0.025	0.024	0.300	0.374	0.180	0.030
BOD_7	mg O_2/l	1.80	4.90	1.48	4.80	2.98	2.90	6.40	0.70	1.78	1.40	2.40	5.30	4.50	4.00	0.35
COD	mg O_2/l	45.2	70.0	26.2	32.7	34.0	36.8	40.0	32.6	14.7	11.0	14.6	36.0	24.2	28.0	11.8
Phenol	mg/l	0.050	0.150	0.010	0.027	0.014	0.034	0.005	0.009	0.014	0.012	<0.003	0.037	0.025	0.040	<0.003
SSAS	mg/l	0.06	0.11	0.02	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.03	0.01
Oil	mg/l	0.20	0.34	0.30	0.14	0.60	0.25	2.50	0.07	0.20	0.16	0.19	0.10	0.17	0.12	0.06
Cd	µg/l	0.2	0.3	0.2	0.1	0.3	0.5	0.7	0.3	0.3	2.0	1.8	0.9	0.5	0.5	1.0
Cu	µg/l	0.5	1.0	1.0	1.4	1.6	1.8	1.0	0.9	0.7	1.0	1.4	1.0	0.7	0.6	1.7
Ni	µg/l	0.8	0.7	0.6	0.8	2.0	1.4	1.6	0.8	0.8	1.0	1.2	1.1	0.7	0.9	1.8
Pb	µg/l	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Cr	µg/l	<1.54	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hg	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Results of water chemical analyses **(Valmieras street)**

Well		1	2	3	4	5
Ca^{2+}	mg/l	65.1	91.2	144	127	231
Mg^{2+}	mg/l	16.9	24.9	43.0	37.9	69.1
Na^{+}	mg/l	117	18.4	78.2	14.0	19.3
K^{+}	mg/l	5.9	3.9	4.7	3.1	3.9
HCO_3^{-}	mg/l	335	349	732	525	970
SO_4^{2}	mg/l	86.5	30.7	35.5	48.0	40.8
Cl^{-}	mg/l	85.1	35.8	64.2	26.2	34.7
Dry residue	mg/l	587	411	780	550	998
N/NH_4	mg/l	0.65	0.34	0.61	1.06	0.70
N/NO_2	mg/l	0.013	0.015	0.014	0.038	0.026
N/NO_3	mg/l	3.20	0.78	1.12	1.00	1.20
N total	mg/l	7.90	6.85	2.58	4.11	4.44
P/PO_4	mg/l	1.05	1.70	2.90	0.50	2.08
BOD_7	mg O_2/l	2.55	0.67	4.38	3.32	6.78
COD	mg O_2/l	70.0	41.0	88.0	92.0	110
Phenol	mg/l	0.004	0.009	0.025	0.015	0.030
SSAS	mg/l	0.03	0.02	0.04	0.02	0.04
Oil	mg/l	0.08	0.08	0.18	0.06	0.04
Cd	µg/l	0.3	0.3	0.8	0.5	1.3
Cu	µg/l	0.9	1.0	2.0	1.8	3.0
Ni	µg/l	1.0	0.9	1.7	1.0	1.9
Pb	µg/l	<1.5	<1.5	<1.5	<1.5	<1.5
Cr	µg/l	<1.5	<1.5	<1.5	<1.5	<1.5
Hg	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05

STATE GEOLOGICAL SURVEY OF LATVIA

5, Eksporta Street, Riga LV-1010, Latvia Phone: (371) 7320379 Fax: (371) 7333218

Date: Our ref. Your ref.

August 1, 1997

To: fax +47 73 92 16 20
NGU
Trondheim, Norway

Attn: Mr David Banks

Dear David,

Sorry for the delay in answering your fax.

Thank you for the software diskettes and the analytical results. Please find enclosed the analytical results for the water samples taken at Viestura Pros. and Valmieras St. (2 pages).

The collection of samples within the framework of the Baltic Soil Survey continues. It takes place parallel to the sampling within the framework of the Latvian geochemical mapping, scale 1:500,000. It is planned to complete the sampling till the end of August. The samples will be sent to Norway in mid-September.

I will send the information necessary for modelling next week.

Best regards,

Agris

Results of water chemical analyses **(Viestura prospekts)**

Well		1	2	3	4	5	6	7	8	9	10	11	12	14	15	222A
Ca^{2+}	mg/l	131	155	94.2	169	162	178	128	69.7	77.8	83.2	62.3	218	124	121	61.5
Mg^{2+}	mg/l	40.9	44.3	27.2	50.5	48.5	51.0	41.8	19.1	22.1	20.2	18.6	59.6	38.5	36.2	17.1
Na^{+}	mg/l	1.8	2.3	3.0	1.4	2.8	2.1	2.8	4.6	1.8	1.8	2.8	1.6	2.3	2.3	4.6
K^{+}	mg/l	1.2	1.2	2.0	1.2	2.0	1.6	2.3	2.7	2.0	1.6	2.0	1.2	2.0	2.0	2.7
HCO_3^-	mg/l	519	665	366	604	635	732	555	244	293	232	244	781	421	433	223
SO_4^{2-}	mg/l	57.6	43.2	44.7	111	65.8	41.8	32.2	40.8	38.9	86.5	33.6	125	98.0	86.5	40.8
Cl^-	mg/l	4.6	3.5	2.5	1.8	6.4	3.2	5.3	10.6	5.3	5.7	6.7	3.5	6.0	4.3	12.4
Dry residue	mg/l	526	612	374	688	639	688	523	282	315	334	266	855	503	282	261
N/NH_4	mg/l	0.70	1.90	0.60	0.47	0.34	0.68	1.10	0.24	0.40	0.30	0.20	0.90	0.70	0.62	0.94
N/NO_2	mg/l	0.014	0.034	0.010	0.030	0.018	0.020	0.030	0.013	0.017	0.018	0.015	0.017	0.035	0.040	0.016
N/NO_3	mg/l	0.43	0.74	0.62	0.71	0.80	0.84	1.03	0.40	0.70	0.30	0.20	1.07	0.90	0.50	0.30
N total	mg/l	1.40	5.40	1.98	3.70	3.07	4.50	5.00	1.03	2.98	1.41	1.90	5.70	3.00	4.20	2.49
P/PO_4	mg/l	0.230	0.340	0.290	0.128	0.110	0.184	0.070	0.030	0.050	0.025	0.024	0.300	0.374	0.180	0.030
BOD_7	mg O_2/l	1.80	4.90	1.48	4.80	2.98	2.90	6.40	0.70	1.78	1.40	2.40	5.30	4.50	4.00	0.35
COD	mg O_2/l	45.2	70.0	26.2	32.7	34.0	36.8	40.0	32.6	14.7	11.0	14.6	36.0	24.2	28.0	11.8
Phenol	mg/l	0.050	0.150	0.010	0.027	0.014	0.034	0.005	0.009	0.014	0.012	<0.003	0.037	0.025	0.040	<0.003
SSAS	mg/l	0.06	0.11	0.02	0.03	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.03	0.02	0.03	0.01
Oil	mg/l	0.20	0.34	0.30	0.14	0.60	0.25	2.50	0.07	0.20	0.16	0.19	0.10	0.17	0.12	0.06
Cd	µg/l	0.2	0.3	0.2	0.1	0.3	0.5	0.7	0.3	0.3	2.0	1.8	0.9	0.5	0.5	1.0
Cu	µg/l	0.5	1.0	1.0	1.4	1.6	1.8	1.0	0.9	0.7	1.0	1.4	1.0	0.7	0.6	1.7
Ni	µg/l	0.8	0.7	0.6	0.8	2.0	1.4	1.6	0.8	0.8	1.0	1.2	1.1	0.7	0.9	1.8
Pb	µg/l	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Cr	µg/l	<1.54	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Hg	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Results of water chemical analyses **(Valmieras street)**

Well		1	2	3	4	5
Ca^{2+}	mg/l	65.1	91.2	144	127	231
Mg^{2+}	mg/l	16.9	24.9	43.0	37.9	69.1
Na^{+}	mg/l	117	18.4	78.2	14.0	19.3
K^{+}	mg/l	5.9	3.9	4.7	3.1	3.9
HCO_3^-	mg/l	335	349	732	525	970
SO_4^{2}	mg/l	86.5	30.7	35.5	48.0	40.8
Cl^-	mg/l	85.1	35.8	64.2	26.2	34.7
Dry residue	mg/l	587	411	780	550	998
N/NH_4	mg/l	0.65	0.34	0.61	1.06	0.70
N/NO_2	mg/l	0.013	0.015	0.014	0.038	0.026
N/NO_3	mg/l	3.20	0.78	1.12	1.00	1.20
N total	mg/l	7.90	6.85	2.58	4.11	4.44
P/PO_4	mg/l	1.05	1.70	2.90	0.50	2.08
BOD_7	mg O_2/l	2.55	0.67	4.38	3.32	6.78
COD	mg O_2/l	70.0	41.0	88.0	92.0	110
Phenol	mg/l	0.004	0.009	0.025	0.015	0.030
SSAS	mg/l	0.03	0.02	0.04	0.02	0.04
Oil	mg/l	0.08	0.08	0.18	0.06	0.04
Cd	µg/l	0.3	0.3	0.8	0.5	1.3
Cu	µg/l	0.9	1.0	2.0	1.8	3.0
Ni	µg/l	1.0	0.9	1.7	1.0	1.9
Pb	µg/l	<1.5	<1.5	<1.5	<1.5	<1.5
Cr	µg/l	<1.5	<1.5	<1.5	<1.5	<1.5
Hg	µg/l	<0.05	<0.05	<0.05	<0.05	<0.05

Parameter	Methods	Sample volume, flash weight	Solvent for extraction	Clean up method	Analytical method
Cd, Cu, Ni, Pb	Filtration of sample through membrane filters 0.45 µm. Adding 5 ml 6 N HCl + 0.25 g ammonium peroxydisulphate, boiling 20 min, cooling to room temperature, neutralization with ammonia 6 N solution. Adding chelating agents 0.1% 8-oxiquinoline and 5% sodium diethyldithiocarbamate	0.25 l	Chloroform 3 times extraction	Distillation of chloroform, residue digestion with 1ml HNO_3, in oven at 500° C. After digestion dry residue was dissolved in 1ml 6N HCl and have used for injection to graphite furnace	AASGF
Cr	Filtration of sample through membrane filters 0.45 µm. Adding 5 ml 6 N HCl + 0.25 g ammonium peroxydisulphate, boiling 20 min, cooling to room temperature, neutralization with ammonia 6 N solution.	0.25 l	none	none	AAS Flame
Hg	Filtration of sample through membrane filters 0.45 µm. Adding 0.5 ml 2% $KMnO_4$ + 1 ml H_2SO_4 1:1	0.1 l	none		Cold vapour AAS
	At the day of determination adding 0.5 ml 20 % $SnCl_2$ in 6 N HCl to the sample.	2.5 ml	none	none	
Oil in water.	2 times extraction with 25 ml CCl_4 30 min ; drying with anhydrous Na_2SO_4	1l	CCl_4	extract passes through column with aluminium oxide	IR spectrometry
Oil in soil	We extract the soil sample 2g with 15 ml acetone using electromechanical stirer during 3 minutes, centrifugate extract 10 min with the velosity 1500 revolution per minute, pour the extract in the flask and repeat these procedure once more. After that we add 15 ml of methylene chloride to the soil and extract using electromechanical stirrer during 3 min, centrifuge the extract 10 min with the velosity 1500 revolution per minute, pour the extract in the flask and repeat these procedure two times more. After that we combine all, methylene chloride and acetone extract to a volume approximately 2ml of extract by solvent evaporation in water bath. Then we add 8-10ml CCl_4 to approximately 2ml of extract and clean up these extract	2g	methylene chloride and acetone	We prepare a chromatography column with 6g of aluminium oxide and transrfer the extract to the column and close these system. The extract passes the column under atmospheric pressure. After that we dry these extract under room temperature to dry state and disolve these dry material in 20 ml CCl_4 and transfer these extract quantitatively into 25 ml volumetric flask and fill up to the mark with CCl_4. The purified extract will be measured by Ir spectrometry	IR spectrometry

Appendix 4:

Analyses carried out by NGU in 1996 on soil and groundwater samples from Viestura Prospekts site.

Latvia Sediment Samples

LvS1 = Viestura prospekt, Soil sample 31
LvS2 = Valmieras, borehole 3 @ 5.5 m
LvS3 = Valmieras, borehole 4 @ 3.1 m

All analytical results refer to < 2 mm fraction

The suffix R (e.g. LvS1R) refers to a portion of the sample where soluble hydrocarbons (e.g. diesel) have been removed by rinsing with toluene. The results for TC and TOC for toluene-rinsed samples should give «refractory» (non-toluene-soluble) contents.

SOIL

tvia

NGU Norges geologiske undersøkelse
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ANALYSERAPPORT

NORSK AKKREDITERING Nr. P020

ANALYSEKONTRAKT NR.: 1996.0240
NGU PROSJEKT NR.: 2699.00

OPPDRAGSGIVER: NGU, Miljøundersøkelser i Latvia

ADRESSE:

TLF.: 310

KONTAKTPERSON: David Banks

PRØVETYPE: Sediment
ANTALL PRØVER: 3
IDENTIFIKASJON AV PRØVER: Iflg. liste fra oppdragsgiver
PRØVER MOTTATT: 09.10.96
ANMERKNINGER: Ingen

SPESIFIKASJON AV OPPDRAGET I HENHOLD TIL ANALYSEKONTRAKT:

METODE	DOKUMENTASJON *)	OMFATTES AV AKKREDITERING
ICP-AES geologisk materiale	NGU-SD 2.11	Ja
GFAAS - Cd og Pb	NGU-SD 2.12	Ja
CVAAS - Hg	NGU-SD 2.13	Ja
Bestemmelse av total karbon (TC)	NGU-SD 2.14	Ja
Best. av total organisk karbon (TOC)	NGU-SD 2.15	Ja

Denne rapporten inneholder i alt 10 sider + vedlegg. Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Alle forhold ved prøvetaking, behandling og transport av prøvene før innlevering til NGU-Lab er underlagt oppdragsgivers ansvar. Analyseresultater framlagt i denne rapporten refererer derfor kun til det prøvematerialet som er mottatt av NGU-Lab.

Trondheim, 5. november 1996

Magne Ødegård (e.f.)

*) Fortegnelse over dokumentasjon finnes i NGU-Labs Kvalitetshåndbok, NGU-SD 0.1, som kan rekvireres fra NGU-Labs sekretariat.

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NGU-Lab

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ICP-AES ANALYSER
GEOLOGISK MATERIALE
Analysekontraktsnr: 1996.0240

NORSK AKKREDITERING Nr. P020

Metoden er basert på fremstilling av analyseløsninger ved ekstraksjon med 7 N HNO_3 i autoklav i samsvar med Norsk Standard - NS 4770

INSTRUMENT TYPE : **Thermo Jarrell Ash ICP 61**

NEDRE BESTEMMELSESGRENSER FOR PLASMA ANALYSER BASERT PÅ AUTOKLAVEKSTRASJON (1 g prøve i 100 ml analysevolum)
(For analyser med tynningsfaktor som avviker fra 100, blir deteksjonsgrensene automatisk omregnet.)

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
100.-	20.-	5.-	1.-	100.-	200.-	200.-	100.-	0.2	10.-

Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1.-	2.-	5.-	2.-	1.-	1.-	1.-	1.-	1.-	1.-

Sr	Zr	Ag	B	Be	Li	Sc	Ce	La	Y
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
2.-	1.-	1.-	5.-	0.2	1.-	0.2	10.-	1.-	0.2

ANALYSEUSIKKERHET: For samtlige elementer regnes med en total usikkerhet i ekstraksjon og analyse på ± 10 %.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 3

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	28. oktober 1996	Brit Inger Vongraven
	Dato	OPERATØR

NGU
Norges geologiske undersøkelse
NGU-Lab

Postboks 3006 - Lade
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ICP-AES ANALYSER
GEOLOGISK MATERIALE
Analysekontraktsnr: 1996.0240

NORSK AKKREDITERING
Nr. P020

	LvS1	LvS2	LvS3
Si	150ppm	143ppm	151ppm
Al	0.22%wt	0.19%wt	0.14%wt
Fe	0.20%wt	0.22%wt	0.20%wt
Ti	61.3ppm	71.2ppm	60.0ppm
Mg	305ppm	0.63%wt	0.66%wt
Ca	424ppm	1.9%wt	2.2%wt
Na	< 200ppm	< 200ppm	< 200ppm
K	265ppm	561ppm	435ppm
Mn	23.5ppm	100ppm	99.2ppm
P	186ppm	236ppm	266ppm
Cu	2.4ppm	5.6ppm	8.7ppm
Zn	9.2ppm	10.2ppm	10.1ppm
Ni	< 2.0ppm	< 2.0ppm	< 2.0ppm
Co	< 1.0ppm	< 1.0ppm	< 1.0ppm
V	3.7ppm	4.7ppm	4.4ppm
Mo	< 1.0ppm	< 1.0ppm	< 1.0ppm
Cr	2.2ppm	2.2ppm	2.2ppm
Ba	6.4ppm	10.9ppm	8.8ppm
Sr	3.0ppm	15.1ppm	20.3ppm
Zr	1.9ppm	3.4ppm	2.6ppm
Ag	< 1.0ppm	< 1.0ppm	< 1.0ppm
B	< 5.0ppm	< 5.0ppm	5.0ppm
Be	585ppb	650ppb	617ppb
Li	1.4ppm	2.0ppm	2.0ppm
Sc	495ppb	693ppb	594ppb
Ce	16.0ppm	29.4ppm	35.5ppm
La	7.8ppm	7.4ppm	8.5ppm
Y	2.7ppm	4.6ppm	4.5ppm

4.

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ATOMABSORPSJONS-ANALYSE (Cd og Pb - Grafittovn teknikk)
GEOLIGISK MATERIALE
Analysekontraktsnr:1996.0240

NORSK AKKREDITERING Nr. P020

Metoden er basert på fremstilling av analyseløsninger ved ekstraksjon med 7 N HNO_3 i autoklav i samsvar med NORSK STANDARD - NS 4770

INSTRUMENT TYPE : **Perkin Elmer type SIMAA 6000**

NEDRE BESTEMMELSES GRENSER : Cd : 0.02 ppm Pb : 0.4 ppm
(For analyser med tynningsfaktor som avviker fra 100, blir deteksjonsgrensene automatisk omregnet.)

ANALYSEUSIKKERHET Analyseusikkerheten er gitt i tabellen under

Element	Usikkerhet
Cd	± 20 % rel.
Pb	± 10 % rel.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 3

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	4. november 1996	Frank Berge
	Dato	OPERATØR

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Norges geologiske undersøkelse

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Tlf.: 73 90 40 11
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ATOMABSORPSJONS-ANALYSE (Cd og Pb - Grafittovn teknikk)
GEOLIGISK MATERIALE
Analysekontraktsnr:1996.0240

NORSK AKKREDITERING Nr. P020

Resultater.

Prøve nr.	Cd mg/kg	Pb mg/kg
1	0.107	2.86
2	0.013	1.5
3	0.026	0.969

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Norges geologiske undersøkelse

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ATOMABSORPSJONS-ANALYSE (Hg-Kalddampteknikk AA/HMS-1)
GEOLOGISK MATERIALE
Analysekontraktsnr: 1996.0240

NORSK AKKREDITERING Nr. P020

Metoden er basert på fremstilling av analyseløsninger ved ekstraksjon med 7 N HNO_3 i autoklav i samsvar med Norsk Standard - NS 4770

INSTRUMENT TYPE : **Perkin Elmer type 403 (AA) / 1 (MHS)**

NEDRE BESTEMMELSES GRENSER : 0.010 ppm
(For analyser med tynningsfaktor som avviker fra 100, blir deteksjonsgrensene automatisk omregnet.)

ANALYSEUSIKKERHET **± 10 % rel.**

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 3

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	28. oktober 1996	Frank Berge
	Dato	OPERATØR

NGU
Norges geologiske undersøkelse

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Tlf.: 73 90 40 11
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ATOMABSORPSJONS-ANALYSE (Hg-Kalddampteknikk AA/HMS-1)
GEOLOGISK MATERIALE
Analysekontraktsnr: 1996.0240

NORSK AKKREDITERING
Nr. P020

Resultater.

Prøve nr.	Hg mg/kg
1.	0.010
2.	< 0.01
3.	< 0.01

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NORGES GEOLOGISKE UNDERSØKELSE
NGU-Lab

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TOTAL KARBON/TOTAL SVOVEL/TOTAL ORGANISK KARBON
GEOLGISK MATERIALE
Analysekontraktsnr: 1996.0240

NORSK AKKREDITERING Nr. P020

BESTEMMELSE AV TOTAL KARBON(TC) / TOTAL SVOVEL(TS) / TOTAL ORGANISK KARBON (TOC) (LECO OVN)

INSTRUMENT TYPE : Leco SC-444

I) TOTAL KARBON

Nedre bestemmelsesgrense : 0.07 %

Analyseusikkerehet

Måleområde/ %	Usikkerhet
0.07-3.0	± 0.07 %
> 3.0	± 2.5 % rel.

II TOTAL SVOVEL

Nedre bestemmelsesgrense : 0.01 %

Analyseusikkerehet

Måleområde/ %	Usikkerhet
0.01-1.0	± 10 % rel.
1.0-3.0	± 5 % rel
> 3.0	± 2.5 % rel.

III) TOTAL ORGANISK KARBON

Nedre bestemmelsesgrense : 0.10 %

Analyseusikkerehet

Måleområde/ %	Usikkerhet
0.1-3.0	± 15 % rel.
> 3.0	± 10 % rel.

PRESISJON :
Det kjøres rutinemessig kontrollprover, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANMERKNINGER :Ingen.

Ferdig analysert	1/11-96	Anne Nordtømme
	Dato	OPERATØR

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NGU-Lab

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TOTAL KARBON/TOTAL SVOVEL/TOTAL ORGANISK KARBON
GEOLGISK MATERIALE
Analysekontraktsnr: 1996.0240

NORSK AKKREDITERING Nr. P020

ID Code	TC %	TOC %
LVS-2R	0.43	< 0.10
LVS-3R	0.70	< 0.10
LVS-2	0.97	0.10
LVS-3	0.90	< 0.10

1. november 1996

Samples from Latvia

All samples are filtered at 0,45 μm in the field but not conserved with acid.

In the lab all samples were gently shaken and a small portion (ca. 10 ml) of water was removed for analysis by Ion Chromatograph (anions)

The remaining sample in the flask was acidified with Suprapur kons. HNO_3 (10 drops / 100 ml, or more if necessary to dissolve iron precipitate). The samples were then gently shaken and allowed to stand for 24 hours. These acidified samples were then analysed by:

ICP (cations + metals)
AA for As, Hg, Sb, Pb, Cd

Field Measurements	EC μS/cm	T °C	pH	CO_2 mg/l	Date
Lv1F - Bore no. 1, Viestura prospekt, Riga	670	9,6	6,68	100	26/9/96
Lv2F - Bore no. 2, Viestura prospekt, Riga					26/9/96
Lv3F - Bore no. 3, Viestura prospekt, Riga	622	8,8	7,10	60	26/9/96
Lv4F - Bore no. 4, Viestura prospekt, Riga	833	9,5	6,71	100	26/9/96
Lv6F - Bore no. 6, Viestura prospekt, Riga	856	11,2	6,53	>100	26/9/96
Lv7F - Bore no. 7, Viestura prospekt, Riga	843	10,2	6,27		26/9/96
Lv8F - Bore no. 8 (3,92m), Viestura prospekt, Riga					26/9/96
Lv9F - Bore no. 9, Viestura prospekt, Riga	463	9,3	7,20		26/9/96
Lv10F - Bore no. 10, Viestura prospekt, Riga	472	8,3	7,58		26/9/96
Lv11F - Bore no. 11, Viestura prospekt, Riga				40	26/9/96
Lv7aF - Bore no. 7a, Viestura prospekt, Riga	873	11,8	6,11		3/10/96
Lv14F - Bore no. 14, Viestura prospekt, Riga	558	9,5	6,14	>100	3/10/96
Lv15F - Bore no. 15, Viestura prospekt, Riga	527	10(?)	6,56		3/10/96
Lv20F - Bore no. 222a, Viestura prospekt, Riga	323	7,2	7,81		3/10/96
Lv21F -Cemetry well (SE of Viestura prospekt)		8,7*	7,96*		3/10/96
Lv22F -Cemetry well (SW of Viestura prospekt)		8,8*	7,54*		3/10/96
Lv23F - stream draining Skrunda radar base 28/9/96					
Lv24F - water (lake?) downstream of chem. weapons store Daugavpils 1/10/96					
Lv25F - well in cemetry SW of chem. store, Daugavpils					1/10/96
Lv26F - well downstream of area 1, Daugavpils					1/10/96

NB: samples Lv5F, Lv12F, Lv13F & Lv16F-19F do not exist

* measured with NGUs pH-meter, which gives results consistently c. 0,2 pH units higher than the Latvian equipment and 0,3°C higher for temperature.

WATER

NGU, Miljøundersøkelser i Latvia
v/David Banks
Prosjektnr. 2699.00

Analyserapport 1996.0238

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ANALYSERAPPORT

NORSK AKKREDITERING
Nr. P020

ANALYSEKONTRAKT NR.: 1996.0238
NGU PROSJEKT NR.: 2699.00

OPPDRAGSGIVER: NGU, Miljøundersøkelser i Latvia

ADRESSE:

TLF.: 310

KONTAKTPERSON: David Banks

PRØVETYPE: Vann
ANTALL PRØVER: 20
IDENTIFIKASJON AV PRØVER: Iflg. liste fra oppdragsgiver
PRØVER MOTTATT: 08.10.96
ANMERKNINGER: Ingen

SPESIFIKASJON AV OPPDRAGET I HENHOLD TIL ANALYSEKONTRAKT:

METODE	DOKUMENTASJON *)	OMFATTES AV AKKREDITERING
ICP-AES vann	NGU-SD 3.1	Ja
GFAAS - Cd og Pb	NGU-SD 3.2	Ja
GFAAS - As og Sb		Nei
CVAAS - Hg	NGU-SD 3.3	Ja
IC	NGU-SD 3.4	Ja

Denne rapporten inneholder i alt 11 sider. Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Alle forhold ved prøvetaking, behandling og transport av prøvene før innlevering til NGU-Lab er underlagt oppdragsgivers ansvar. Analyseresultater framlagt i denne rapporten refererer derfor kun til det prøvematerialet som er mottatt av NGU-Lab.

Trondheim, 13. november 1996

Magne Ødegård (e.f.)

*) Fortegnelse over dokumentasjon finnes i NGU-Labs Kvalitetshåndbok, NGU-SD 0.1, som kan rekvireres fra NGU-Labs sekretariat.

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ICP-AES ANALYSER
VANN
Analysekontraktsnr:1996.0238

NORSK AKKREDITERING Nr. P020

INSTRUMENT TYPE : **Thermo Jarrell Ash ICP 61**

NEDRE BESTEMMELSESGRENSER VANNANALYSER
(For vannprøver som tynnes, blir deteksjonsgrensene automatisk omregnet).

Si ppb	Al ppb	Fe ppb	Ti ppb	Mg ppb	Ca ppb	Na ppb	K ppb	Mn ppb	P ppb
20.-	20.-	10.-	5.-	50.-	20.-	50.-	500.-	1.-	100.-
Cu ppb	Zn ppb	Pb ppb	Ni ppb	Co ppb	V ppb	Mo ppb	Cd ppb	Cr ppb	Ba ppb
5.-	2.-	50.-	20.-	10.-	5.-	10.-	5.-	10.-	2.-
Sr ppb	Zr ppb	Ag ppb	B ppb	Be ppb	Li ppb	Sc ppb	Ce ppb	La ppb	Y ppb
1.-	5.-	10.-	10.-	1.-	5.0	1.-	50.-	10.-	1.-

3

ANALYSEUSIKKERHET: ± 20 rel. % for K, Pb, Cd, Li, Ce.
± 10 rel. % for Si, Al, Na, Mo, Cr, Zr, Ag, B og La.
± 5 rel. % for Fe, Ti, Mg, Ca, Mn, P, Cu, Zn, Ni, Co, V, Ba, Sr, Be, Sc, Y.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	11. oktober 1996	Brit Inger Vongraven
	Dato	OPERATØR

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ICP-AES ANALYSER
VANN
Analysekontraktsnr:1996.0238

	Lv1F	Lv2F	Lv3F	Lv4F	Lv6F	Lv7F	Lv8F	Lv9F	Lv10F	Lv11F
Si	3.7ppm	7.9ppm	8.7ppm	6.5ppm	4.2ppm	7.1ppm	2.8ppm	8.6ppm	4.1ppm	7.5ppm
Al	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb
Fe	22.1ppm	26.7ppm	33.0ppm	37.2ppm	15.7ppm	40.1ppm	2.1ppm	14.1ppm	2.9ppm	23.2ppm
Ti	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Mg	17.3ppm	12.1ppm	13.9ppm	18.3ppm	18.8ppm	16.7ppm	12.3ppm	9.8ppm	16.6ppm	5.7ppm
Ca	116ppm	173ppm	102ppm	131ppm	169ppm	140ppm	69.0ppm	71.5ppm	70.9ppm	56.7ppm
Na	4.5ppm	2.0ppm	2.9ppm	5.5ppm	2.1ppm	3.8ppm	3.8ppm	6.2ppm	12.2ppm	3.6ppm
K	1.9ppm	2.7ppm	4.9ppm	23.3ppm	5.0ppm	4.3ppm	1.8ppm	9.3ppm	2.3ppm	2.7ppm
Mn	1.8ppm	2.1ppm	249ppb	1.7ppm	1.6ppm	2.7ppm	38.6ppb	114ppb	1.1ppm	209ppb
P	464ppb	228ppb	< 100ppb	597ppb	465ppb	426ppb	< 100ppb	< 100ppb	< 100ppb	< 100ppb
Cu	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Zn	52.1ppb	3.1ppb	67.2ppb	22.9ppb	32.6ppb	10.5ppb	80.5ppb	30.9ppb	77.2ppb	28.4ppb
Ni	27.4ppb	<20.0ppb	52.5ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	25.6ppb	<20.0ppb
Co	<10.0ppb	<10.0ppb	40.5ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
V	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Mo	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
Cr	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
Ba	86.8ppb	78.8ppb	215ppb	193ppb	142ppb	188ppb	71.9ppb	119ppb	67.9ppb	118ppb
Sr	128ppb	220ppb	213ppb	385ppb	202ppb	241ppb	69.7ppb	190ppb	92.0ppb	75.5ppb
Zr	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Ag	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
B	26.7ppb	14.4ppb	41.1ppb	20.6ppb	12.3ppb	39.1ppb	<10.0ppb	26.7ppb	35.0ppb	30.8ppb
Be	5.5ppb	6.8ppb	8.4ppb	9.6ppb	3.7ppb	10.0ppb	<1.00ppb	3.5ppb	<1.00ppb	5.9ppb
Li	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Sc	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb
Ce	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb
La	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
Y	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb

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ICP-AES ANALYSER
VANN
Analysekontraktsnr:1996.0238

NORSK AKKREDITERING Nr. P020

	Lv7aF	Lv14F	Lv15F	Lv20F	LV21F	Lv22F	Lv23F	Lv24F	Lv25F	Lv26F
Si	4.3ppm	5.6ppm	8.2ppm	3.9ppm	4.3ppm	3.5ppm	1.7ppm	238ppb	3.1ppm	3.7ppm
Al	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb
Fe	30.9ppm	32.7ppm	9.4ppm	139ppb	97.0ppb	881ppb	72.8ppb	38.4ppb	<10.0ppb	443ppb
Ti	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Mg	16.8ppm	7.2ppm	8.4ppm	11.9ppm	12.4ppm	18.7ppm	18.4ppm	9.6ppm	19.4ppm	12.9ppm
Ca	150ppm	89.2ppm	90.9ppm	48.6ppm	51.0ppm	87.5ppm	85.9ppm	36.0ppm	71.2ppm	59.1ppm
Na	2.4ppm	5.5ppm	8.1ppm	3.4ppm	10.1ppm	13.8ppm	20.2ppm	2.9ppm	6.4ppm	6.5ppm
K	3.2ppm	3.0ppm	9.2ppm	1.1ppm	8.5ppm	6.6ppm	18.2ppm	1.2ppm	2.7ppm	2.9ppm
Mn	4.7ppm	6.3ppm	1.7ppm	40.8ppb	5.2ppb	17.4ppb	260ppb	18.6ppb	31.6ppb	30.2ppb
P	475ppb	321ppb	405ppb	< 100ppb	< 100ppb	< 100ppb	< 100ppb	< 100ppb	< 100ppb	< 100ppb
Cu	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Zn	23.5ppb	104ppb	27.3ppb	10.3ppb	4.6ppb	1.1ppm	5.2ppb	74.8ppb	312ppb	147ppb
Ni	<20.0ppb	58.4ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb	<20.0ppb
Co	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
V	< 5.0ppb	5.3ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Mo	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
Cr	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
Ba	118ppb	117ppb	77.2ppb	39.1ppb	45.7ppb	38.7ppb	88.8ppb	16.6ppb	25.8ppb	30.5ppb
Sr	149ppb	123ppb	151ppb	69.6ppb	99.1ppb	158ppb	247ppb	48.5ppb	80.6ppb	84.6ppb
Zr	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Ag	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
B	18.5ppb	59.6ppb	28.8ppb	18.5ppb	30.8ppb	69.9ppb	20.6ppb	<10.0ppb	10.3ppb	16.4ppb
Be	8.0ppb	8.4ppb	2.0ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb
Li	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb
Sc	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb
Ce	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb	<50.0ppb
La	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb
Y	<1.00ppb	1.7ppb	<1.00ppb	<1.00ppb	8.8ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb	<1.00ppb

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ATOMABSORPSJONS-ANALYSE (Cd og Pb - Grafittovn teknikk)
Vann
Analysekontraktsnr: 1996.0238

NORSK AKKREDITERING Nr. P020

INSTRUMENT TYPE : **Perkin Elmer type SIMAA 6000**

NEDRE BESTEMMELSES GRENSER : Cd : 0.02 µg/l **Pb : 0.2 µg/l**
As : 3.00 µg/l **Sb : 0.5 µg/l**

ANALYSEUSIKKERHET Analyseusikkerheten er gitt i tabellen under

Element	Usikkerhet
Cd	± 10 % rel.
As	± 10 % rel.
Pb	± 10 % rel.
Sb	± 10 % rel.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	24. oktober 1996	Frank Berge
	Dato	OPERATØR

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Norges geologiske undersøkelse

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ATOMABSORPSJONS-ANALYSE (Cd og Pb - Grafittovn teknikk)
Vann
Analysekontraktsnr: 1996.0238

NORSK AKKREDITERING Nr. P020

Resultater:

Prøve nr.	Cd µg/l	Pb µg/l	As µg/l	Sb µg/l
1F	0.73	1.33	< 3.0	< 0.5
2F	< 0.02	0.47	5.67	< 0.5
3F	0.033	1.23	< 3.0	< 0.5
4F	0.143	3.20	13.14	< 0.5
6F	0.303	2.33	4.63	< 0.5
7F	0.177	2.18	12.38	< 0.5
8F	< 0.02	0.53	< 3.0	< 0.5
9F	< 0.02	0.54	< 3.0	< 0.5
10F	0.031	1.27	< 3.0	< 0.5
11F	0.154	2.66	4.77	< 0.5
7aF	0.168	4.05	8.60	< 0.5
14F	0.129	1.74	9.60	< 0.5
15F	0.062	4.67	12.43	< 0.5
20F	0.079	3.48	< 3.0	< 0.5
21F	0.083	0.53	< 3.0	< 0.5
22F	0.071	0.52	< 3.0	< 0.5
23F	< 0.02	0.35	< 3.0	< 0.5
24F	0.021	4.64	< 3.0	< 0.5
25F	0.169	0.38	< 3.0	< 0.5
26F	< 0.02	0.20	< 3.0	< 0.5

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ATOMABSORPSJONS-ANALYSE (Hg-Kalddampteknikk AA/HMS-1)
VANN
Analysekontraktsnr: 1996.0238

NORSK AKKREDITERING Nr. P020

Metoden er utviklet for bestemmelse av kvikksølv i vann med Perkin Elmer Mercury Hydride System - 20 og en gullfelleenhet koblet til Perkin Elmer AA.

INSTRUMENT TYPE : **Perkin Elmer type 460 (AA) / 20 (MHS)**

NEDRE BESTEMMELSES GRENSER : 10 pg/ml (10 ppt)

ANALYSEUSIKKERHET **± 10 % rel.**

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	29. oktober 1996	Frank Berge
	Dato	OPERATØR

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ATOMABSORPSJONS-ANALYSE (Hg-Kalddampteknikk AA/HMS-1)
VANN
Analysekontraktsnr:1996.0238

NORSK AKKREDITERING Nr. P020

Resultater.

Prøve nr.	Hg µg/l
1F.	< 0.010
2F.	< 0.010
3F.	< 0.010
4F.	< 0.010
6F.	< 0.010
7F.	< 0.010
8F.	< 0.010
9F.	< 0.010
10F.	< 0.010
11F.	< 0.010
7AF	< 0.010
14F.	< 0.010
15F.	< 0.010
20F.	< 0.010
21F.	< 0.010
22F.	< 0.010
23F.	< 0.010
24F.	< 0.010
25F.	< 0.010
26F.	< 0.010

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IC- ANALYSER
VANN
Analysekontraktsnr:1996.0238

NORSK AKKREDITERING Nr. P020

7 ANIONER : F^-, Cl^-, NO_2^-, Br^-, NO_3^-, PO_4^{3-}, SO_4^{2-}

INSTRUMENT TYPE : **DIONEX IONEKROMATOGRAF 2120i**

NEDRE BESTEMMELSESGRENSER

ION	F^-	Cl^-	NO_2^-*	Br^-	NO_3^-	PO_4^{3-}	SO_4^{2-}
Nedre bestemmelsesgrense - mg/l	0.05	0.1	0.05	0.1	0.05	0.2	0.1

ANALYSEUSIKKERHET : **10 % rel. for alle ionene**

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PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Prøvene er filtrert (0.45my) og kjørt gjennom Waters Sep-Pak ionebytterpatron.

* NGU-LAB er ikke akkreditert for NO_2^- *

Ferdig analysert	7. november 1996	Egil Kvam
	Dato	OPERATØR

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NGU-Lab

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IC- ANALYSER
VANN
Analysekontraktsnr:1996.0238

NORSK AKKREDITERING Nr. P020

Prøve Id.	F^- [mg/l]	Cl^- [mg/l]	NO_2^- [mg/l]	Br^- [mg/l]	NO_3^- [mg/l]	PO_4^{3-} [mg/l]	SO_4^{2-} [mg/l]
238/96 - Lv F 1	< 0.05	9.51	< 0.05	< 0.1	< 0.05	< 0.2	5.52
238/96 - Lv F 2	0.269	3.85	< 0.05	< 0.1	< 0.05	< 0.2	< 0.1
238/96 - Lv F 3	0.550	3.29	< 0.05	< 0.1	< 0.05	< 0.2	1.01
238/96 - Lv F 4	< 0.05	8.26	< 0.05	< 0.1	< 0.05	< 0.2	6.93
238/96 - Lv F 6	< 0.05	5.83	< 0.05	< 0.1	< 0.05	< 0.2	3.00
238/96 - Lv F 7	< 0.05	5.03	< 0.05	< 0.1	< 0.05	< 0.2	< 0.1
238/96 - Lv F 8	< 0.05	5.18	< 0.05	< 0.1	0.224	< 0.2	34.3
238/96 - Lv F 9	< 0.05	10.7	< 0.05	< 0.1	< 0.05	< 0.2	67.4
238/96 - Lv F 10	< 0.05	9.32	< 0.05	< 0.1	< 0.05	< 0.2	96.3
238/96 - Lv F 11	0.249	9.39	< 0.05	< 0.1	< 0.05	< 0.2	41.2
238/96 - Lv F 7a	0.071	4.73	< 0.05	< 0.1	< 0.05	< 0.2	< 0.1
238/96 - Lv F 14	0.324	10.5	< 0.05	< 0.1	< 0.05	< 0.2	3.15
238/96 - Lv F 15	0.251	6.86	< 0.05	< 0.1	< 0.05	< 0.2	19.1
238/96 - Lv F 20	< 0.05	8.74	< 0.05	< 0.1	2.26	< 0.2	92.7
238/96 - Lv F 21	0.325	14.4	< 0.05	< 0.1	25.9	< 0.2	101
238/96 - Lv F 22	0.499	49.1	< 0.05	< 0.1	57.4	< 0.2	63.2
238/96 - Lv F 23	0.339	52.8	< 0.05	< 0.1	< 0.05	< 0.2	70.9
238/96 - Lv F 24	0.093	6.18	< 0.05	< 0.1	0.307	< 0.2	35.1
238/96 - Lv F 25	< 0.05	11.5	< 0.05	< 0.1	21.1	< 0.2	37.5
238/96 - Lv F 26	0.195	10.6	< 0.05	< 0.1	7.20	< 0.2	42.9

Appendix 5:

Analyses carried out by NGU in 1997 on groundwater samples from Viestura Prospekts site.

1997.0153

2699.00

Groundwater Samples from Latvia - June 1997

All samples are filtered at 0,45 um, but unacidified.

- 0 = no visible colour
- b = brown tinge
- B = brown colour
- BB = very brown colour (presumably precipitated iron)

Viestura Prospekt Oil Store

Location	Marking	Colour	Tilsatt HNO_3
Borehole 1	Lv1BF	B	1.1 ml
Borehole 2	Lv2BF	BB	1.1 "
Borehole 3	Lv3BF	B	1.1 "
Borehole 4	Lv4BF	BB	1.1 "
Borehole 5	Lv5BF	BB	1.1 "
Borehole 6	Lv6BF	B	1.1 "
Borehole 7	Lv7BF	BB	
Borehole 8	Lv8BF	b	1.1 "
Borehole 9	Lv9BF	B	0.2 "
Borehole 10	Lv10BF	b	0.3 "
Borehole 11	Lv11BF	BB	1.1 "
Borehole 12	Lv12BF	BB	1.1 "
Borehole 14	Lv14BF	BB	1.1 "
Borehole 15	Lv15BF	b	0.2 "
Borehole222a	Lv222aBF	O	0.1 "

Valmieras iela tank repair works

Location	Marking	Colour	Tilsatt HNO_3
Borehole 1	Vm1BF	b	0.4 "
Borehole 2	Vm2BF	b	0.4 "
Borehole 3	Vm3BF	B	1.1 "
Borehole 4	Vm4BF	B	1.1 "
Borehole 5	Vm5BF	b	1.1 "

26/6-97 3.S

Analytical Procedure

Prøvene kan inneholde mindre mengder oppløst olje. Dette gjelder spesielt Lv12BF og Vm3BF. Prøvene inneholder antakelig også mye oppløst jern.

1. Ryst flaskene sakte for å distribuere bunnfelt jern.
2. Ta ut ca. 10 ml vann til IC analyse
3. Surgjør gjenværende 90 ml i flasken for å løse opp utfelt jern.
4. Analyser den surgjorte prøven med
   (a) ICP
   (b) AA (Sn. Sb. Cd. Hg, Pb. As)

NGU results

Viestura no.	Free phase	T (NGU)	Eh	Alkalinity 1	Alkalinity 2	Average alkalinity
	cm	deg C	mV	meq/L	meq/L	meq/L
1	0	9.6	-240	9	9.2	9.1
2	0	8.7	-148	12.1	12.5	12.3
3	0	8.5	-134	6.2	6.3	6.25
4	0			11.6	11.5	11.55
5	0	8.9	-134	10.5	10.7	10.6
6	0	9.9	-166	12.1	12.2	12.15
7	0	9.7	-157	10.2	10.4	10.3
8	0	7.7	-154	4.4	4.6	4.5
9	0	9.9	-167	4.6	4.8	4.7
10	0			4	4.2	4.1
11	0	8.7	-203	5.2	5.3	5.25
12	20			14.2	14.1	14.15
13	45					
14	0	8.1	-168	7.7	7.7	7.7
15	0	9.2	-180	7.3		7.3
222a	0	7.7	-180	2.4	2.2	2.3
Valmieras no.						
Vm1	0	10.1	-67	3.5	3.4	3.45
Vm2	0	11.3	-23	5.3	5.3	5.3
Vm3	60	9.1	-138	13.4	13.6	13.5
Vm4	0	9.1	-149	8.9	9.2	9.05
Vm5	0	9.6	-186	16.2	16.6	16.4

Checked DB 24/6/97

Original Report
- B not cited due
to analytical interference

NGU, Miljøundersøkelser Latvia
v/David Banks
Prosjektnr. 2699.00

Analyserapport 1997.0153

NGU
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ANALYSERAPPORT

ANALYSEKONTRAKT NR.: 1997.0153
NGU PROSJEKT NR.: 2699.00

OPPDRAGSGIVER: NGU, Miljøundersøkelser Latvia

ADRESSE:

TLF.: 310

KONTAKTPERSON: David Banks

PRØVETYPE: Vann
ANTALL PRØVER: 20
IDENTIFIKASJON AV PRØVER: Iflg. liste fra oppdragsgiver
PRØVER MOTTATT: 24.06.97
ANMERKNINGER: Ingen

SPESIFIKASJON AV OPPDRAGET I HENHOLD TIL ANALYSEKONTRAKT:

METODE	DOKUMENTASJON *)	OMFATTES AV AKKREDITERING
ICP-AES vann	NGU-SD 3.1	Ja
GFAAS - Cd, Pb, As, Sn	NGU-SD 3.2	Ja
GFAAS - Sb		Nei
CVAAS - Hg	NGU-SD 3.3	Ja
IC	NGU-SD 3.4	Ja

Denne rapporten inneholder i alt 13 sider. Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Alle forhold ved prøvetaking, behandling og transport av prøvene før innlevering til NGU-Lab er underlagt oppdragsgivers ansvar. Analyseresultater framlagt i denne rapporten refererer derfor kun til det prøvematerialet som er mottatt av NGU-Lab.

Trondheim, 10. juli 1997

Magne Ødegård/(e.f.)

*) Fortegnelse over dokumentasjon finnes i NGU-Labs Kvalitetshåndbok, NGU-SD 0.1, som kan rekvireres fra NGU-Labs sekretariat.

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ICP-AES ANALYSER
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

INSTRUMENT TYPE : ***Thermo Jarrell Ash ICP 61***

NEDRE BESTEMMELSESGRENSER VANNANALYSER
(For vannprøver som tynnes, blir deteksjonsgrensene automatisk omregnet).

Si ppb	Al ppb	Fe ppb	Ti ppb	Mg ppb	Ca ppb	Na ppb	K ppb	Mn ppb	P ppb
20.-	20.-	10.-	5.-	50.-	20.-	50.-	500.-	1.-	100.-
Cu ppb	Zn ppb	Pb ppb	Ni ppb	Co ppb	V ppb	Mo ppb	Cd ppb	Cr ppb	Ba ppb
5.-	2.-	50.-	20.-	10.-	5.-	10.-	5.-	10.-	2.-
Sr ppb	Zr ppb	Ag ppb	B ppb	Be ppb	Li ppb	Sc ppb	Ce ppb	La ppb	Y ppb
1.-	5.-	10.-	10.-	1.-	5.0	1.-	50.-	10.-	1.-

3

ANALYSEUSIKKERHET: ± 20 rel. % for K, Pb, Cd, Li, Ce.
± 10 rel. % for Si, Al, Na, Mo, Cr, Zr, Ag, B og La.
± 5 rel. % for Fe, Ti, Mg, Ca, Mn, P, Cu, Zn, Ni, Co, V, Ba, Sr, Be, Sc, Y.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: *B slettes p.g.a. forurensinger av B i systemet*

Ferdig analysert	2. juli 1997	Brit Inger Vongraven og Baard Søberg
	Dato	OPERATØR

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ICP-AES ANALYSER
VANN
Analysekontraktsnr:1997.0153

	Lv1BF	Lv2BF	Lv3BF	Lv4BF	Lv5BF	Lv6BF	Lv7BF	Lv8BF	Lv9BF	Lv10BF
Si	3.2ppm	7.0ppm	7.2ppm	6.1ppm	5.3ppm	4.1ppm	4.0ppm	2.6ppm	9.0ppm	3.6ppm
Al	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.1ppb	<20.1ppb
Fe	24.6ppm	47.9ppm	25.6ppm	38.4ppm	38.5ppm	18.6ppm	29.6ppm	2.6ppm	16.0ppm	4.0ppm
Ti	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.0ppb	< 5.0ppb
Mg	19.6ppm	12.9ppm	11.0ppm	20.2ppm	18.1ppm	17.4ppm	14.7ppm	13.7ppm	10.6ppm	15.2ppm
Ca	118ppm	174ppm	75.5ppm	135ppm	129ppm	175ppm	140ppm	70.0ppm	71.7ppm	63.6ppm
Na	3.9ppm	1.9ppm	1.1ppm	5.0ppm	3.8ppm	1.7ppm	2.4ppm	2.8ppm	6.3ppm	16.1ppm
K	1.9ppm	1.6ppm	4.5ppm	23.4ppm	5.9ppm	3.8ppm	3.0ppm	1.6ppm	7.9ppm	1.9ppm
Mn	2.3ppm	2.5ppm	141ppb	1.4ppm	3.8ppm	1.3ppm	4.1ppm	30.8ppb	117ppb	881ppb
P	559ppb	205ppb	< 101ppb	547ppb	454ppb	500ppb	478ppb	< 101ppb	< 100ppb	< 100ppb
Cu	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.0ppb	< 5.0ppb
Zn	< 2.0ppb	3.7ppb	3.2ppb	< 2.0ppb	< 2.0ppb	3.6ppb	< 2.0ppb	78.1ppb	17.8ppb	30.4ppb
Ni	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.3ppb	<20.1ppb	<20.1ppb
Co	<10.1ppb	<10.1ppb	20.6ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb
V	< 5.1ppb	10.2ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.0ppb	< 5.0ppb
Mo	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb
Cr	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb
Ba	82.2ppb	154ppb	171ppb	190ppb	156ppb	132ppb	109ppb	73.1ppb	114ppb	63.0ppb
Sr	130ppb	242ppb	159ppb	400ppb	196ppb	223ppb	143ppb	69.1ppb	178ppb	84.0ppb
Zr	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.0ppb	< 5.0ppb
Ag	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb
Be	4.9ppb	9.7ppb	5.1ppb	7.7ppb	7.5ppb	3.6ppb	5.7ppb	< 1.0ppb	3.1ppb	< 1.0ppb
Li	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.0ppb	< 5.0ppb
Sc	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb
Ce	<50.7ppb	<50.7ppb	<50.7ppb	<50.7ppb	<50.7ppb	<50.7ppb	<50.7ppb	<50.7ppb	<50.1ppb	<50.2ppb
La	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb
Y	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb

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ICP-AES ANALYSER
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

	Lv11BF	Lv12BF	Lv14BF	Lv15BF	Lv222aBF	Vm1BF	Vm2BF	Vm3BF	Vm4BF	Vm5BF
Si	7.4ppm	6.3ppm	5.0ppm	8.6ppm	3.7ppm	3.0ppm	4.4ppm	8.0ppm	6.0ppm	7.7ppm
Al	<20.3ppb	<20.3ppb	<20.3ppb	<20.1ppb	<20.0ppb	<20.1ppb	<20.1ppb	<20.3ppb	<20.3ppb	<20.3ppb
Fe	21.8ppm	51.5ppm	31.4ppm	9.1ppm	182ppb	54.7ppb	16.8ppb	28.9ppm	22.0ppm	5.0ppm
Ti	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb
Mg	9.0ppm	19.9ppm	7.3ppm	7.6ppm	12.2ppm	15.2ppm	16.6ppm	43.6ppm	22.7ppm	72.9ppm
Ca	64.1ppm	176ppm	98.1ppm	96.3ppm	48.1ppm	42.2ppm	81.7ppm	142ppm	113ppm	124ppm
Na	4.6ppm	2.7ppm	3.7ppm	7.9ppm	3.7ppm	63.3ppm	25.0ppm	25.1ppm	13.4ppm	49.5ppm
K	2.9ppm	8.0ppm	2.0ppm	19.2ppm	1.4ppm	53.4ppm	17.1ppm	11.2ppm	11.0ppm	37.4ppm
Mn	209ppb	1.9ppm	5.3ppm	1.3ppm	32.4ppb	81.7ppb	1.8ppb	1.4ppm	829ppb	1.5ppm
P	< 101ppb	554ppb	461ppb	295ppb	< 100ppb	1.3ppm	438ppb	965ppb	1.4ppm	691ppb
Cu	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb
Zn	< 2.0ppb	25.8ppb	13.9ppb	< 2.0ppb	< 2.0ppb	3.8ppb	10.9ppb	5.1ppb	< 2.0ppb	< 2.0ppb
Ni	<20.3ppb	<20.3ppb	<20.3ppb	<20.1ppb	<20.0ppb	<20.1ppb	<20.1ppb	<20.3ppb	<20.3ppb	<20.3ppb
Co	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.1ppb	<10.1ppb	<10.1ppb
V	< 5.1ppb	9.1ppb	6.9ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb
Mo	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.1ppb	<10.1ppb	<10.1ppb
Cr	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.1ppb	<10.1ppb	<10.1ppb
Ba	135ppb	141ppb	127ppb	109ppb	37.8ppb	39.2ppb	91.2ppb	322ppb	137ppb	301ppb
Sr	91.2ppb	336ppb	118ppb	206ppb	72.0ppb	159ppb	171ppb	590ppb	369ppb	461ppb
Zr	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.0ppb	< 5.1ppb	< 5.1ppb	< 5.1ppb
Ag	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.1ppb	<10.1ppb	<10.1ppb
Be	4.3ppb	10.1ppb	6.1ppb	1.6ppb	<1.00ppb	< 1.0ppb	< 1.0ppb	5.5ppb	4.1ppb	< 1.0ppb
Li	< 5.1ppb	< 5.1ppb	< 5.1ppb	< 5.0ppb	< 5.0ppb	10.2ppb	9.6ppb	19.3ppb	24.8ppb	15.9ppb
Sc	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	<1.00ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb
Ce	<50.7ppb	<50.7ppb	<50.7ppb	<50.1ppb	<50.0ppb	<50.2ppb	<50.2ppb	<50.7ppb	<50.7ppb	<50.7ppb
La	<10.1ppb	<10.1ppb	<10.1ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.0ppb	<10.1ppb	<10.1ppb	<10.1ppb
Y	< 1.0ppb	< 1.0ppb	1.3ppb	< 1.0ppb	<1.00ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb	< 1.0ppb

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ATOMABSORPSJONS-ANALYSE (Cd, Pb, As og Sn - Grafittovn teknikk)

Vann

Analysekontraktsnr: 1997.0153

NORSK AKKREDITERING Nr. P020

NGU - Lab

INSTRUMENT TYPE : **Perkin Elmer type SIMAA 6000**

NEDRE BESTEMMELSES GRENSER : Cd : 0.02 µg/l (0.02 ppb) Pb : 0.2 µg/l (0.2ppb) As : 3.0 µg/l (3.0 ppb) Sn : 2.0 µg/l (2.0 ppb)

ANALYSEUSIKKERHET Analyseusikkerheten er gitt i tabellen under

Element	Usikkerhet
Cd	± 10 % rel.
Pb	± 10 % rel.
As	± 20 % rel.
Sn	± 20 % rel.

9

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	8. juli 1997	Frank Berge
	Dato	OPERATØR

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ATOMABSORPSJONS-ANALYSE (Cd, Pb, As og Sn - Grafittovn teknikk)

Vann

Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

NGU - Lab

Prøvenr.	As ~~mg/kg~~ µg/l	Cd ~~mg/kg~~ µg/l	Pb ~~mg/kg~~ µg/l	Sn ~~mg/kg~~ µg/l
Lv1BF	< 3.0	< 0.02	0.44	< 2.0
Lv2BF	6.0	0.03	4.46	< 2.0
Lv3BF	3.8	< 0.02	0.66	< 2.0
Lv4BF	9.0	< 0.02	0.99	< 2.0
Lv5BF	3.6	0.15	16.78	< 2.0
Lv6BF	< 3.0	0.04	1.99	< 2.0
Lv7BF	3.4	0.02	2.13	< 2.0
Lv8BF	< 3.0	0.02	0.81	< 2.0
Lv9BF	< 3.0	< 0.02	0.75	< 2.0
Lv10BF	< 3.0	0.03	0.76	< 2.0
Lv11BF	< 3.0	0.10	2.15	< 2.0
Lv12BF	< 3.0	< 0.02	< 0.20	< 2.0
Lv14BF	< 3.0	< 0.02	0.57	< 2.0
Lv15BF	6.0	< 0.02	0.60	< 2.0
Lv222aBF	< 3.0	< 0.02	0.32	< 2.0
Vm1BF	3.4	< 0.02	0.46	< 2.0
Vm2BF	< 3.0	< 0.02	0.44	< 2.0
Vm3BF	5.3	< 0.02	0.93	< 2.0
Vm4BF	< 3.0	< 0.02	0.28	2.0
Vm5BF	< 3.0	< 0.02	0.20	< 2.0

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ATOMABSORPSJONS-ANALYSE (Sb - Grafittovn teknikk)
Vann
Analysekontraktsnr:1997.0153

NGU - Lab

INSTRUMENT TYPE : **Perkin Elmer type SIMAA 6000**

NEDRE BESTEMMELSES GRENSER : Sb 0.5 µg/l

ANALYSEUSIKKERHET Analyseusikkerheten er gitt i tabellen under

Element	Usikkerhet
Sb	± 10 % rel.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	8. juli 1997	Frank Berge
	Dato	OPERATØR

NGU Norges geologiske undersøkelse
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ATOMABSORPSJONS-ANALYSE (Sb - Gr[illegible]ovn teknikk)
Vann
Analysekontraktsnr: 1997.0153

NGU - Lab

Prøvenr.	Sb (µg/l)
Lv1BF	< 0.50
Lv2BF	1.00
Lv3BF	< 0.50
Lv4BF	< 0.50
Lv5BF	< 0.50
Lv6BF	< 0.50
Lv7BF	0.50
Lv8BF	< 0.50
Lv9BF	< 0.50
Lv10BF	0.80
Lv11BF	0.88
Lv12BF	0.59
Lv14BF	< 0.50
Lv15BF	0.52
Lv222aBF	< 0.50
Vm1BF	1.32
Vm2BF	1.80
Vm3BF	< 0.50
Vm4BF	< 0.50
Vm5BF	0.56

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ATOMABSORPSJONS-ANALYSE (Hg-Kalddampteknikk AA/HMS-1)
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

NGU - Lab

Metoden er utviklet for bestemmelse av kvikksølv i vann med Perkin Elmer Mercury Hydride System - 20 og en gullfelleenhet koblet til Perkin Elmer AA.

INSTRUMENT TYPE : **Perkin Elmer type 460 (AA) / 20 (MHS)**

NEDRE BESTEMMELSES GRENSER : 10 pg/ml (10 ppt)

ANALYSEUSIKKERHET **± 10 % rel.**

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	7. juli 1997	Idun Melby
	Dato	OPERATØR

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ATOMABSORPSJONS-ANALYSE (Hg-Kalddampteknikk AA/HMS-1)
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING
Nr. P020

NGU - Lab

Prøvenr.	Hg µg/l
Lv1BF	< 0.010
Lv2BF	< 0.010
Lv3BF	< 0.010
Lv4BF	< 0.010
Lv5BF	< 0.010
Lv6BF	< 0.010
Lv7BF	< 0.010
Lv8BF	< 0.010
Lv9BF	< 0.010
Lv10BF	< 0.010
Lv11BF	< 0.010
Lv12BF	< 0.010
Lv14BF	< 0.010
Lv15BF	< 0.010
Lv222aBF	< 0.010
Vm1BF	< 0.010
Vm2BF	< 0.010
Vm3BF	< 0.010
Vm4BF	< 0.010
Vm5BF	< 0.010

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IC- ANALYSER
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

7 ANIONER : F^-, Cl^-, NO_2^-, Br^-, NO_3^-, PO_4^{3-}, SO_4^{2-}

INSTRUMENT TYPE : **DIONEX IONEKROMATOGRAF 2120i**

NEDRE BESTEMMELSESGRENSER

ION	F^-	Cl^-	NO_2^-*	Br^-	NO_3^-	PO_4^{3-}	SO_4^{2-}
Nedre bestemmelsesgrense - mg/l	0.05	0.1	0.05	0.1	0.05	0.2	0.1

\LYSEUSIKKERHET : **10 % rel. for alle ionene**

:SISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ALL PRØVER: 20.

IERKNINGER: Alle prøvene er kjørt gjennom Sep Pak C_{18} patron før analyse.

*** NGU-LAB er ikke akkreditert for NO_2^- ***

ıorten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

lig analysert	2. juli 1997	Egil Kvam
	Dato	OPERATØR

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Norges geologiske undersøkelse

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Tlf.: 73 90 40 11
Telefaks: 73 92 16 20

IC- ANALYSER
VANN
Analysekontraktsnr: 1997.0153

NORSK AKKREDITERING Nr. P020

Prøve Id.	Analyse dato	F^- [mg/l]	Cl^- [mg/l]	NO_2^- [mg/l]	Br^- [mg/l]	NO_3^- [mg/l]	PO_4^{3-} [mg/l]	SO_4^{2-} [mg/l]
153/97 - Lv BF 1	30.06.97	0.076	6.69	< 0.05	< 0.1	< 0.05	< 0.2	0.386
153/97 - Lv BF 2	30.06.97	0.172	4.06	< 0.05	0.228	< 0.05	< 0.2	0.560
153/97 - Lv BF 3	30.06.97	0.373	2.44	< 0.05	< 0.1	< 0.05	< 0.2	0.382
153/97 - Lv BF 4	30.06.97	0.051	4.98	< 0.05	< 0.1	< 0.05	< 0.2	0.742
153/97 - Lv BF 5	30.06.97	0.058	5.19	< 0.05	< 0.1	< 0.05	< 0.2	< 0.1
153/97 - Lv BF 6	30.06.97	0.098	3.07	< 0.05	< 0.1	< 0.05	< 0.2	0.209
153/97 - Lv BF 7	30.06.97	0.068	3.71	< 0.05	< 0.1	< 0.05	< 0.2	0.281
153/97 - Lv BF 8	30.06.97	0.058	2.90	< 0.05	< 0.1	< 0.05	< 0.2	25.8
153/97 - Lv BF 9	30.06.97	< 0.05	4.80	< 0.05	< 0.1	< 0.05	< 0.2	47.6
153/97 - Lv BF 10	30.06.97	< 0.05	5.44	< 0.05	< 0.1	< 0.05	< 0.2	70.1
153/97 - Lv BF 11	30.06.97	0.119	5.76	< 0.05	< 0.1	< 0.05	< 0.2	1.63
153/97 - Lv BF 12	30.06.97	0.062	3.57	< 0.05	< 0.1	< 0.05	< 0.2	3.34
153/97 - Lv BF 14	30.06.97	0.224	5.54	< 0.05	< 0.1	< 0.05	< 0.2	0.918
153/97 - Lv BF 15	30.06.97	0.187	3.98	< 0.05	< 0.1	< 0.05	< 0.2	6.16
153/97 - Lv BF 222a	30.06.97	0.100	5.67	< 0.05	< 0.1	1.75	< 0.2	63.8
153/97 - Vm BF 1	30.06.97	0.166	52.2	2.56	< 0.1	51.9	3.29	91.5
153/97 - Vm BF 2	30.06.97	0.139	26.2	< 0.05	< 0.1	19.4	1.07	60.6
153/97 - Vm BF 3	30.06.97	0.239	45.5	< 0.05	< 0.1	< 0.05	< 0.2	0.192
153/97 - Vm BF 4	30.06.97	0.153	14.1	< 0.05	< 0.1	< 0.05	< 0.2	45.2
153/97 - Vm BF 5	30.06.97	0.141	13.2	< 0.05	< 0.1	< 0.05	< 0.2	27.3

Samples re-analysed
to obtain correct
B - results

NGU, Miljøundersøkelser Latvia
v/ David Banks
Prosjektnr.2699.00
Endring av analyserapport 1997.0153
Analyserapport 1997.0153

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ANALYSERAPPORT

NORSK AKKREDITERING Nr. P020

ANALYSEKONTRAKT NR.: 1997.0153
NGU PROSJEKT NR.: 2699.00

OPPDRAGSGIVER: NGU, Miljøundersøkelser Latvia

ADRESSE:

TLF.: 310

KONTAKTPERSON: David Banks

PRØVETYPE: Vann
ANTALL PRØVER: 20
IDENTIFIKASJON AV PRØVER: Iflg. liste fra oppdragsgiver
PRØVER MOTTATT: 24.06.97
ANMERKNINGER: Ingen

SPESIFIKASJON AV OPPDRAGET I HENHOLD TIL ANALYSEKONTRAKT:

METODE	DOKUMENTASJON *)	OMFATTES AV AKKREDITERING
ICP-AES vann	NGU-SD 3.1	Ja
GFAAS - Cd, Pb, As, Sn	NGU-SD 3.2	Ja
GFAAS - Sb		Nei
CVAAS - Hg	NGU-SD 3.3	Ja
IC	NGU-SD 3.4	Ja

Endring av analyserapport 1997.0153. Tidligere utsendte rapporter er ugyldig, og skal makuleres.
Denne rapporten inneholder i alt 13 sider. Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Alle forhold ved prøvetaking, behandling og transport av prøvene før innlevering til NGU-Lab er underlagt oppdragsgivers ansvar. Analyseresultater framlagt i denne rapporten refererer derfor kun til det prøvematerialet som er mottatt av NGU-Lab.

Trondheim, 20. august 1997

Magne Ødegård (e.f.)

*) Fortegnelse over dokumentasjon finnes i NGU-Labs Kvalitetshåndbok, NGU-SD 0.1, som kan rekvireres fra NGU-Labs sekretariat

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ICP-AES ANALYSER
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

INSTRUMENT TYPE : **Thermo Jarrell Ash ICP 61**

NEDRE BESTEMMELSESGRENSER VANNANALYSER
(For vannprøver som tynnes, blir deteksjonsgrensene automatisk omregnet).

Si	Al	Fe	Ti	Mg	Ca	Na	K	Mn	P
ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
20.-	20.-	10.-	5.-	50.-	20.-	50.-	500.-	1.-	100.-
Cu	Zn	Pb	Ni	Co	V	Mo	Cd	Cr	Ba
ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
5.-	2.-	50.-	20.-	10.-	5.-	10.-	5.-	10.-	2.-
Sr	Zr	Ag	B	Be	Li	Sc	Ce	La	Y
ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
1.-	5.-	10.-	20.-	1.-	5.0	1.-	50.-	10.-	1.-

ANALYSEUSIKKERHET: ± 20 rel. % for K, Pb, Cd, Li, Ce.
± 10 rel. % for Si, Al, Na, Mo, Cr, Zr, Ag, B og La.
± 5 rel. % for Fe, Ti, Mg, Ca, Mn, P, Cu, Zn, Ni, Co, V, Ba, Sr, Be, Sc, Y.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Ny rapport erstatter 02.07.97. Endring gjelder inkludering av B og korigering av inteferens av Fe på Be.

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	14.08.97	Brit I. Vongraven
	Dato	OPERATØR

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Norges geologiske undersøkelse
NGU-Lab

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ICP-AES ANALYSER
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

Prøve navn	Si ppm	Al ppm	Fe ppm	Ti ppm	Mg ppm	Ca ppm	Na ppm	K ppm	Mn ppm	P ppm	Cu ppm	Zn ppm	Ni ppm	Co ppm	V ppm
Lv1BF	3.35	<0.02	25.6	<0.005	20.2	122	4.06	1.76	2.44	0.562	<0.005	<0.002	<0.02	<0.01	<0.005
Lv2BF	7.35	0.0434	49.8	<0.005	13.4	180	2.02	1.78	2.62	0.294	<0.005	0.00511	<0.02	<0.01	0.0159
Lv3BF	7.59	<0.02	26.6	<0.005	11.3	78.0	1.12	4.34	0.149	0.101	<0.005	0.00499	<0.02	0.0193	<0.005
Lv4BF	6.42	<0.02	39.9	<0.005	20.7	139	5.15	24.4	1.52	0.579	<0.005	0.00255	<0.02	<0.01	0.00906
Lv5BF	5.53	<0.02	39.8	<0.005	18.6	133	3.98	5.61	4.03	0.465	<0.005	<0.002	<0.02	<0.01	0.00877
Lv6BF	4.29	0.0283	19.3	<0.005	17.8	178	1.76	4.30	1.33	0.500	<0.005	0.00484	<0.02	<0.01	0.00713
Lv7BF	4.27	0.0226	30.9	<0.005	15.3	144	2.51	3.00	4.35	0.441	<0.005	<0.002	<0.02	<0.01	0.00773
Lv8BF	2.68	<0.02	2.80	<0.005	14.0	71.6	2.93	1.35	0.0317	0.145	<0.005	0.0807	<0.02	<0.01	<0.005
Lv9BF	9.42	<0.02	16.7	<0.005	10.8	73.5	6.40	8.17	0.124	<0.1	<0.005	0.0191	<0.02	<0.01	<0.005
Lv10BF	3.75	<0.02	4.16	<0.005	15.4	64.5	16.2	2.17	0.920	0.142	<0.005	0.0312	<0.02	<0.01	<0.005
Lv11BF	7.70	<0.02	22.5	<0.005	9.10	65.4	4.65	2.44	0.221	0.135	<0.005	0.00233	<0.02	<0.01	<0.005
Lv12BF	6.67	<0.02	53.8	<0.005	20.6	181	2.67	8.30	2.04	0.653	<0.005	0.0275	<0.02	<0.01	0.0141
Lv14BF	5.31	0.0548	33.0	<0.005	7.52	102	3.71	1.94	5.66	0.530	<0.005	0.0214	<0.02	<0.01	0.0131
Lv15BF	9.10	<0.02	9.56	<0.005	7.87	100	8.19	20.5	1.38	0.515	<0.005	0.00265	<0.02	<0.01	<0.005
Lv222aBF	3.93	<0.02	0.204	<0.005	12.8	50.6	3.74	0.698	0.0355	<0.1	<0.005	0.00267	<0.02	<0.01	<0.005
Vm1BF	3.08	<0.02	0.0584	<0.005	15.5	43.8	64.4	55.9	0.0888	1.39	<0.005	0.00549	<0.02	<0.01	<0.005
Vm2BF	4.71	<0.02	0.0195	<0.005	17.6	87.4	26.4	18.3	0.00323	0.491	<0.005	0.0139	<0.02	<0.01	<0.005
Vm3BF	8.57	<0.02	30.5	<0.005	45.7	149	26.1	11.4	1.55	1.02	<0.005	0.00623	<0.02	<0.01	0.00817
Vm4BF	6.41	<0.02	23.1	<0.005	23.7	118	13.8	11.6	0.889	1.48	<0.005	<0.002	<0.02	<0.01	<0.005
Vm5BF	8.23	<0.02	5.30	<0.005	75.7	130	51.0	39.4	1.57	0.789	<0.005	<0.002	<0.02	<0.01	<0.005

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ICP-AES ANALYSER
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

Prøve navn	Mo	Cr	Ba	Sr	Zr	Ag	B	Be	Li	Sc	Ce	La	Y
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Lv1BF	<0.01	<0.01	0.0838	0.132	<0.005	<0.01	0.0374	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Lv2BF	<0.01	<0.01	0.181	0.247	<0.005	<0.01	0.0270	<0.001	<0.005	<0.001	0.0607	<0.01	<0.001
Lv3BF	<0.01	<0.01	0.176	0.162	<0.005	<0.01	0.0312	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Lv4BF	<0.01	<0.01	0.195	0.406	<0.005	<0.01	0.0333	<0.001	<0.005	<0.001	0.0698	<0.01	<0.001
Lv5BF	<0.01	<0.01	0.158	0.200	<0.005	<0.01	0.0374	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Lv6BF	<0.01	<0.01	0.150	0.226	<0.005	<0.01	<0.02	<0.001	<0.005	<0.001	0.0563	<0.01	<0.001
Lv7BF	<0.01	<0.01	0.113	0.147	<0.005	<0.01	0.0333	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Lv8BF	<0.01	<0.01	0.0746	0.0708	<0.005	<0.01	<0.02	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Lv9BF	<0.01	<0.01	0.117	0.182	<0.005	<0.01	<0.02	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Lv10BF	<0.01	<0.01	0.0637	0.0852	<0.005	<0.01	0.0309	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Lv11BF	<0.01	<0.01	0.136	0.0925	<0.005	<0.01	0.0416	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Lv12BF	<0.01	<0.01	0.146	0.344	<0.005	<0.01	0.0270	<0.001	<0.005	<0.001	0.0782	<0.01	<0.001
Lv14BF	<0.01	<0.01	0.133	0.122	<0.005	<0.01	0.0437	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Lv15BF	<0.01	<0.01	0.113	0.213	<0.005	<0.01	0.0206	<0.001	<0.005	<0.001	0.0591	<0.01	<0.001
Lv222a	<0.01	<0.01	0.0392	0.0752	<0.005	<0.01	<0.02	<0.001	<0.005	<0.001	<0.05	<0.01	<0.001
Vm1BF	<0.01	<0.01	0.0397	0.163	<0.005	<0.01	0.0660	<0.001	0.00716	<0.001	<0.05	<0.01	<0.001
Vm2BF	<0.01	<0.01	0.0973	0.184	<0.005	<0.01	0.0783	<0.001	0.00716	<0.001	<0.05	<0.01	<0.001
Vm3BF	<0.01	<0.01	0.336	0.616	<0.005	<0.01	0.112	<0.001	0.0177	<0.001	0.0580	<0.01	<0.001
Vm4BF	<0.01	<0.01	0.143	0.383	<0.005	<0.01	0.106	<0.001	0.0249	<0.001	<0.05	<0.01	<0.001
Vm5BF	<0.01	<0.01	0.309	0.475	<0.005	<0.01	0.156	<0.001	0.0161	<0.001	<0.05	<0.01	<0.001

NGU Norges geologiske undersøkelse

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ATOMABSORPSJONS-ANALYSE (Cd, Pb, As og Sn - Grafittovn teknikk)
Vann
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

NGU - Lab

INSTRUMENT TYPE : **Perkin Elmer type SIMAA 6000**

NEDRE BESTEMMELSES GRENSER : Cd : 0.02 µg/l (0.02 ppb) Pb : 0.2 µg/l (0.2ppb) As : 3.0 µg/l (3.0 ppb) Sn : 2.0 µg/l (2.0 ppb)

ANALYSEUSIKKERHET Analyseusikkerheten er gitt i tabellen under

Element	*Usikkerhet*
Cd	± 10 % rel.
Pb	± 10 % rel.
As	± 20 % rel.
Sn	± 20 % rel.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: *20*

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	8. juli 1997	Frank Berge
	Dato	OPERATØR

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ATOMABSORPSJONS-ANALYSE (Cd, Pb, As og Sn - Grafittovn teknikk)

Vann

Analysekontraktsnr:1997.0153

NGU - Lab

Prøvenr.	As µg/l	Cd µg/l	Pb µg/l	Sn µg/l
Lv1BF	< 3.0	< 0.02	0.44	< 2.0
Lv2BF	6.0	0.03	4.46	< 2.0
Lv3BF	3.8	< 0.02	0.66	< 2.0
Lv4BF	9.0	< 0.02	0.99	< 2.0
Lv5BF	3.6	0.15	16.78	< 2.0
Lv6BF	< 3.0	0.04	1.99	< 2.0
Lv7BF	3.4	0.02	2.13	< 2.0
Lv8BF	< 3.0	0.02	0.81	< 2.0
Lv9BF	< 3.0	< 0.02	0.75	< 2.0
Lv10BF	< 3.0	0.03	0.76	< 2.0
Lv11BF	< 3.0	0.10	2.15	< 2.0
Lv12BF	< 3.0	< 0.02	< 0.20	< 2.0
Lv14BF	< 3.0	< 0.02	0.57	< 2.0
Lv15BF	6.0	< 0.02	0.60	< 2.0
Lv222aBF	< 3.0	< 0.02	0.32	< 2.0
Vm1BF	3.4	< 0.02	0.46	< 2.0
Vm2BF	< 3.0	< 0.02	0.44	< 2.0
Vm3BF	5.3	< 0.02	0.93	< 2.0
Vm4BF	< 3.0	< 0.02	0.28	2.0
Vm5BF	< 3.0	< 0.02	0.20	< 2.0

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ATOMABSORPSJONS-ANALYSE (Sb - Grafittovn teknikk)
Vann
Analysekontraktsnr:1997.0153

NGU - Lab

INSTRUMENT TYPE : **Perkin Elmer type SIMAA 6000**

NEDRE BESTEMMELSES GRENSER : Sb 0.5 µg/l

ANALYSEUSIKKERHET Analyseusikkerheten er gitt i tabellen under

Element	Usikkerhet
Sb	± 10 % rel.

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	8. juli 1997	Frank Berge
	Dato	OPERATØR

NGU
Norges geologiske undersøkelse

Postboks 3006 - Lade
7002 TRONDHEIM
Tlf.: 73 90 40 11
Telefaks: 73 92 16 20

ATOMABSORPSJONS-ANALYSE (Sb - Grafittovn teknikk)
Vann
Analysekontraktsnr:1997.0153

NGU - Lab

Prøvenr.	Sb µg/l
Lv1BF	< 0.50
Lv2BF	1.00
Lv3BF	< 0.50
Lv4BF	< 0.50
Lv5BF	< 0.50
Lv6BF	< 0.50
Lv7BF	0.50
Lv8BF	< 0.50
Lv9BF	< 0.50
Lv10BF	0.80
Lv11BF	0.88
Lv12BF	0.59
Lv14BF	< 0.50
Lv15BF	0.52
Lv222aBF	< 0.50
Vm1BF	1.32
Vm2BF	1.80
Vm3BF	< 0.50
Vm4BF	< 0.50
Vm5BF	0.56

NGU
Norges geologiske undersøkelse

Postboks 3006 - Lade
7002 TRONDHEIM
Tlf.: 73 90 40 11
Telefaks: 73 92 16 20

ATOMABSORPSJONS-ANALYSE (Hg-Kalddampteknikk AA/HMS-1)
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

NGU - Lab

Metoden er utviklet for bestemmelse av kvikksølv i vann med Perkin Elmer Mercury Hydride System - 20 og en gullfelleenhet koblet til Perkin Elmer AA.

INSTRUMENT TYPE : **Perkin Elmer type 460 (AA) / 20 (MHS)**

NEDRE BESTEMMELSES GRENSER : 10 pg/ml (10 ppt)

ANALYSEUSIKKERHET **± 10 % rel.**

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20

ANMERKNINGER: Ingen

Rapporten må ikke gjengis i utdrag uten skriftlig godkjenning fra NGU-Lab.

Ferdig analysert	7. juli 1997	Idun Melby
	Dato	OPERATØR

NGU
Norges geologiske undersøkelse

Postboks 3006 - Lade
7002 TRONDHEIM
Tlf.: 73 90 40 11
Telefaks: 73 92 16 20

ATOMABSORPSJONS-ANALYSE (Hg-Kalddampteknikk AA/HMS-1)
VANN
Analysekontraktsnr: 1997.0153

NORSK AKKREDITERING Nr. P020

NGU - Lab

Prøvenr.	Hg µg/l
Lv1BF	< 0.010
Lv2BF	< 0.010
Lv3BF	< 0.010
Lv4BF	< 0.010
Lv5BF	< 0.010
Lv6BF	< 0.010
Lv7BF	< 0.010
Lv8BF	< 0.010
Lv9BF	< 0.010
Lv10BF	< 0.010
Lv11BF	< 0.010
Lv12BF	< 0.010
Lv14BF	< 0.010
Lv15BF	< 0.010
Lv222aBF	< 0.010
Vm1BF	< 0.010
Vm2BF	< 0.010
Vm3BF	< 0.010
Vm4BF	< 0.010
Vm5BF	< 0.010

NGU
Norges geologiske undersøkelse

Postboks 3006 - Lade
7002 TRONDHEIM
Tlf.: 73 90 40 11
Telefaks: 73 92 16 20

IC- ANALYSER
VANN
Analysekontraktsnr:1997.0153

NORSK AKKREDITERING Nr. P020

7 ANIONER : F^-, Cl^-, NO_2^-, Br^-, NO_3^-, PO_4^{3-}, SO_4^{2-}

INSTRUMENT TYPE : **DIONEX IONEKROMATOGRAF 2120i**

NEDRE BESTEMMELSESGRENSER

ION	F^-	Cl^-	NO_2^-*	Br^-	NO_3^-	PO_4^{3-}	SO_4^{2-}
Nedre bestemmelsesgrense - mg/l	0.05	0.1	0.05	0.1	0.05	0.2	0.1

ANALYSEUSIKKERHET : **10 % rel. for alle ionene**

PRESISJON : Det kjøres rutinemessig kontrollprøver, som føres i kontrolldiagram (X-diagram). Disse kan forevises om ønskelig.

ANTALL PRØVER: 20.

ANMERKNINGER: Alle prøvene er kjørt gjennom Sep Pak C_{18} patron før analyse.

*** NGU-LAB er ikke akkreditert for NO_2^- ***

Ferdig analysert	2. juli 1997	Egil Kvam
	Dato	OPERATØR

NGU
Norges geologiske undersøkelse

Postboks 3006 - Lade
7002 TRONDHEIM
Tlf.: 73 90 40 11
Telefaks: 73 92 16 20

IC- ANALYSER
VANN
Analysekontraktsnr: 1997.0153

Prøve Id.	Analyse dato	F^- [mg/l]	Cl^- [mg/l]	NO_2^- [mg/l]	Br^- [mg/l]	NO_3^- [mg/l]	PO_4^{3-} [mg/l]	SO_4^{2-} [mg/l]
153/97 - Lv BF 1	30.06.97	0.076	6.69	< 0.05	< 0.1	< 0.05	< 0.2	0.386
153/97 - Lv BF 2	30.06.97	0.172	4.06	< 0.05	0.228	< 0.05	< 0.2	0.560
153/97 - Lv BF 3	30.06.97	0.373	2.44	< 0.05	< 0.1	< 0.05	< 0.2	0.382
153/97 - Lv BF 4	30.06.97	0.051	4.98	< 0.05	< 0.1	< 0.05	< 0.2	0.742
153/97 - Lv BF 5	30.06.97	0.058	5.19	< 0.05	< 0.1	< 0.05	< 0.2	< 0.1
153/97 - Lv BF 6	30.06.97	0.098	3.07	< 0.05	< 0.1	< 0.05	< 0.2	0.209
153/97 - Lv BF 7	30.06.97	0.068	3.71	< 0.05	< 0.1	< 0.05	< 0.2	0.281
153/97 - Lv BF 8	30.06.97	0.058	2.90	< 0.05	< 0.1	< 0.05	< 0.2	25.8
153/97 - Lv BF 9	30.06.97	< 0.05	4.80	< 0.05	< 0.1	< 0.05	< 0.2	47.6
153/97 - Lv BF 10	30.06.97	< 0.05	5.44	< 0.05	< 0.1	< 0.05	< 0.2	70.1
153/97 - Lv BF 11	30.06.97	0.119	5.76	< 0.05	< 0.1	< 0.05	< 0.2	1.63
153/97 - Lv BF 12	30.06.97	0.062	3.57	< 0.05	< 0.1	< 0.05	< 0.2	3.34
153/97 - Lv BF 14	30.06.97	0.224	5.54	< 0.05	< 0.1	< 0.05	< 0.2	0.918
153/97 - Lv BF 15	30.06.97	0.187	3.98	< 0.05	< 0.1	< 0.05	< 0.2	6.16
153/97 - Lv BF 222a	30.06.97	0.100	5.67	< 0.05	< 0.1	1.75	< 0.2	63.8
153/97 - Vm BF 1	30.06.97	0.166	52.2	2.56	< 0.1	51.9	3.29	91.5
153/97 - Vm BF 2	30.06.97	0.139	26.2	< 0.05	< 0.1	19.4	1.07	60.6
153/97 - Vm BF 3	30.06.97	0.239	45.5	< 0.05	< 0.1	< 0.05	< 0.2	0.192
153/97 - Vm BF 4	30.06.97	0.153	14.1	< 0.05	< 0.1	< 0.05	< 0.2	45.2
153/97 - Vm BF 5	30.06.97	0.141	13.2	< 0.05	< 0.1	< 0.05	< 0.2	27.3

Data from A. Misund and D. Banks collected during fieldwork in Riga, Sept. - Oct. 1996.

SOILVAPOR measuring with PHOTO-IONISASION-DETECTOR (PID). Detection of volatile organic carbon (VOC) that can ionise using a 10.6 V lamp. The soil samples were put into a plastic bag and stored for approx. 2 hours to allow a the soil to degas. After opening the bags we did another experiment, shaking the soil and immediately measuring the content of VOC.

Volatile organic carbons		**After 2 hour (PPM)**	**After shaking (PPM)**
Well 12	**5-6 m depth**	90	350
Well 13	**5 m depth**	142	350
Well 13	**7 m depth**	< 10	13
Well 14	**3.5 m depth**	90	280
Well 14	**7 m depth**	< 10	< 10
Well 15	**4.5 m depth**	< 10	< 10
Well 15	**5.7 m depth**	> 210	500

Appendix 6:

Analyses carried out by FFI in 1996 / 97 on soil and groundwater samples from Viestura Prospekts site.

FORSVARETS FORSKNINGSINSTITUTT
Norwegian Defence Research Establishment
Division for Environmental Toxicology

Date
3 April 1997
Our reference
97/00339-10/FFITOX/AJo/138.22
Previous reference

1996

FFITOX
Att:Bjørn A Johnsen
P.O. Box 25
N-2007 KJELLER

ANALYSIS OF WATER AND SOIL SAMPLES FOR CONTENT OF HYDROCARBONS

Enclosed you will find our analysis report with the result from the analysis of water and soil samples for content of hydrocarbons. The report has our internal report number FFITOX/ANALYSERAPPORT-97/009.

Arnt Johnsen
Arnt Johnsen
Senior Scientist

Enclosures: 1

Exec officer : Arnt Johnsen
Address : P. O. Box 25, N-2007 Kjeller, Norway
Direct : 63 80 78 33
Telephone : + 47 63 80 70 00
Telefax : + 47 63 80 78 11
V.A.T reg. No. : NO 970 963 340 V.A.T

ANALYSIS REPORT

FROM
MILJØLABORATORIET
FFITOX

ANALYSIS OF SAMPLES FOR CONTENT OF HYDROCARBONS

FFITOX/ANALYSERAPPORT-97/009

ANALYSIS OF SAMPLES FOR CONTENT OF HYDROCARBONS

Client: Forsvarets forskningsinstitutt
Address: P.O. Box 25, N-2007 KJELLER
Sample types: Soil and water
Number of samples: 21
Samples received: 17 December 1996 and 15 January 1997
Comments: The samples has been stored in room temperature from 26 September 1996 until received.

The analysis report deals with the following analyses:

Analysis-parameter	Method-identity	Accredited	Measure range	Uncertainty, %	Date of analysis
THC	B1	Yes	0,060 - 2,4 mg/l	10	1 feb 1997
THC	B2	Yes	30 - 1200 mg/kg	10	19 feb 1997

The analysis report has a total of 4 pages.

The analysis report relates only to the samples as they were received at the laboratory. The report should not be reproduced except in full without the written approval by the Norwegian Defence Research Establishment. The samples will be kept for two months. Any complaints should be forwarded to the laboratory within one month from the receipt of this report.

Kjeller, 4. April 1997

Bjørn A Johnsen
Director of Research

Arnt Johnsen
Senior Scientist

ANALYSIS OF SAMPLES FOR CONTENT OF HYDROCARBONS

Intrument: Gas chromatograph, autosystem, Perkin Elmer (FID) for analysis of THC in soil
Operator: Arnt Johnsen

Internal id.	External id.	mg/kg dry soil
96-525	Viestura prospect, 5-6 m, #12	3200
96-528	Viestura prospect, 4.6 m, #13	47000
96-534	Viestura prospect, 25 cm, no 32 A, oil layer	420
96-541	Valmieras, Bore 1, 2 m	< 30
96-542	Valmieras, Bore 2, 4.3 m, groundwater	< 30
96-543	Valmieras, Bore 3, 5 m	11000
96-544	Valmieras, Bore 4, 5 m	< 30
96-545	Valmieras, Bore 4, 6 m	< 30
96-546	Valmieras, II-7A, 25 cm	15000
96-548	Valmieras, II-9, 25 cm	8500
96-550	Valmieras, II-16, 25 cm	120

ANALYSIS OF SAMPLES FOR CONTENT OF HYDROCARBONS

Intrument: Gas chromatograph, autosystem, Perkin Elmer (FID) for analysis of THC in water
Operators: Arnt Johnsen

Internal id.	External id.	mg/l
96-513	Viestura prospect, # 1	< 0.06
96-514	Viestura prospect, # 2	0.45
96-515	Viestura prospect, # 6	2.6
96-516	Viestura prospect, # 7	0.22
96-518	Viestura prospect, # 14	1.1
96-521	Viestura prospect, # P2	0.32
96-522	Viestura prospect, # 222 A	< 0.06
97-10	Valmieras, # 2	0.33
97-11	Valmieras, # 3	0.11
97-12	Valmieras, # 4	0.32

FORSVARETS FORSKNINGSINSTITUTT
Norwegian Defence Research Establishment
Division for Environmental Toxicology

Date
3 April 1997
Our reference
96/01321-6/FFITOX/AJo/204.4
Previous reference

FFITOX
Att:John Tørnes
P.O. Box 25
N-2007 KJELLER

ANALYSIS OF HYDROCARBONS IN SOIL SAMPLES WITH TEST KIT

The table shows the result from analysis of soil samples with ENSys test kit for hydrocarbons.

External id.	mg/kg
Viestura prospect, # 12, 5-6 m	> 2000
Viestura prospect, # 12, 7-8 m	100 - 400
Viestura prospect, # 13, 4.6 m	> 2000
Viestura prospect, # 13, 6-6.7 m	< 100
Viestura prospect, # 14, 3.5 m	100-400
Viestura prospect, # 14, 7.5 m	< 100
Viestura prospect, # 15, 4.5 m	< 100
Viestura prospect, # 15, 6.0 m	> 2000

Arnt Johnsen
Senior Scientist

Enclosures: 0

Exec officer : Arnt Johnsen   Direct : 63 80 78 33   Telefax : + 47 63 80 78 11
Address : P. O. Box 25, N-2007 Kjeller, Norway   Telephone : + 47 63 80 70 00   V.A.T reg. No. : NO 970 963 340 V.A.T

FORSVARETS FORSKNINGSINSTITUTT
Norwegian Defence Research Establishment
Division for Environmental Toxicology

Date
24 September 1997
Our reference
97/00339-19/FFITOX/AJo/138.22
Previous reference

KOPI

1997

FFITOX
Att:Bjørn A Johnsen
P.O. Box 25
N-2007 KJELLER

ANALYSIS OF WATER AND SOIL SAMPLES FOR CONTENT OF HYDROCARBONS

Due to contamination of Si-columns used to clean-up the extract of water samples, the samples are reportet with too high concentration of THC. Investigations at our laboratory show that the results are approximately 0.18 mg/l too high. The results are therefore corrected for this in the new report. The earlier report should be marked with "Replaced with amended Analysis report no 97/015".

Sincerely,

Arnt Johnsen

Arnt Johnsen
Senior Scientist

Enclosures: 1

Exec officer : Arnt Johnsen
Address : P. O. Box 25, N-2007 Kjeller, Norway
Direct : 63 80 78 33
Telephone : + 47 63 80 70 00
Telefax : + 47 63 80 78 11
V.A.T reg. No. : NO 970 963 340 V.A.T

Amendment to Analysis report no 97/013
Analysis of samples from Latvia

Customer:	Forsvarets forskningsinstitutt	Number of samples:	21
Address:	Postboks 25, N-2007 KJELLER	Date received:	21.06.97
		Sample type:	Soil and water

Comments: The samples has been stored in room temperature from 16 june 1997 until received

The analysis report applies to the following analyses:

Parameter of analysis	Identity of method	Accredited analysis	Range of measure	Uncertainty, %	Date of analysis
THC	B1	Yes	0.060 - 2.4 mg/l	10	30 june 97
THC	B2	Yes	30 - 1200 mg/kg	10	9 july 97

The analysis report has a total of 3 pages, including potential appendices. The analysis report applies only to the samples as they were received by the Norwegian Defence Research Establishment (FFI). The report can not be reproduced except in full without the written approval of FFI. The methods of analysis can be requested from the laboratory. The samples will be kept for 2 months. The period for entering a complaint is 1 month.

Kjeller, 24 September 1997

Bjørn Arne Johnsen
Acting Director of Research

Arnt Johnsen
Senior Scientist

ANALYSIS OF THC IN WATER

Instrument: Gas Chromatograph, Autosystem, Perkin Elmer for analysis of THC.
Operator: Marita Ljønes

Internal id.	External id.	mg/l
97-158	Valmieras Iela, Borehole 3, oil layer on water surface	820000
97-169	Valmieras Iela, Borehole 2	0.29
97-170	Valmieras Iela, Borehole 5	1.2
97-171	Valmieras Iela, Borehole 3	1.4
97-172	Viestura prospect II, Borehole 11	2.1
97-173	Viestura prospect II, Borehole 1	15
97-174	Viestura prospect II, Borehole 3	5.0
97-175	Viestura prospect II, Borehole 14	12
97-176	Viestura prospect II, Borehole 10	1.2
97-177	Viestura prospect II, Borehole 12	14
97-178	Viestura prospect II, Borehole 8	0.45
97-179	Viestura prospect II, Borehole 9	0.90
97-180	Viestura prospect II, Borehole 7	16
97-181	Viestura prospect II, Borehole 222A, (Meza Parks)	0.21
97-182	Valmieras Iela, Borehole 4	1.9

ANALYSIS OF THC IN SOIL

Intrument: Gas Chromatograph, Autosystem, Perkin Elmer for analysis of THC.
Operator: Marita Ljønes

Internal id.	External id.	mg/kg dry soil
97-132	Valmieras no. 9	8400
97-133	Valmieras no. 16	710
97-136	Viesturas prospect II no. 32A	6000
97-137	Viesturas prospect II no. 32 A, black soil	4800
97-156	Valmieras Iela no. 8	6000
97-157	Valmieras Iela no. 7	1200

FORSVARETS FORSKNINGSINSTITUTT
Norwegian Defence Research Establishment
Division for Environmental Toxicology

KOPI

Date
18 July 1997
Our reference
97/00339-14/FFITOX/AJo/138.22
Previous reference

Original (uncorrected) version

FFITOX
Att:Bjørn A Johnsen
P.O. Box 25
N-2007 KJELLER

ANALYSIS OF WATER AND SOIL SAMPLES FOR CONTENT OF HYDROCARBONS

Enclosed you will find our analysis report with the result from the analysis of water and soil samples for content of hydrocarbons. The report has our internal report number FFITOX/ANALYSERAPPORT-97/013. The oil in samples from Valmieras iela is similar to diesel. The oil in samples from Viestura prospect II is more similar to jet fuel or paraffin. There is little or no signs of degradation of the oil in water samples and the soil sample from Viestura prospect II. There is distinct signs of degradation of the oil in soil samples from Valmieras iela.

Arnt Johnsen

Arnt Johnsen
Senior Scientist

Enclosures: 1

Exec officer : Arnt Johnsen | Direct : 63 80 78 33 | Telefax : + 47 63 80 78 11
Address : P. O. Box 25, N-2007 Kjeller, Norway | Telephone : + 47 63 80 70 00 | V.A.T reg. No. : NO 970 963 340 V.A.T

ANALYSIS REPORT

FROM
MILJØLABORATORIET
FFITOX

ANALYSIS OF SAMPLES FOR CONTENT OF HYDROCARBONS

FFITOX/ANALYSERAPPORT-97/013

FORSVARETS FORSKNINGSINSTITUTT
Norwegian Defence Research Establishment
Postboks 25, 2007 Kjeller, Norge

ANALYSIS OF SAMPLES FOR CONTENT OF HYDROCARBONS

Client: Forsvarets forskningsinstitutt, Bjørn A Johnsen
Address: P.O. Box 25, N-2007 KJELLER
Sample types: Water and soil
Number of samples: 21
Samples received: 23. June 1997
Comments: The samples has been stored in room temperature from 16 june 1997 until received

The analysis report deals with the following analyses:

Analysis-parameter	Method-identity	Accredited	Measure range	Uncertainty, %	Date of analysis
THC	B1	Yes	0,060 - 2,4 mg/l	10	30 june 1997
THC	B2	Yes	30 - 1200 mg/kg dry soil	10	9 july 1997

The analysis report has a total of 4 pages.

The analysis report relates only to the samples as they were received at the laboratory. The report should not be reproduced except in full without the written approval by the Norwegian Defence Research Establishment. The samples will be kept for two months. Any complaints should be forwarded to the laboratory within one month from the receipt of this report.

Kjeller, 22. July 1997

Bjørn A Johnsen
Director of Research

Arnt Johnsen
Senior Scientist

ANALYSIS OF SAMPLES FOR CONTENT OF HYDROCARBONS

Intrument: Gas chromatograph, autosystem, Perkin Elmer (FID) for analysis of THC in water
Operator: Marita Ljønes

Internal id.	External id.	mg/l
97-158	Valmieras Iela, Borehole 3, oil layer on water surface	820000
97-169	Valmieras Iela, Borehole 2	0,47
97-170	Valmieras Iela, Borehole 5	1,4
97-171	Valmieras Iela, Borehole 3	1,6
97-172	Viestura prospect II, Borehole 11	2,3
97-173	Viestura prospect II, Borehole 1	15
97-174	Viestura prospect II, Borehole 3	5,2
97-175	Viestura prospect II, Borehole 14	12
97-176	Viestura prospect II, Borehole 10	1,4
97-177	Viestura prospect II, Borehole 12	14
97-178	Viestura prospect II, Borehole 8	0,63
97-179	Viestura prospect II, Borehole 9	1,1
97-180	Viestura prospect II, Borehole 7	16
97-181	Viestura prospect II, Borehole 222A, (Meza Parks)	0,39
97-182	Valmieras Iela, Borehole 4	2,1

ANALYSIS OF SAMPLES FOR CONTENT OF HYDROCARBONS

Intrument: Gas chromatograph, autosystem, Perkin Elmer (FID) for analysis of THC in soil
Operators: Marita Ljønes

Internal id.	*External id.*	*mg/kg dry soil*
97-132	Valmieras no. 9	8400
97-133	Valmieras no. 16	710
97-136	Viesturas prospect II no. 32A	6000
97-137	Viesturas prospect II no. 32 A, black soil	4800
97-156	Valmieras Iela no. 8	6000
97-157	Valmieras Iela no. 7	1200

SINTEF

SINTEF Kjemi

Adresse/Address:
Postboks 124 Blindern
N-0314 Oslo 3, NORWAY

Besøksadresse/Location:
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+47 22 06 73 00

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71 536 SI N

Forsvarets Forskningsinstitutt
Avd. for miljøtoksikologi
Postboks 25
2007 Kjeller

Att. John Aa Tørnes

Rapport

Deres ref.:	Vår ref.:	Direkte innvalg:	Oslo,
best.nr. 61960941 96/01321-5/FFITOX /JAT/204.4 Lat	ori\ffi3481r	22 06 74 87	1996-10-29

Oppdrag nr.:
664034.81
Prøveserie.:
1996-657

Oppdragets tittel:

FLYKTIGE ORGANISKE FORBINDELSER (VOC) I VANN

Innledning

Følgende prøver ble mottatt den 08.10.96 for kjemisk analyse med henblikk på innhold av flyktige organiske forbindelser.

Oppdrags-givers merking	SINTEF serienr. 1996-	Prøvetype	Analyse
# 2	657-1	vann	headspace-GC/MS
# 6	657-2	- " -	- " -
# 8	657-3	- " -	- " -
# 15	657-4	- " -	- " -

Eksperimentelt

Prøvene ble analysert innen 24 timer etter prøvemottak.

Prøvene ble analysert med en headspace-GC/MS teknikk (screening av VOC). 20 ml prøve ble overført til et headspace glass, og tilsatt indre standarder. Glasset med innhold ble forseglet og satt i ovn ved 40oC. En delprøve av atmosfæren i glasset ble tatt ut med en forvarmet, gasstett sprøyte og analysert med GC/MS (Ion Trap massespektrometer).

Påviste forbindelser ble identifisert utfra kromatografiske retensjonstider og opptatte massespektre. Forbindelsene ble kvantifisert ved sammenligning av detektorrespons til forbindelser og indre standarder.

Resultater

Resultatene er tabellført under.
B = benzen, T = toluen, EX = etylbenzen og xylen

Prøve J.nr.	SINTEF Kjemi serienr.	B	T	EX	Sum C3-C4 benzener *	Sum halo-former
	1996-657	µg/l (ppb)				
# 2	1	95	30	330	1.400	ip
# 6	2	1,5	0,2	1.600	2.900	ip
# 8	3	0,15	<0,05	0,7	8	ip
# 15	4	20	1,0	430	1.500	ip
Deteksjons-grense		0,1	0,05	0,1	2	**

ip = ikke påvist
* = Sum C3- C4 benzener er sum av alkylbenzener med karbontall C9 og C10.
** = Deteksjonsgrense haloformer, se under.

Følgende halogenerte C1-C2 alifater ble undersøkt:

Forbindelse	Deteksjons-grense		Forbindelse	Deteksjons-grense
	µg/l (ppb)			µg/l (ppb)
Triklormetan	0,05		Dikloreten	0,05
Diklorbrommetan	0,05		Trikloreten	0,05
Klordibrom-metan	0,2		Tetrakloreten	0,05
Tribrommetan	0,4		1,1,1-trikloretan	0,05
Tetraklor-metan	0,1		Heksakloretan	0,4

Kommentarer

Kromatogrammene som fremkom ved analysene er vedlagt.
Samtlige prøver inneholdt hydrokarboner som kan stamme fra et oljedestillat.
Det var ikke mulig ut fra en headspace analyse alene å identifisere mulig kilde.

Med hilsen
SINTEF Kjemi

Nina Gjøs
Laboratorieleder
Miljøteknologi og analyse

Oddvar Ringstad
Prosjektleder

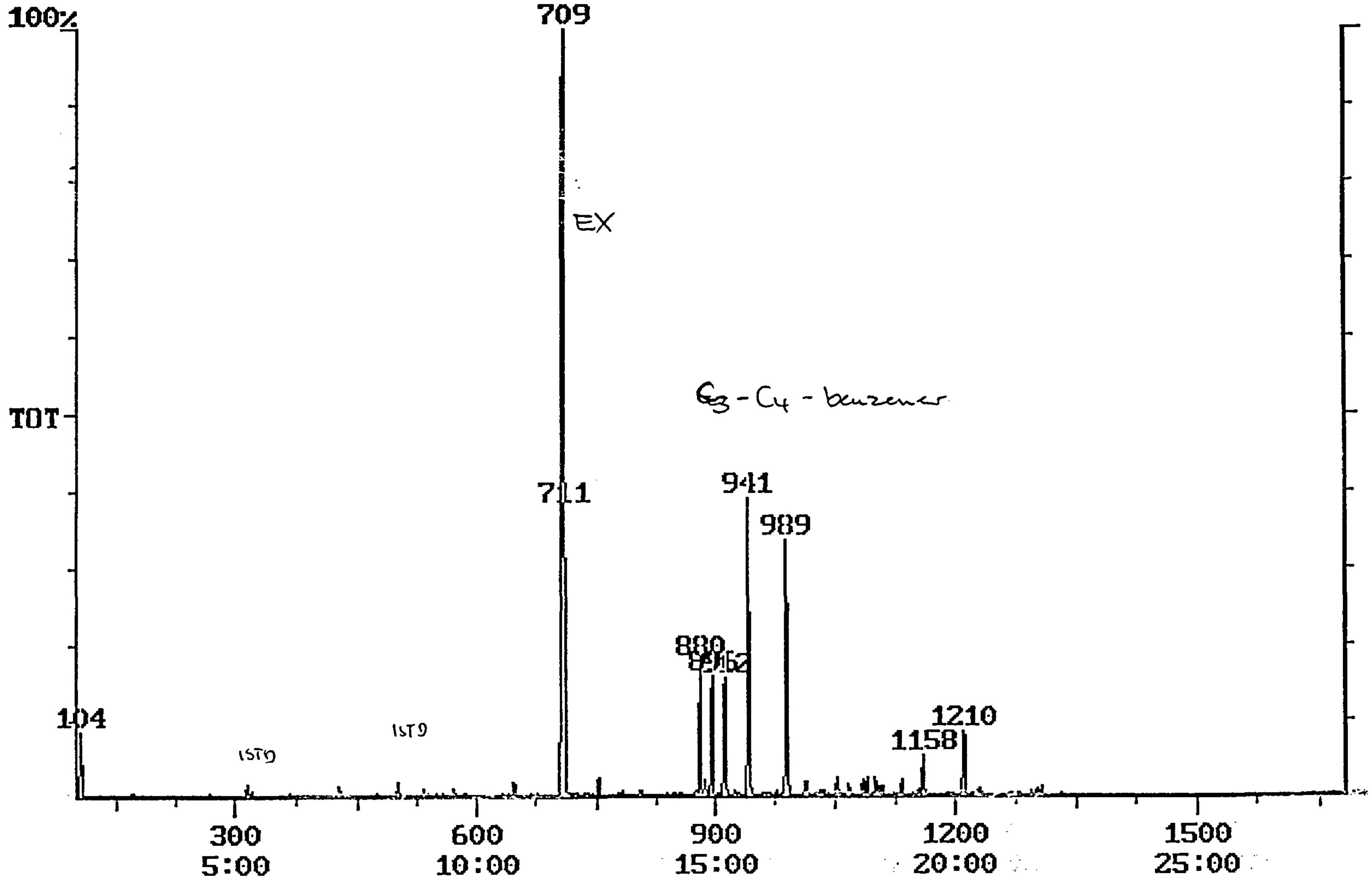
Vedlegg: Kromatogrammer

Spesielle betingelser

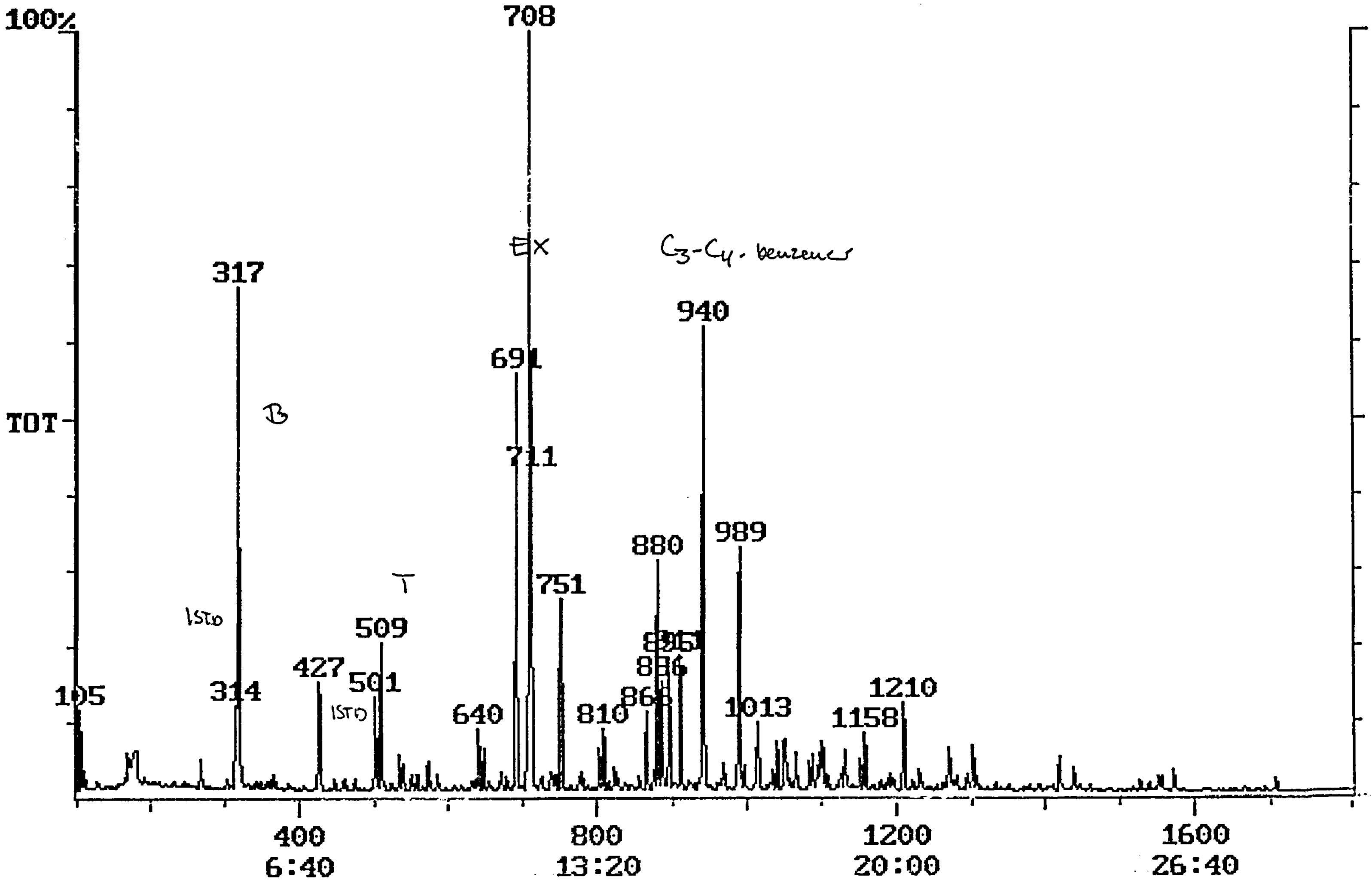
Resterende prøvemateriale oppbevares på SINTEF Industriell kjemi i 6 måneder etter at oppdraget er utført om ikke annet avtales med oppdragsgiver. Analyseresultater rapportert i dette dokument er frembragt ved analyse av de anførte prøver i den stand de ble mottatt ved SINTEFs analyselaboratorium. SINTEF tar intet ansvar for oppdragsgivers bruk av resultatene eller for konsekvenser av slik bruk. *Delvis* kopiering av denne rapport er ikke tillatt uten skriftlig samtykke fra SINTEF.

I dette tilfellet er prøvematerialet benyttet i sin helhet.

Chromatogram Plot   C:\ITS40\DATA\FF1657H2   Date: 10/09/96 10:54:17
Comment: 1996-657 FFI VANN\LOSEMIDDELRESTER   HSP\VOC8 X2
Scan No: 1678   Retention Time: 27:58   RIC: 1870   Mass Range: 45 - 281
Plotted: 100 to 1678   Range: 1 to 1678   100% =

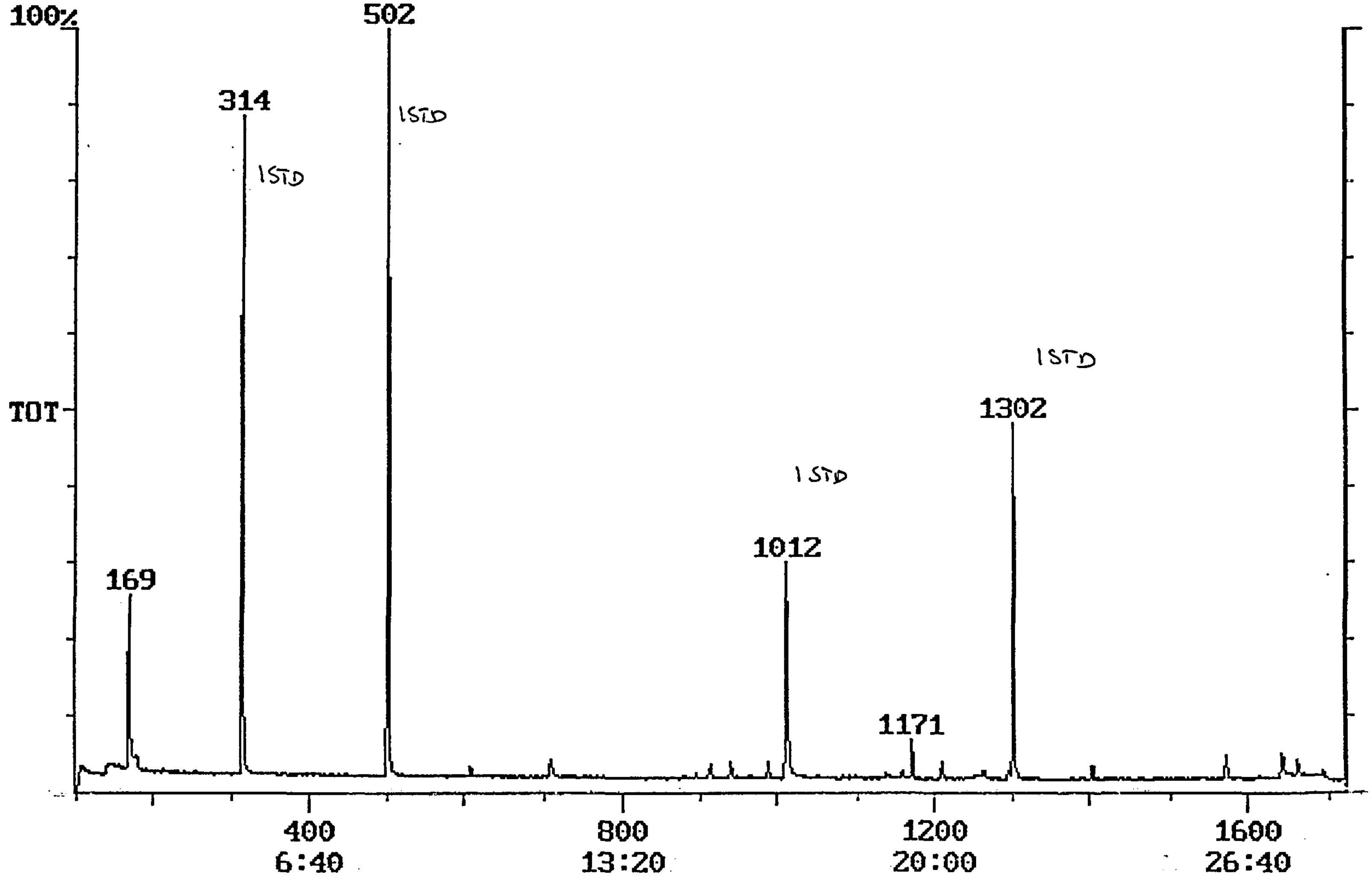


Chromatogram Plot C:\ITS40\DATA\FF1657H1 Date: 10/09/96 10:12:44
Comment: 1996-657 FFI VANN\LOSEMIDDELRESTER HSP\VOC8 X2
Scan No: 100 Retention Time: 1:40 RIC: 0 Mass Range: 0 - 0
Plotted: 100 to 1800 Range: 1 to 1800 100% =



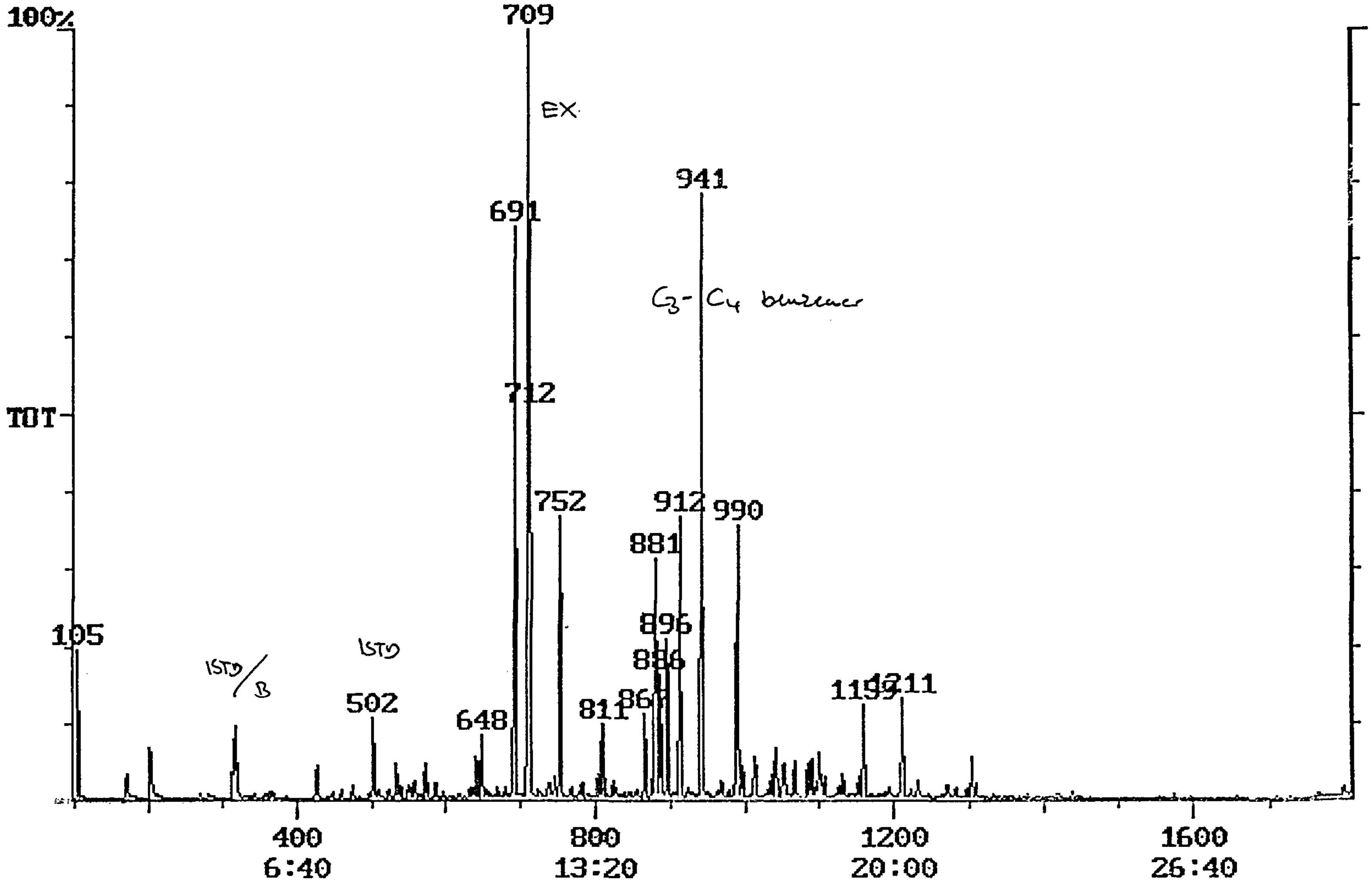
6640324.81
Vedlegg: Headspace-GC/MS av #2

Chromatogram Plot C:\ITS40\DATA\FF1657H3 Date: 10/09/96 11:30:01
Comment: 1996-657 FFI VANN\LOSEMIDDELRESTER HSP\VOC8 X2
Scan No: 1719 Retention Time: 28:39 RIC: 949 Mass Range: 45 - 207
Plotted: 100 to 1719 Range: 1 to 1719 100% =



664034.81
Vedlegg: Headspace - GC/MS av # 8

Chromatogram Plot C:\ITS40\DATA\FF1657H4 Date: 10/09/96 12:00:36
Comment: 1996-657 FFI VANN\LOSEMIDDELRESTER HSP\VOC8 X2
Scan No: 1799 Retention Time: 29:59 RIC: 3566 Mass Range: 45 - 281
Plotted: 100 to 1799 Range: 1 to 1799 100% =



664036.81
Vedlegg: Headspace. GC/MS av # 15

FORSVARETS FORSKNINGSINSTITUTT
Avdeling for miljøtoksikologi

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	Saksbehandler	: Arve Misund
	Telefax	: 73 92 16 20

FRA				
	Saksbehandler	: Arnt Johnsen	Telefon	: 63 80 78 33
	Dato	: 24 juli 1997	Telefax	: 63 80 78 11
	Adresse	: Postboks 25, 2007 Kjeller	Mil retn nr	: 505

SAK

Analyse av flyktige forbindelser i vannprøve fra Latvia

To prøver ble sendt til SINTEF for analyse av flyktige forbindelser. Vedlagt analyserapport fra SINTEF. En vannprøve fra brønn nr 2 og en oljeprøve fra brønn 3 ved Valmieras iela. Det ble ikke funnet klorerte løsemidler og lave konsentrasjoner av aromater i vannet. Det bemerkes at vannprøvene ikke var tatt med formål for denne type analyse.

Med hilsen

Arnt Johnsen

Arnt Johnsen

Antall sider inkl denne: 3

Ved manglende sider ring: 63 80 78 33

SINTEF

SINTEF Kjemi

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Postboks 124 Blindern
N-0314 Oslo 3, NORWAY

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Forskningsveien 1

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+47 22 06 73 00

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71 536 SI N

Foretaksregisteret:
NO 948 007 029 MVA

Forsvarets Forskningsinstitutt
Avd. for miljøtoksikologi
Postboks 25,
2007 Kjeller

Att. Arnt Johnsen

Rapport

Deres ref.:	Vår ref.:	Direkte innvalg:	Oslo,
96/01321-8/FFITOX/AJo/204.4 Lat Best.nr. 61970478	ori\ffi7925r	22 06 74 87	1997-07-02

Oppdrag nr.:
664079.25

Oppdragets tittel:
Innhold av VOC i vann og diesel

Prøveserie:
1997-430

Sammendrag

Det ble ikke påvist klorerte løsemidler i prøvene. Vannprøven inneholdt spor av alkylerte benzener

Innledning

Følgende prøver ble mottatt 27.06.97 for analyse med henblikk på innhold av flyktige organiske forbindelser (VOC), med spesiell vekt på klorerte løsemidler og flyktige aromater.

Prøvemerking	SINTEF Serienr. 1997-	Prøvetype
Valmerias/Ela, brønn 2	430-1	vann
Valmerias/Ela, brønn 3 (olje)	430-2	olje (diesel)

Eksperimentelt

Prøvene ble analysert med en headspace GC/MS teknikk.

Vann: En prøve ble overført til et headspaceglass, og tilsatt indre standarder. Glasset med innhold ble forseglet og satt 45 min. ved 90°C. En delprøve av atmosfæren i glasset ble tatt ut med en forvarmet, gasstett sprøyte og analysert med GC/MS. Påviste forbindelser ble

identifsert utfra opptatte massespektre. Forbindelsene ble kvantifisert ved sammenligning av detektorrespons til forbindelser og indre standarder.
Olje: Oljefasen ble analysert med i prinsipp samme teknikk som for vannfasen.

Resultat

Analysene ga følgende resultat

Forbindelse	Brønn 2 (vann)	Det.grense (vann)	Brønn 3 (olje)	Det.grense (olje)
	µg/l		µg/l	
Triklormetan	-	0,02	-	2
Diklorbrommetan	-	0,05	-	2
Klordibrommetan	-	0,05	-	4
Tribrommetan	-	0,30	-	5
Tetraklormetan	-	0,05	-	1
Dikloreten	-	0,04	-	2
Trikloreten	-	0,04	-	1
Tetrakloreten	-	0,02	-	1
1,1,1-trikloretan	-	0,05	-	2
1,1,2-trikloretan	-	0,15	-	4
Heksakloretan	-	0,30	-	5
Benzen	-	0,05	ia	ia
Toluen	0,05	0,05	ia	ia
Etylbenzen og xylener	1,0	0,05	ia	ia
Sum C3-C4-benzener	1,5	0,1	ia	ia

\- = ikke påvist
ia = ikke analysert/bestemt

Kommentarer

Det ble ikke påvist innhold av klorerte løsemidler i noen av prøvene. Vannprøven inneholdt spor av alkylerte benzener. Innhold av benzen og alkylerte benzener er ikke bestemt i oljeprøven, da disse inngår som bestanddeler i oljedestillater av typen diesel.

Med hilsen
SINTEF Kjemi

for
Nina Gjøs
Laboratorieleder
Miljøteknologi og analyse

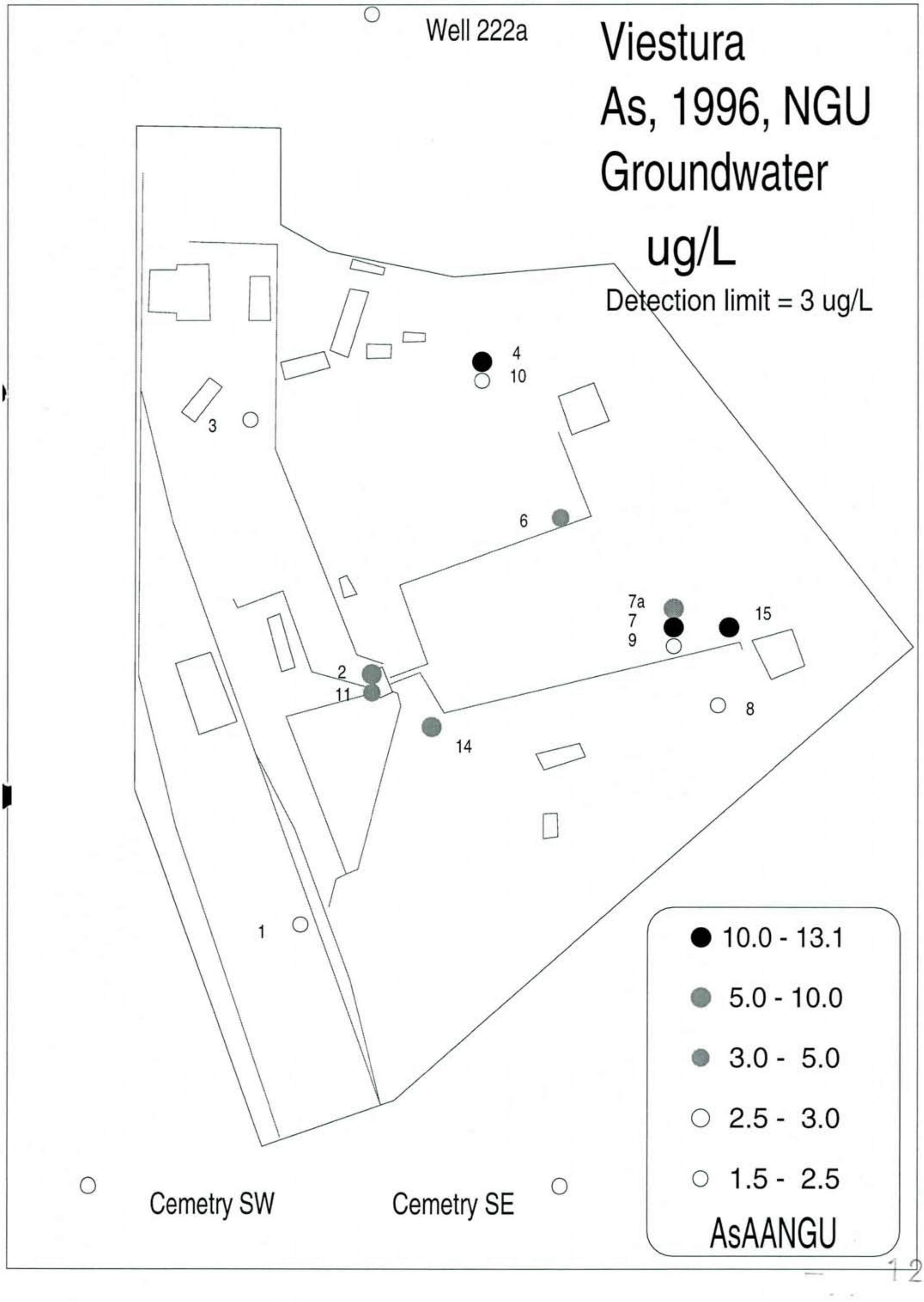
Oddvar Ringstad
Prosjektleder

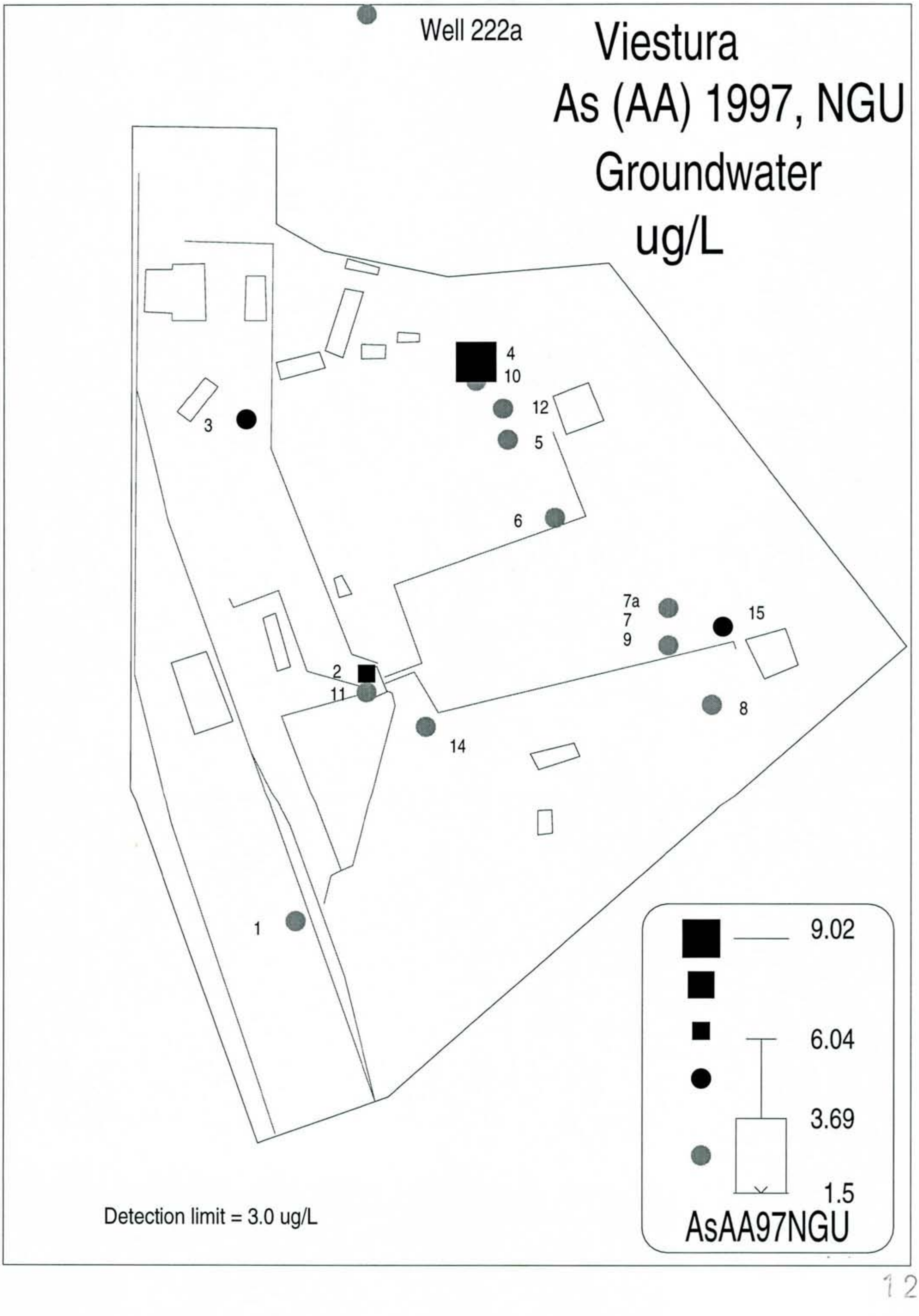
Spesielle betingelser

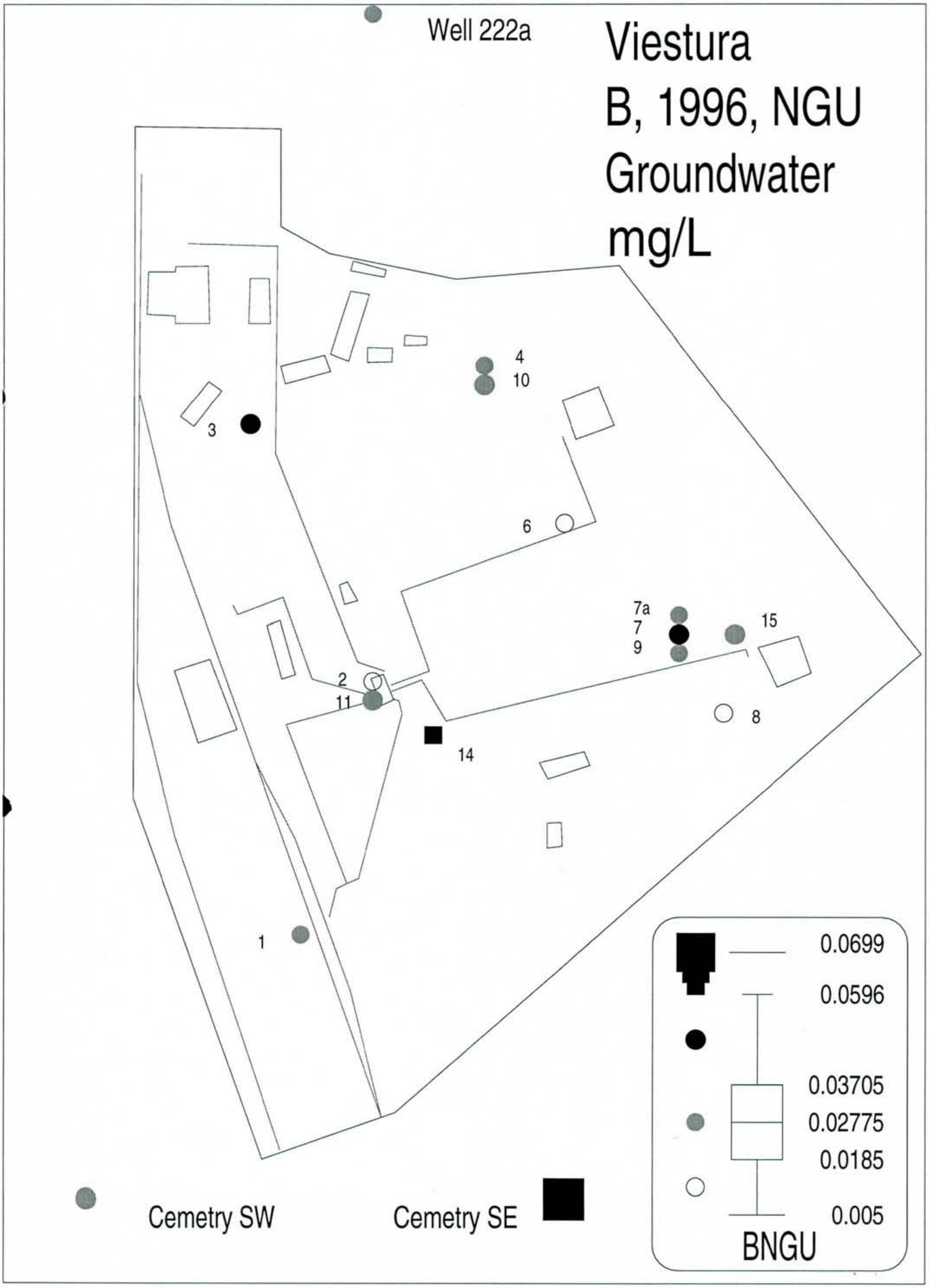
Resterende prøvematerlale oppbevares på SINTEF Kjemi i 6 måneder etter at oppdraget er utført om ikke annet avtales med oppdragsgiver. Analyseresultater rapportert i dette dokument er frembragt ved analyse av de anførte prøver i den stand de ble mottatt. SINTEF Kjemi tar intet ansvar for oppdragsgivers bruk av resultatene eller for konsekvenser av slik bruk. *Delvis* kopiering av denne rapport er ikke tillatt uten skriftlig samtykke fra SINTEF Kjemi.
I dette tilfellet anses prøvematerialet som ikke egnet for videre analyse

Appendix 7:

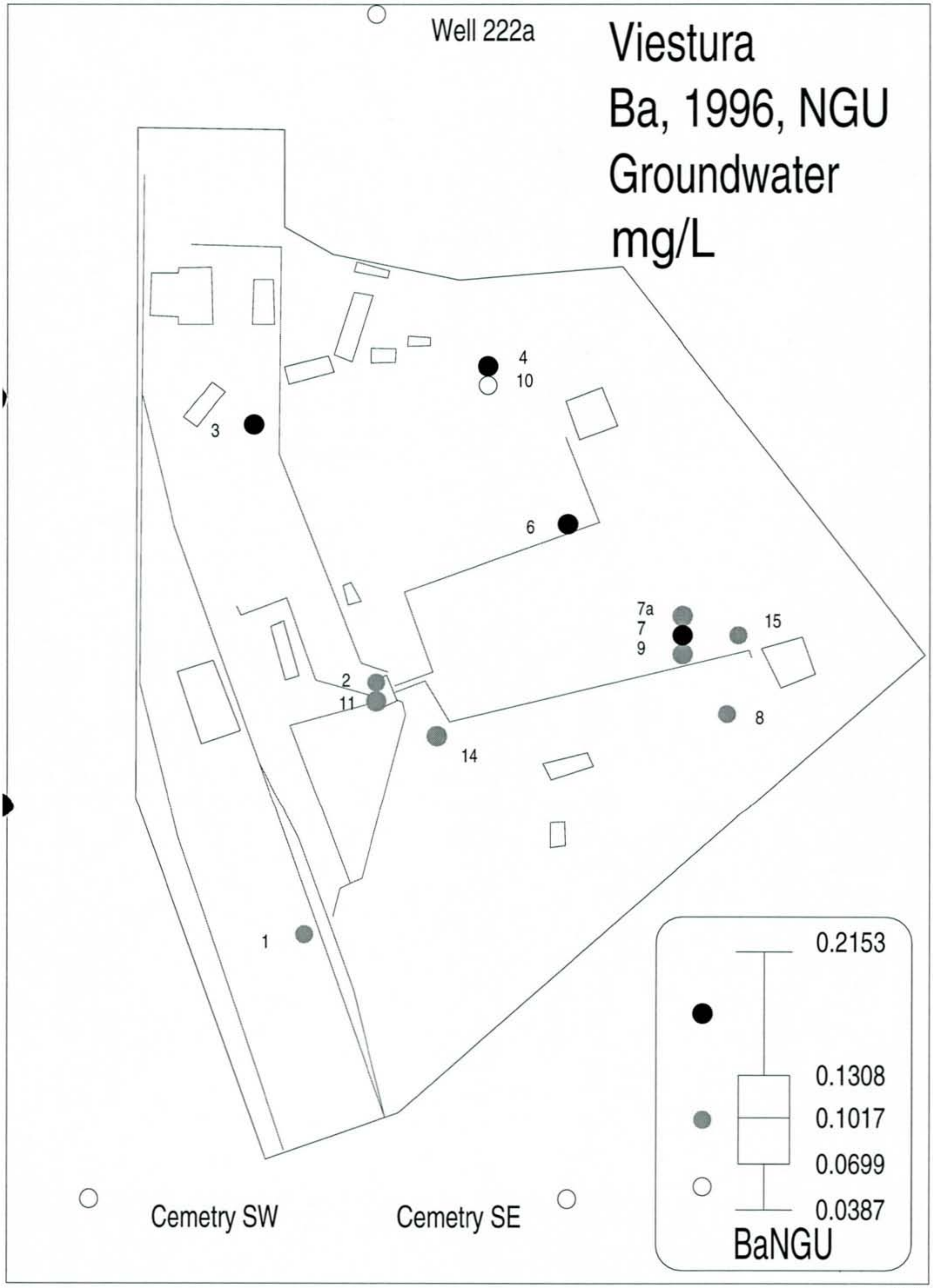
Maps of the Viestura Prospekts site showing concentrations of analysed parameters in groundwater.

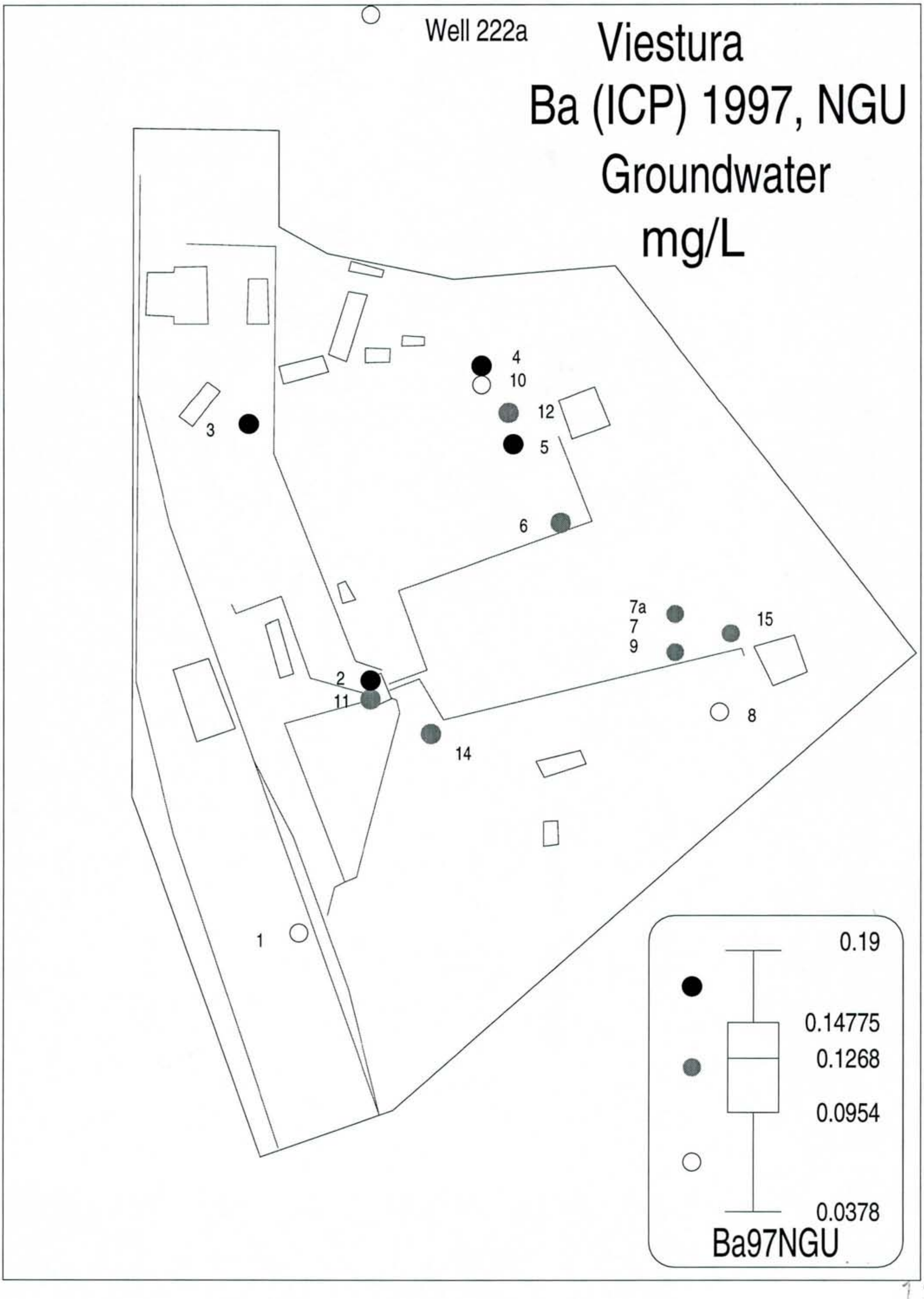

Well 222a
Viestura
As, 1996, NGU
Groundwater
ug/L
Detection limit = 3 ug/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
10.0 - 13.1
5.0 - 10.0
3.0 - 5.0
2.5 - 3.0
1.5 - 2.5
AsAANGU
Cemetry SW
Cemetry SE


Well 222a
Viestura
As (AA) 1997, NGU
Groundwater
ug/L
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
9.02
6.04
3.69
1.5
AsAA97NGU
Detection limit = 3.0 ug/L

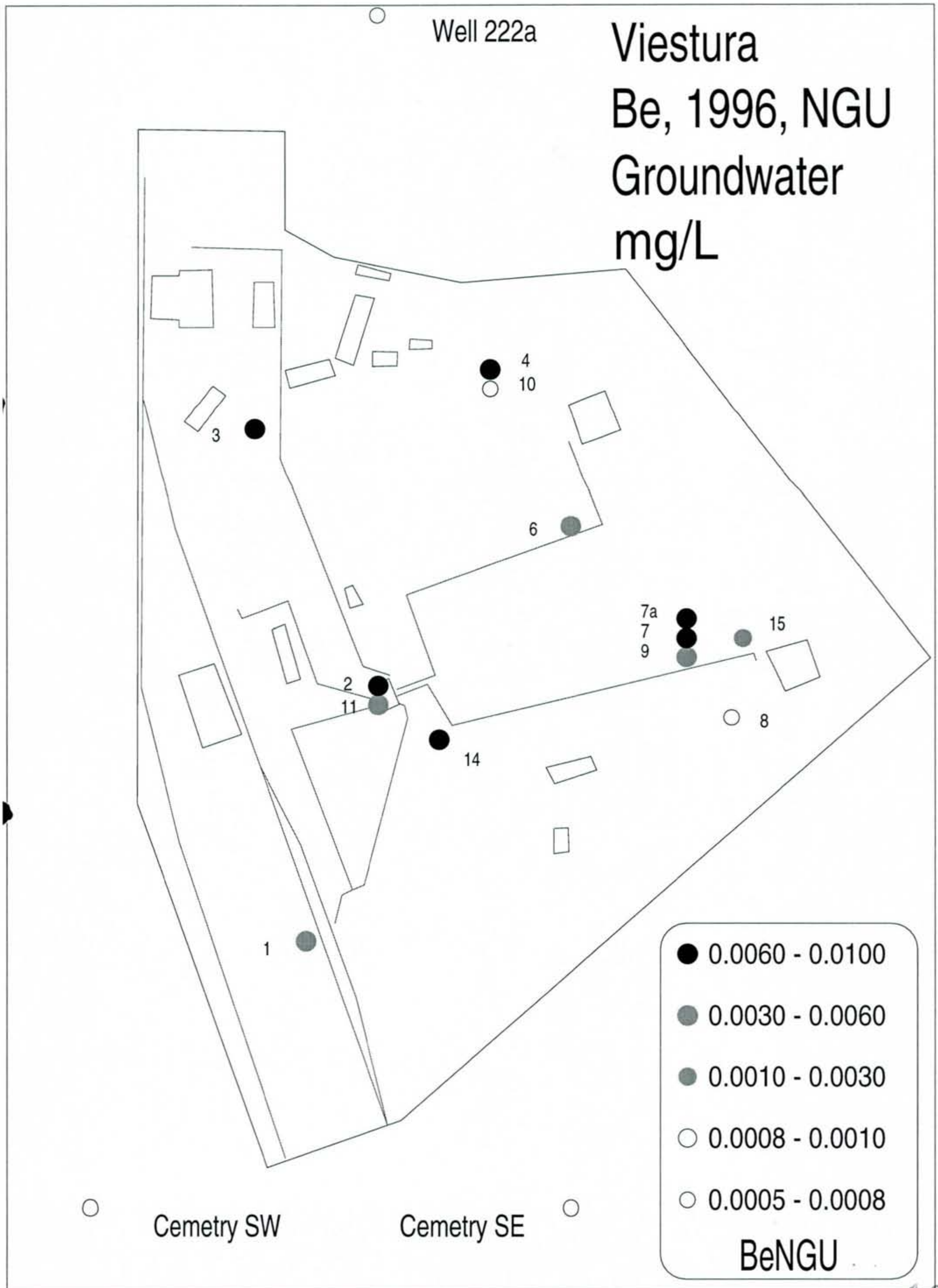


Viestura
B, 1996, NGU
Groundwater
mg/L
Well 222a
4
10
3
6
7a
7
9
15
2
11
8
14
1
Cemetry SW
Cemetry SE
0.0699
0.0596
0.03705
0.02775
0.0185
0.005
BNGU

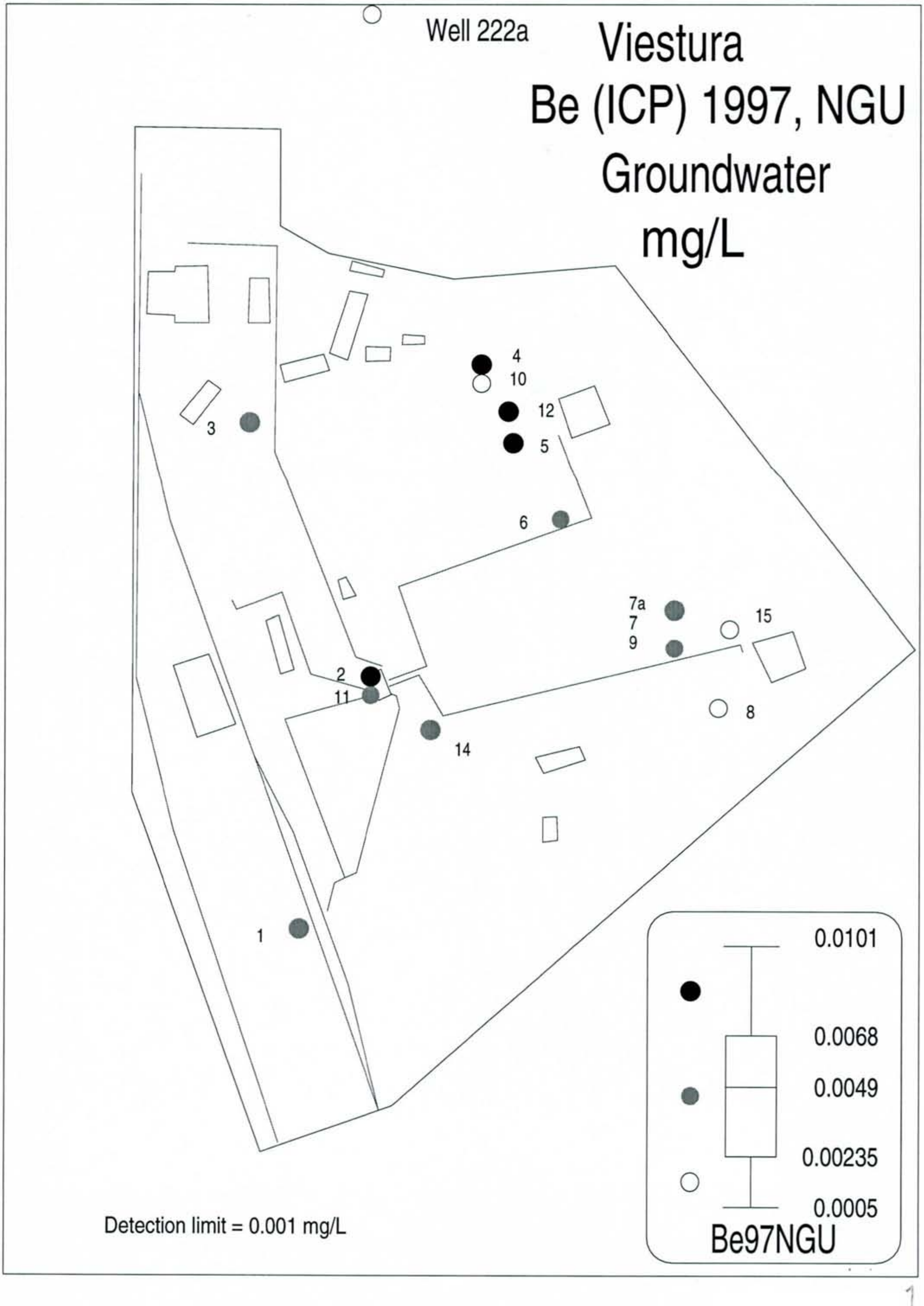

Well 222a
Viestura
Ba, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.2153
0.1308
0.1017
0.0699
0.0387
BaNGU
Cemetry SW
Cemetry SE

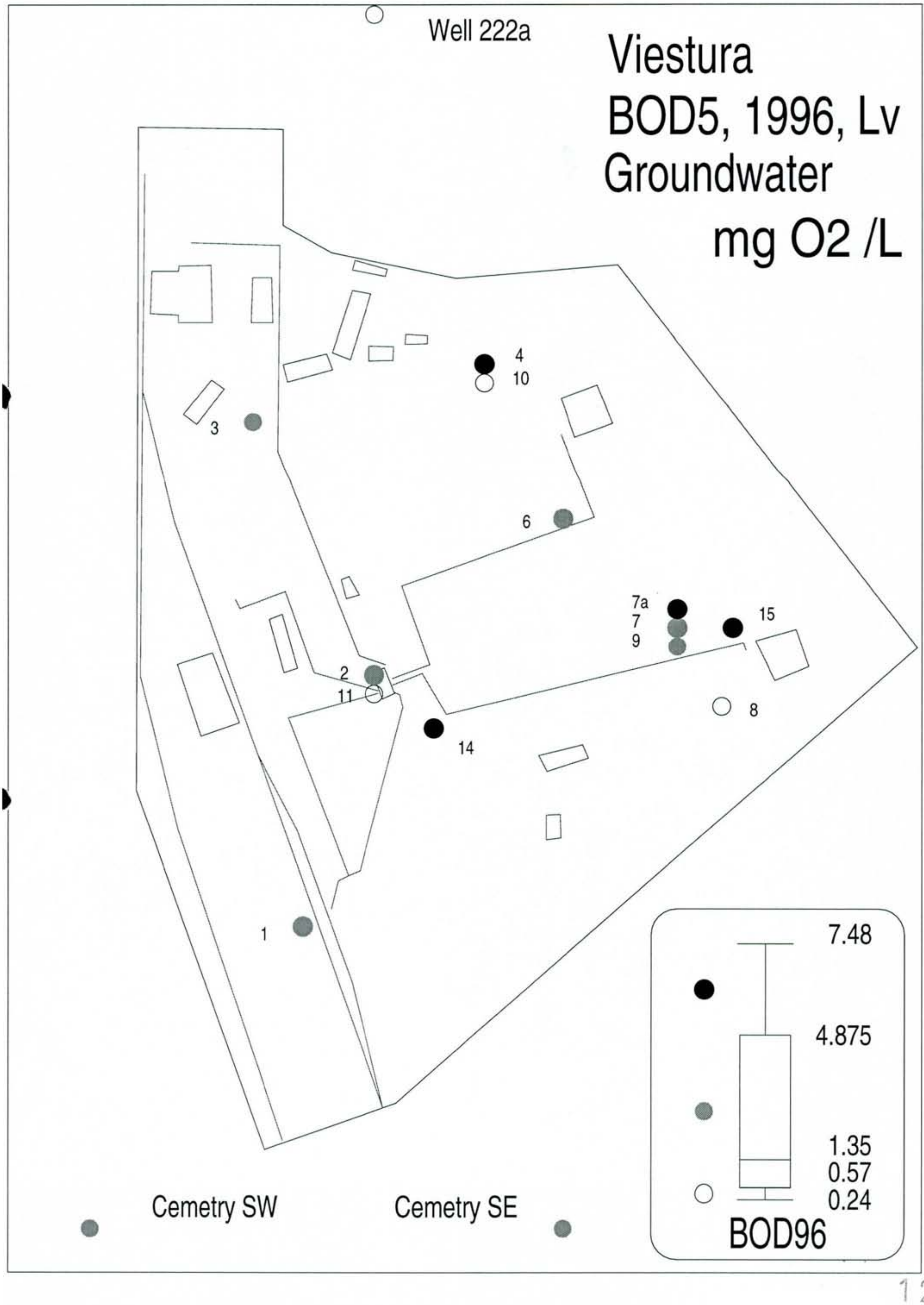

Well 222a
Viestura
Ba (ICP) 1997, NGU
Groundwater
mg/L
1
2
3
4
5
6
7a
7
8
9
10
11
12
14
15
0.19
0.14775
0.1268
0.0954
0.0378
Ba97NGU

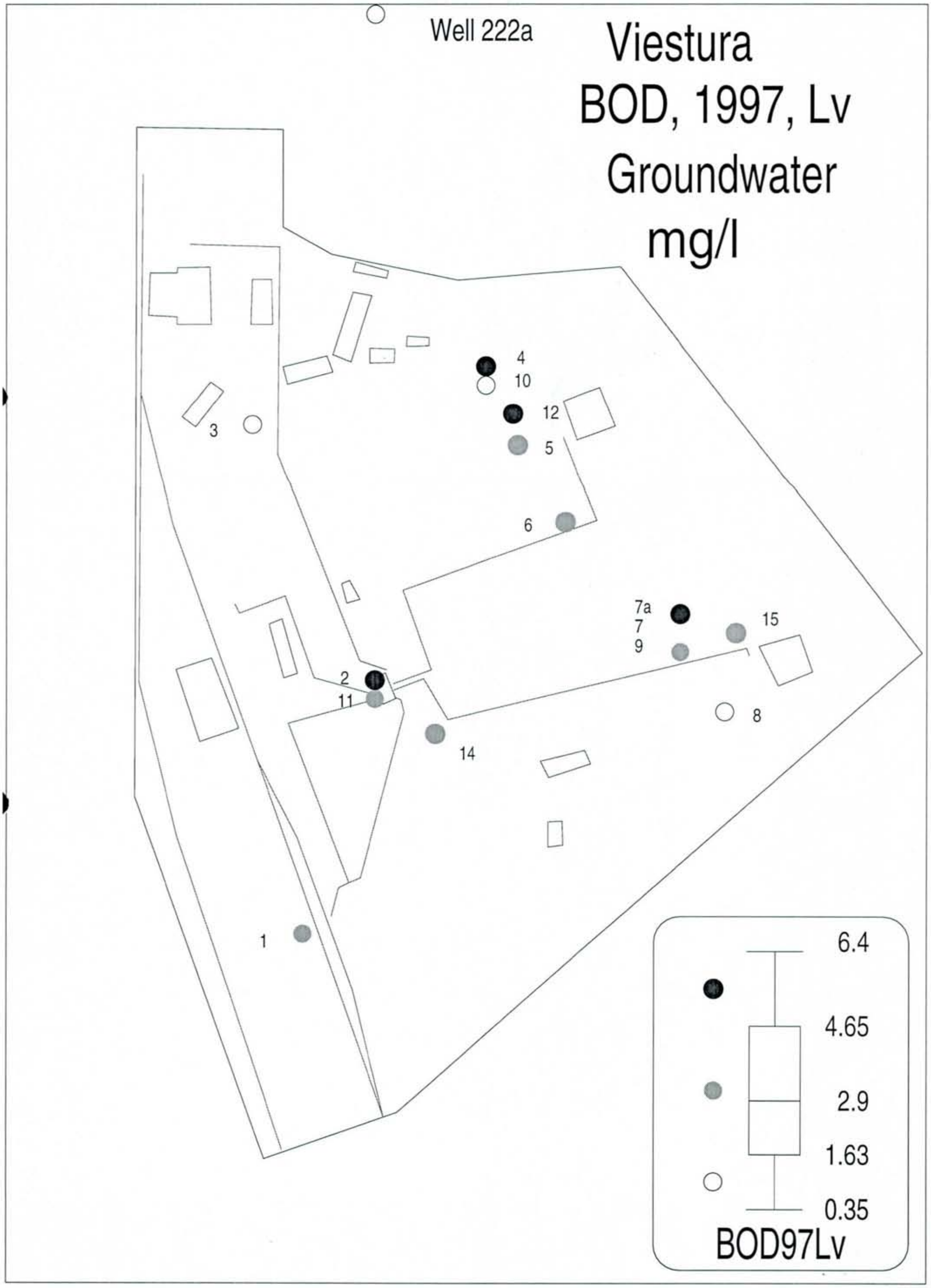
Analysene påvirket av interferense med Fe

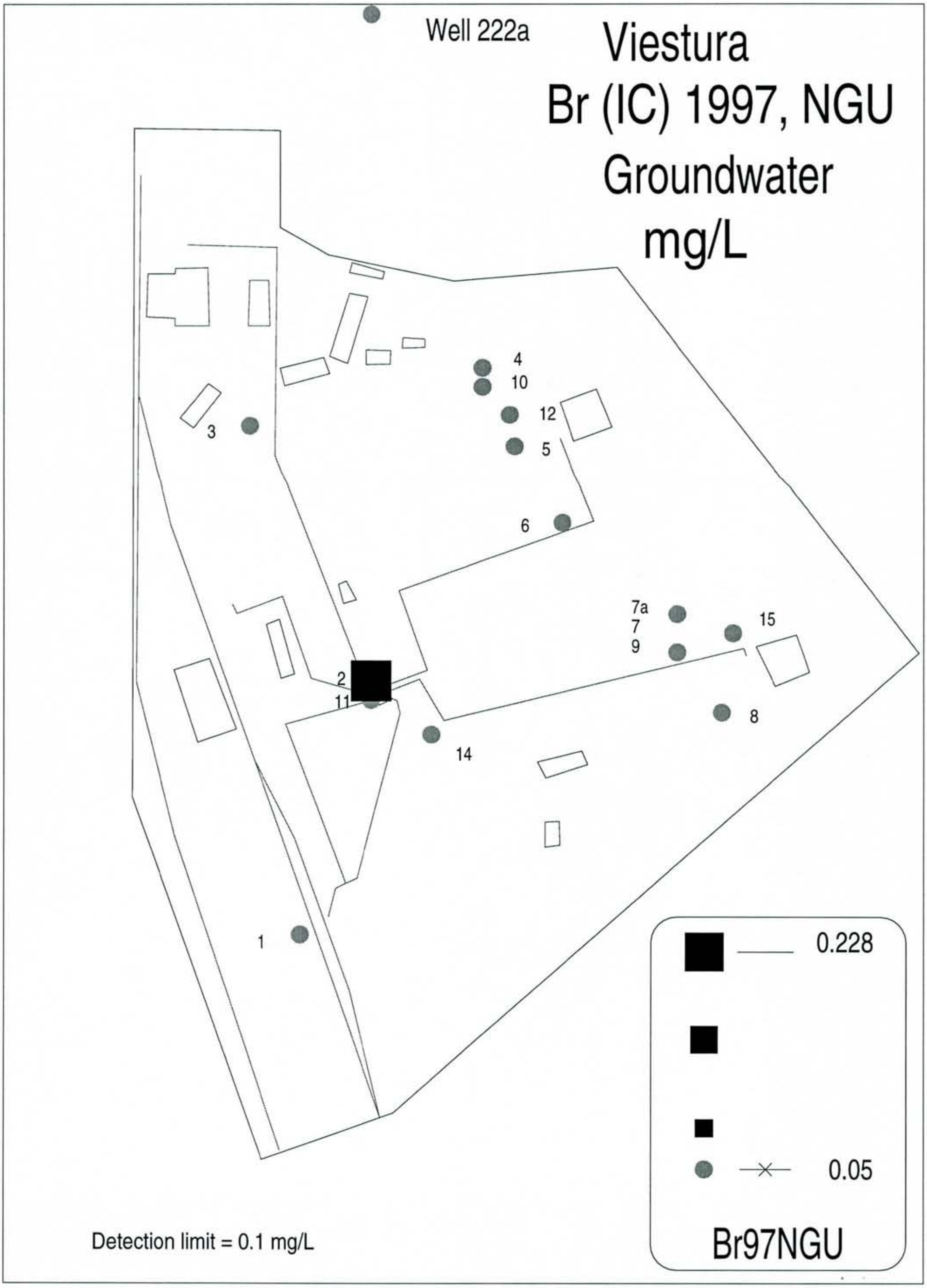


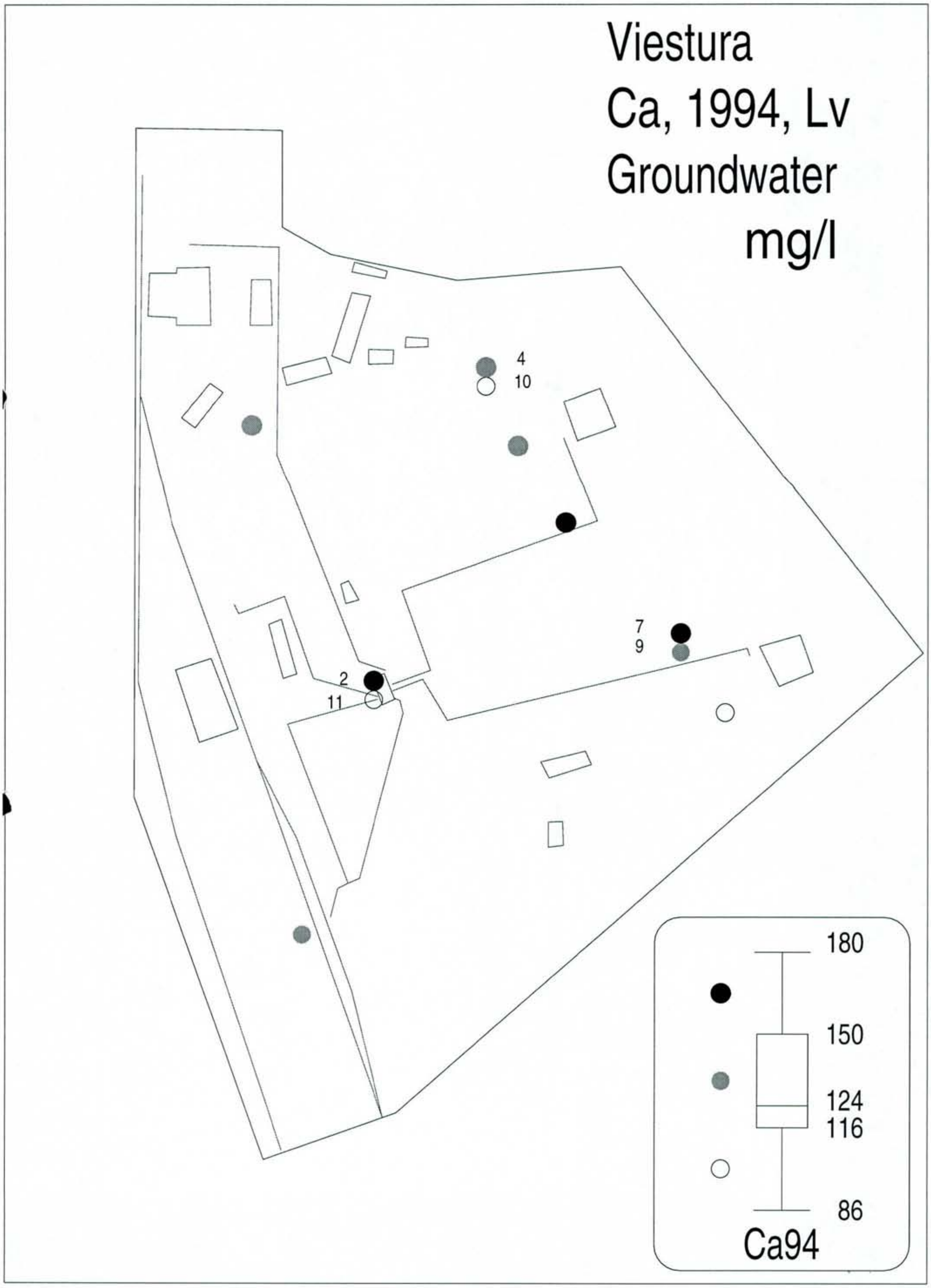
Analysene påvirket av interferense med Fe



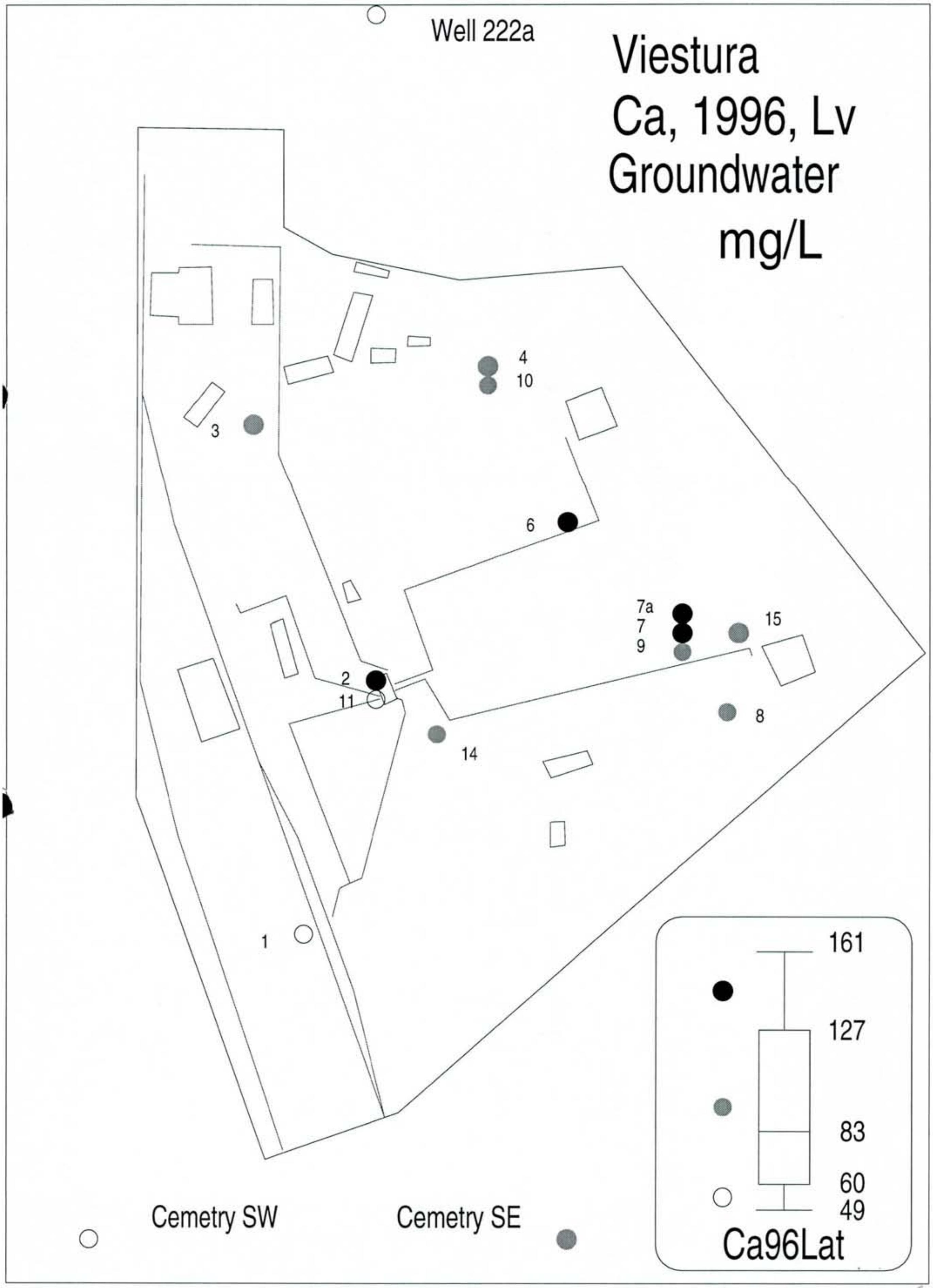

Well 222a
Viestura
BOD5, 1996, Lv
Groundwater
mg O2 /L
4
10
3
6
7a
7
9
15
2
11
8
14
1
7.48
4.875
1.35
0.57
0.24
BOD96
Cemetry SW
Cemetry SE

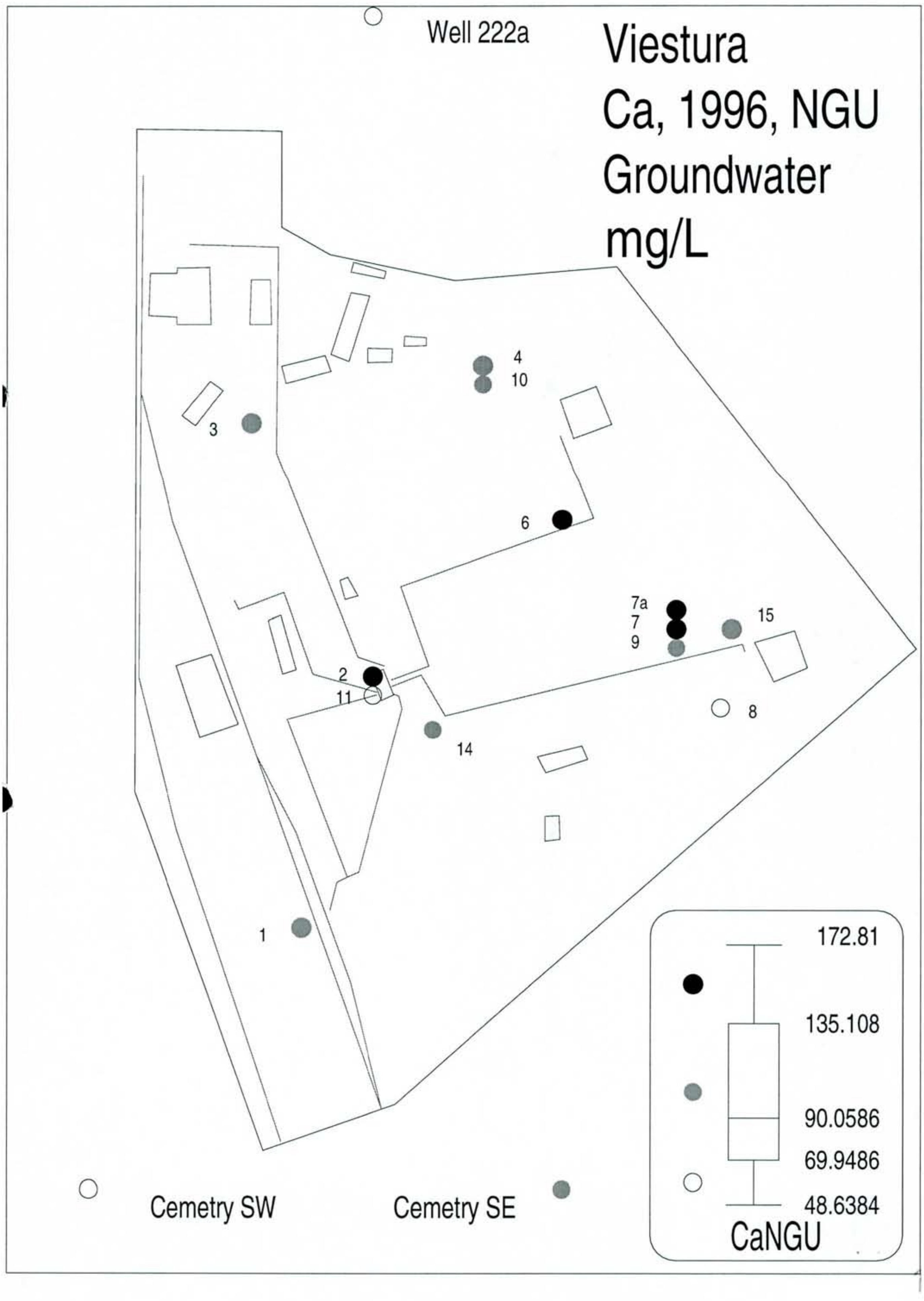

Well 222a
Viestura
BOD, 1997, Lv
Groundwater
mg/l
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
6.4
4.65
2.9
1.63
0.35
BOD97Lv

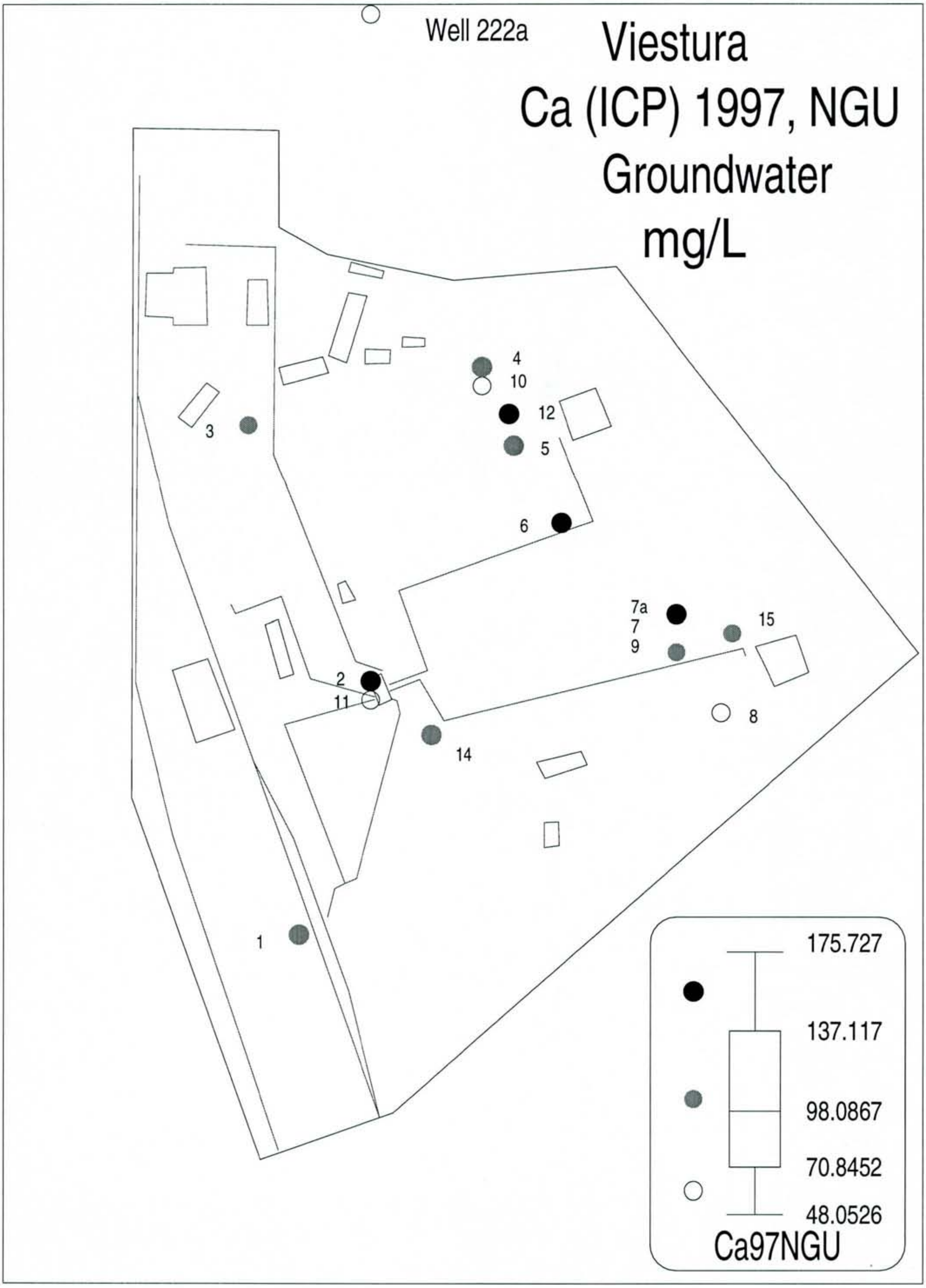

Viestura
Br (IC) 1997, NGU
Groundwater
mg/L
Well 222a
1
2
3
4
5
6
7a
7
8
9
10
11
12
14
15
0.228
0.05
Br97NGU
Detection limit = 0.1 mg/L

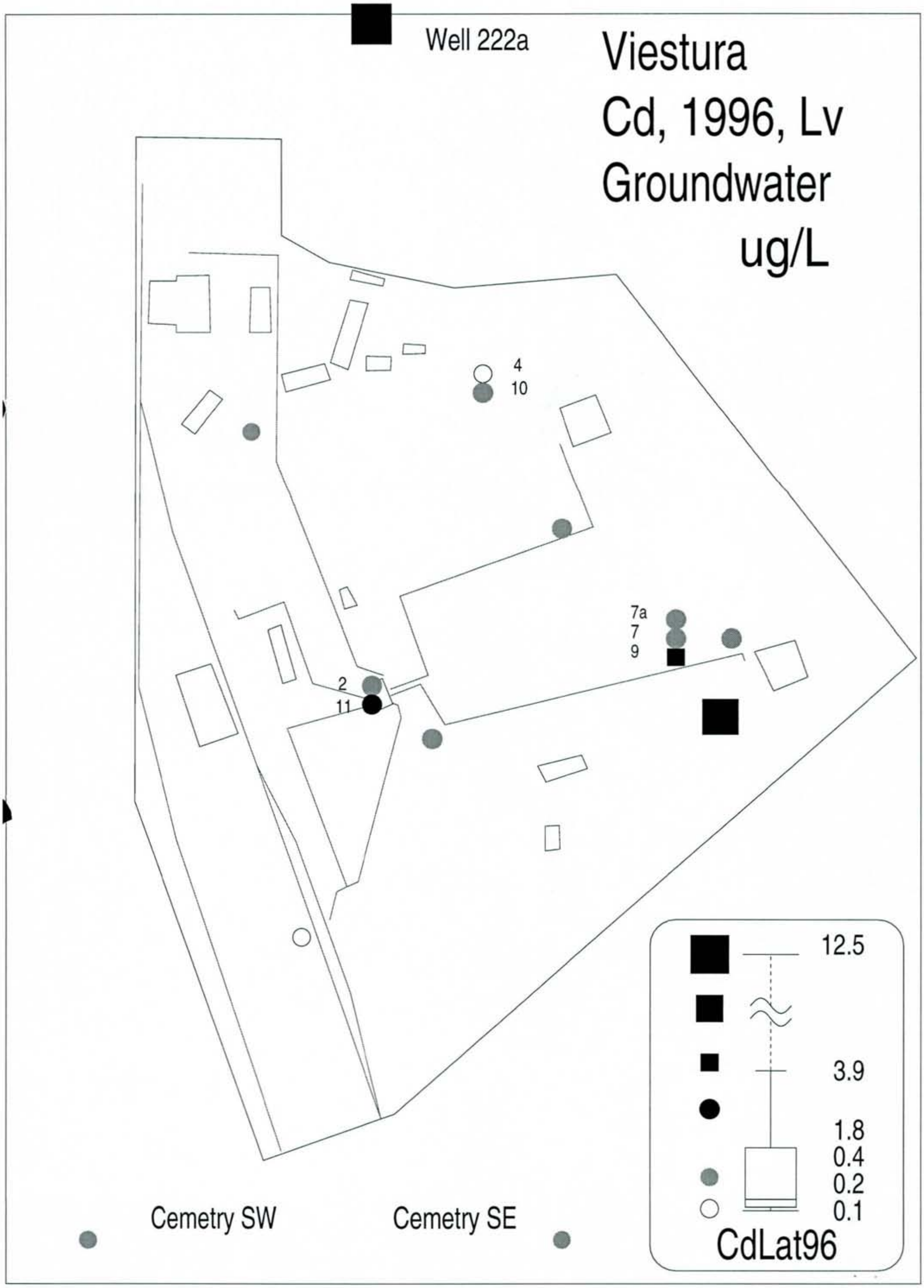


Viestura
Ca, 1994, Lv
Groundwater
mg/l
4
10
7
9
2
11
180
150
124
116
86
Ca94

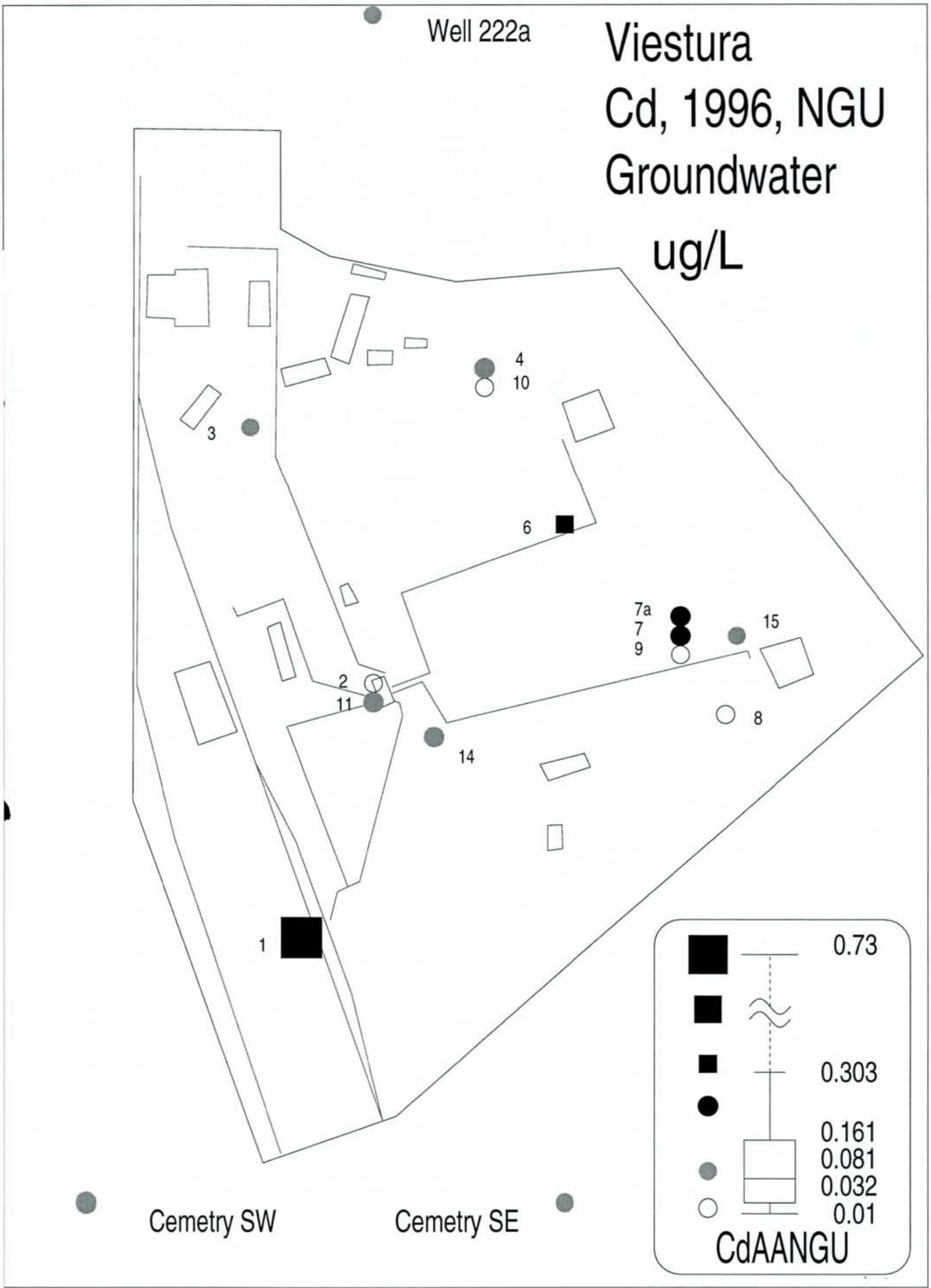

Well 222a
Viestura
Ca, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
161
127
83
60
49
Ca96Lat
Cemetry SW
Cemetry SE

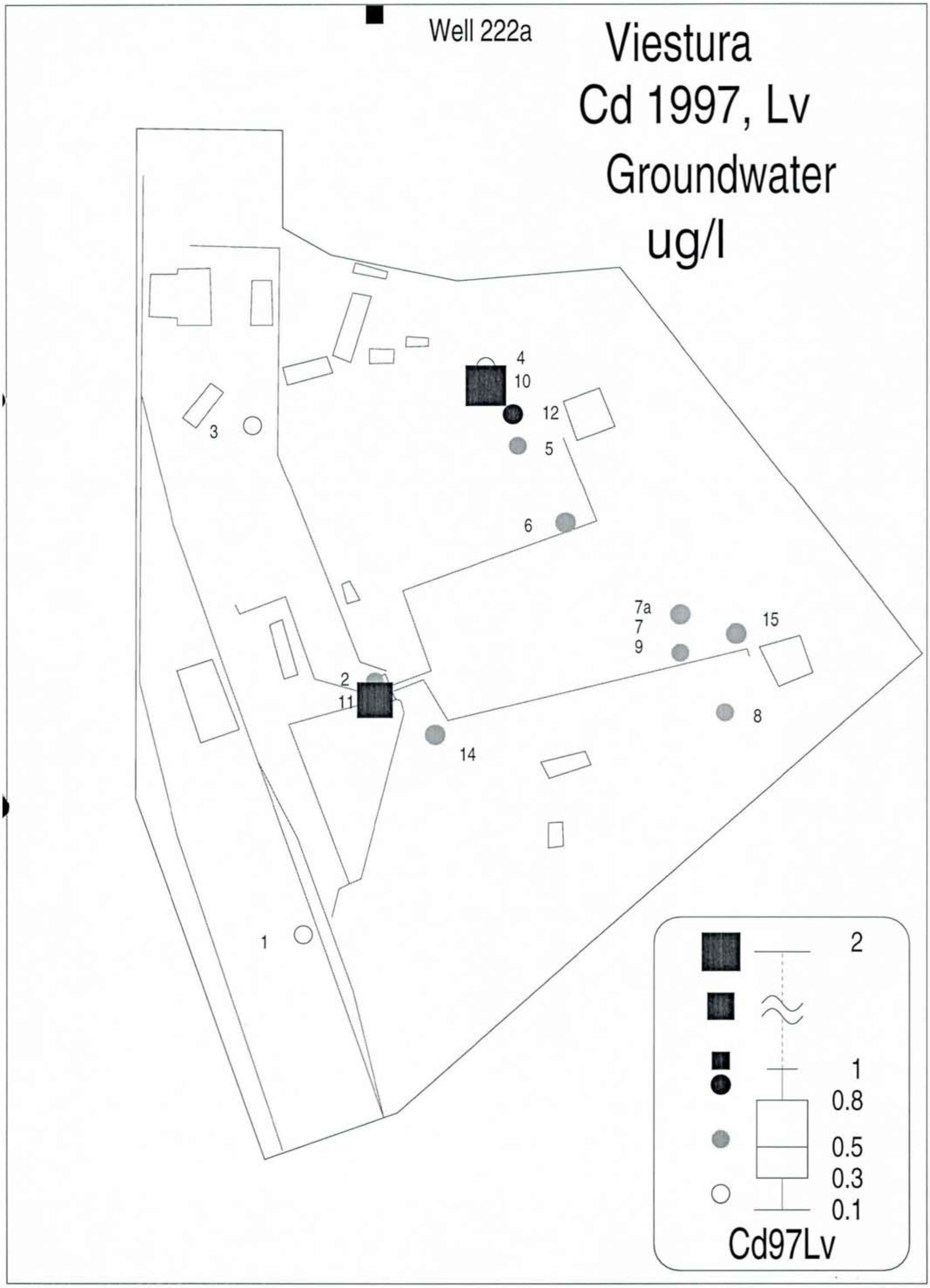

Well 222a
Viestura
Ca, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
172.81
135.108
90.0586
69.9486
48.6384
CaNGU
Cemetery SW
Cemetery SE

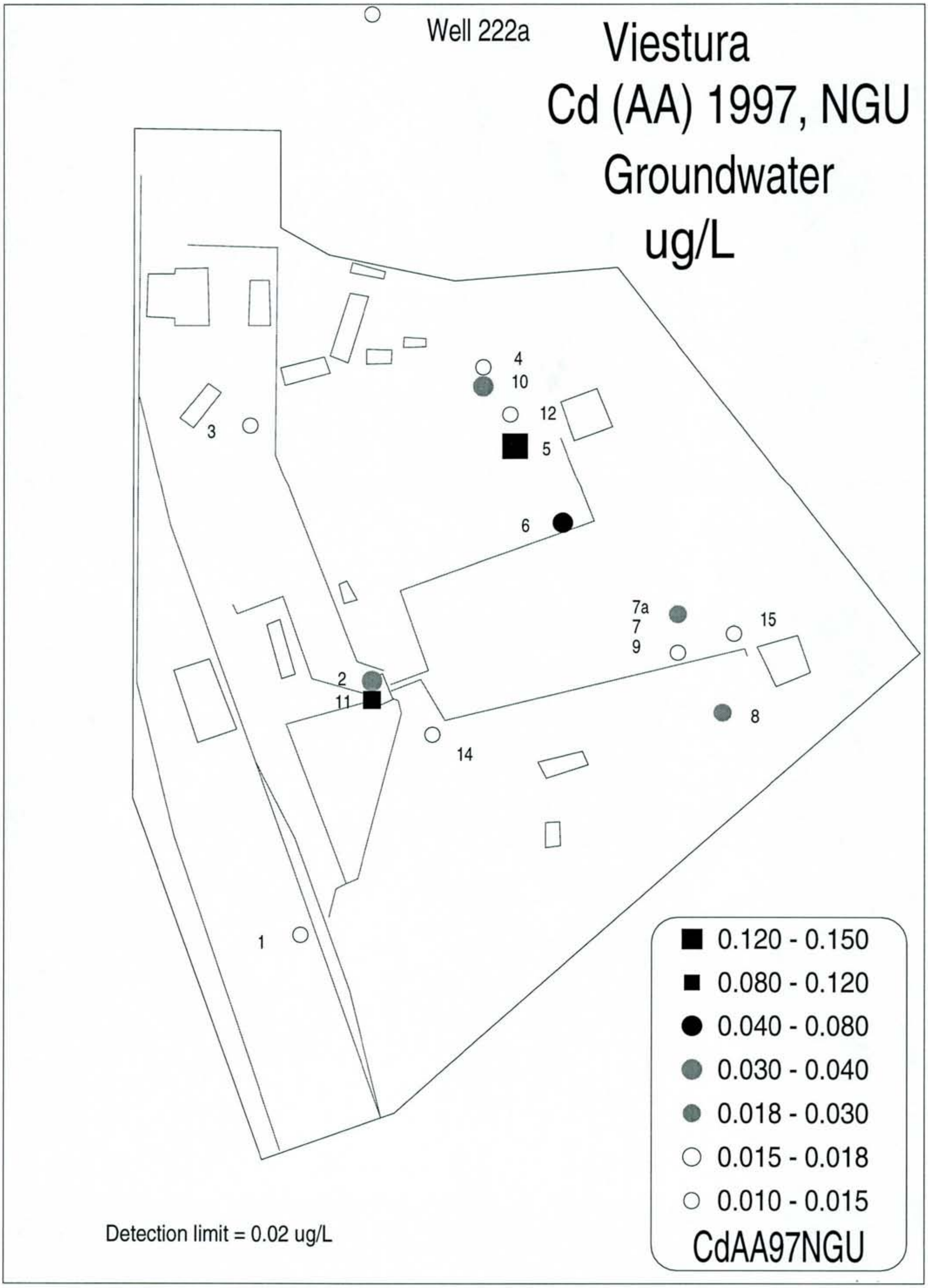

Well 222a
Viestura
Ca (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
175.727
137.117
98.0867
70.8452
48.0526
Ca97NGU



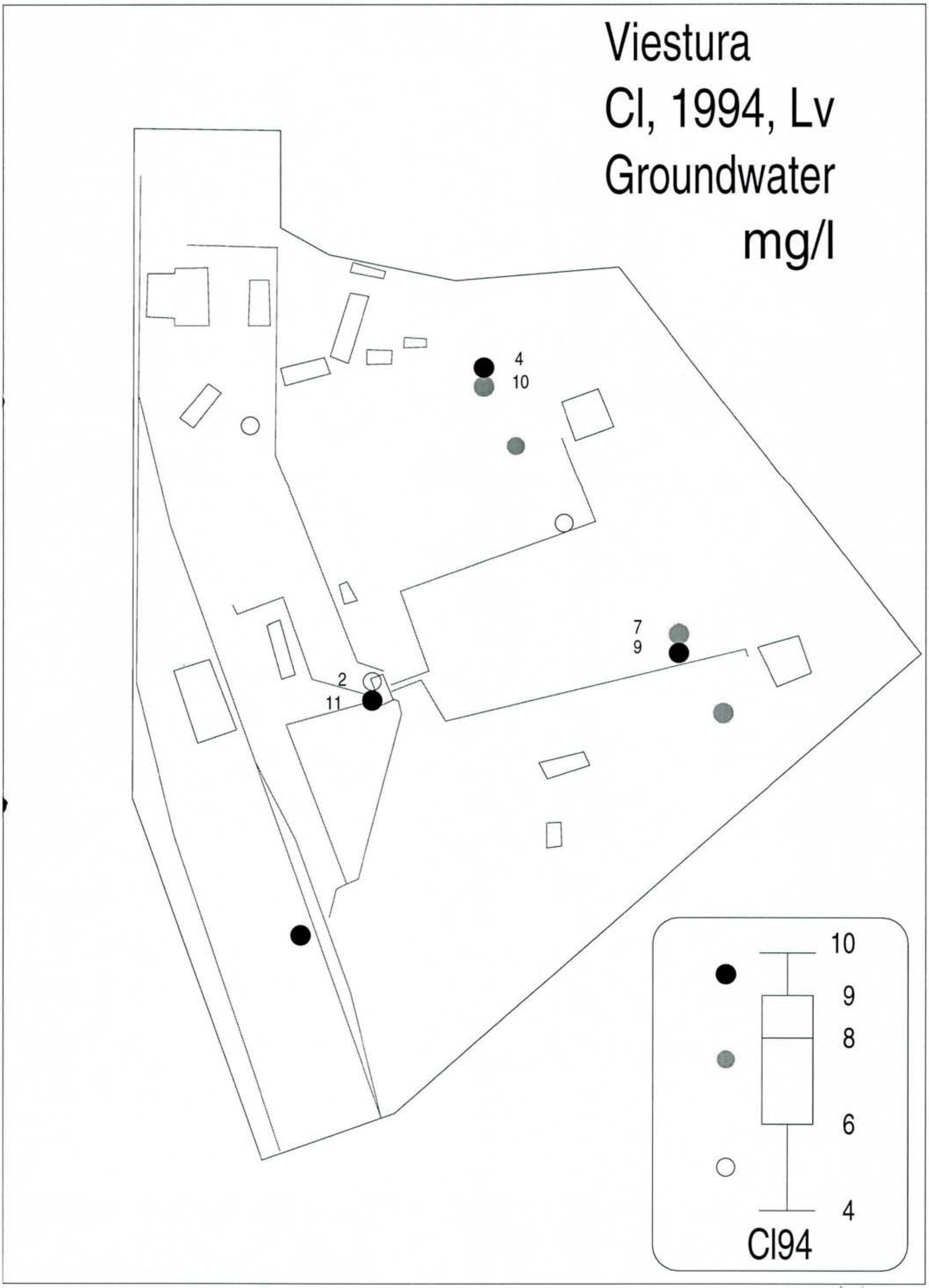
Well 222a
Viestura
Cd, 1996, Lv
Groundwater
ug/L
4
10
7a
7
9
2
11
12.5
3.9
1.8
0.4
0.2
0.1
CdLat96
Cemetry SW
Cemetry SE

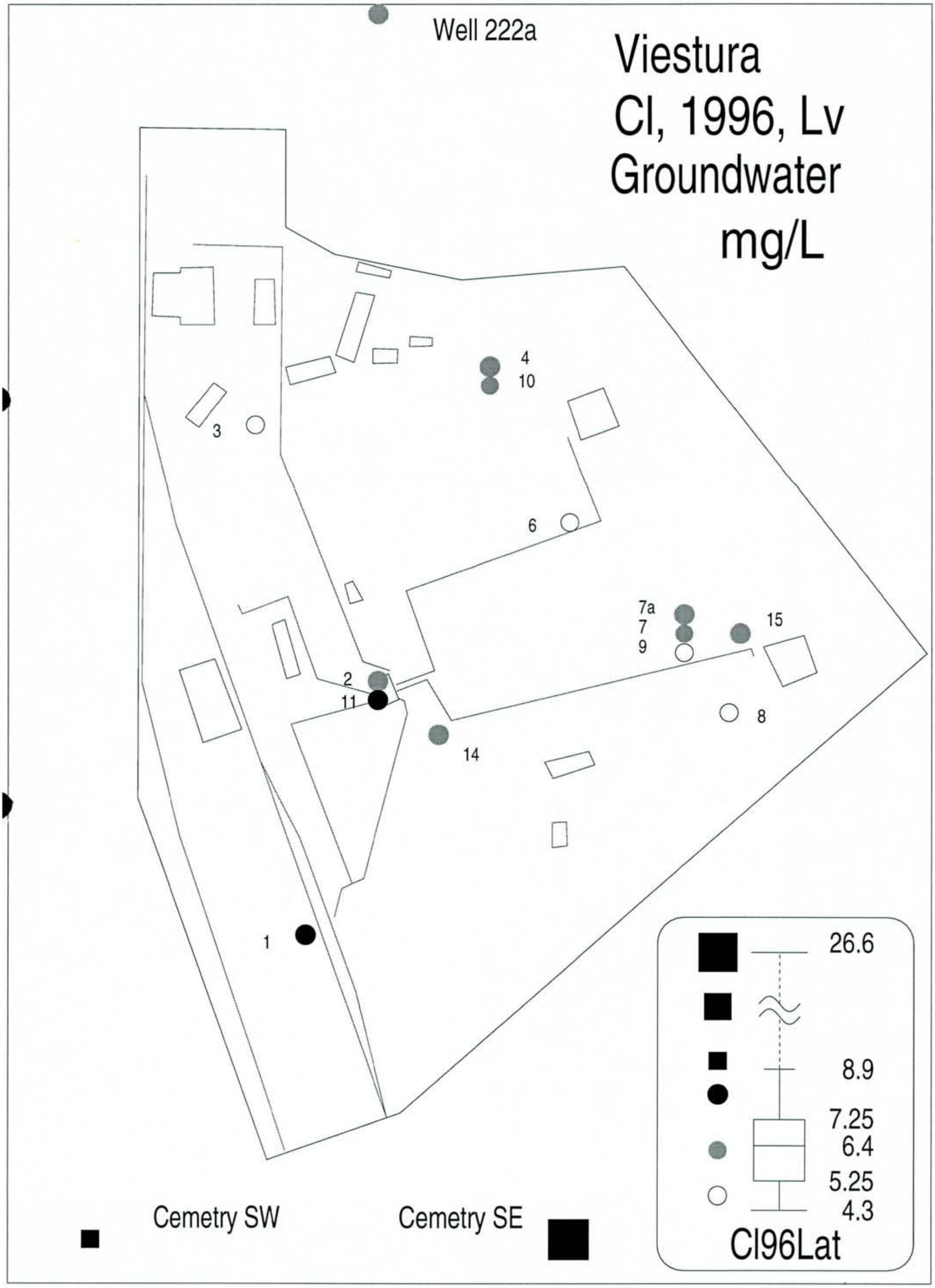

Well 222a
Viestura
Cd, 1996, NGU
Groundwater
ug/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.73
0.303
0.161
0.081
0.032
0.01
CdAANGU
Cemetry SW
Cemetry SE


Well 222a
Viestura
Cd 1997, Lv
Groundwater
ug/l
1
2
3
4
5
6
7a
7
8
9
10
11
12
14
15
2
1
0.8
0.5
0.3
0.1
Cd97Lv

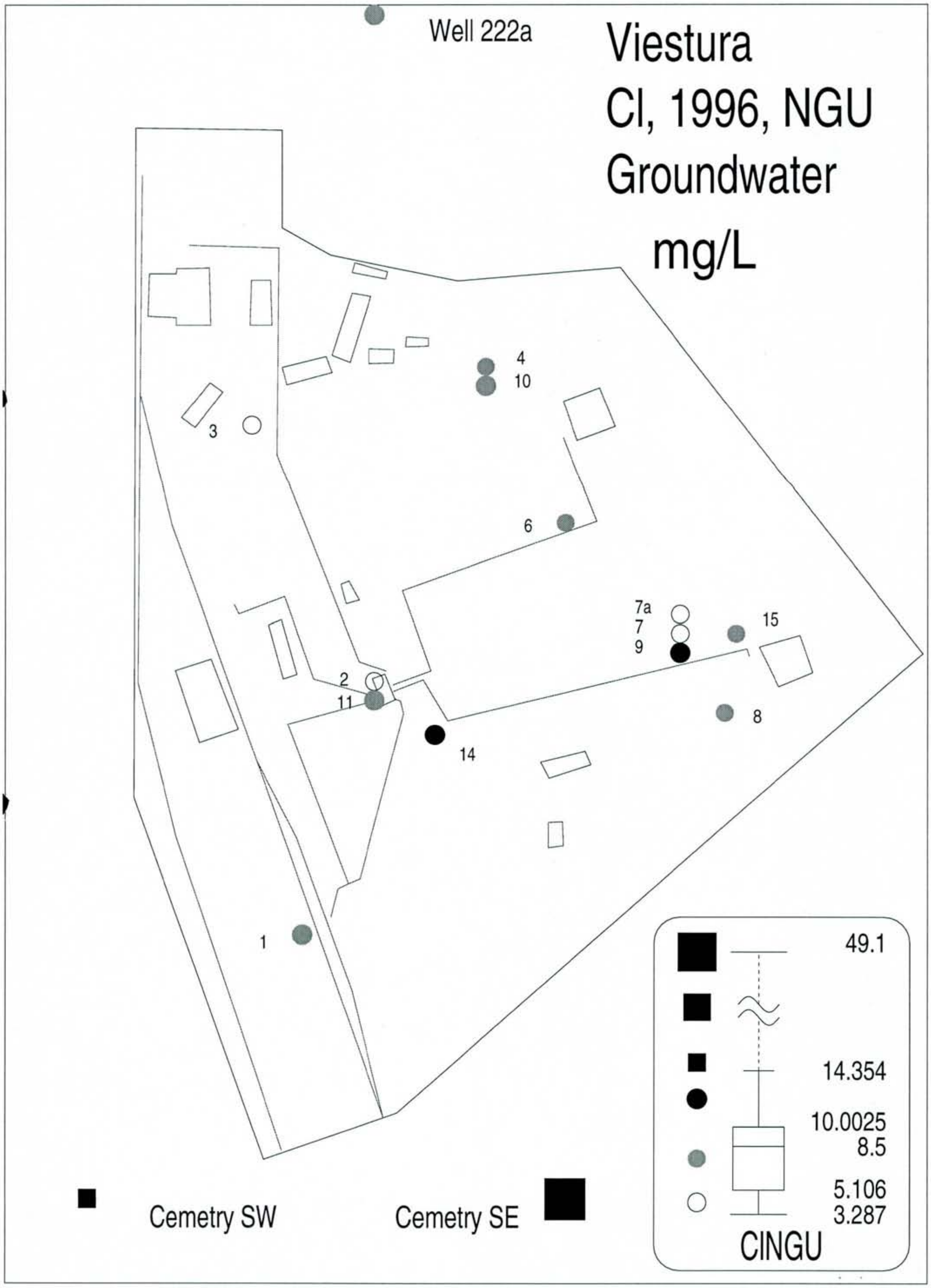


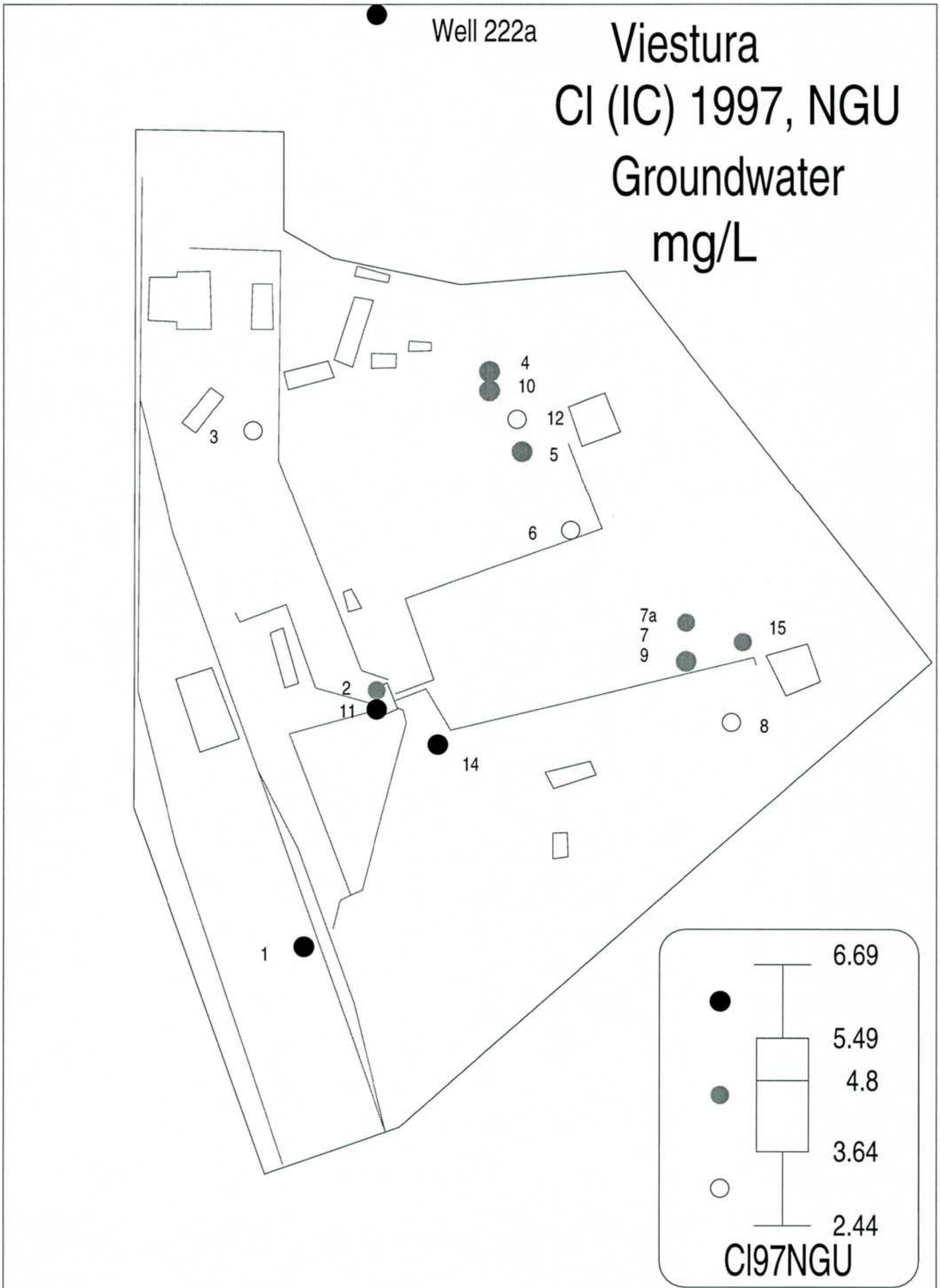
Well 222a
Viestura
Cd (AA) 1997, NGU
Groundwater
ug/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
0.120 - 0.150
0.080 - 0.120
0.040 - 0.080
0.030 - 0.040
0.018 - 0.030
0.015 - 0.018
0.010 - 0.015
CdAA97NGU
Detection limit = 0.02 ug/L


Viestura
Cl, 1994, Lv
Groundwater
mg/l
4
10
7
9
2
11
10
9
8
6
4
Cl94

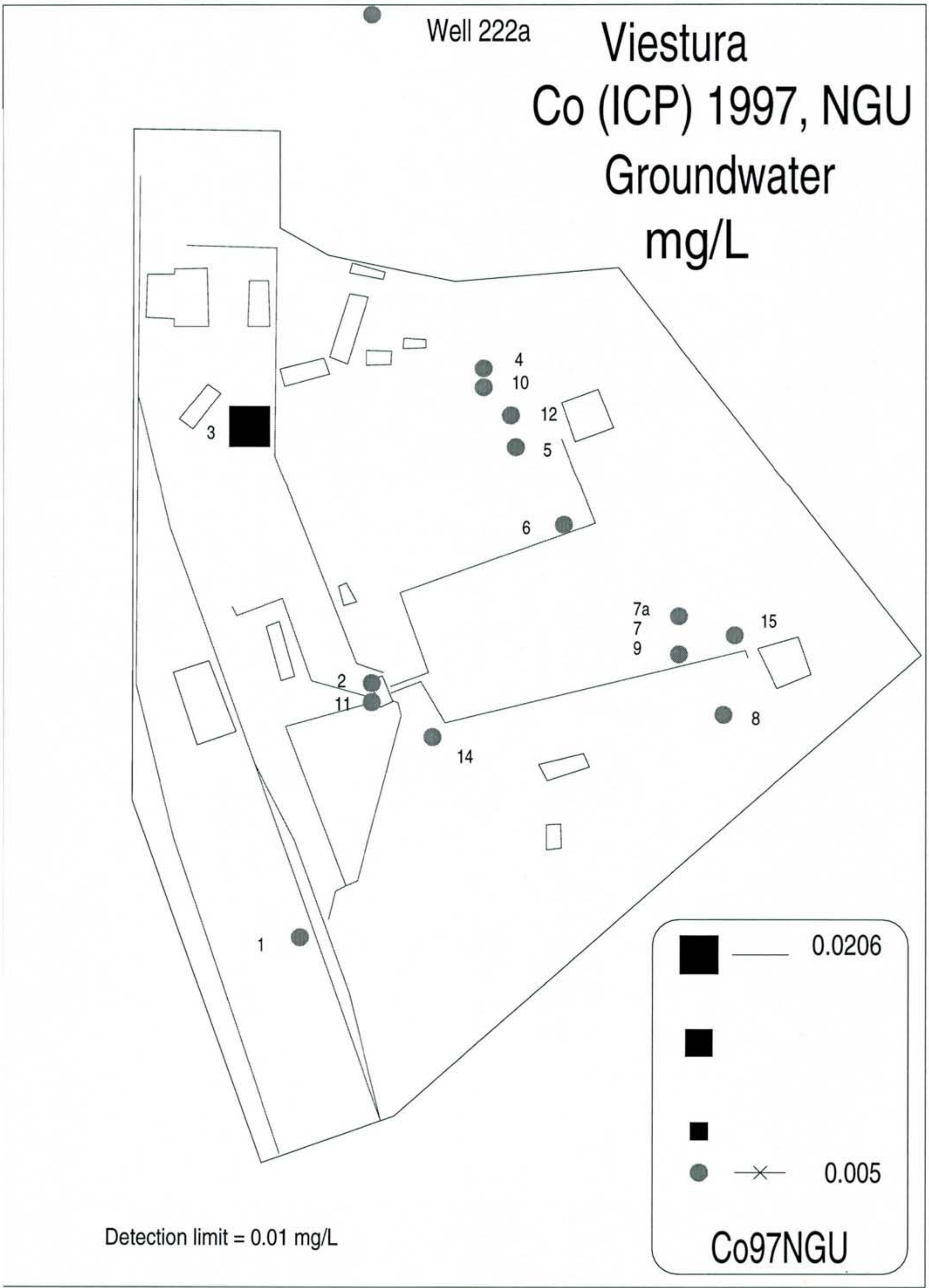


Well 222a
Viestura
Cl, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
26.6
8.9
7.25
6.4
5.25
4.3
Cl96Lat
Cemetry SW
Cemetry SE

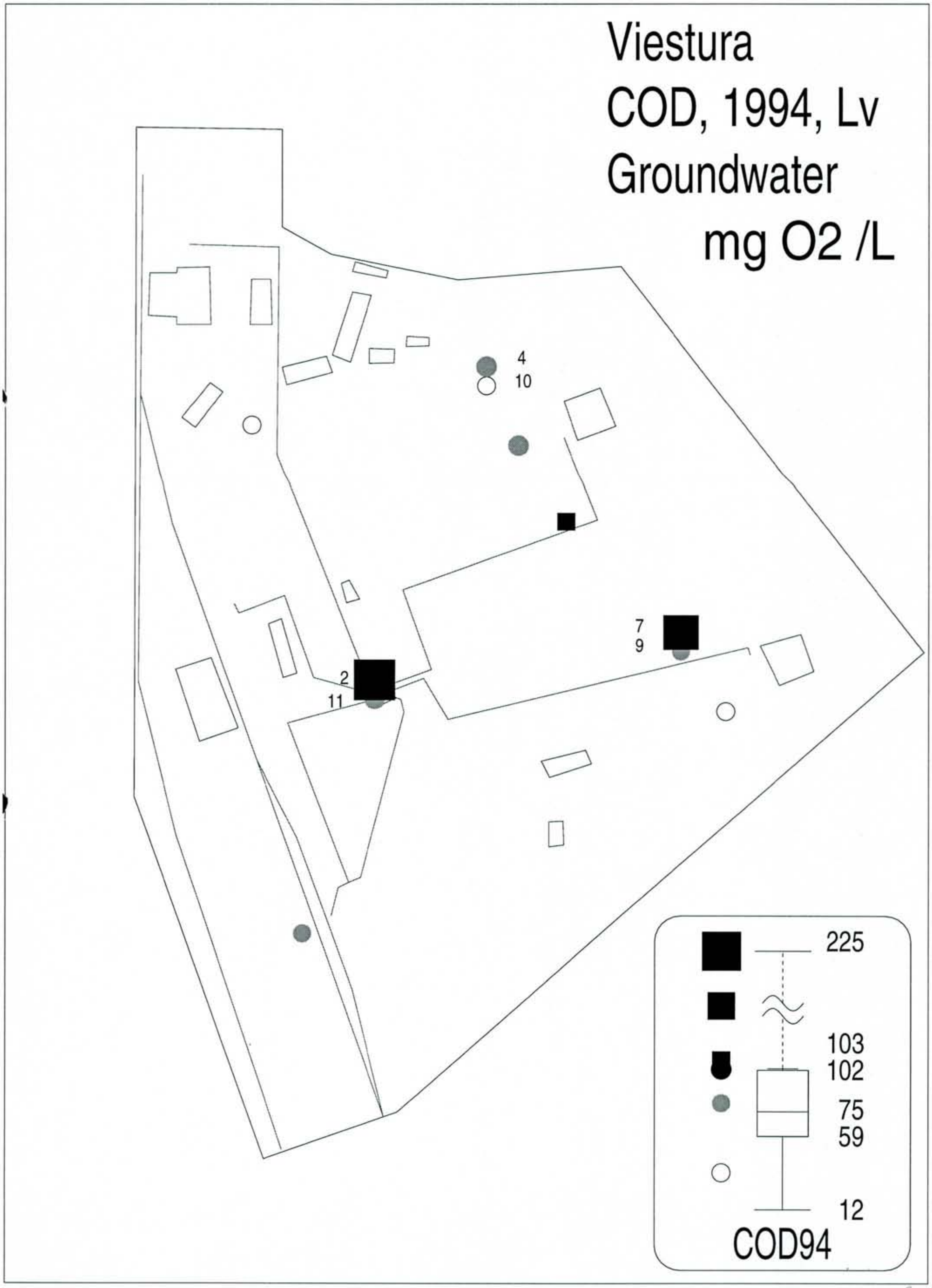

Well 222a
Viestura
Cl, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
14
8
1
49.1
14.354
10.0025
8.5
5.106
3.287
CINGU
Cemetry SW
Cemetry SE

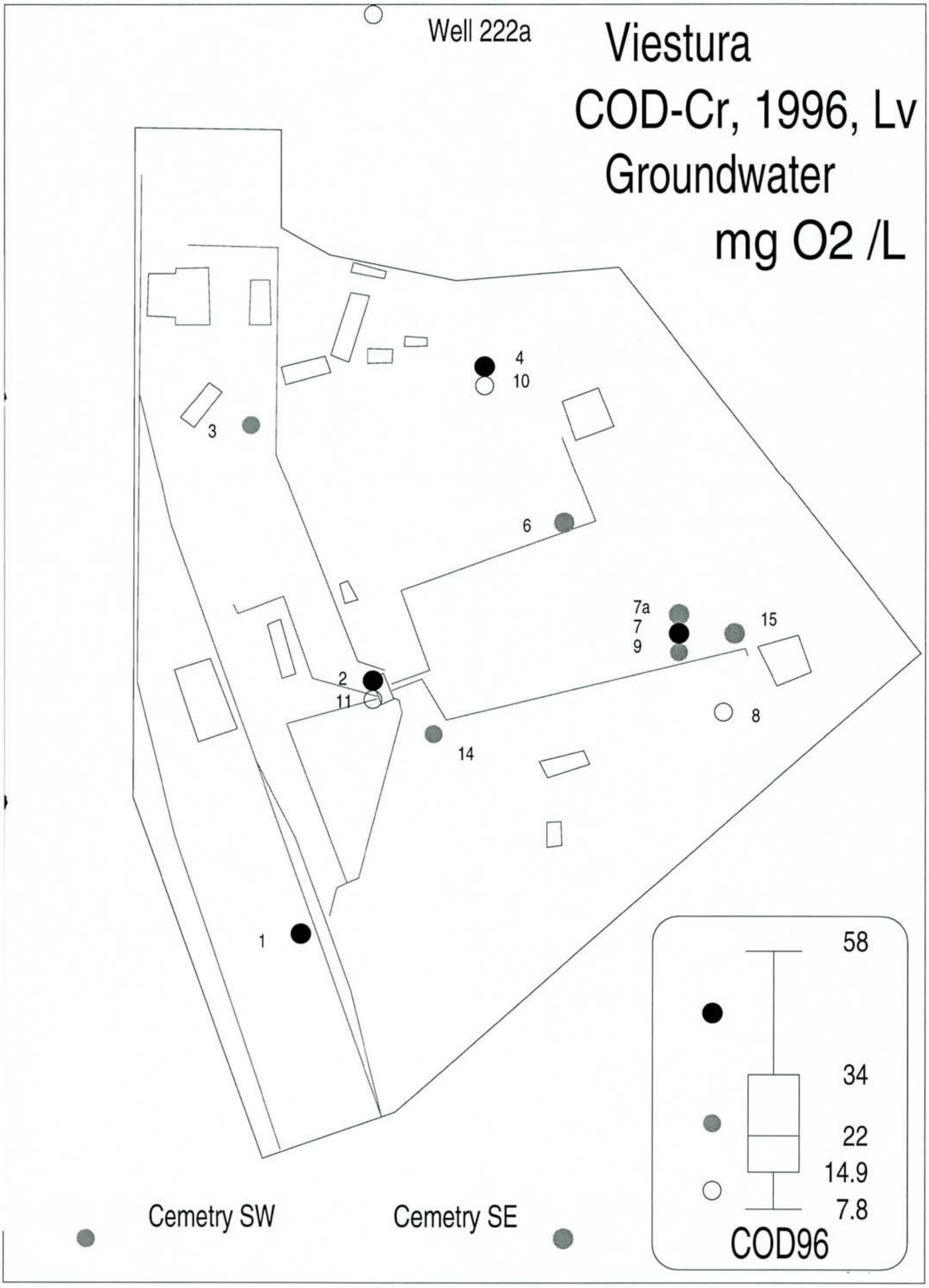


Well 222a
Viestura
Cl (IC) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
6.69
5.49
4.8
3.64
2.44
Cl97NGU

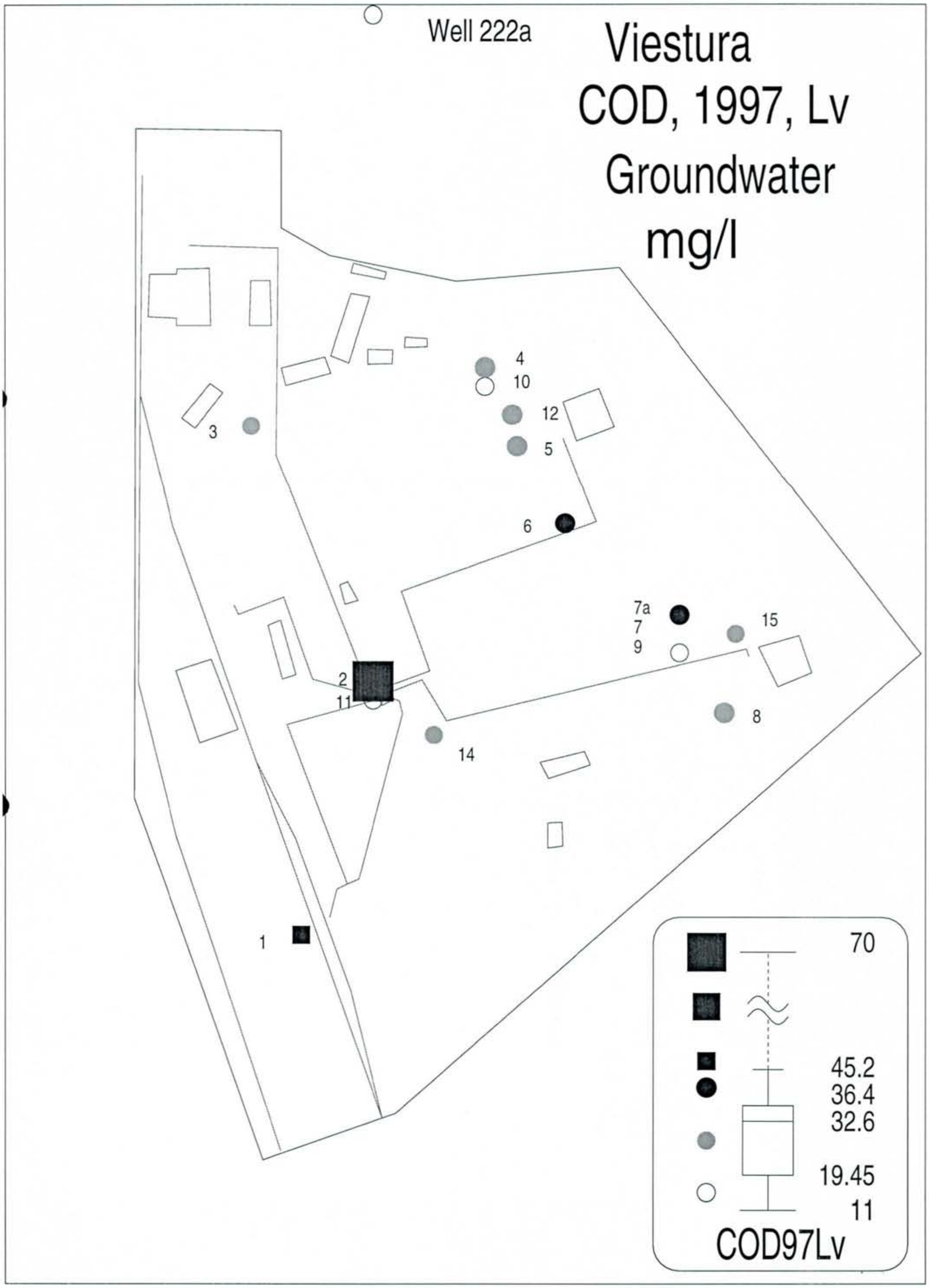


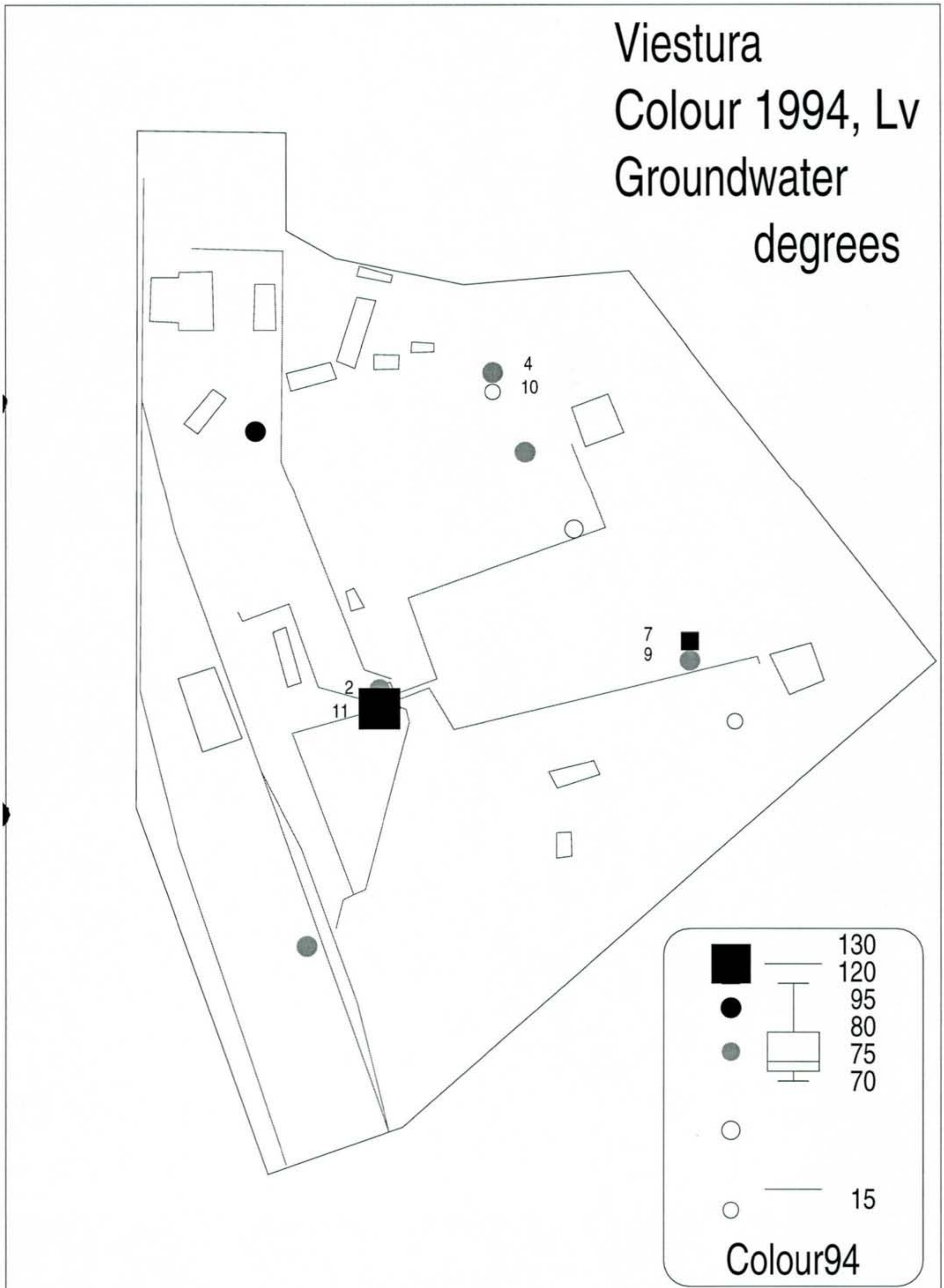
Well 222a
Viestura
Co (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
0.0206
0.005
Co97NGU
Detection limit = 0.01 mg/L


Viestura
COD, 1994, Lv
Groundwater
mg O2 /L
4
10
7
9
2
11
225
103
102
75
59
12
COD94

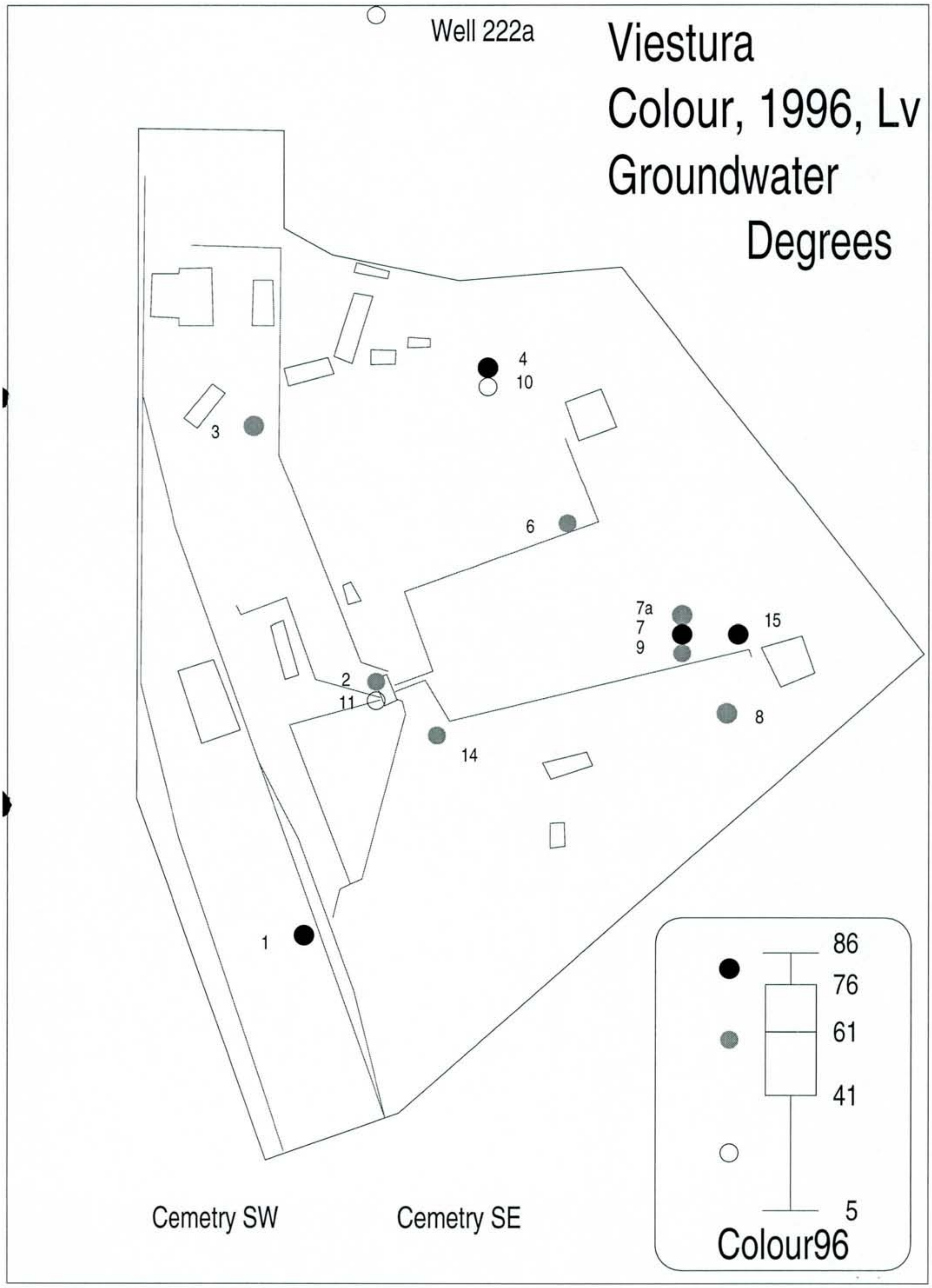


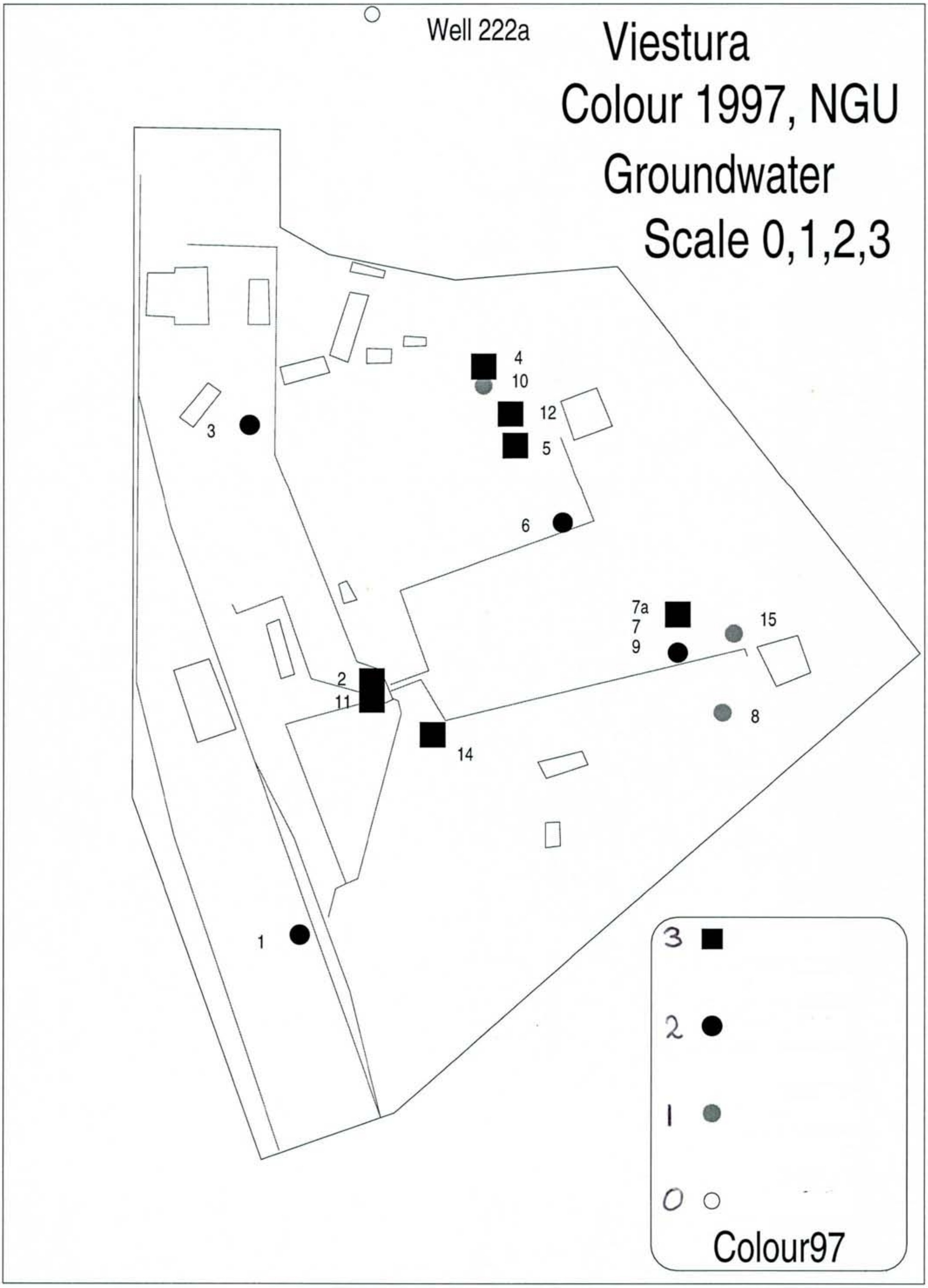
Well 222a
Viestura
COD-Cr, 1996, Lv
Groundwater
mg O2 /L
4
10
3
6
7a
7
9
15
2
11
8
14
1
58
34
22
14.9
7.8
COD96
Cemetery SW
Cemetery SE


Well 222a
Viestura
COD, 1997, Lv
Groundwater
mg/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
70
45.2
36.4
32.6
19.45
11
COD97Lv

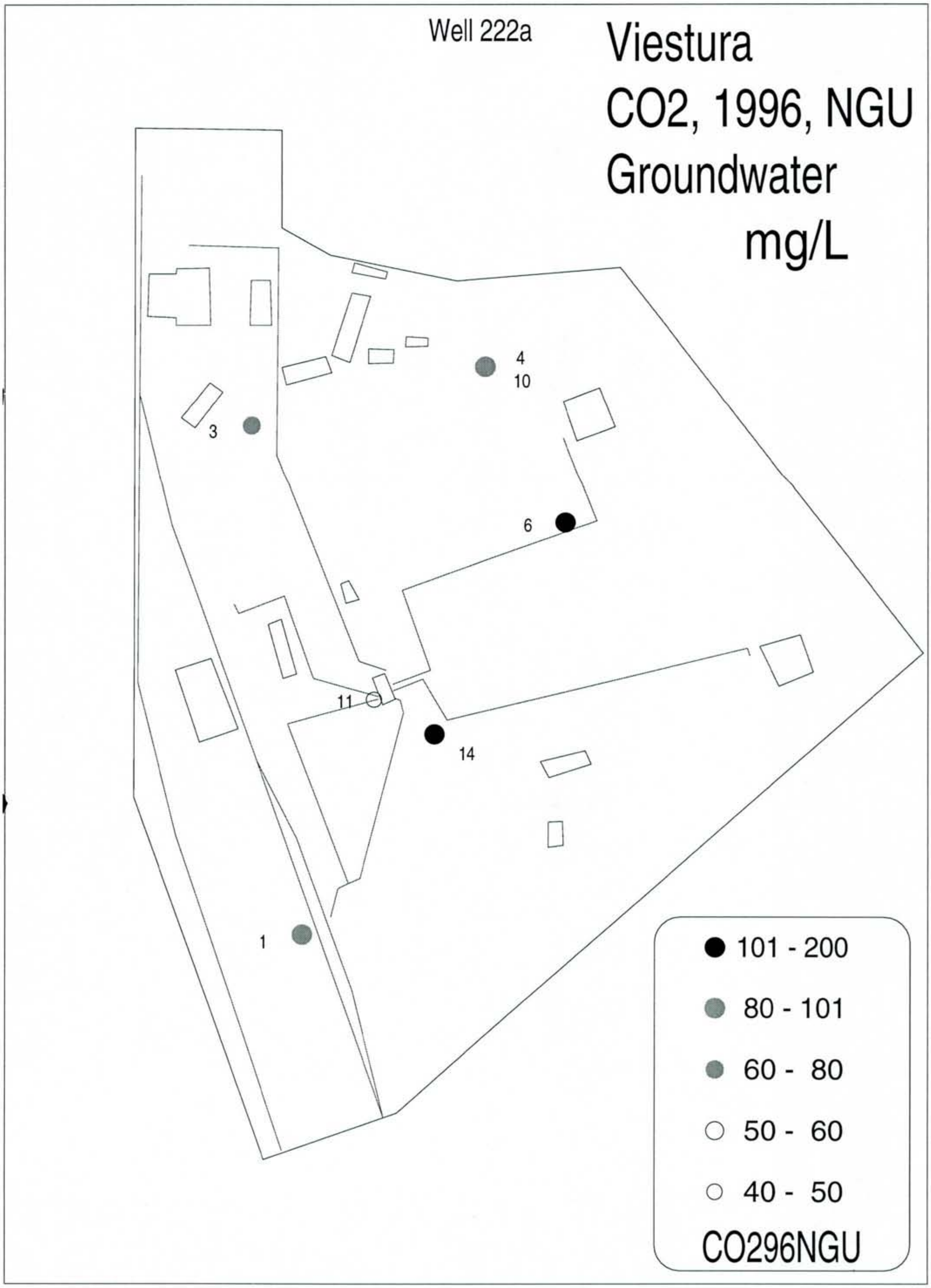


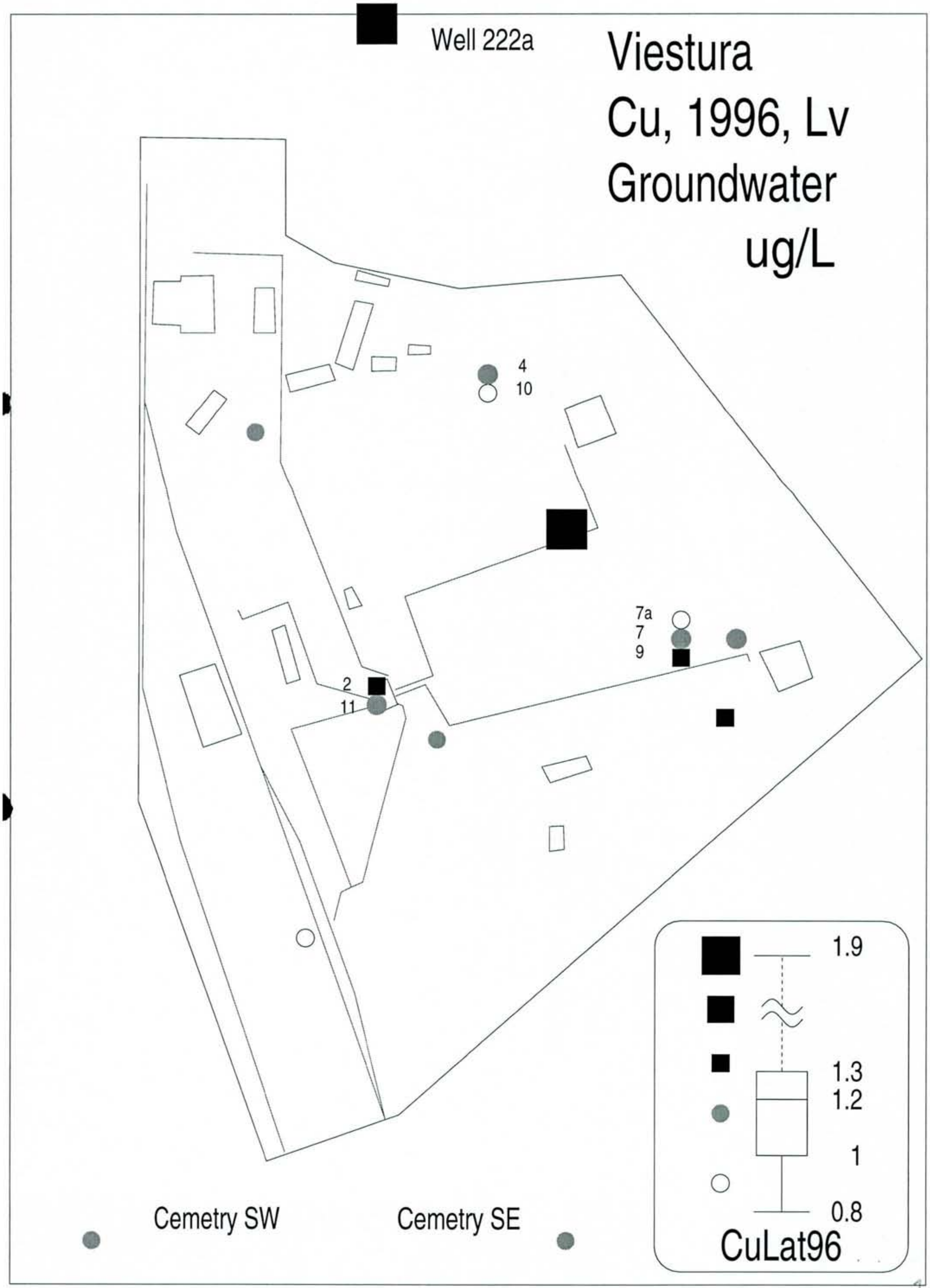
Viestura
Colour 1994, Lv
Groundwater
degrees
4
10
7
9
2
11
130
120
95
80
75
70
15
Colour94

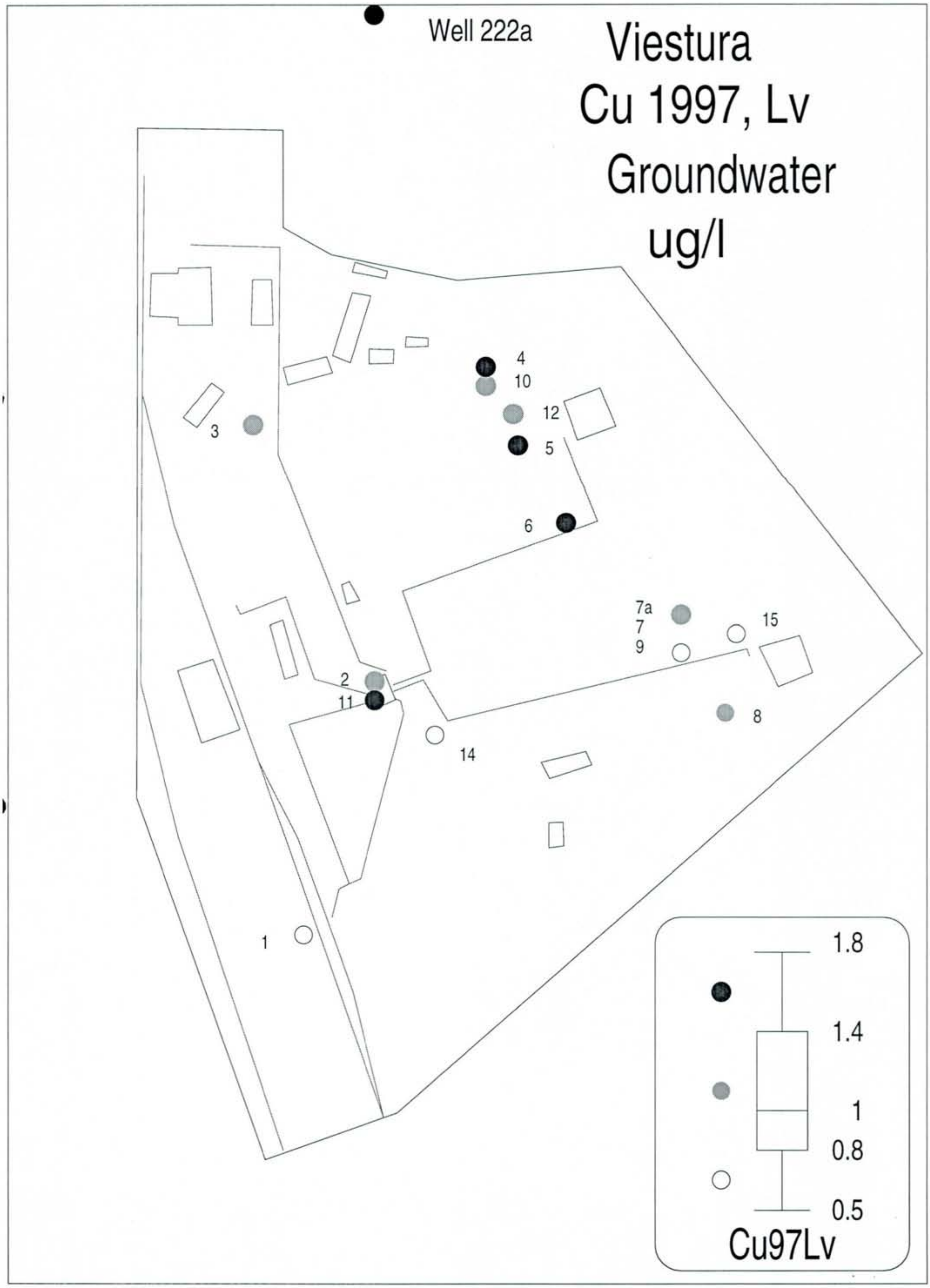

Well 222a
Viestura
Colour, 1996, Lv
Groundwater
Degrees
4
10
3
6
7a
7
9
15
2
11
8
14
1
86
76
61
41
5
Colour96
Cemetery SW
Cemetery SE

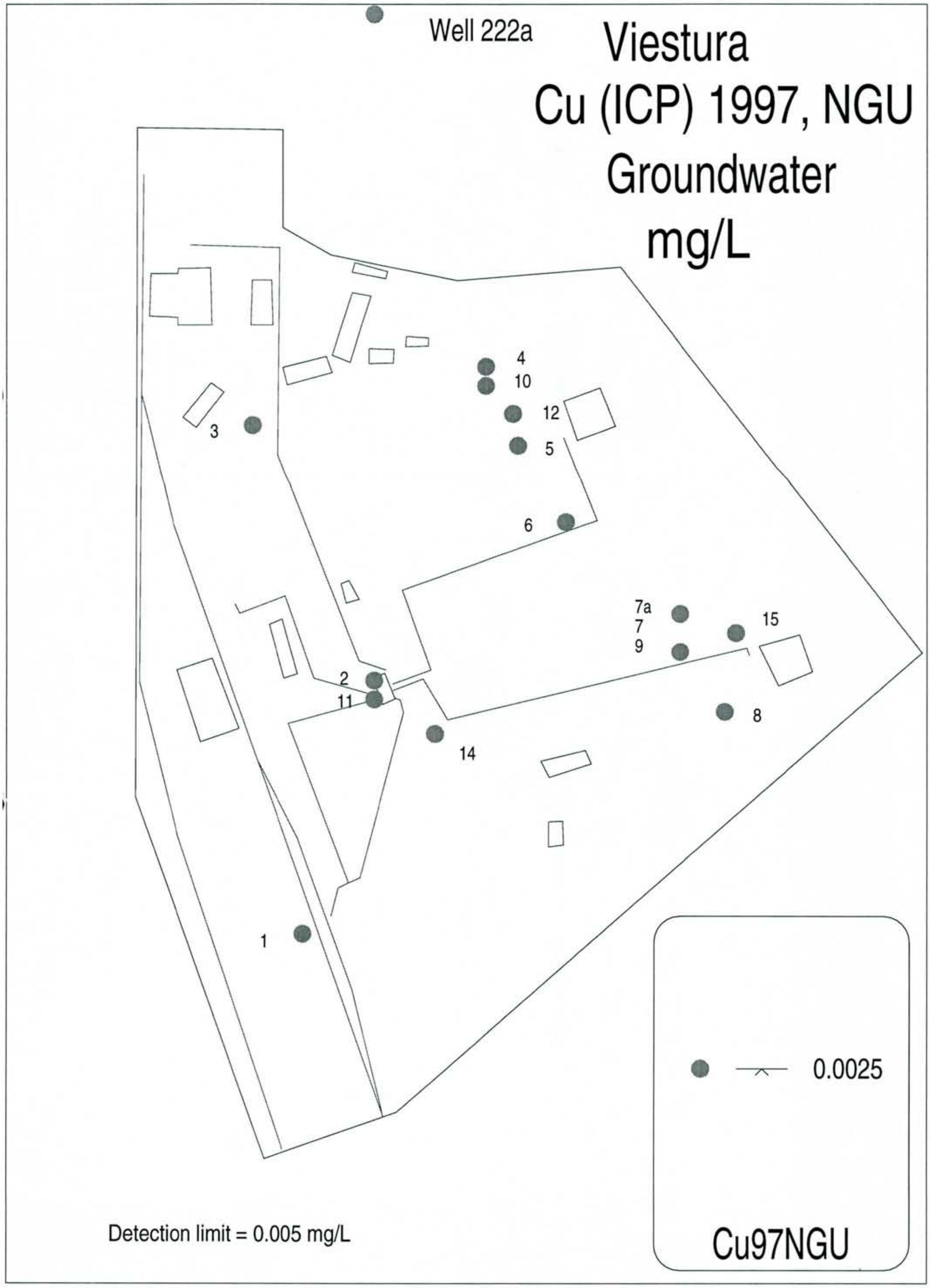


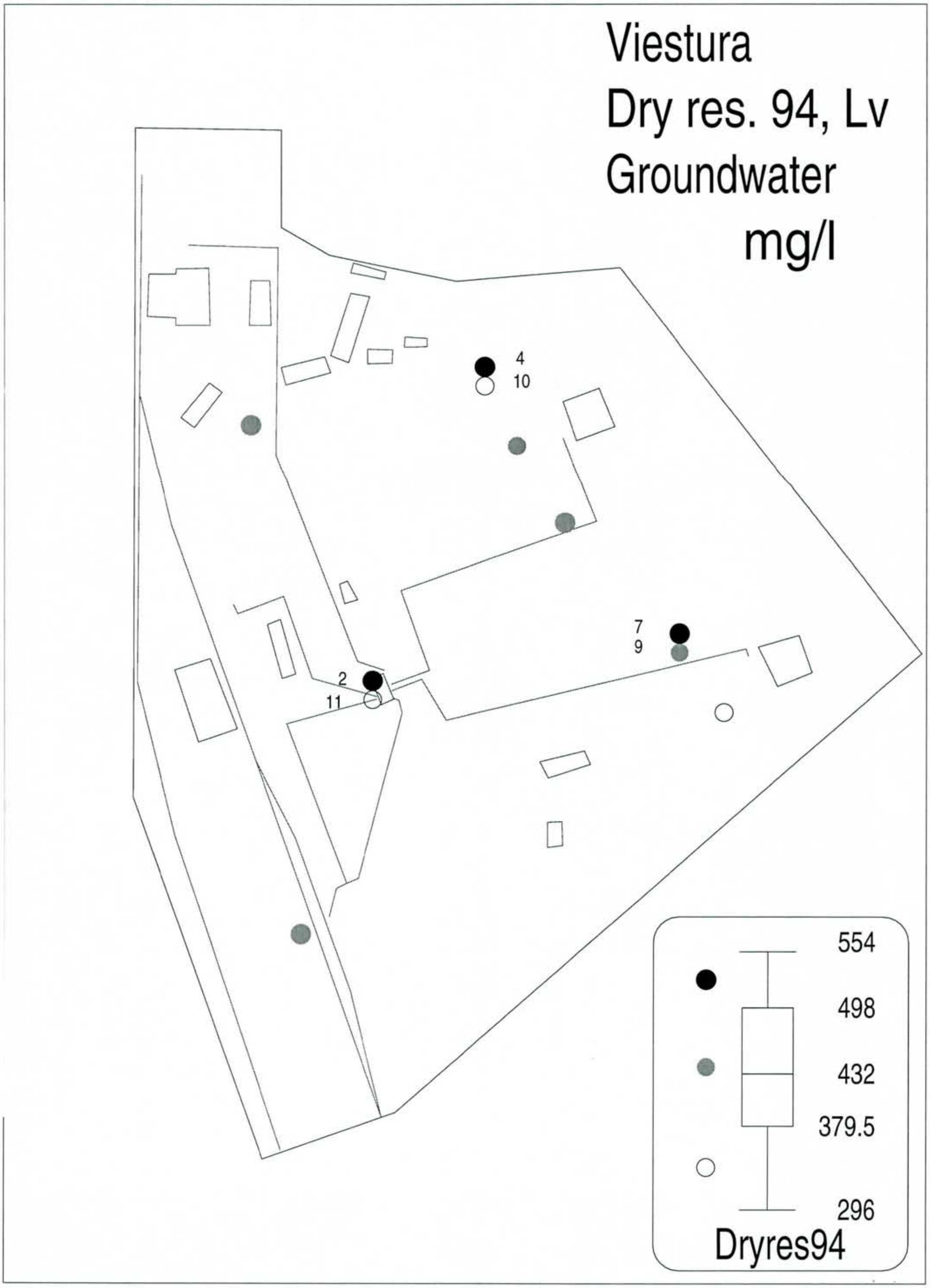
Well 222a
Viestura
Colour 1997, NGU
Groundwater
Scale 0,1,2,3
4
10
12
5
3
6
7a
7
9
15
2
11
14
8
1
3
2
1
0
Colour97

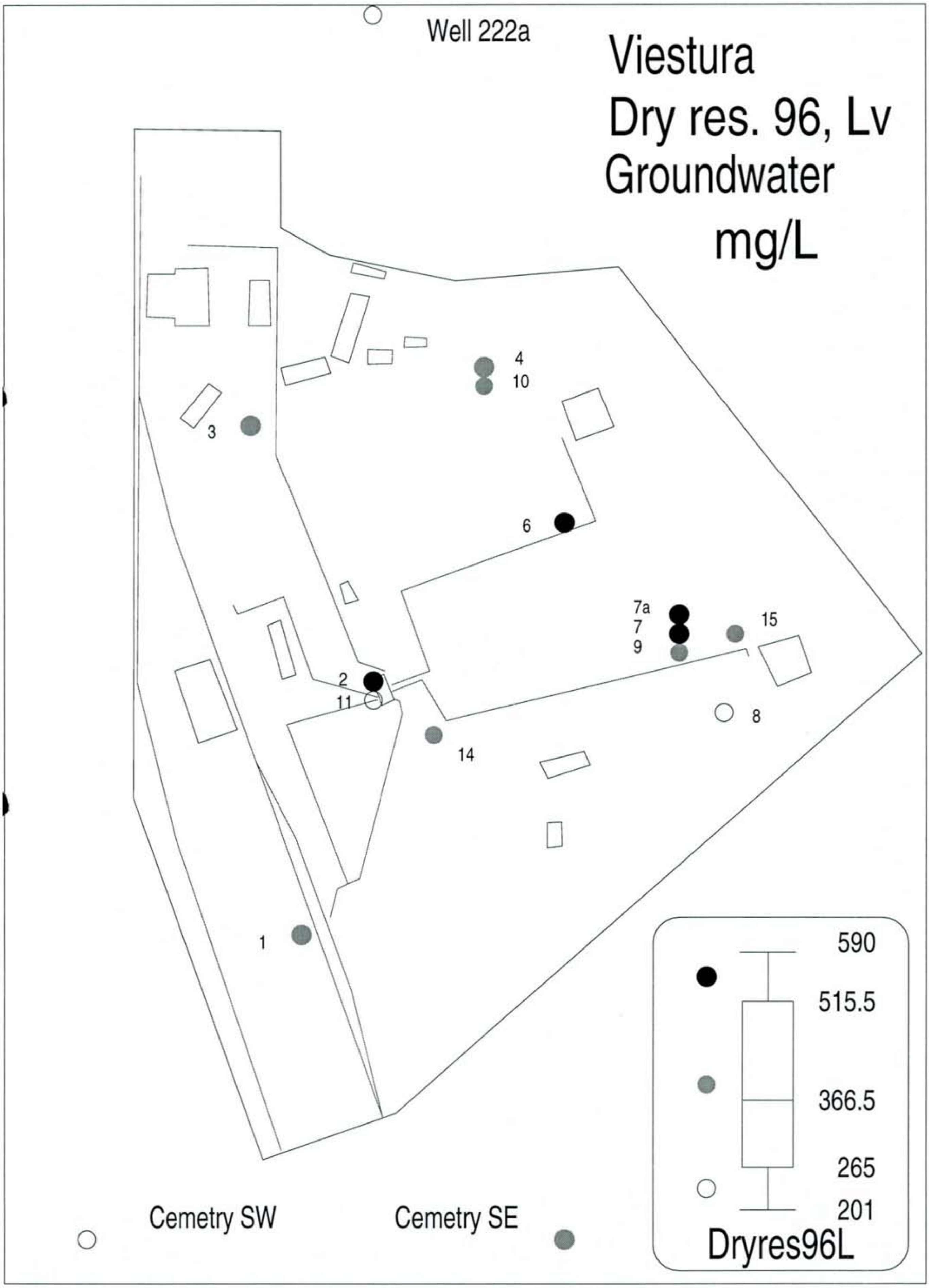

Well 222a
Viestura
CO2, 1996, NGU
Groundwater
mg/L
4
10
3
6
11
14
1
101 - 200
80 - 101
60 - 80
50 - 60
40 - 50
CO296NGU

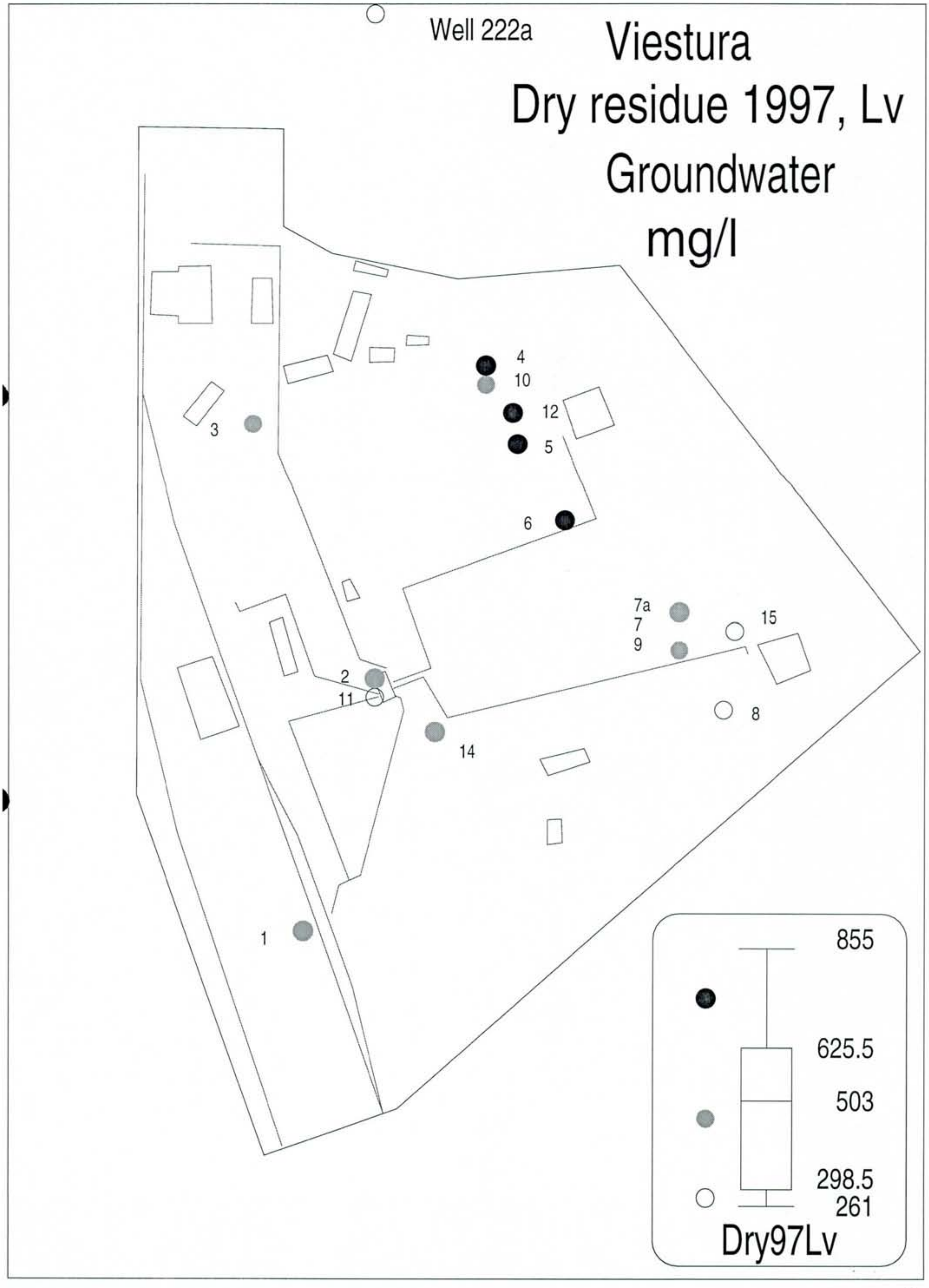

Well 222a
Viestura
Cu, 1996, Lv
Groundwater
ug/L
4
10
7a
7
9
2
11
Cemetery SW
Cemetery SE
1.9
1.3
1.2
1
0.8
CuLat96

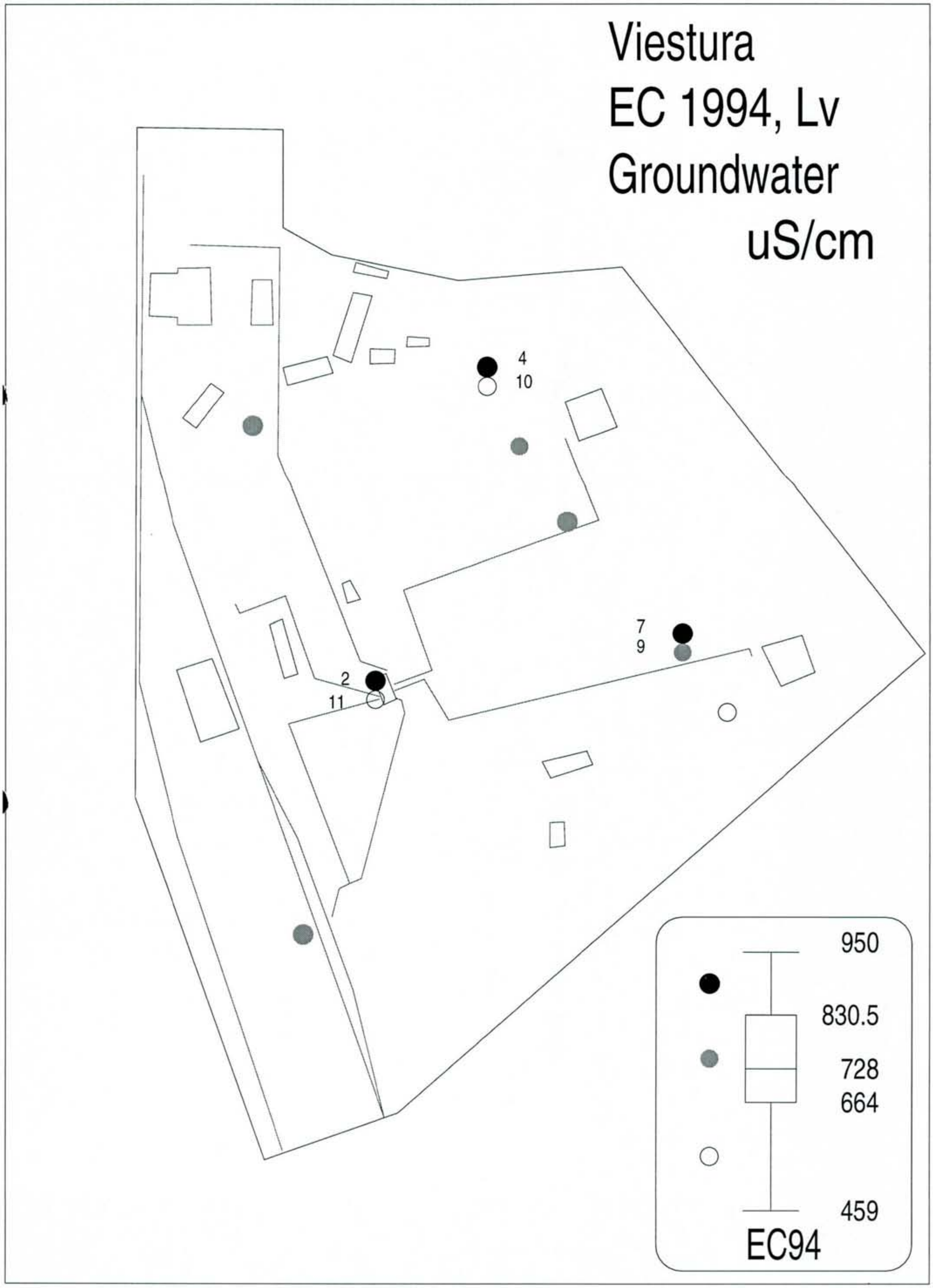

Well 222a
Viestura
Cu 1997, Lv
Groundwater
ug/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
1.8
1.4
1
0.8
0.5
Cu97Lv


Well 222a
Viestura
Cu (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
0.0025
Detection limit = 0.005 mg/L
Cu97NGU

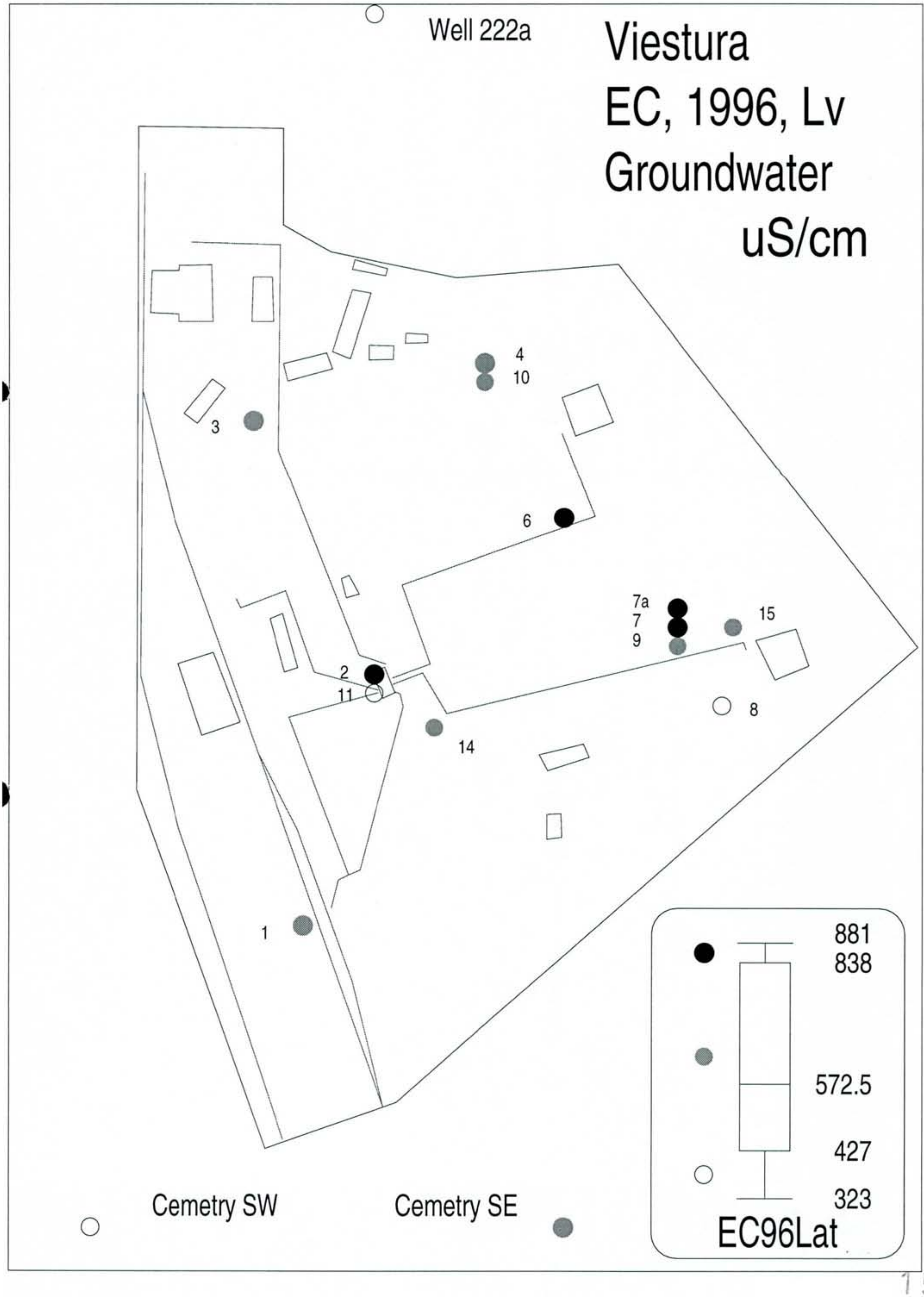

Viestura
Dry res. 94, Lv
Groundwater
mg/l
4
10
7
9
2
11
554
498
432
379.5
296
Dryres94

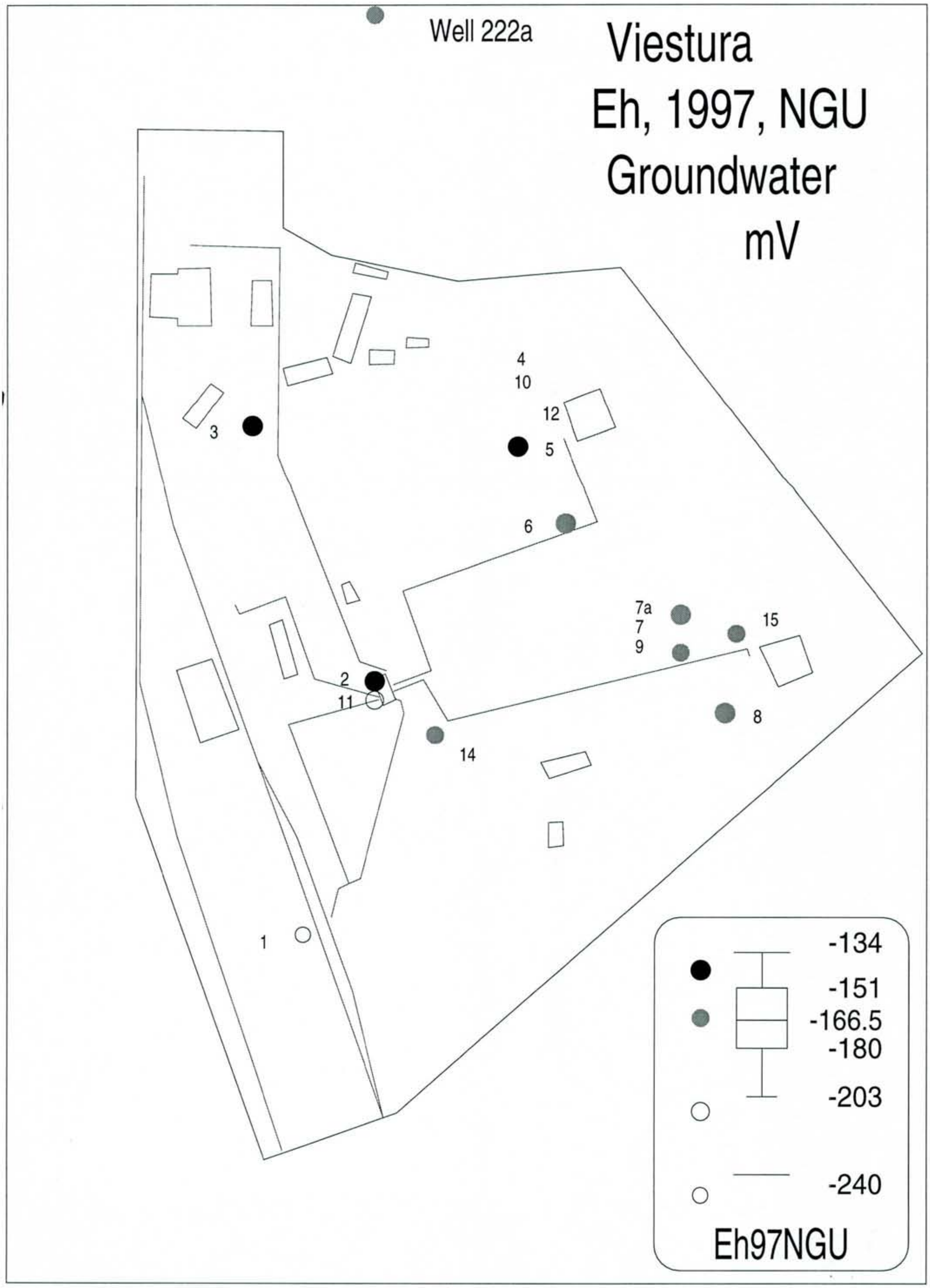

Well 222a
Viestura
Dry res. 96, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
590
515.5
366.5
265
201
Dryres96L
Cemetry SW
Cemetry SE

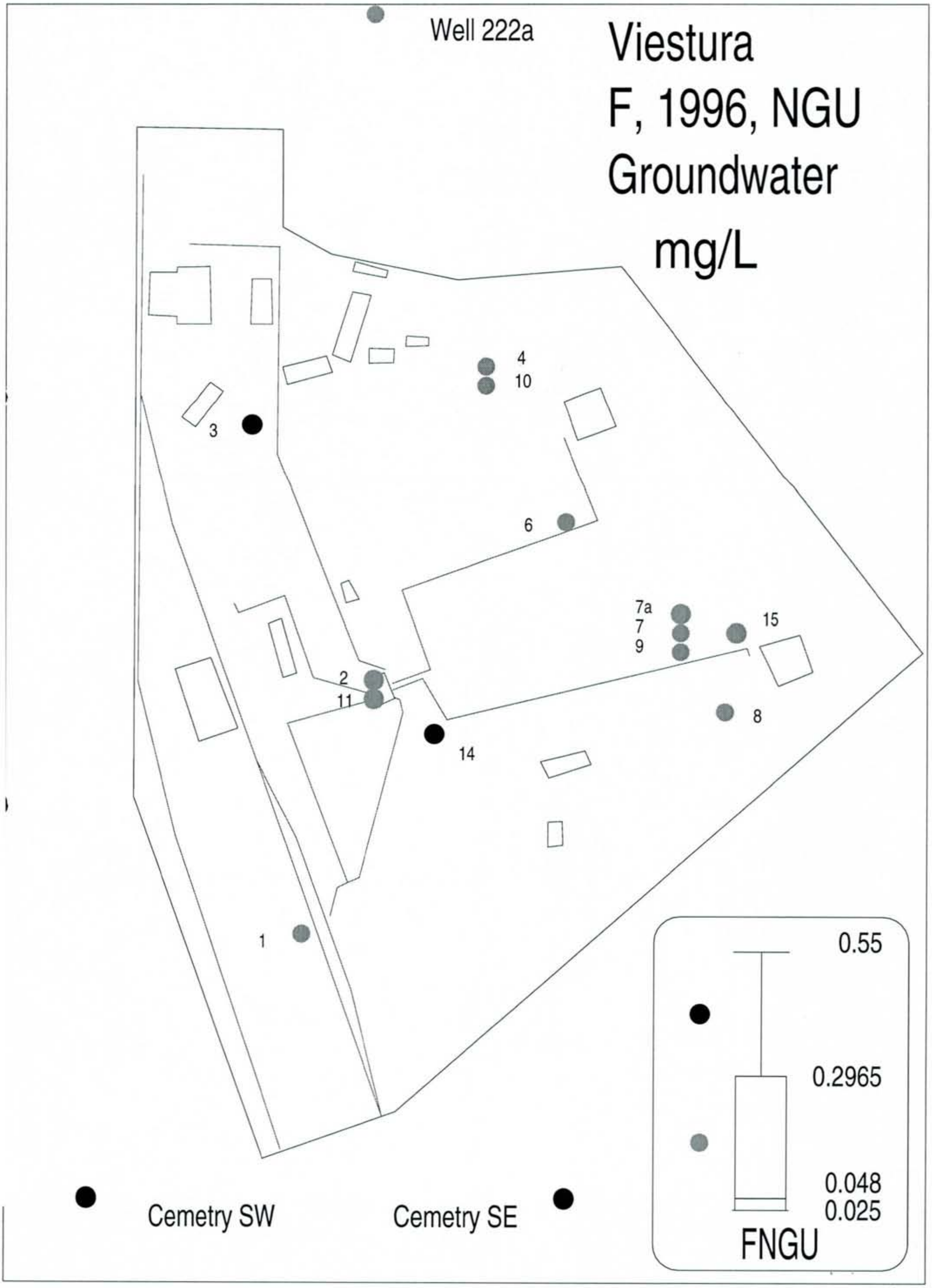

Well 222a
Viestura
Dry residue 1997, Lv
Groundwater
mg/l
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
855
625.5
503
298.5
261
Dry97Lv

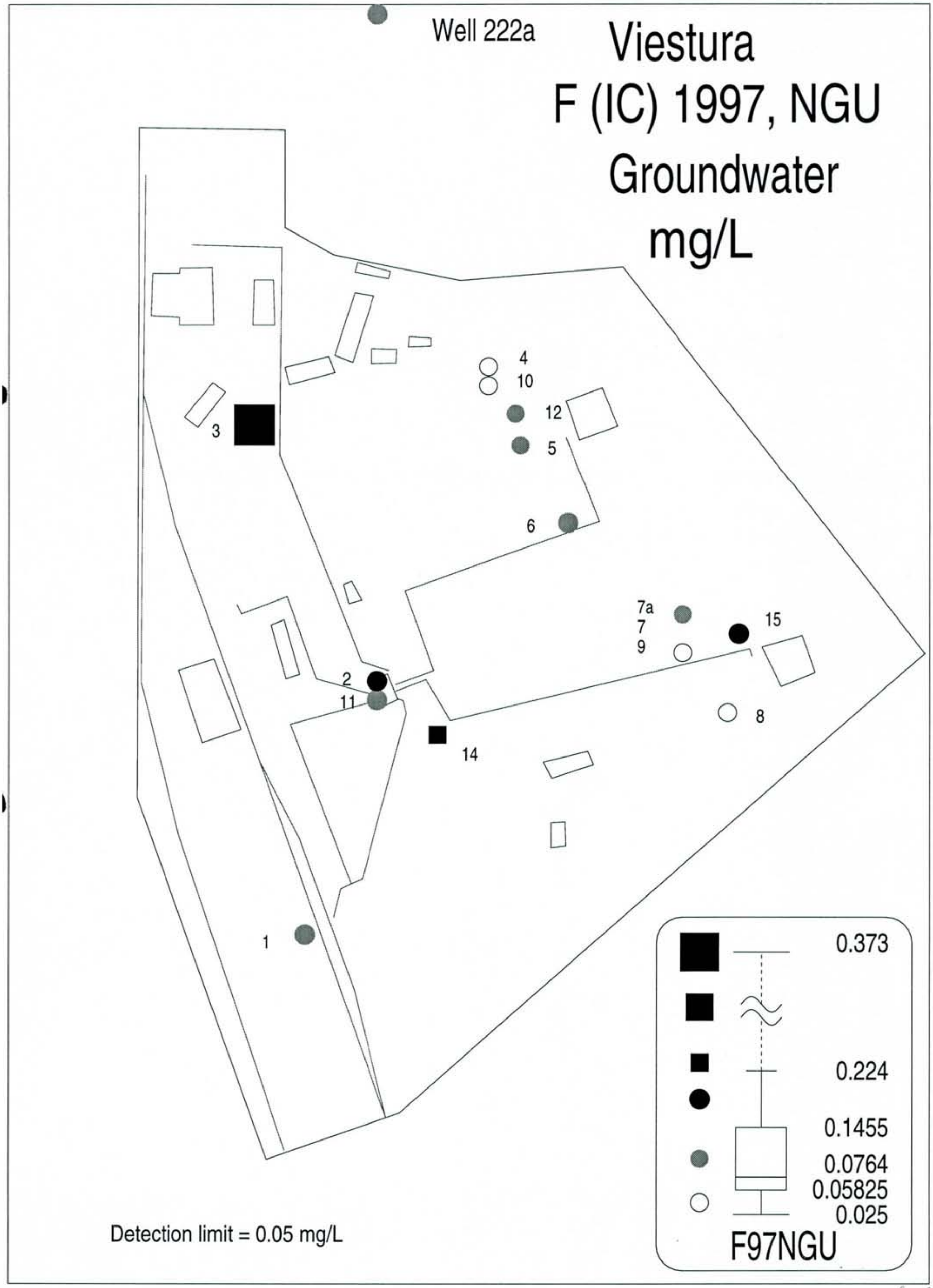


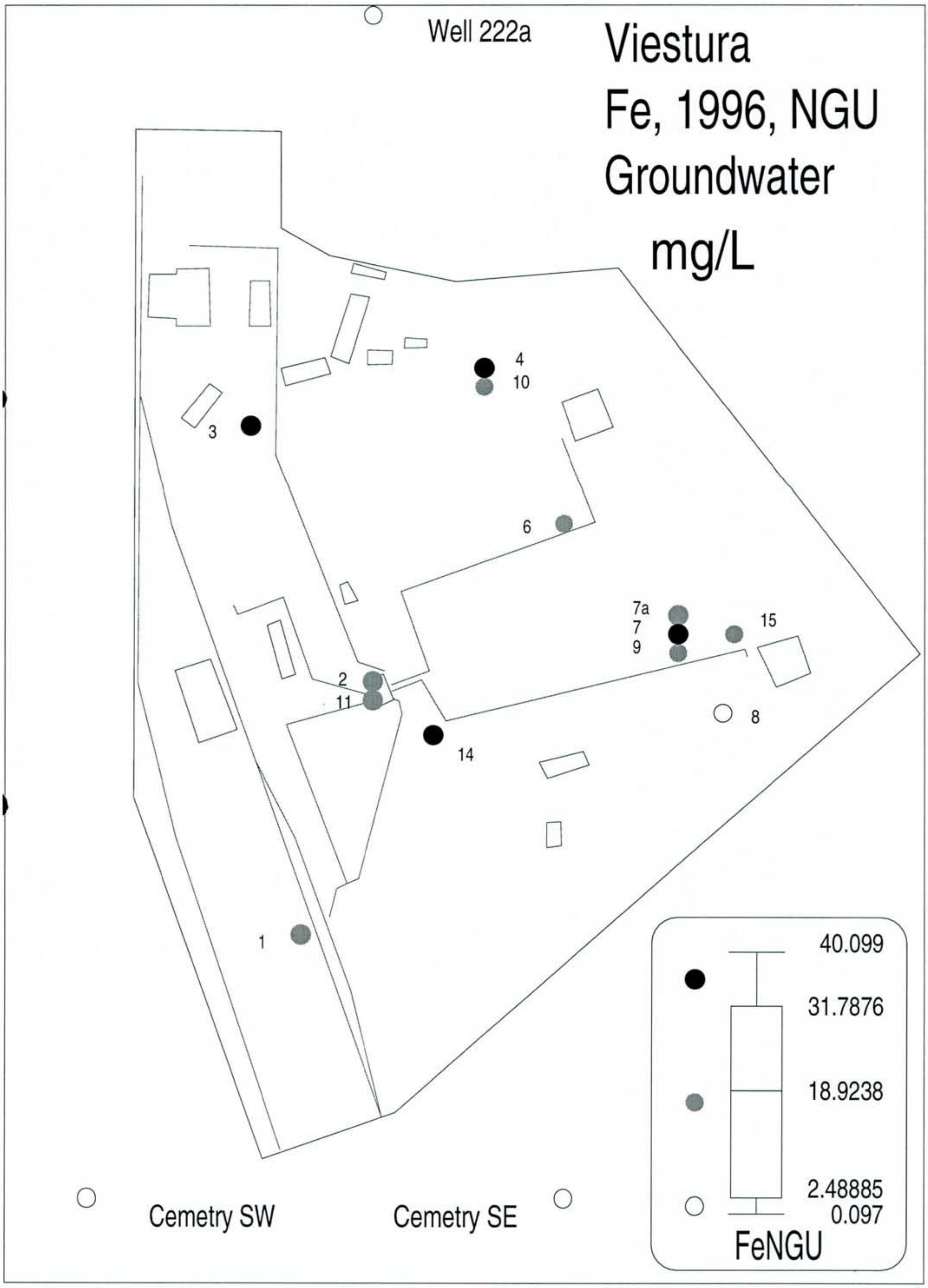
Viestura
EC 1994, Lv
Groundwater
uS/cm
4
10
7
9
2
11
950
830.5
728
664
459
EC94

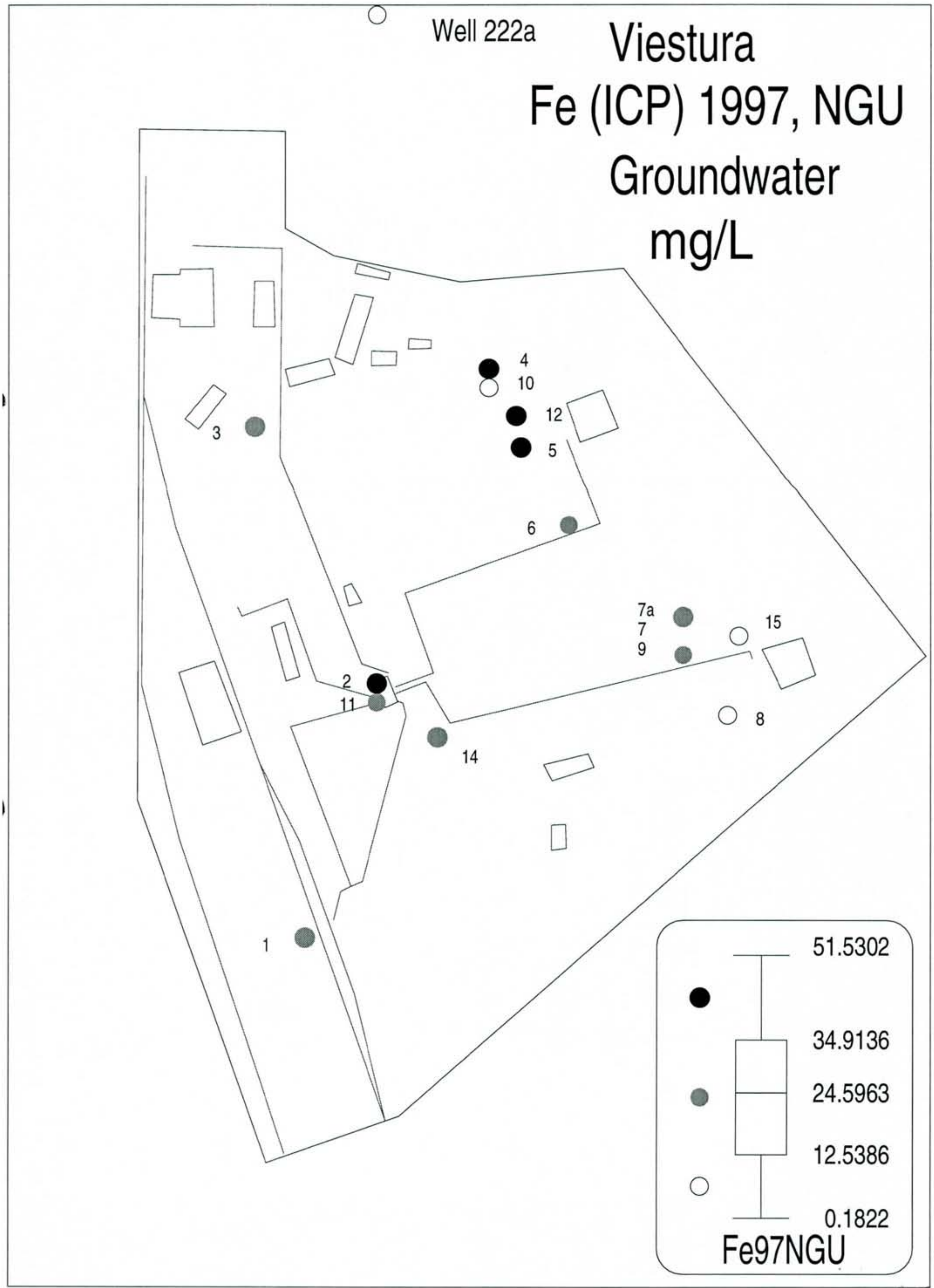

Well 222a
Viestura
EC, 1996, Lv
Groundwater
uS/cm
4
10
3
6
7a
7
9
15
2
11
8
14
1
881
838
572.5
427
323
EC96Lat
Cemetry SW
Cemetry SE


Well 222a
Viestura
Eh, 1997, NGU
Groundwater
mV
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
-134
-151
-166.5
-180
-203
-240
Eh97NGU

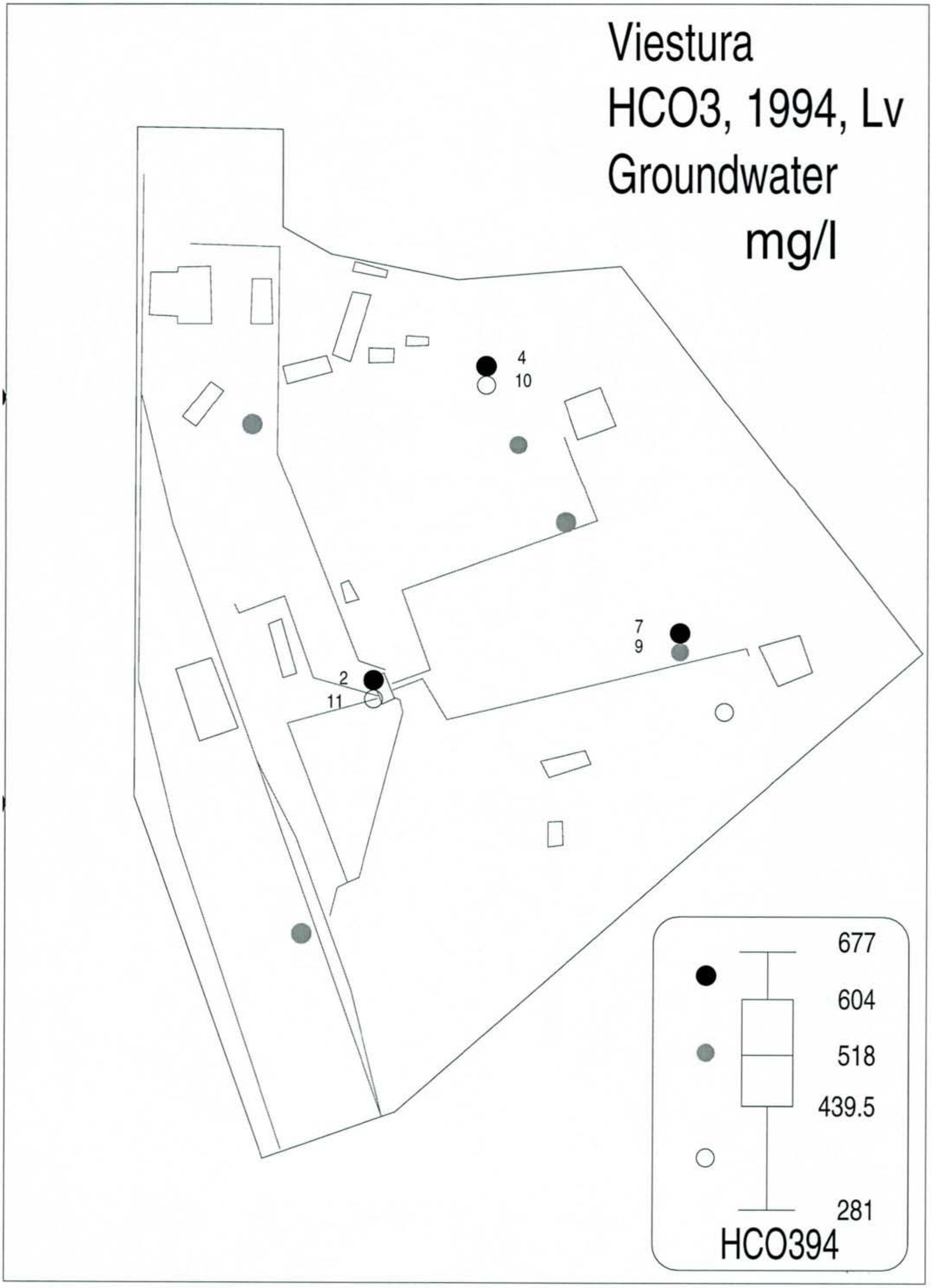

Well 222a
Viestura
F, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.55
0.2965
0.048
0.025
FNGU
Cemetry SW
Cemetry SE

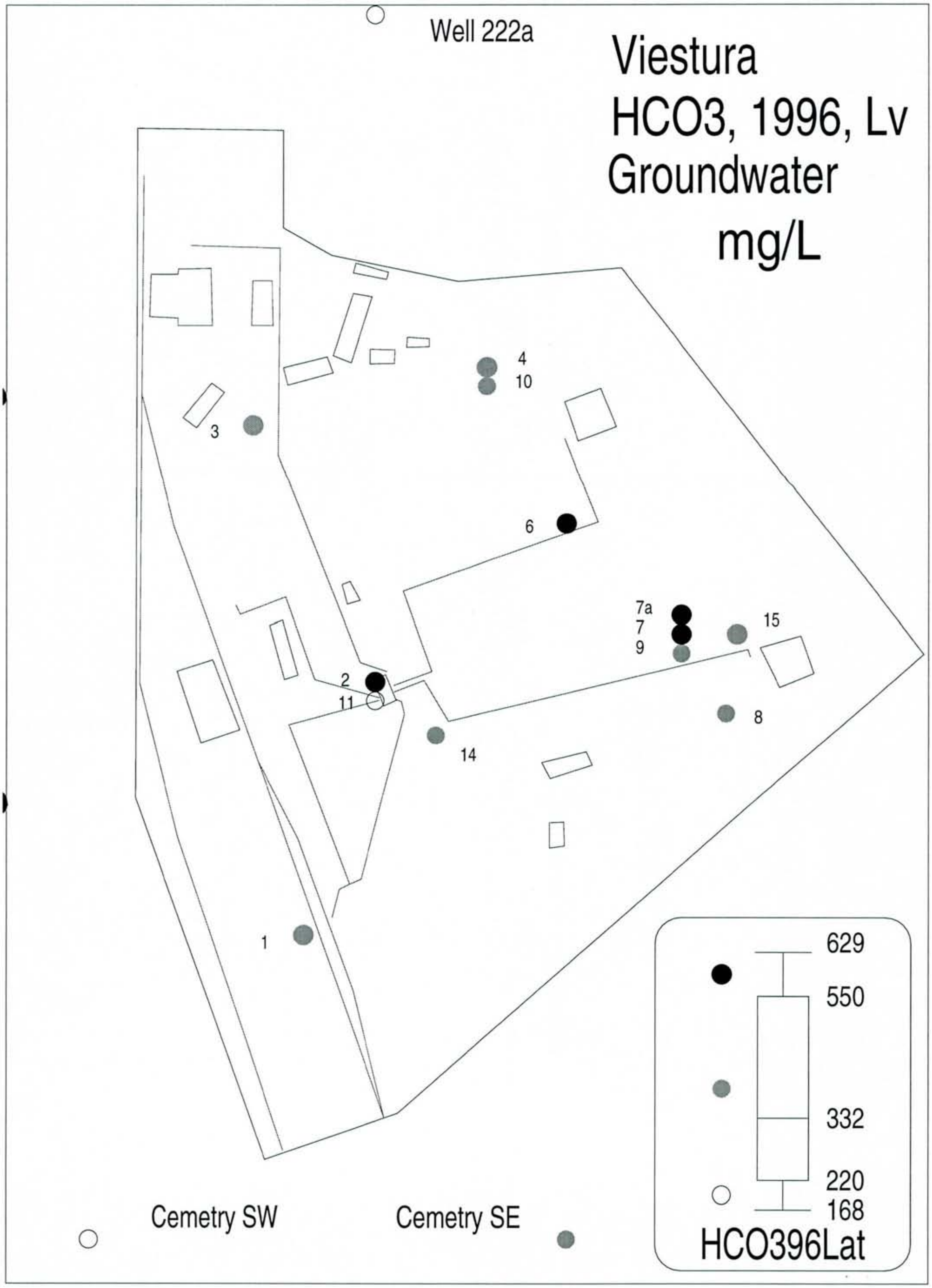

Well 222a
Viestura
F (IC) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
0.373
0.224
0.1455
0.0764
0.05825
0.025
F97NGU
Detection limit = 0.05 mg/L

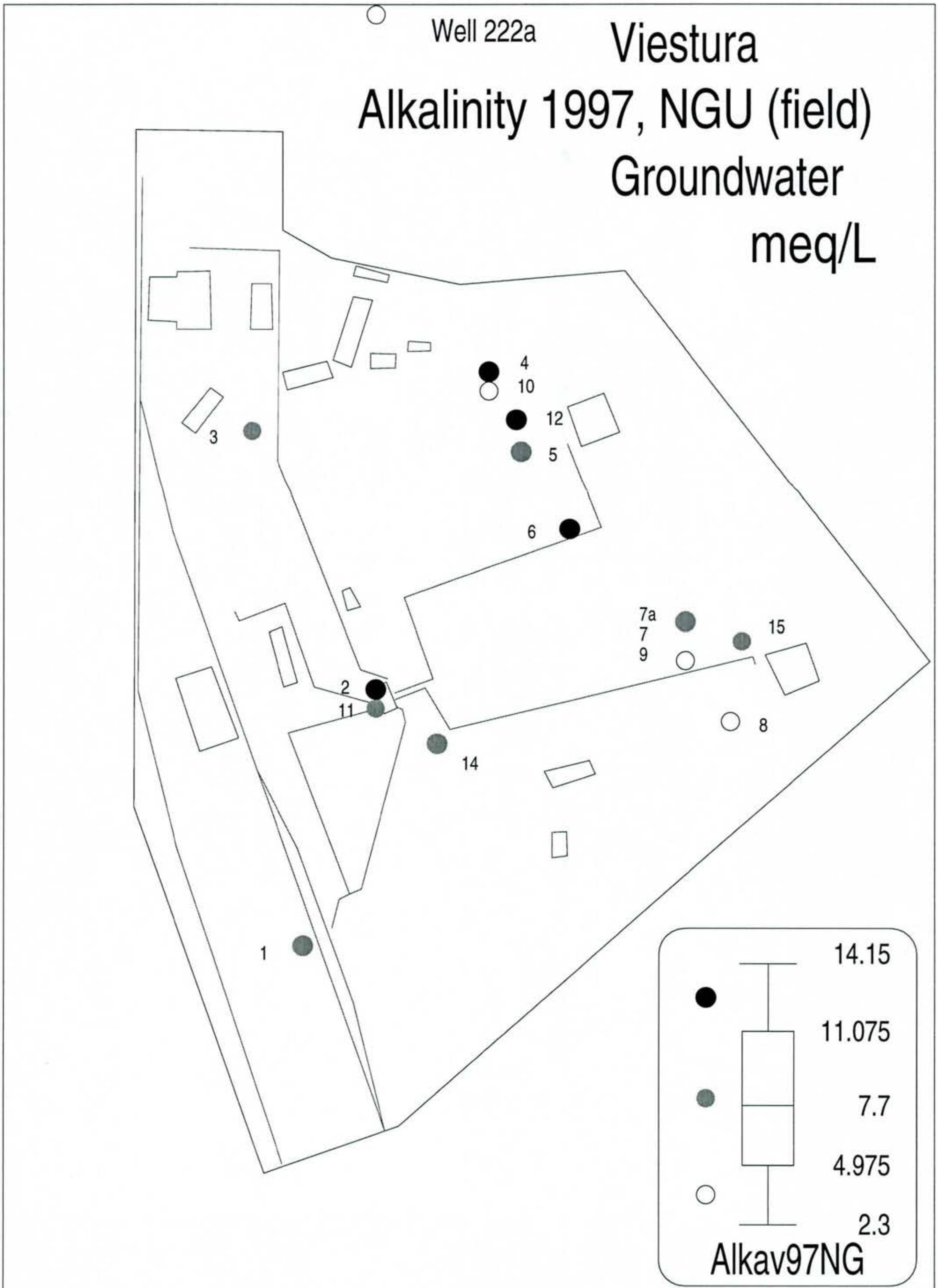

Well 222a
Viestura
Fe, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
40.099
31.7876
18.9238
2.48885
0.097
FeNGU
Cemetry SW
Cemetry SE

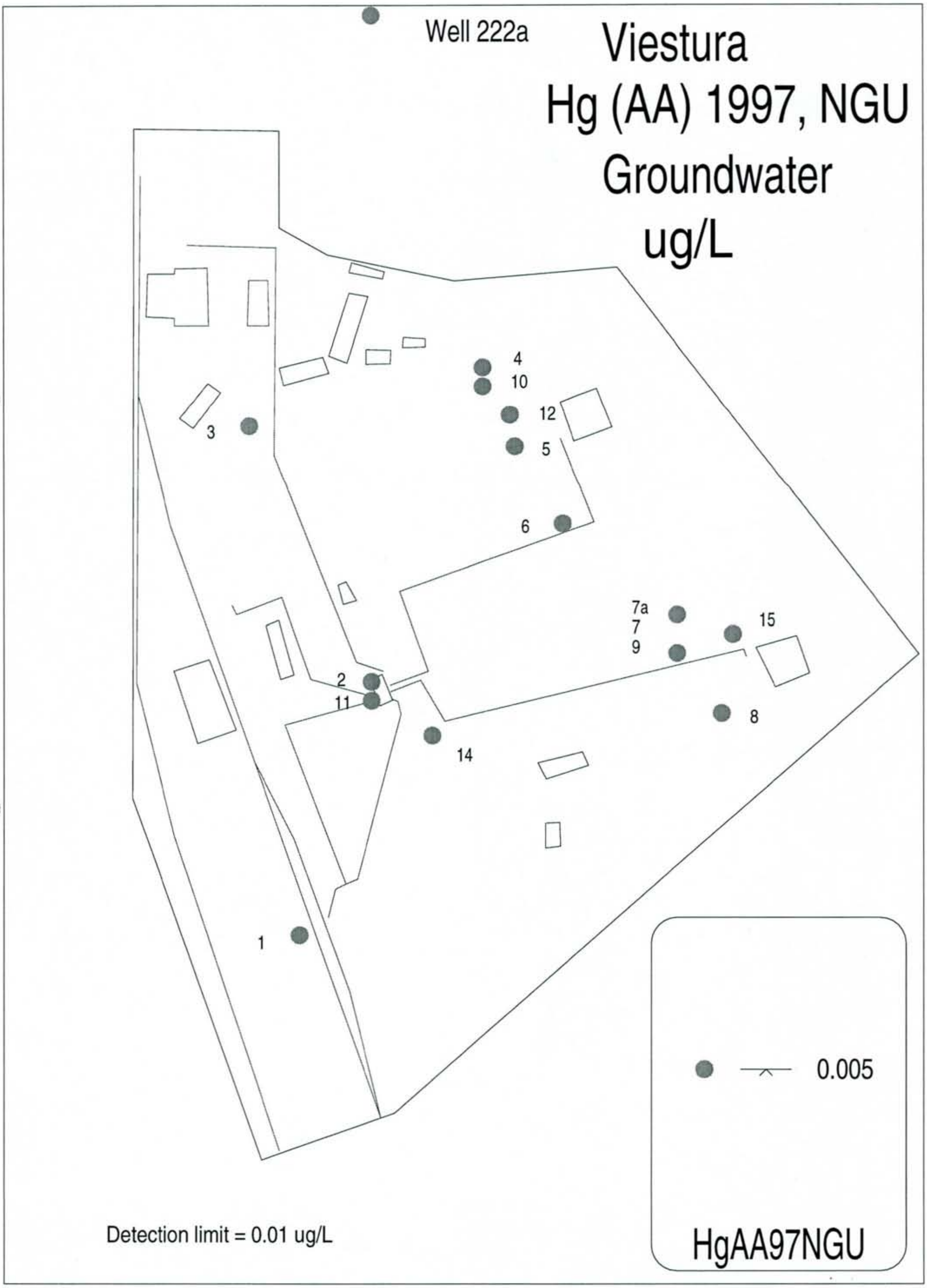


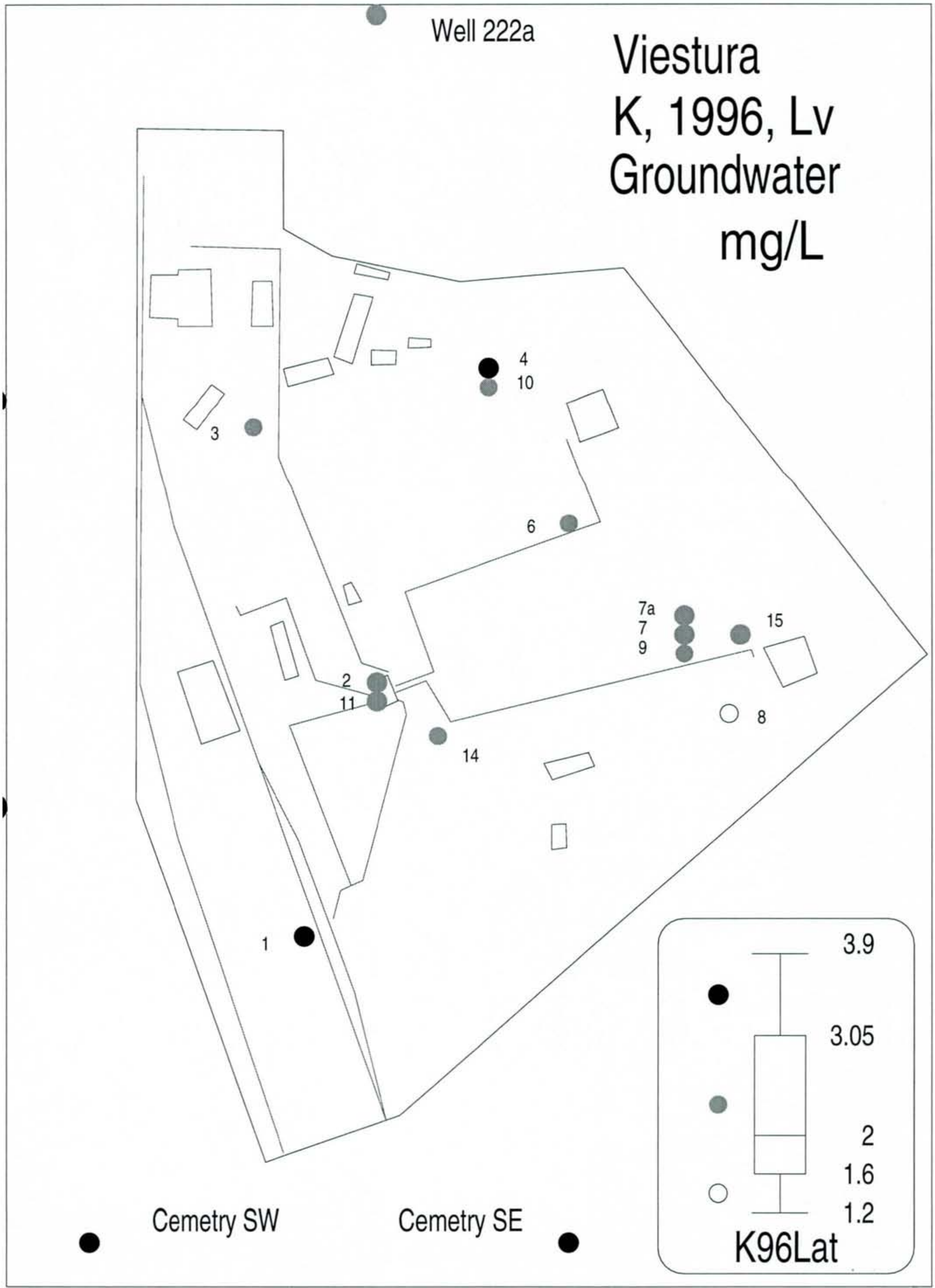
Well 222a
Viestura
Fe (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
5
3
6
7a
7
9
15
2
11
14
8
1
51.5302
34.9136
24.5963
12.5386
0.1822
Fe97NGU

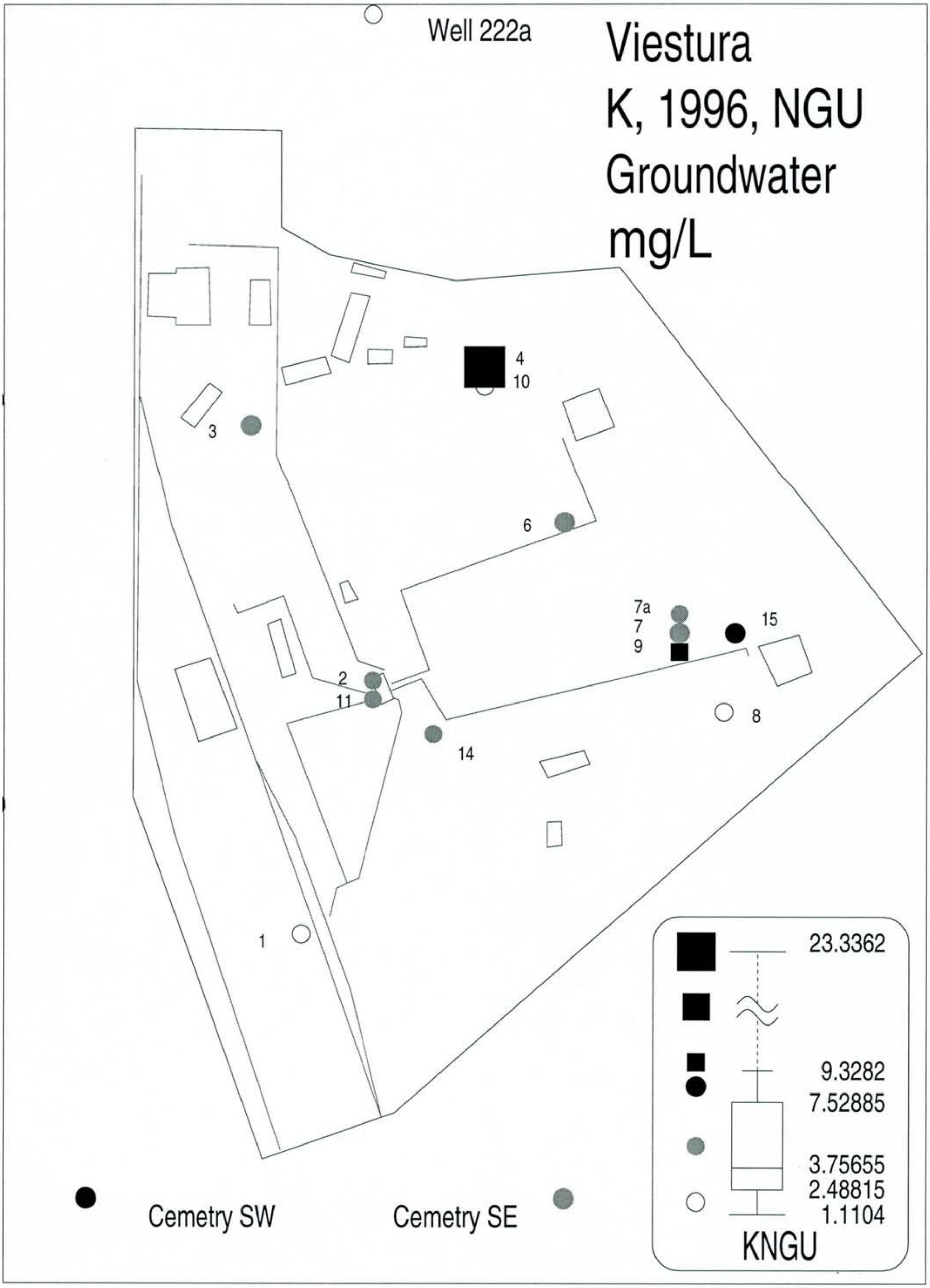

Viestura
HCO3, 1994, Lv
Groundwater
mg/l
4
10
7
9
2
11
677
604
518
439.5
281
HCO394

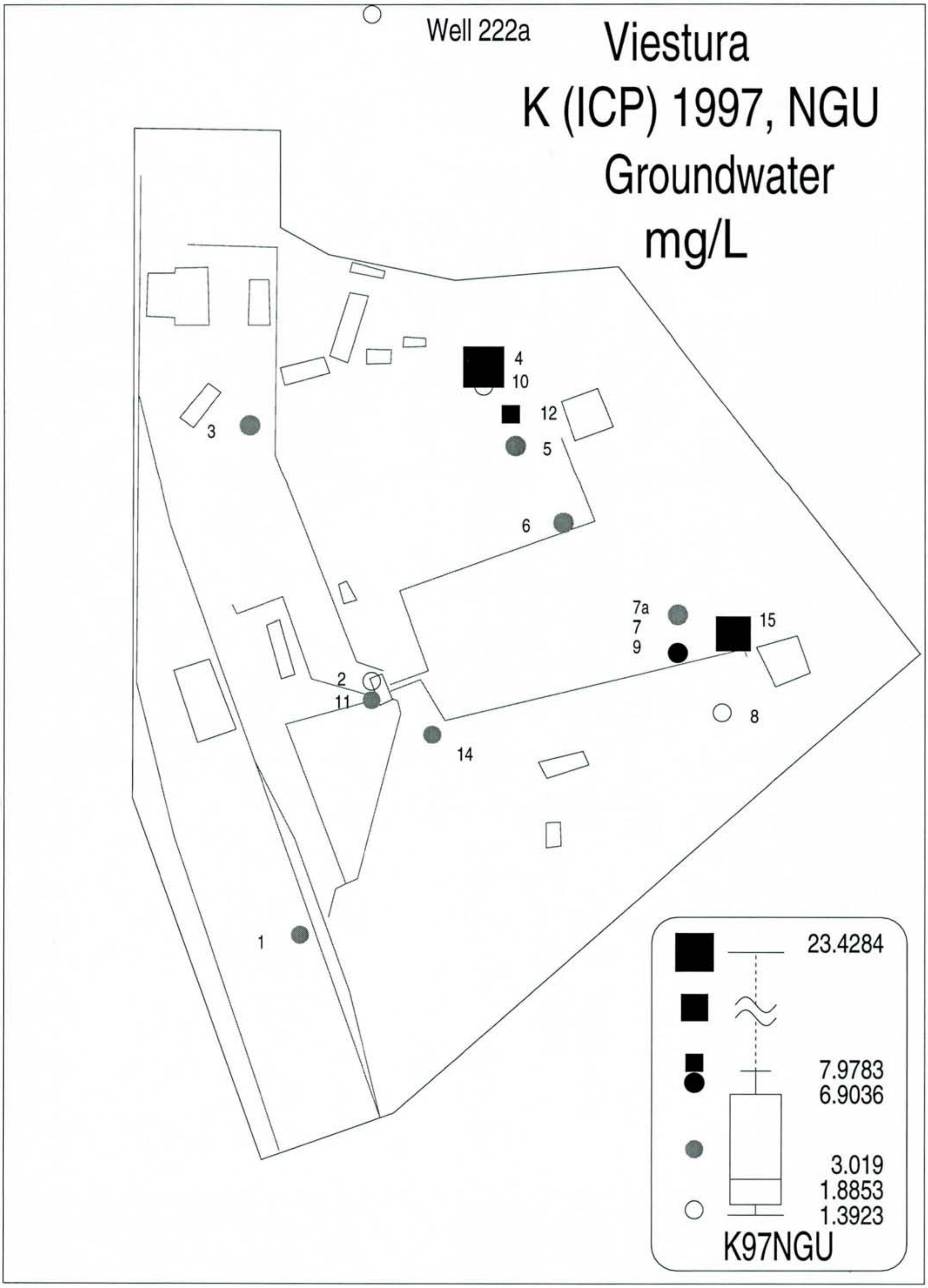

Well 222a
Viestura
HCO3, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
629
550
332
220
168
HCO396Lat
Cemetry SW
Cemetry SE

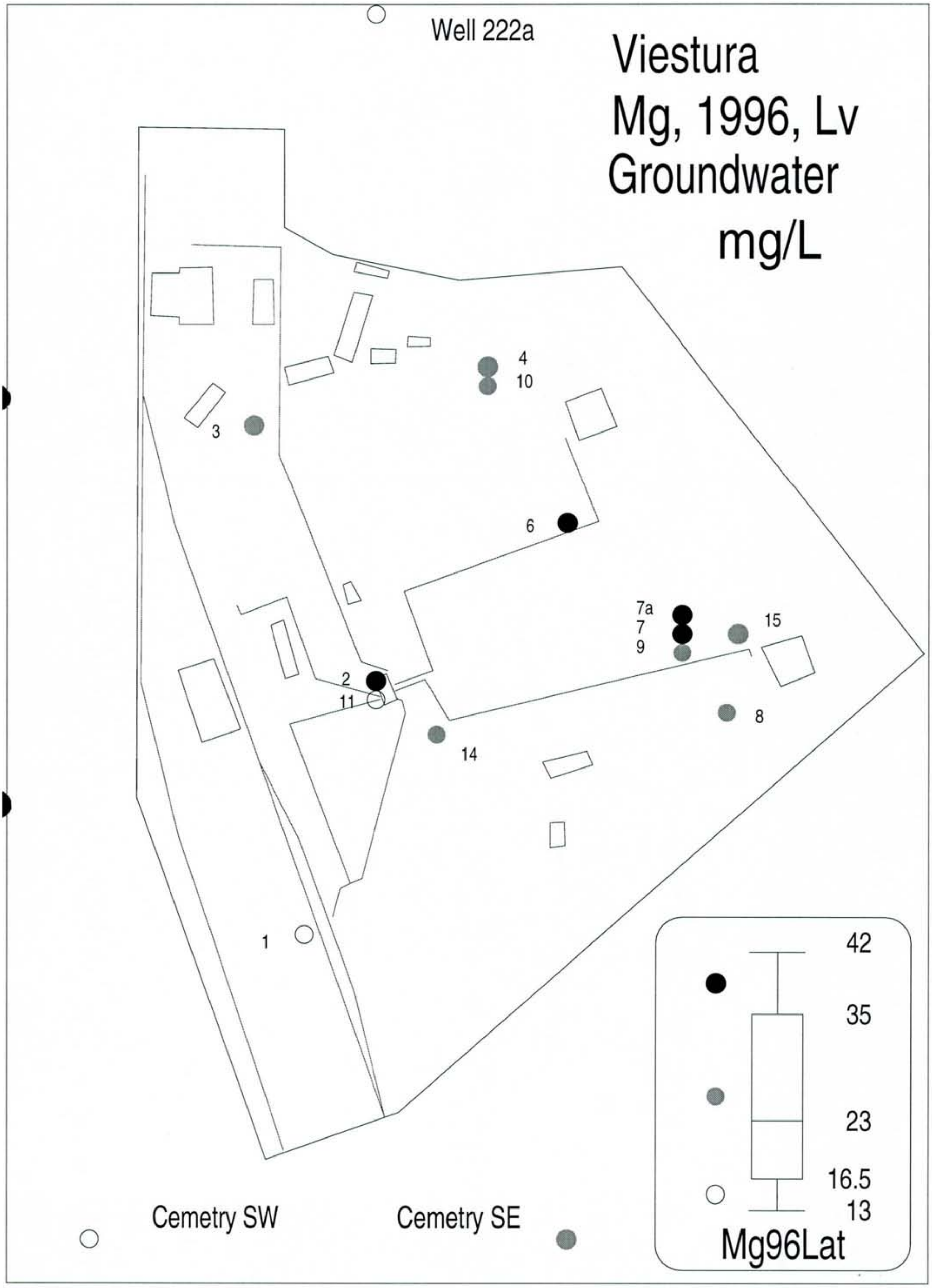

Well 222a
Viestura
Alkalinity 1997, NGU (field)
Groundwater
meq/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
14.15
11.075
7.7
4.975
2.3
Alkav97NG

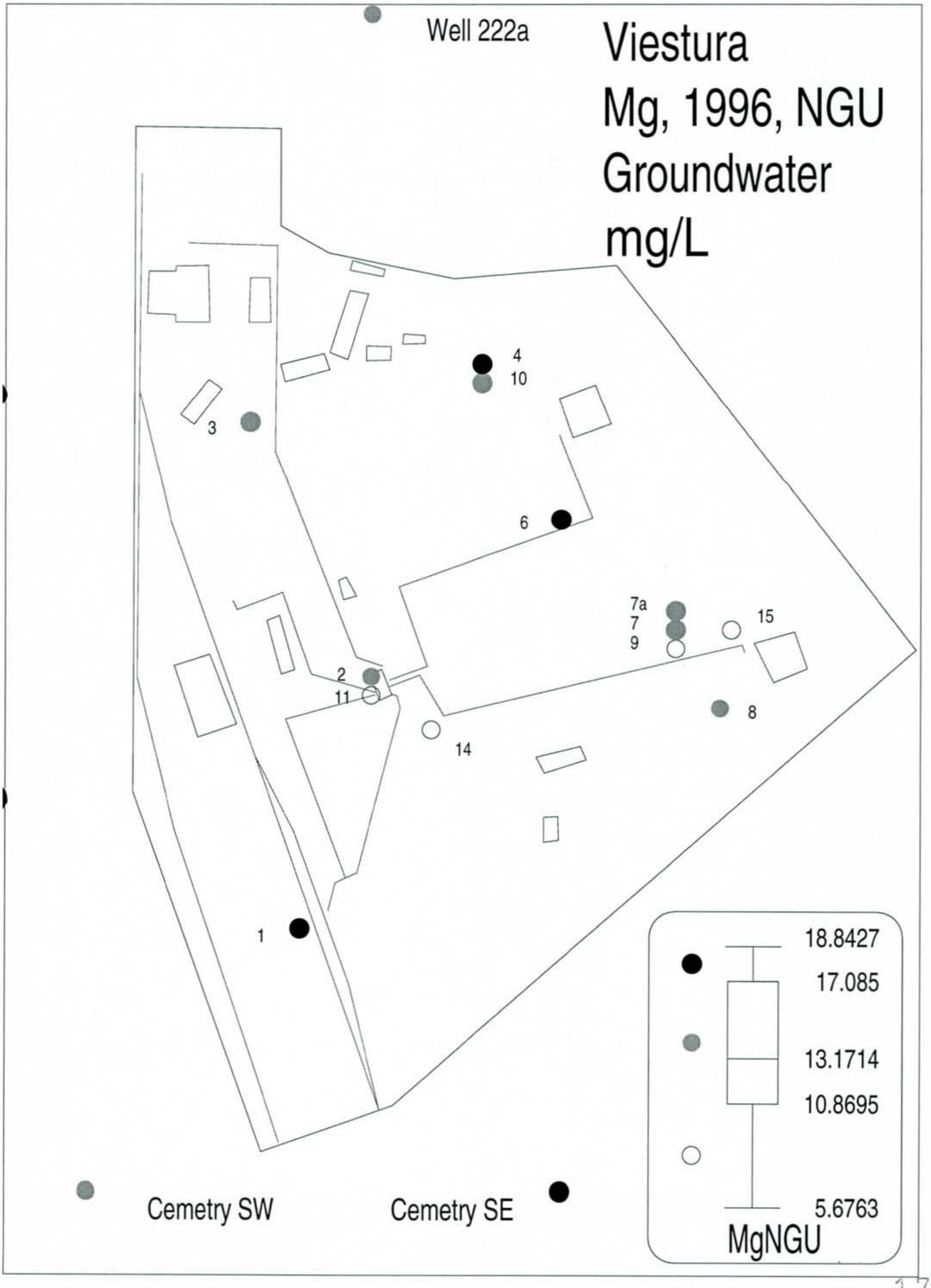

Well 222a
Viestura
Hg (AA) 1997, NGU
Groundwater
ug/L
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
0.005
Detection limit = 0.01 ug/L
HgAA97NGU

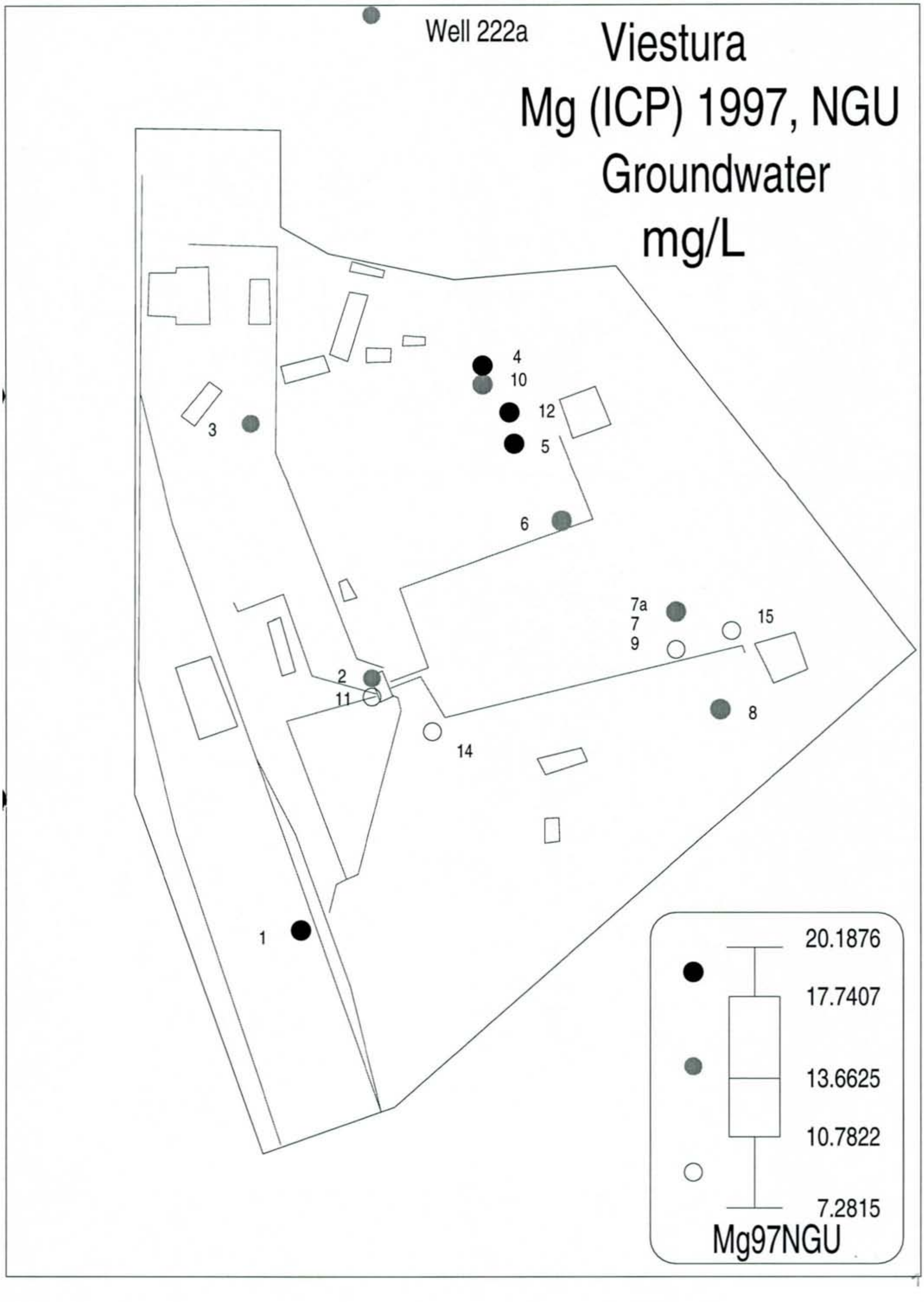

Well 222a
Viestura
K, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
3.9
3.05
2
1.6
1.2
K96Lat
Cemetry SW
Cemetry SE


Well 222a
Viestura
K, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
14
8
1
23.3362
9.3282
7.52885
3.75655
2.48815
1.1104
KNGU
Cemetry SW
Cemetry SE

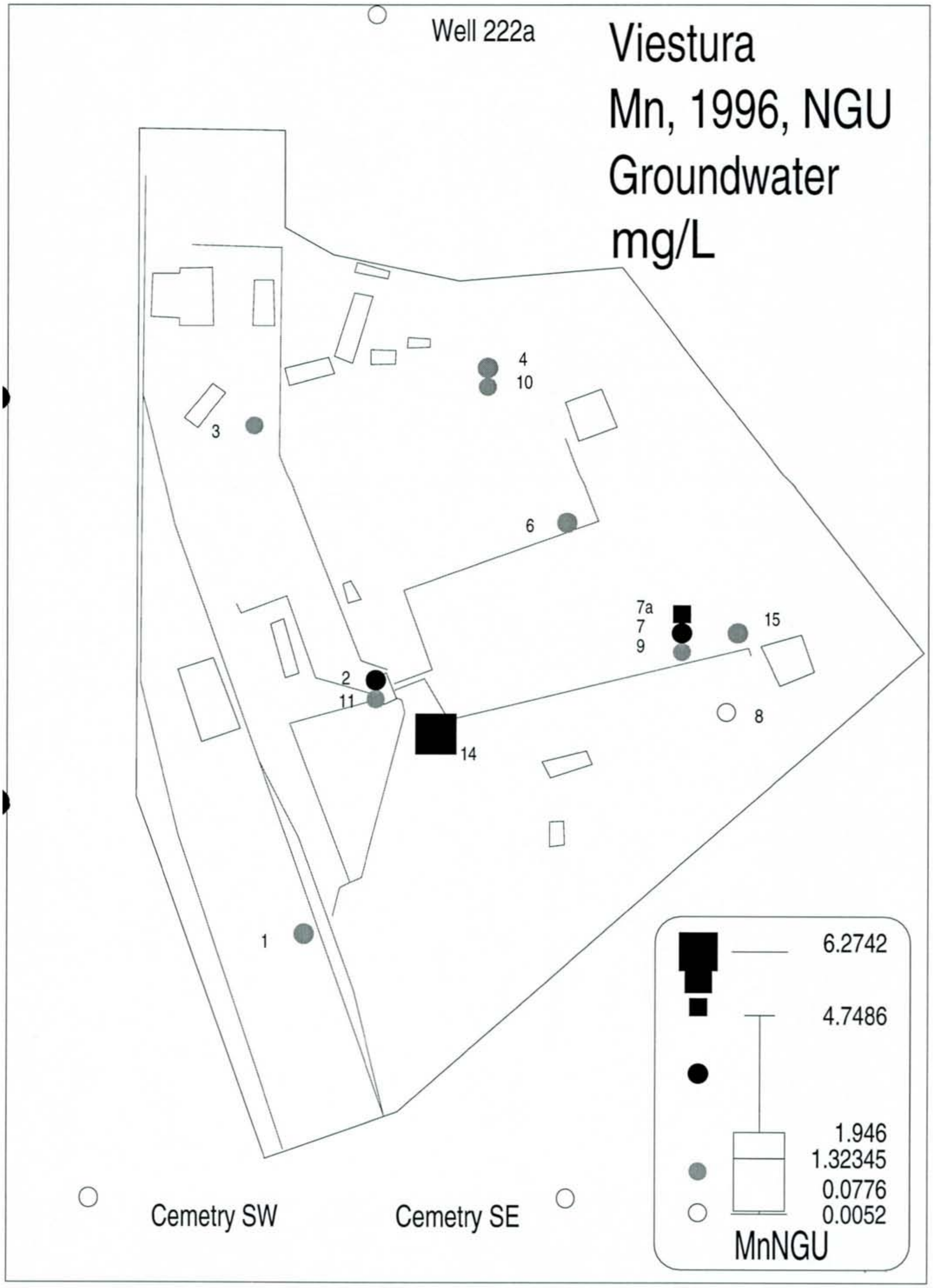

Well 222a
Viestura
K (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
23.4284
7.9783
6.9036
3.019
1.8853
1.3923
K97NGU

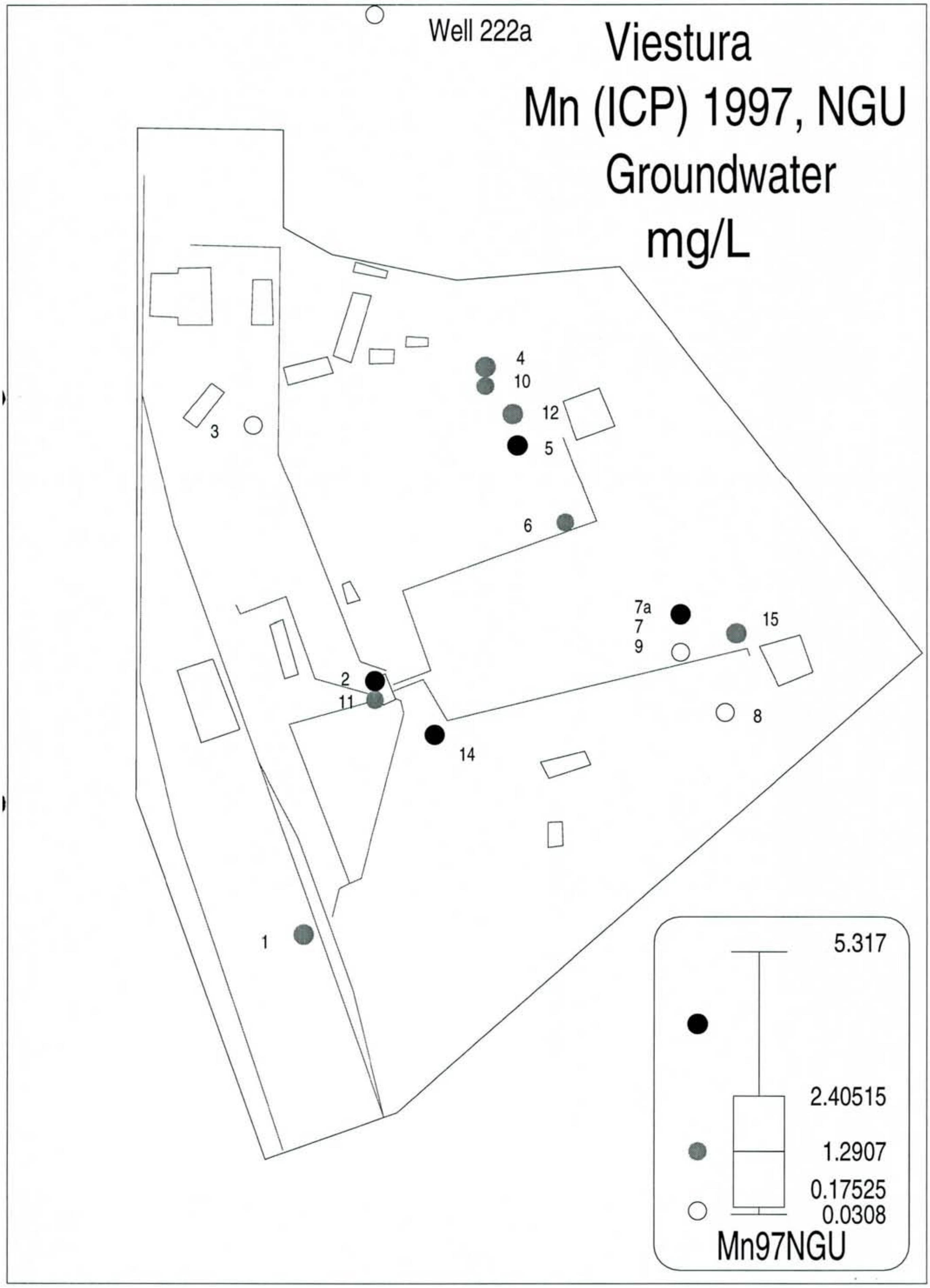

Well 222a
Viestura
Mg, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
42
35
23
16.5
13
Mg96Lat
Cemetry SW
Cemetry SE

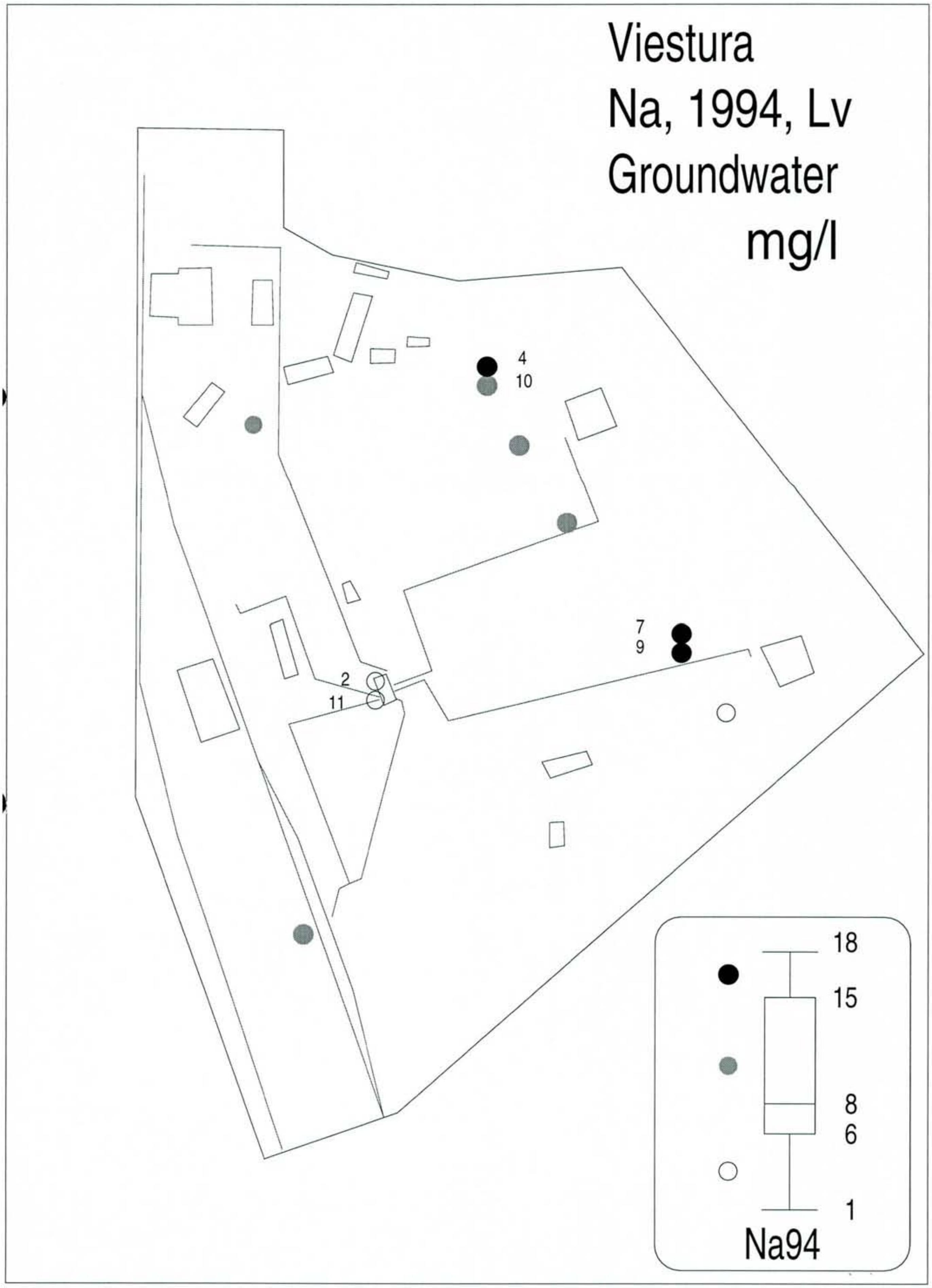

Well 222a
Viestura
Mg, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
18.8427
17.085
13.1714
10.8695
5.6763
MgNGU
Cemetry SW
Cemetry SE



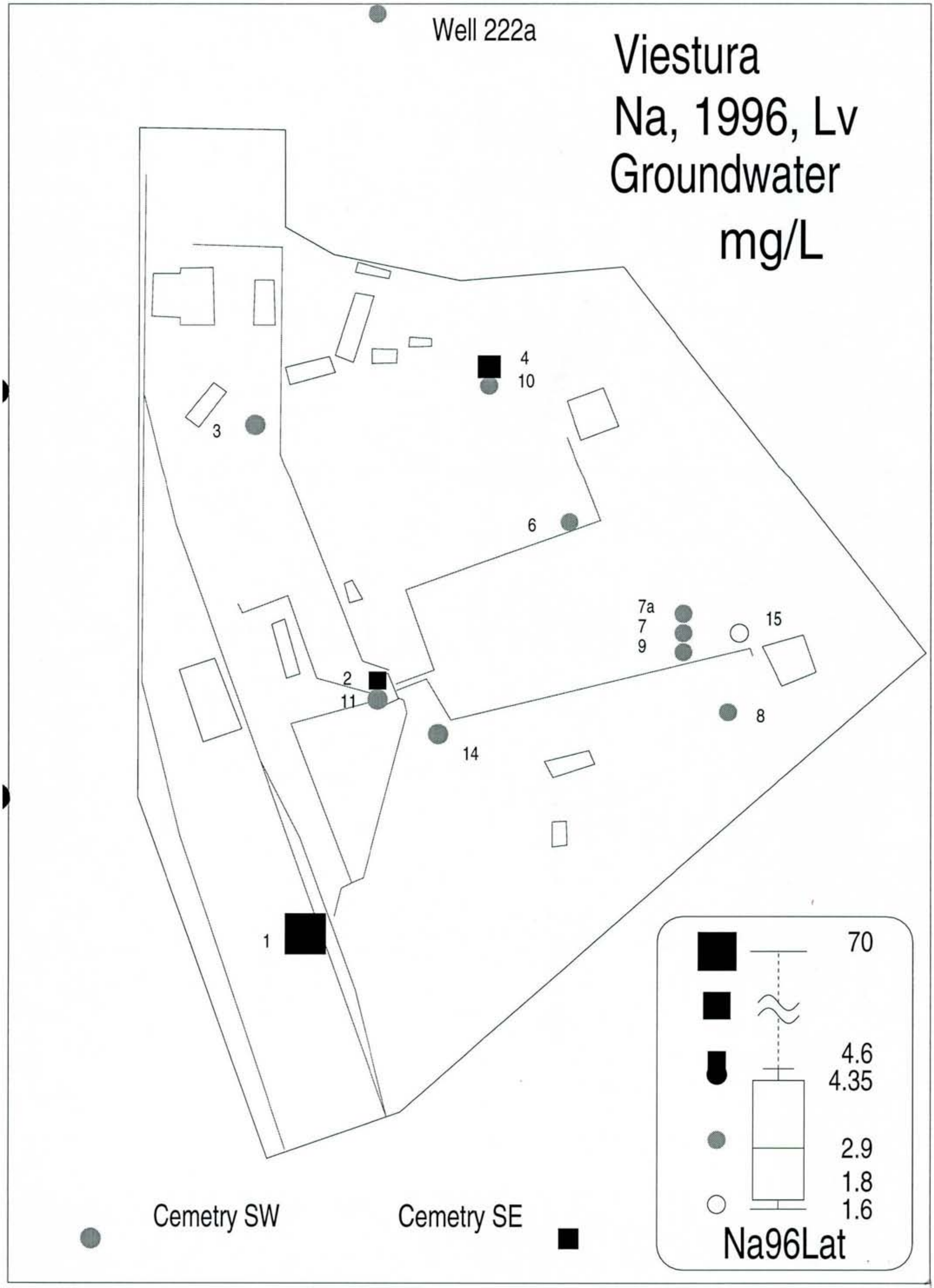
Well 222a
Viestura
Mg (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
20.1876
17.7407
13.6625
10.7822
7.2815
Mg97NGU

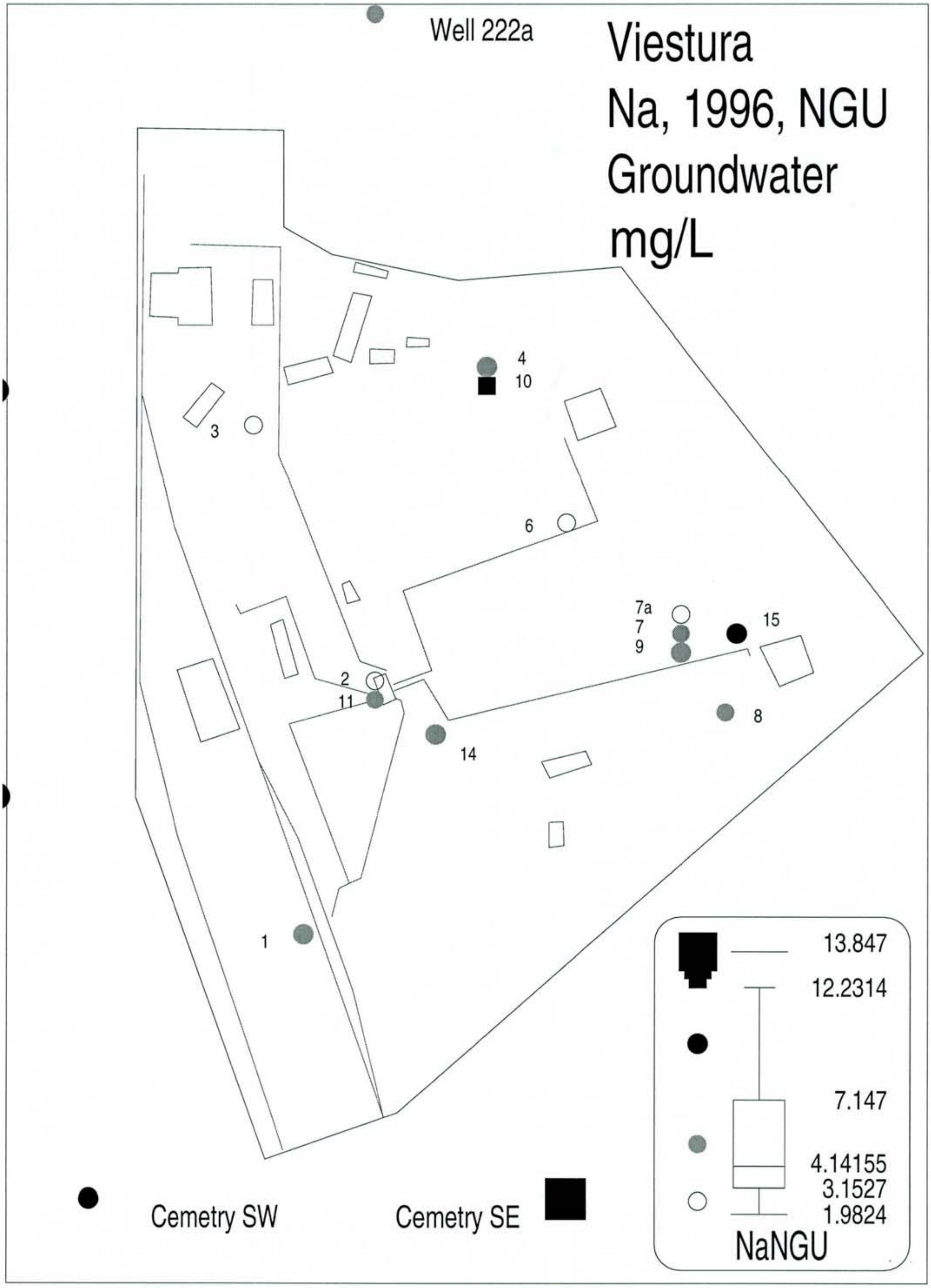

Well 222a
Viestura
Mn, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
14
8
1
6.2742
4.7486
1.946
1.32345
0.0776
0.0052
MnNGU
Cemetery SW
Cemetery SE

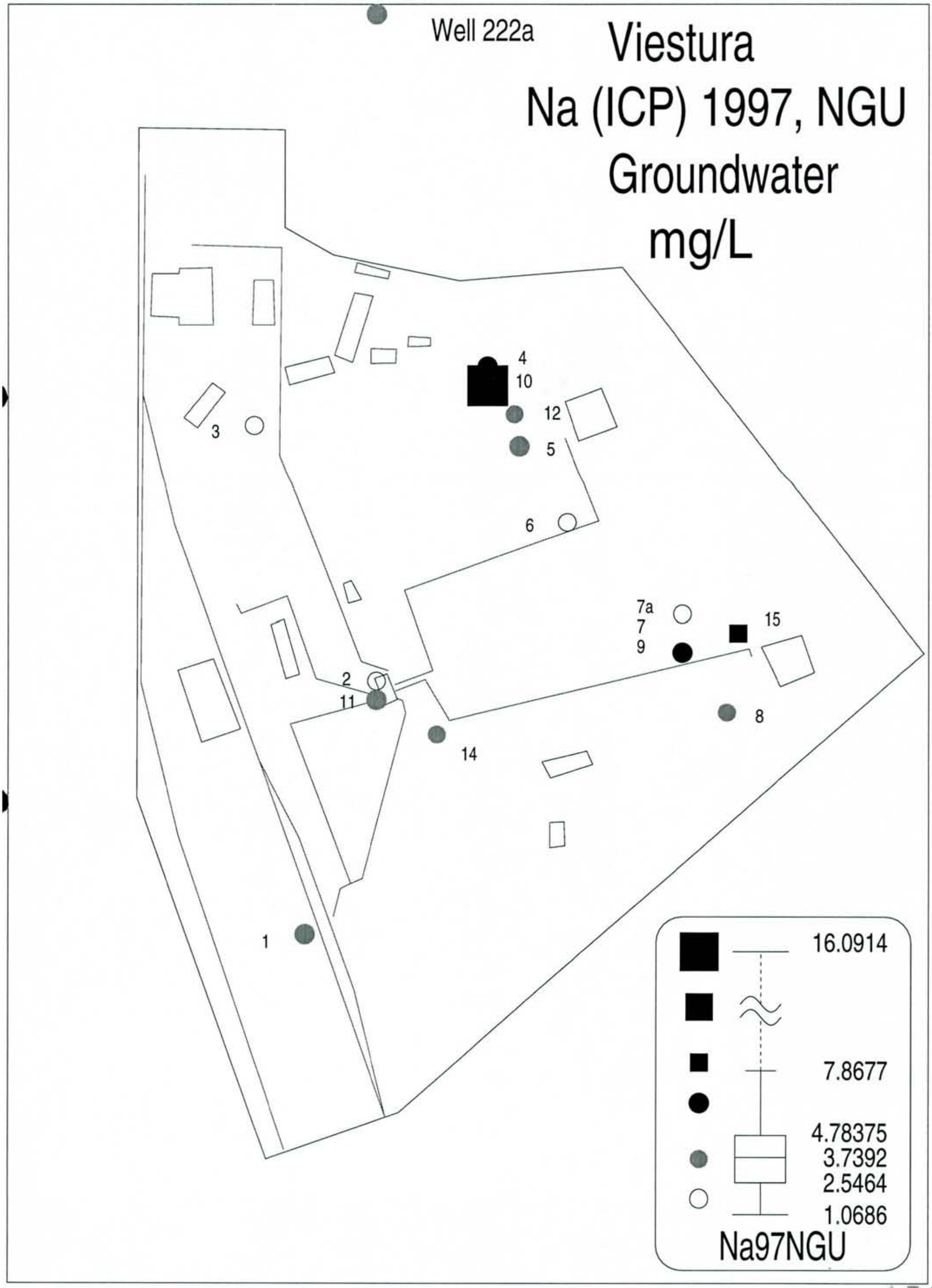

Well 222a
Viestura
Mn (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
5
3
6
7a
7
9
15
2
11
14
8
1
5.317
2.40515
1.2907
0.17525
0.0308
Mn97NGU

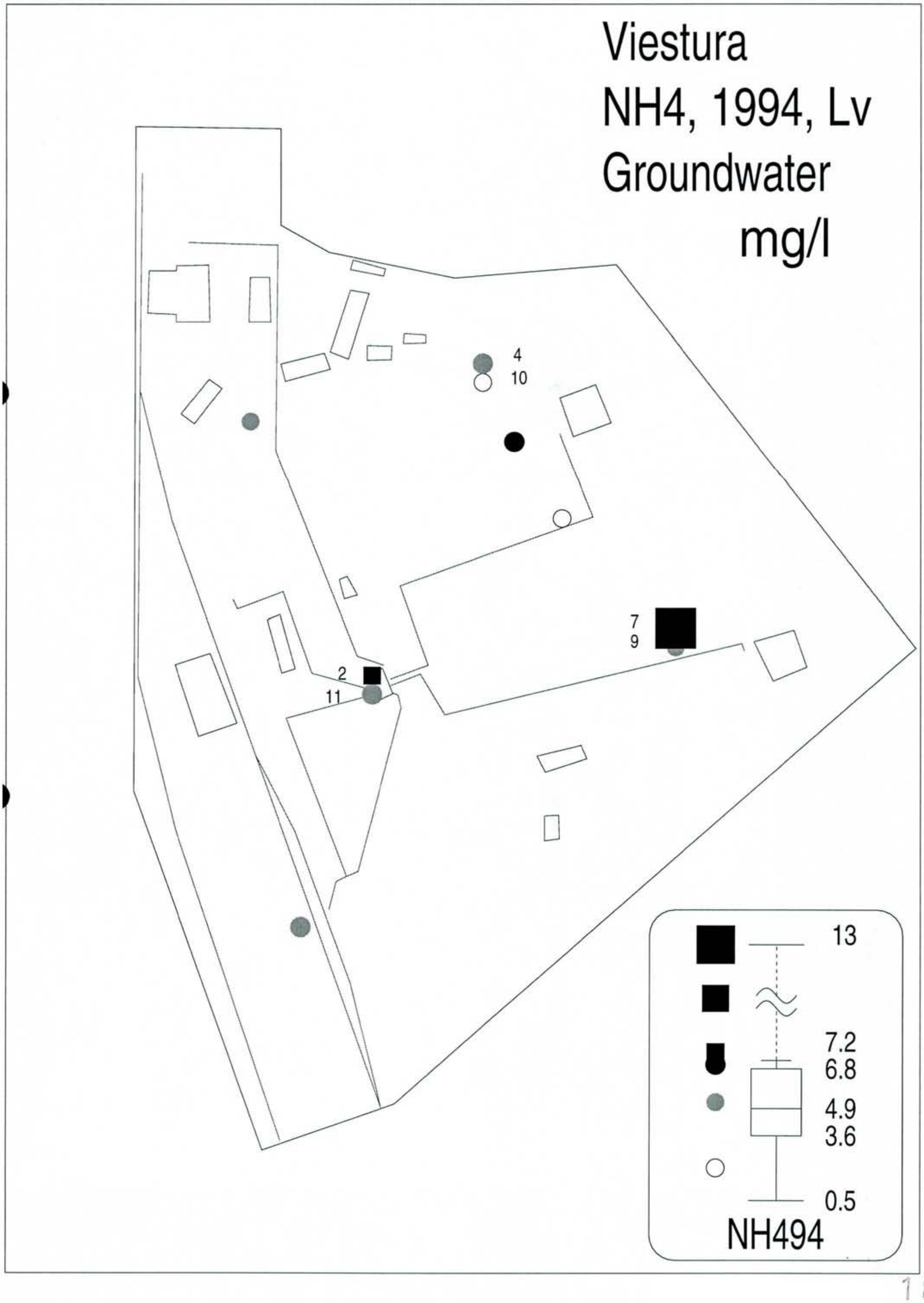


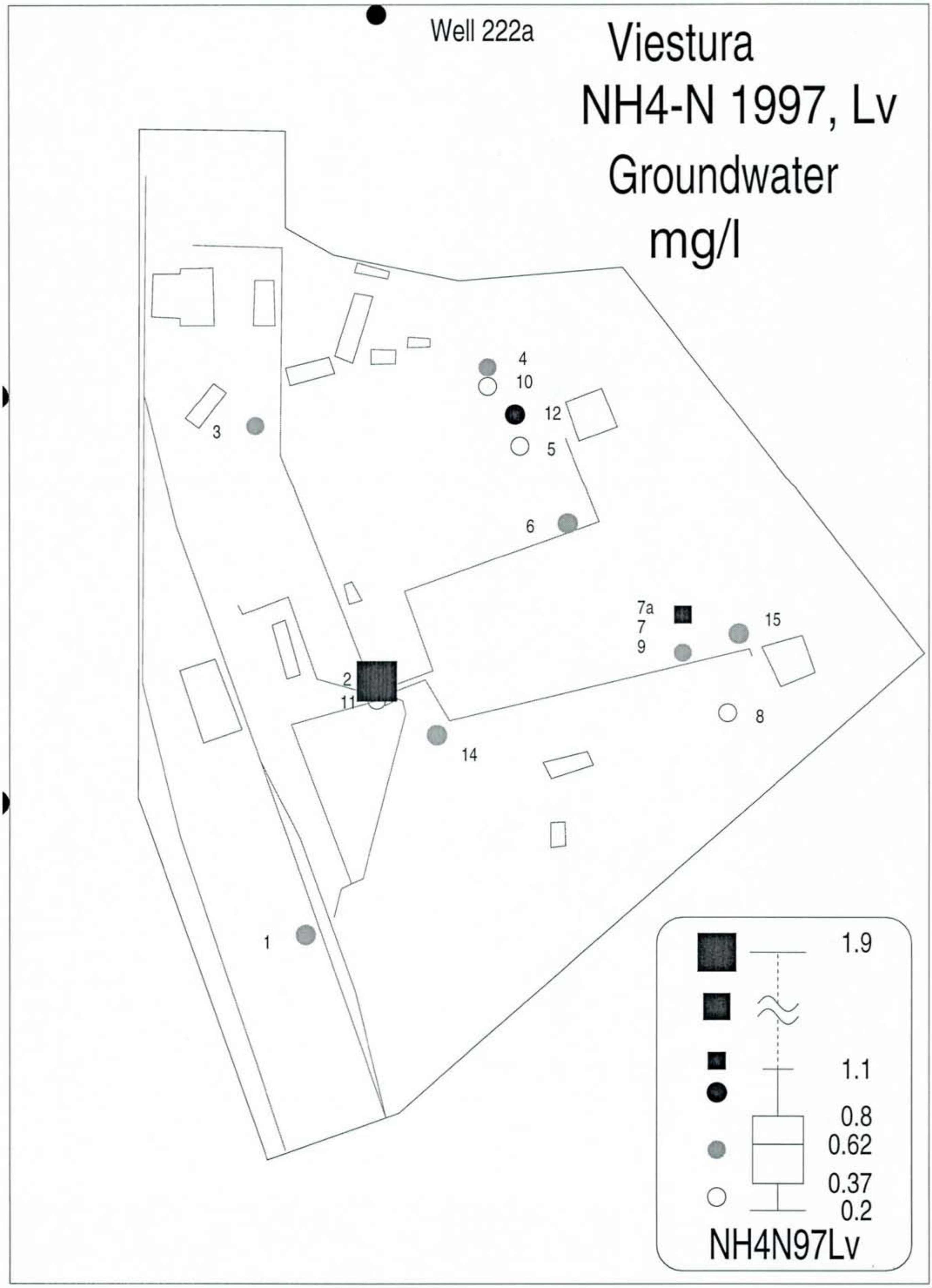
Viestura
Na, 1994, Lv
Groundwater
mg/l
4
10
7
9
2
11
18
15
8
6
1
Na94


Well 222a
Viestura
Na, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
70
4.6
4.35
2.9
1.8
1.6
Na96Lat
Cemetry SW
Cemetry SE

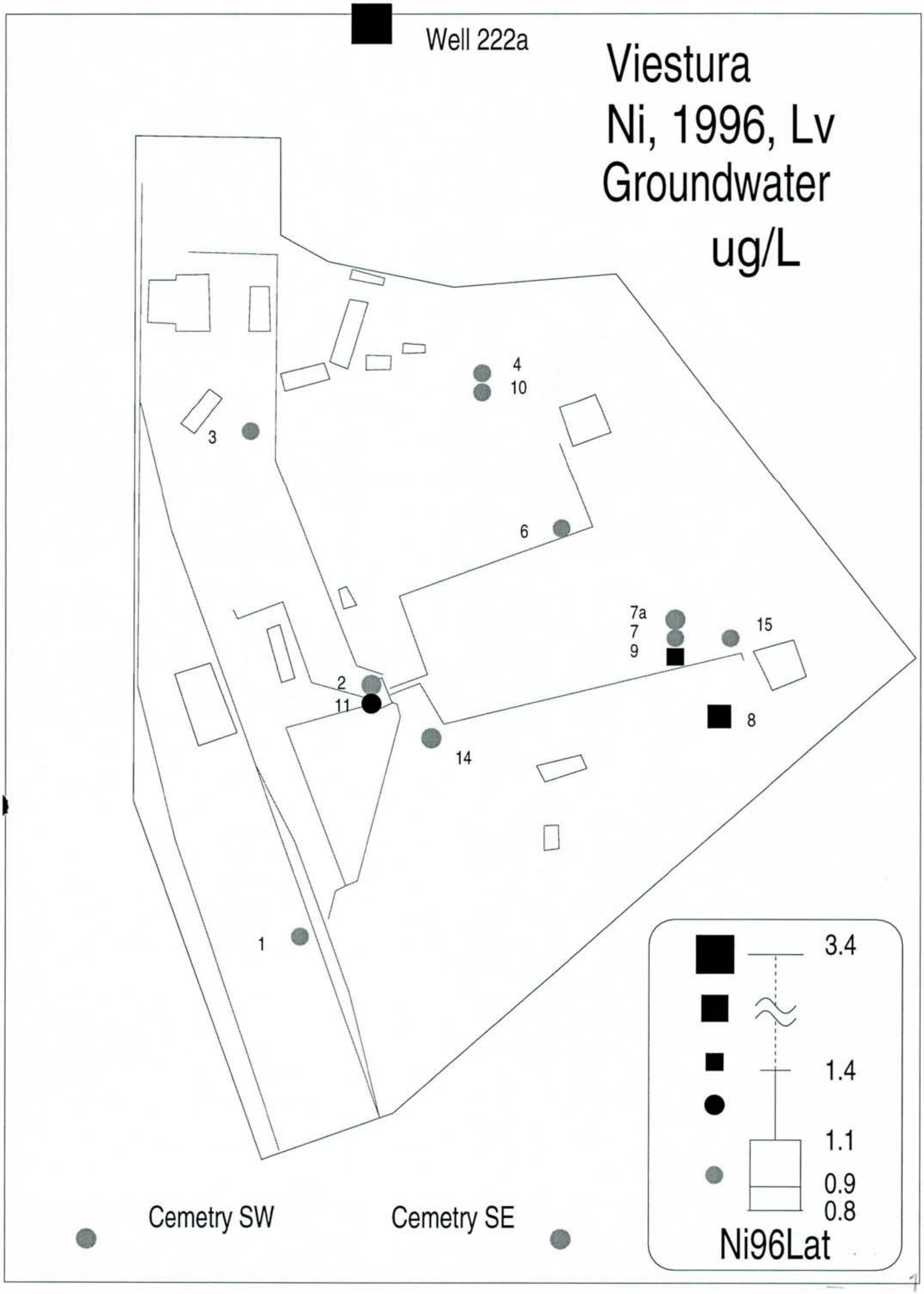

Well 222a
Viestura
Na, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
13.847
12.2314
7.147
4.14155
3.1527
1.9824
NaNGU
Cemetry SW
Cemetry SE

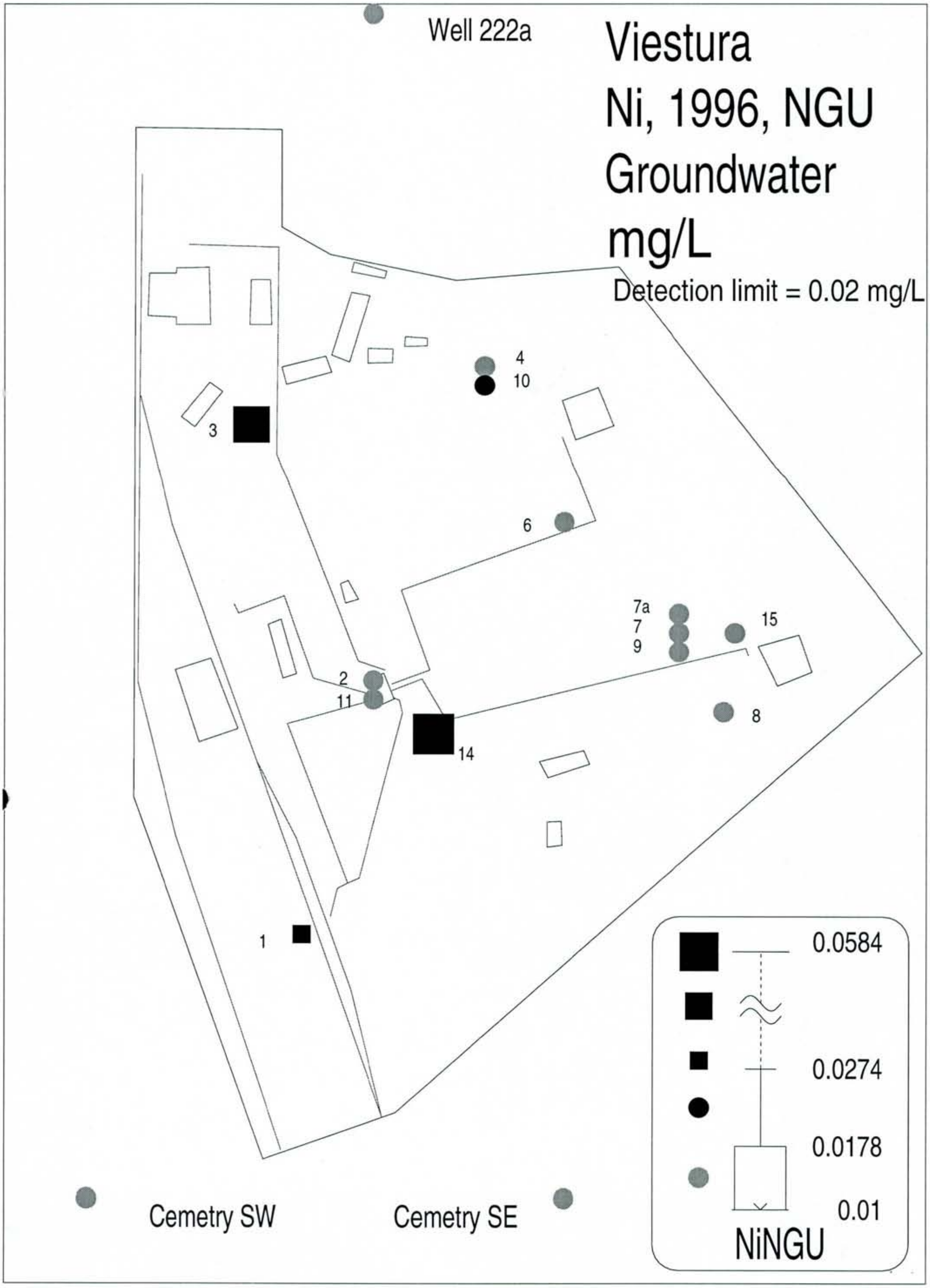

Well 222a
Viestura
Na (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
16.0914
7.8677
4.78375
3.7392
2.5464
1.0686
Na97NGU

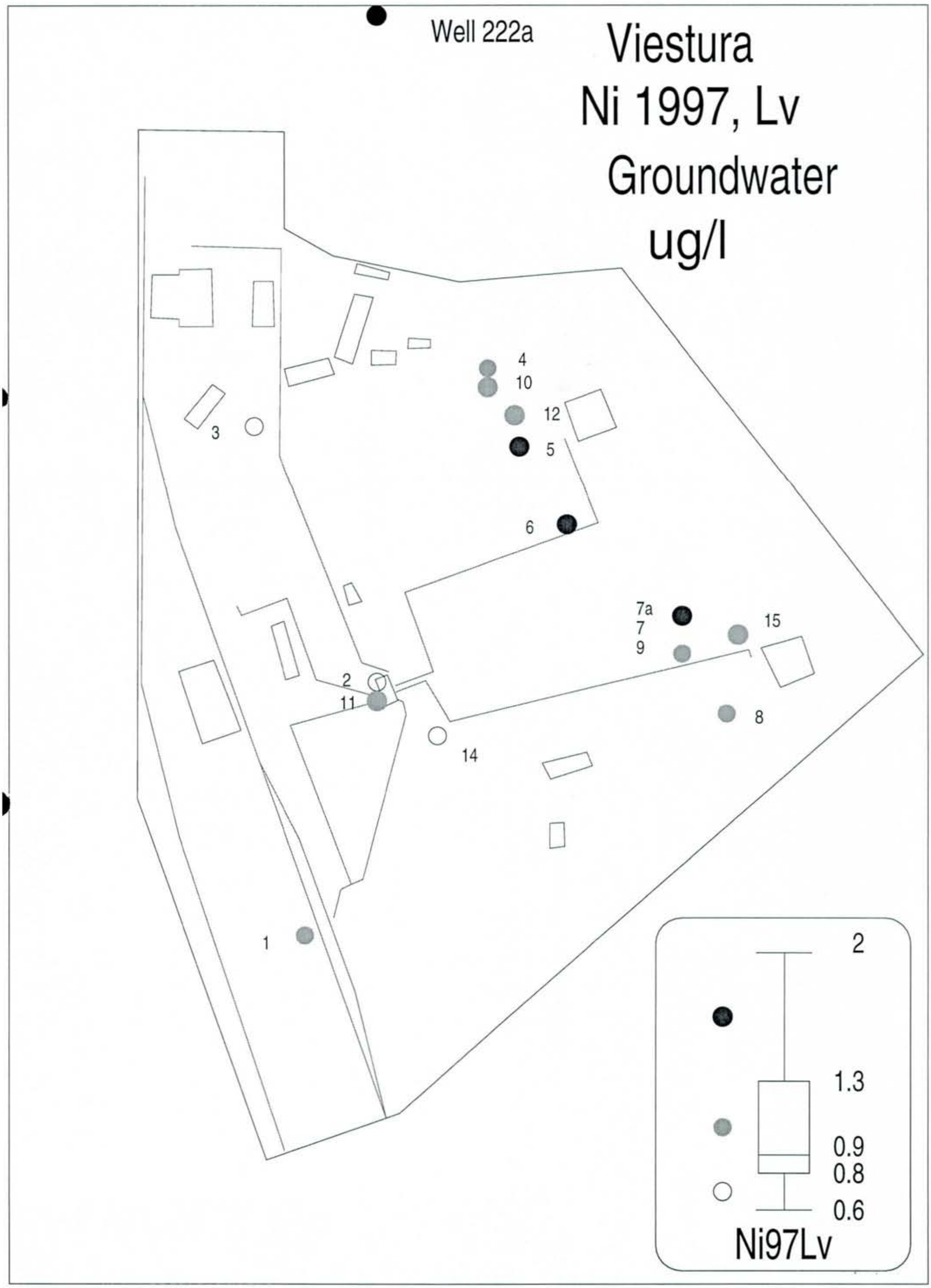

Viestura
NH4, 1994, Lv
Groundwater
mg/l
4
10
7
9
2
11
13
7.2
6.8
4.9
3.6
0.5
NH494



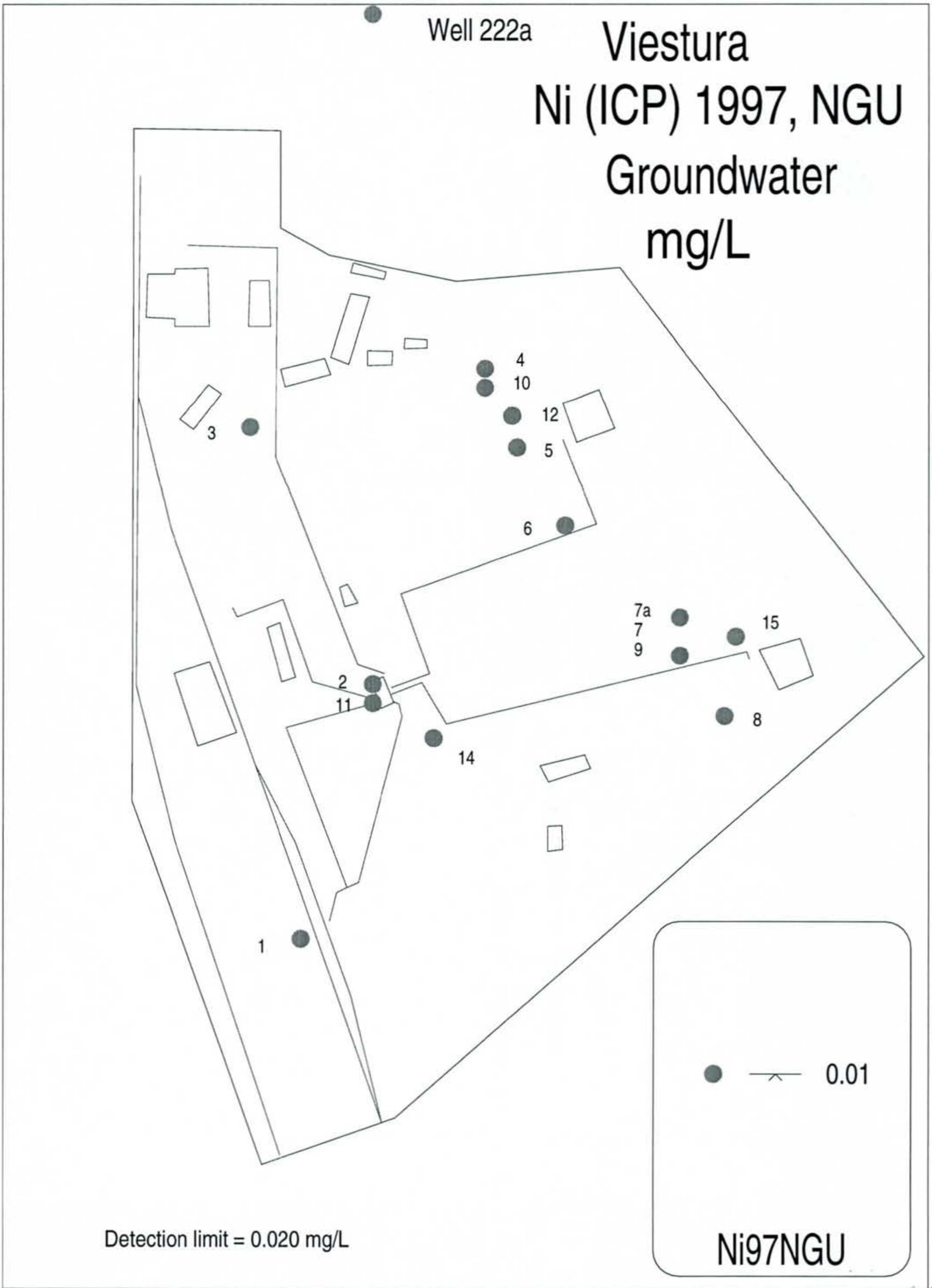
Well 222a
Viestura
NH4-N 1997, Lv
Groundwater
mg/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
1.9
1.1
0.8
0.62
0.37
0.2
NH4N97Lv


Well 222a
Viestura
Ni, 1996, Lv
Groundwater
ug/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
3.4
1.4
1.1
0.9
0.8
Ni96Lat
Cemetry SW
Cemetry SE

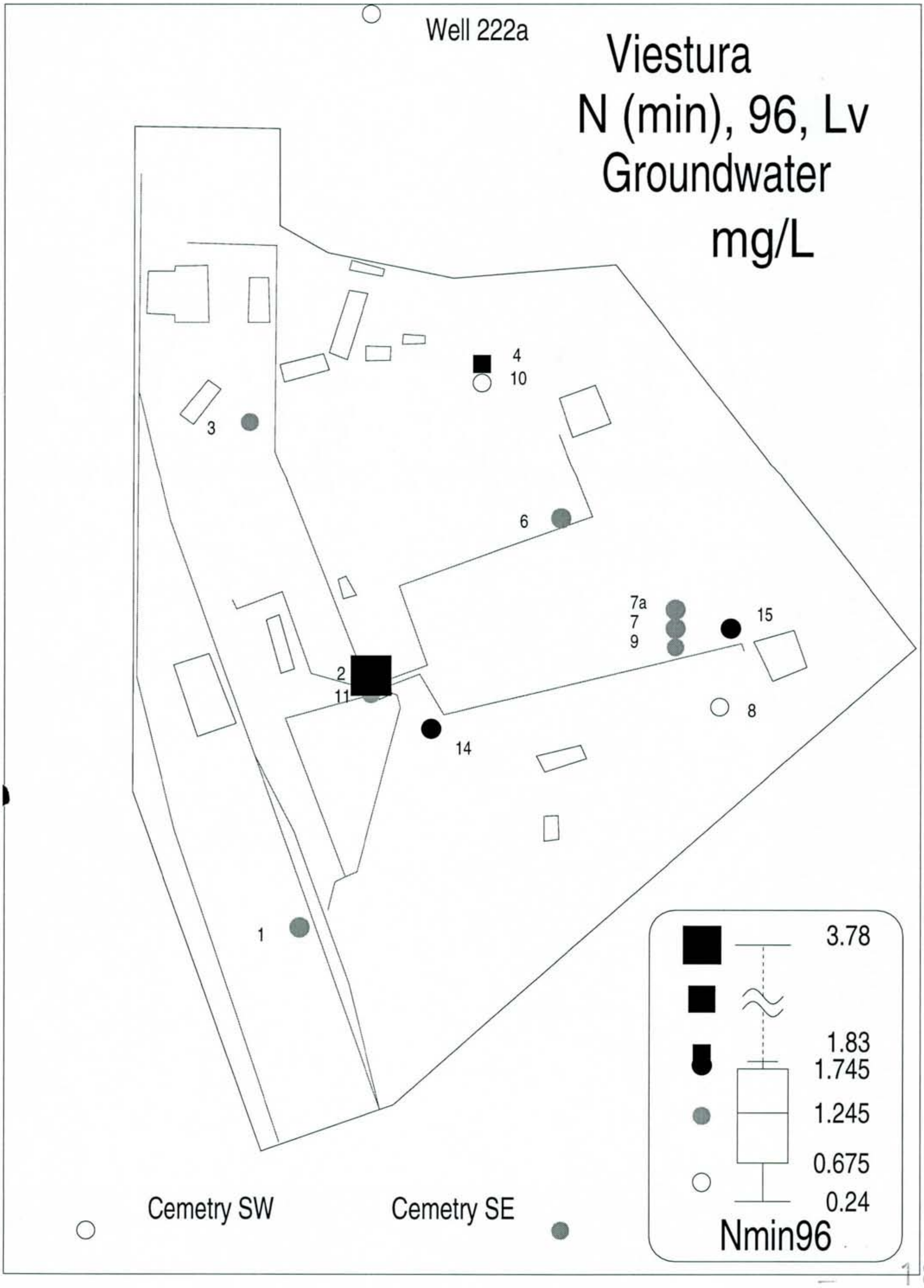

Well 222a
Viestura
Ni, 1996, NGU
Groundwater
mg/L
Detection limit = 0.02 mg/L
4
10
3
6
7a
7
9
15
2
11
14
8
1
0.0584
0.0274
0.0178
0.01
NiNGU
Cemetry SW
Cemetry SE

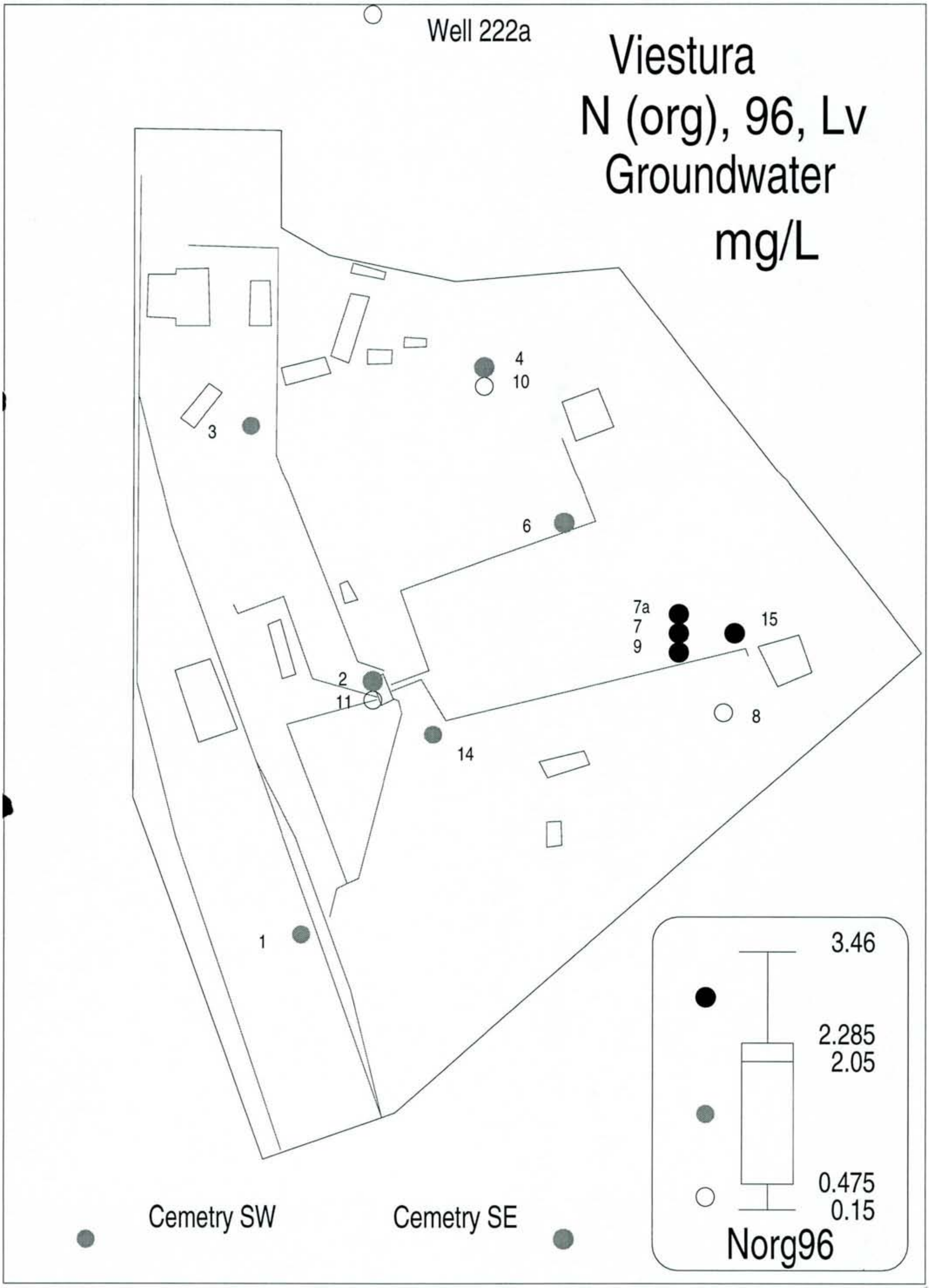


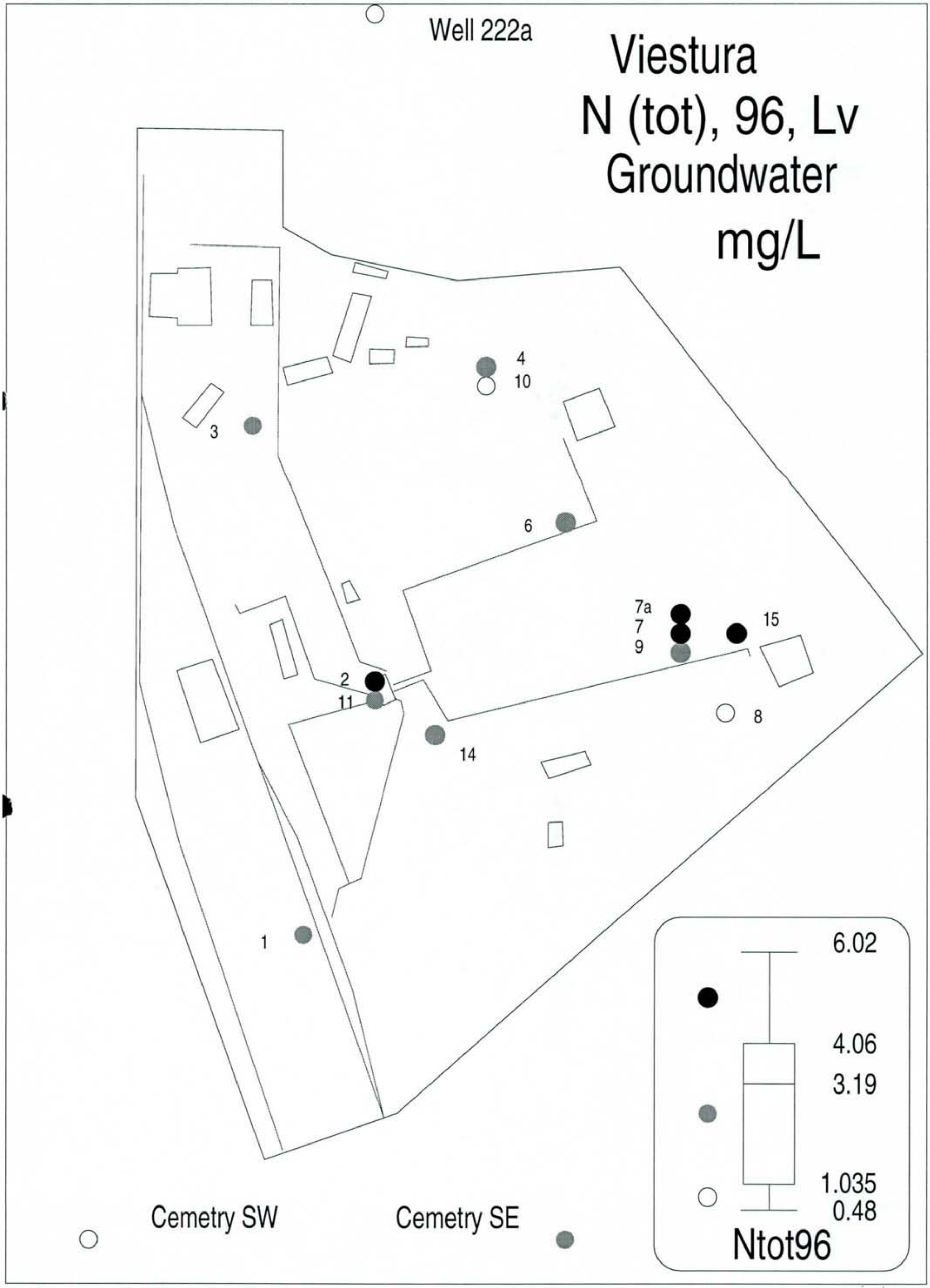
Well 222a
Viestura
Ni 1997, Lv
Groundwater
ug/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
2
1.3
0.9
0.8
0.6
Ni97Lv

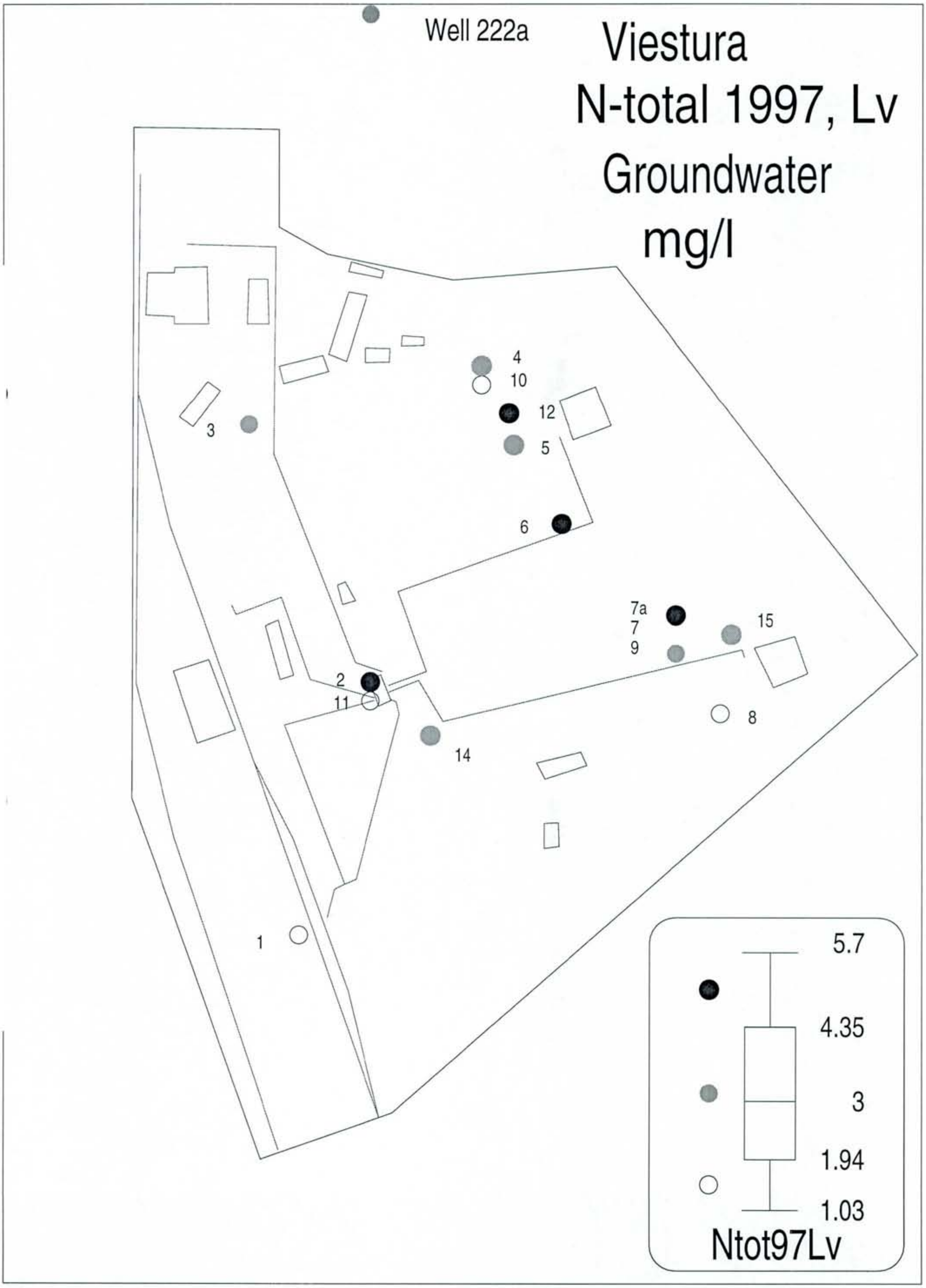


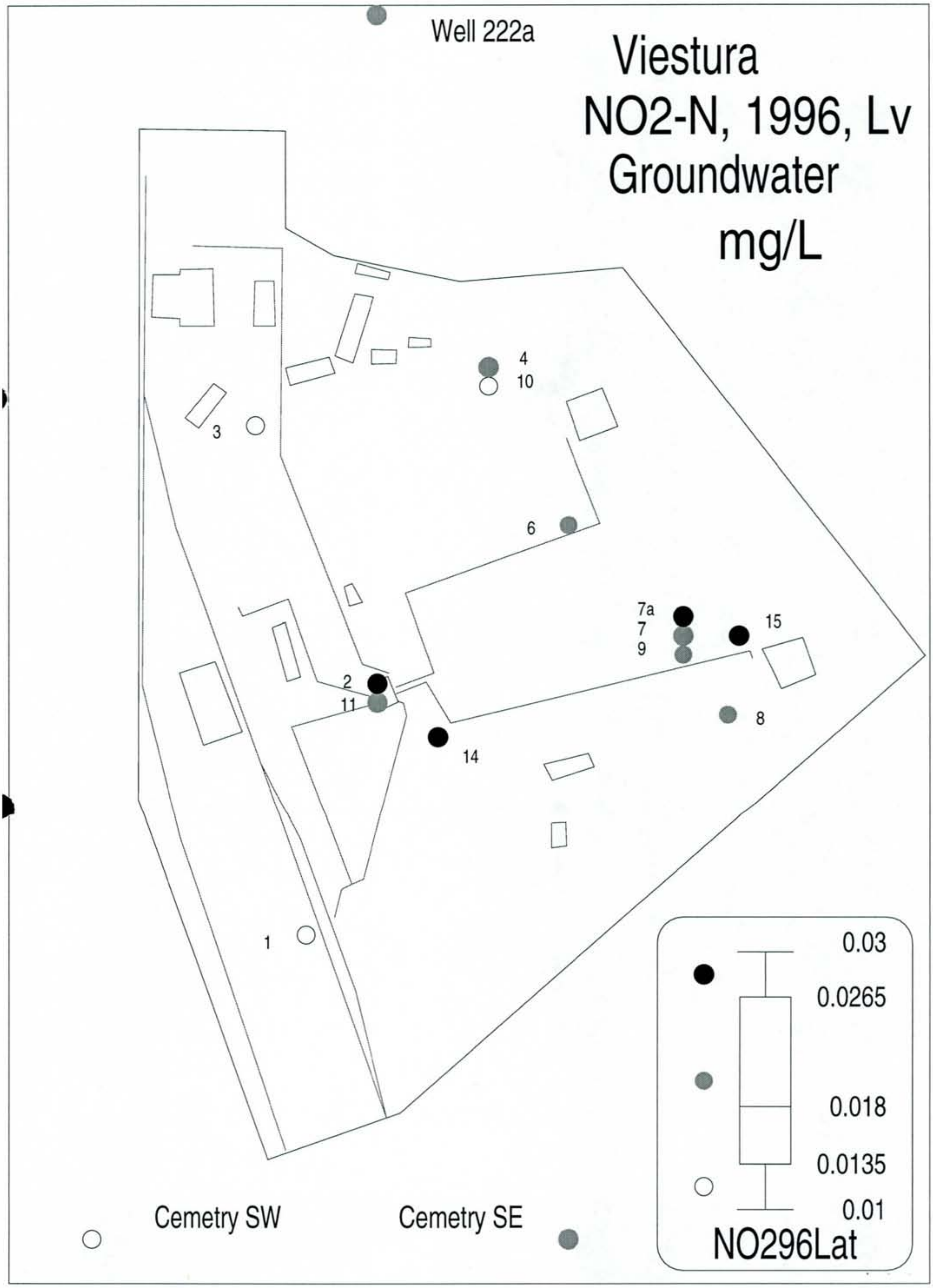
Well 222a
Viestura
Ni (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
0.01
Detection limit = 0.020 mg/L
Ni97NGU

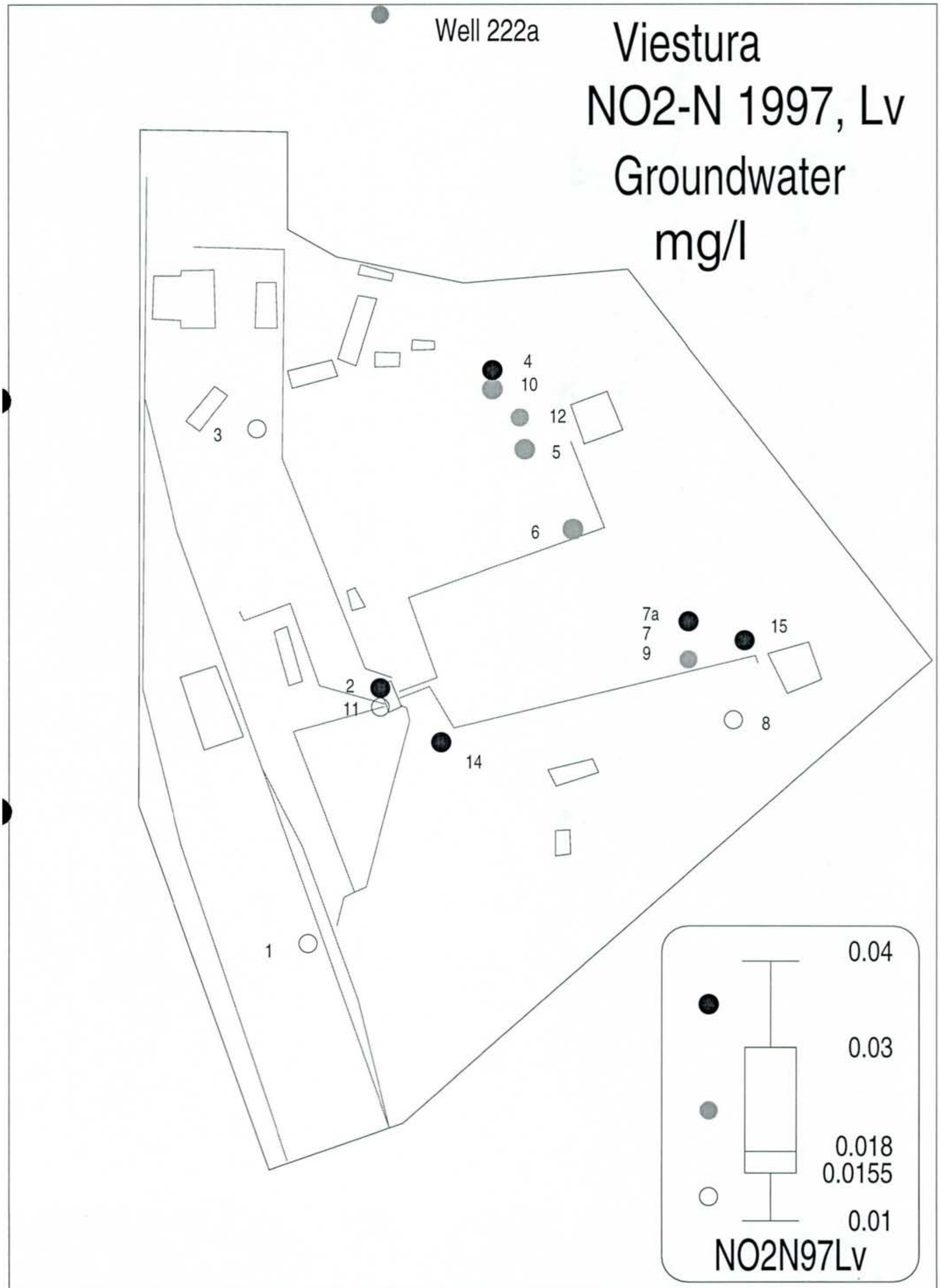

Well 222a
Viestura
N (min), 96, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
14
8
1
Cemetry SW
Cemetry SE
3.78
1.83
1.745
1.245
0.675
0.24
Nmin96

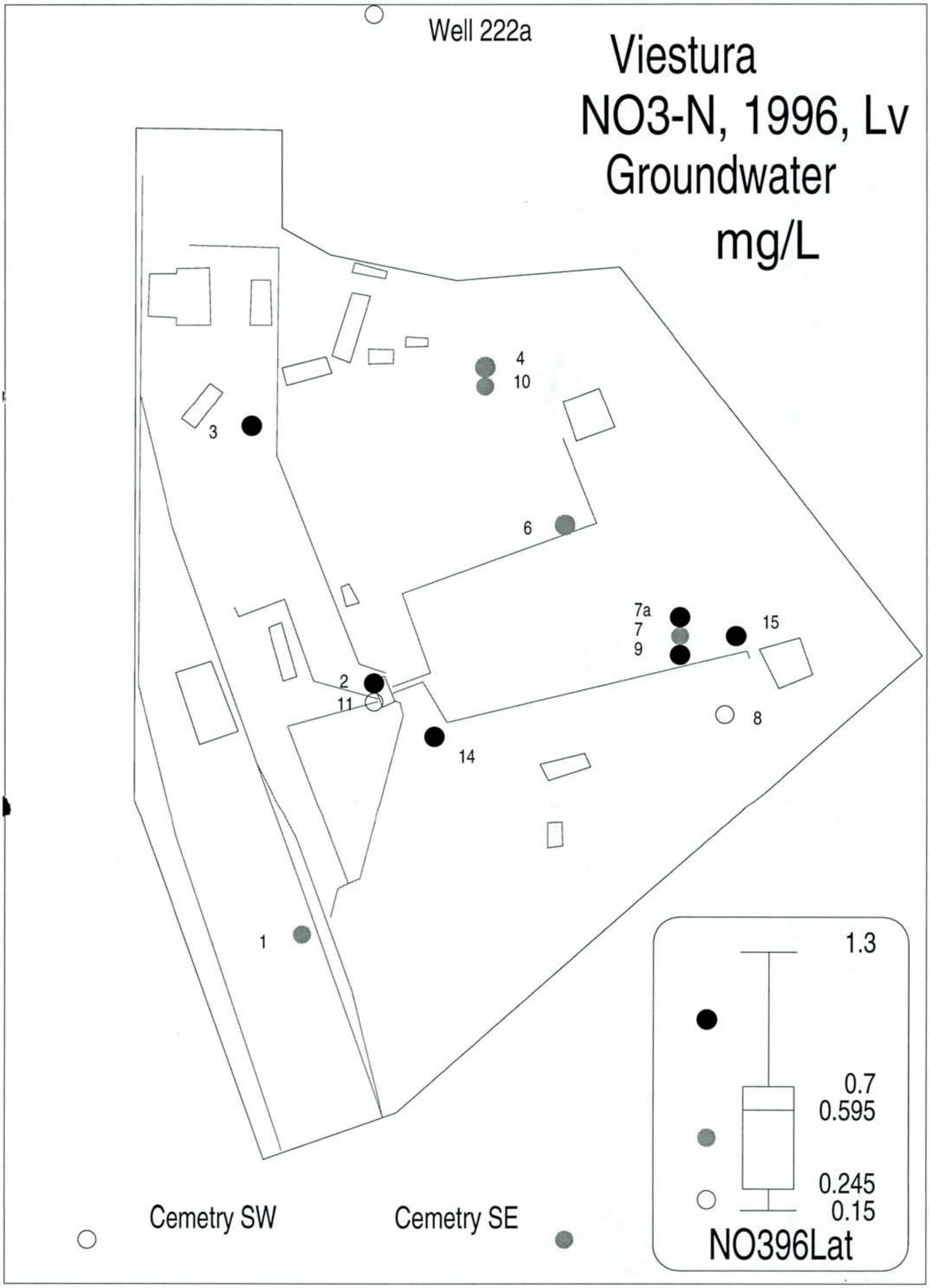

Well 222a
Viestura
N (org), 96, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
3.46
2.285
2.05
0.475
0.15
Norg96
Cemetry SW
Cemetry SE

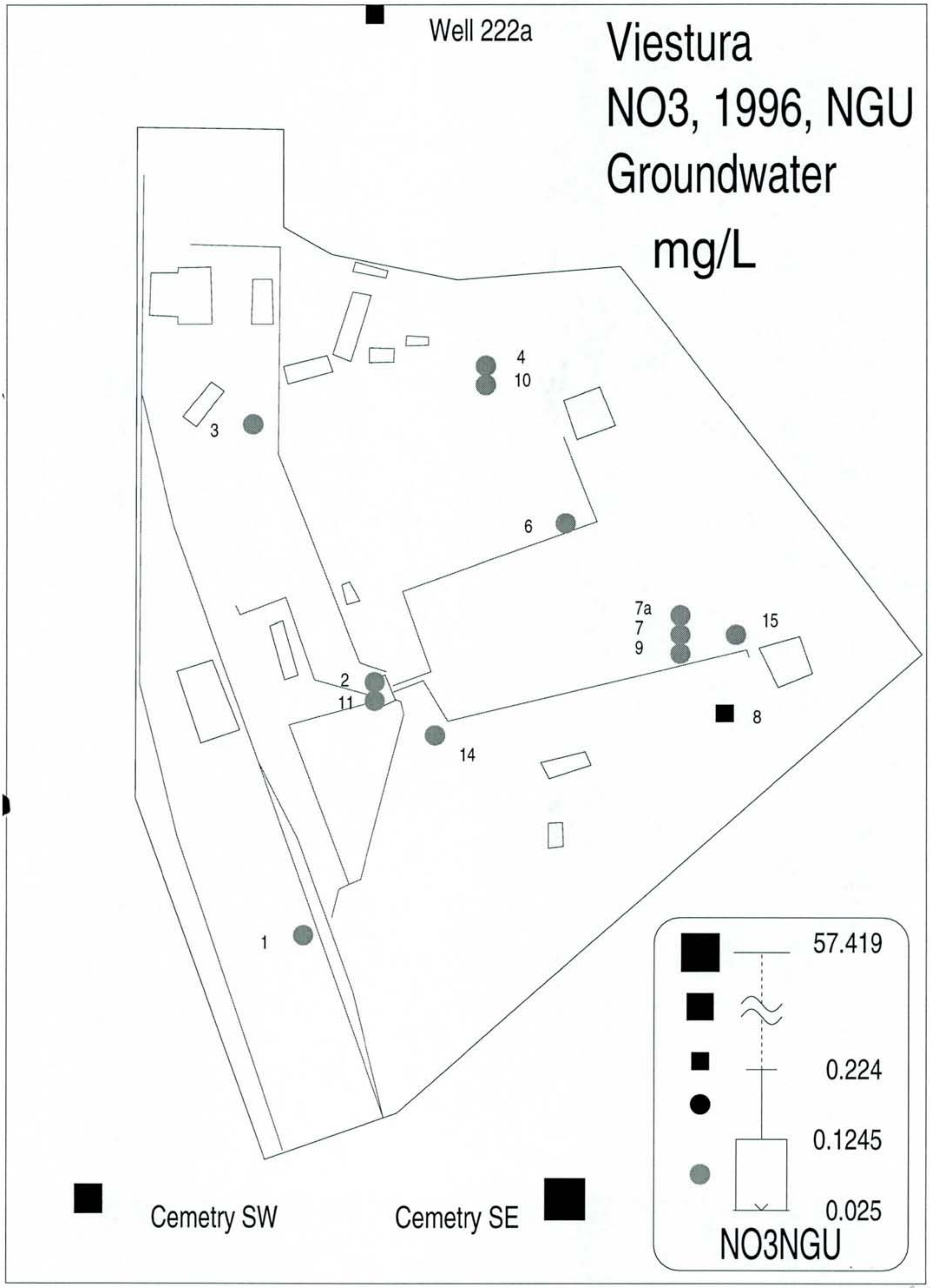

Well 222a
Viestura
N (tot), 96, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
6.02
4.06
3.19
1.035
0.48
Ntot96
Cemetry SW
Cemetry SE

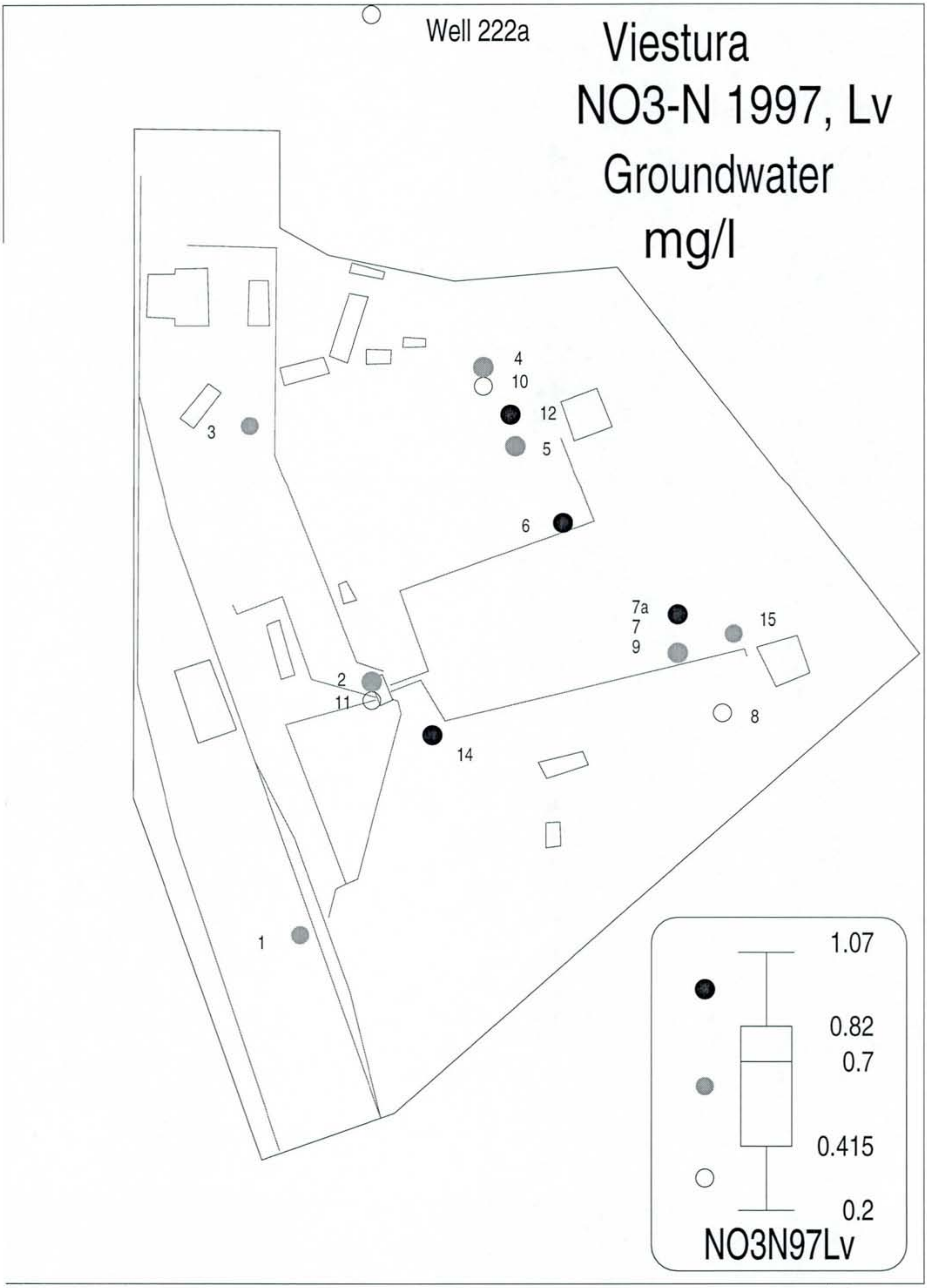

Well 222a
Viestura
N-total 1997, Lv
Groundwater
mg/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
5.7
4.35
3
1.94
1.03
Ntot97Lv

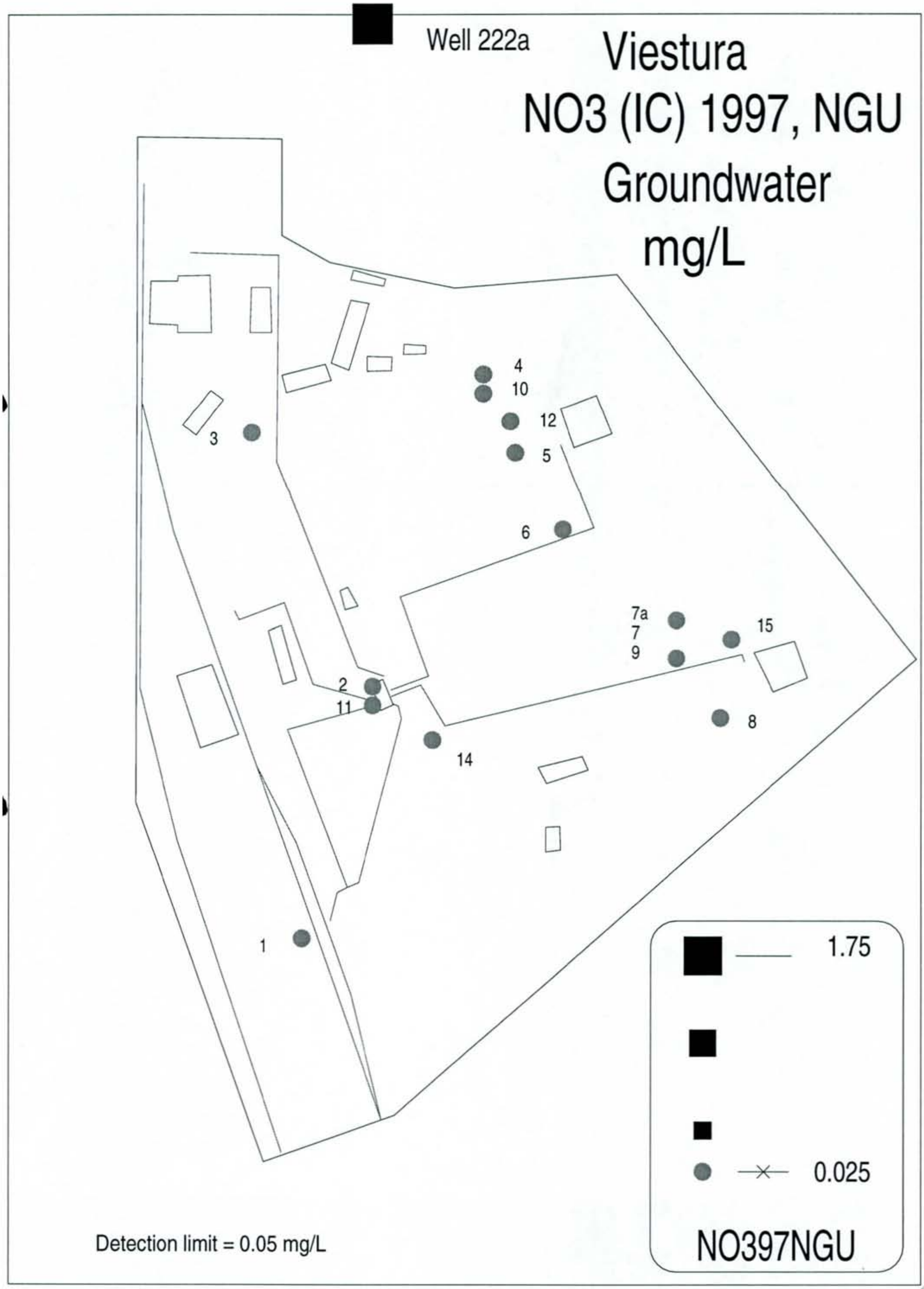

Well 222a
Viestura
NO2-N, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.03
0.0265
0.018
0.0135
0.01
NO296Lat
Cemetry SW
Cemetry SE


Well 222a
Viestura
NO2-N 1997, Lv
Groundwater
mg/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
0.04
0.03
0.018
0.0155
0.01
NO2N97Lv

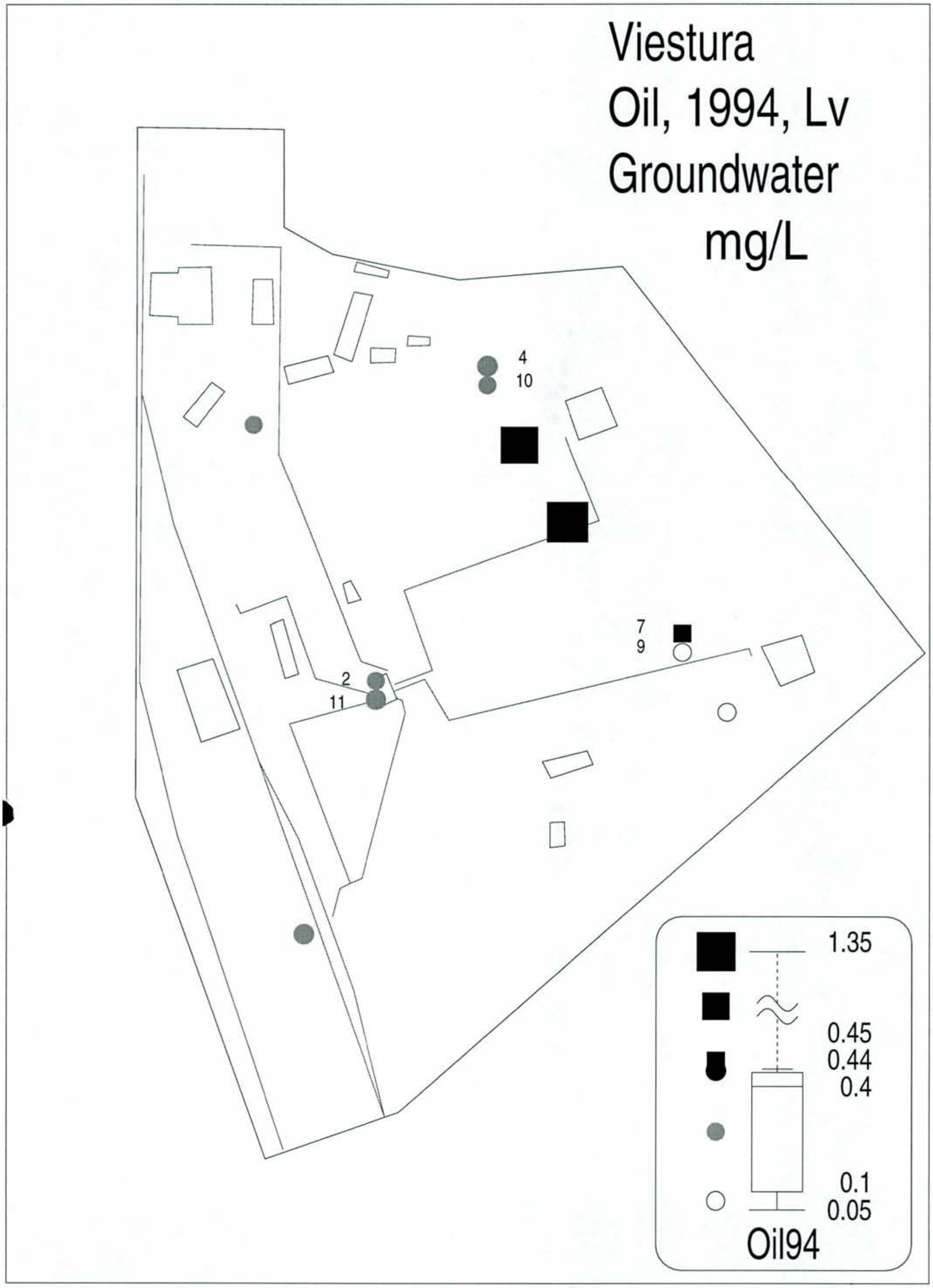

Well 222a
Viestura
NO3-N, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
1.3
0.7
0.595
0.245
0.15
NO396Lat
Cemetry SW
Cemetry SE


Well 222a
Viestura
NO3, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
57.419
0.224
0.1245
0.025
NO3NGU
Cemetry SW
Cemetry SE

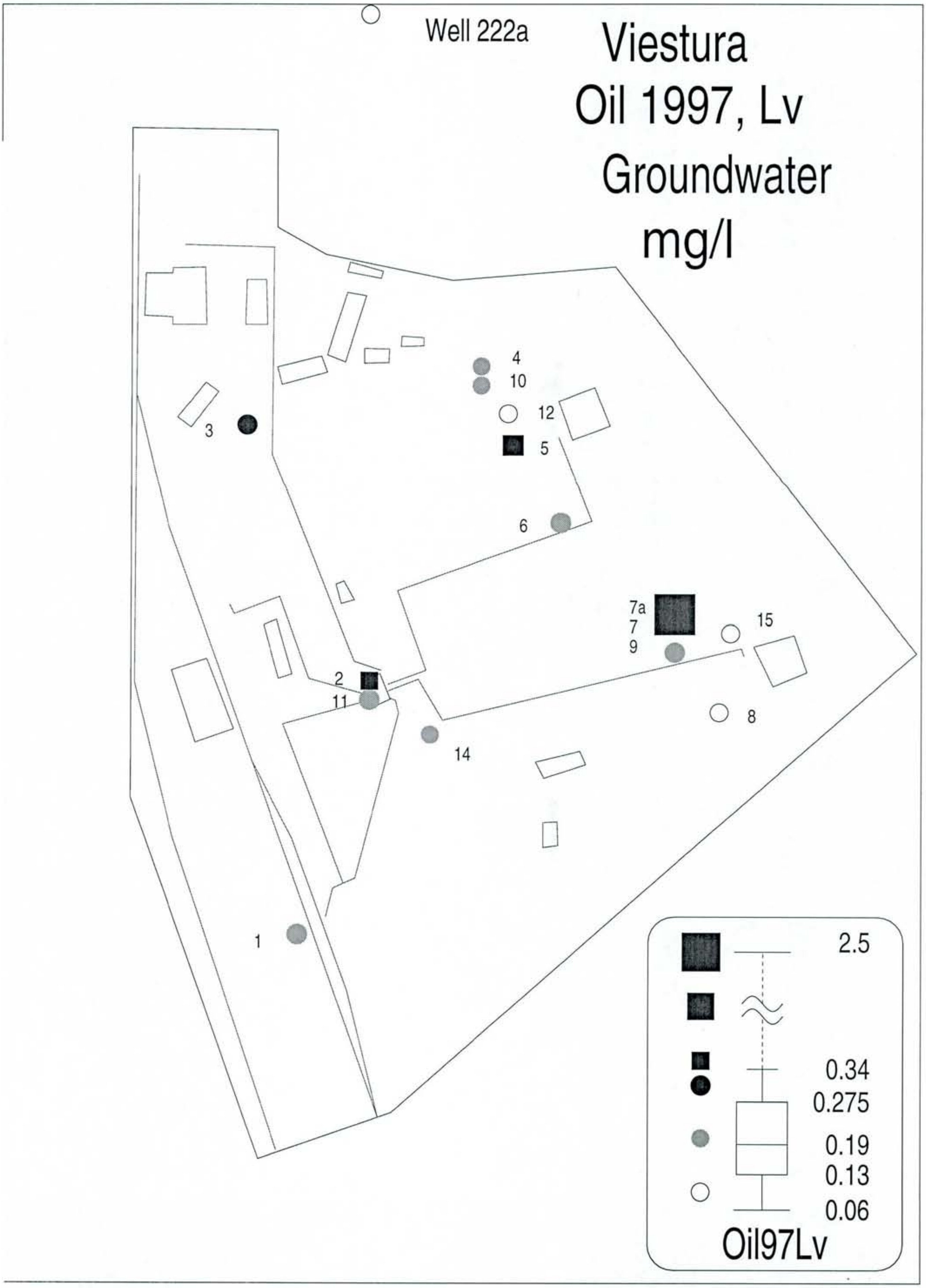

Well 222a
Viestura
NO3-N 1997, Lv
Groundwater
mg/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
1.07
0.82
0.7
0.415
0.2
NO3N97Lv

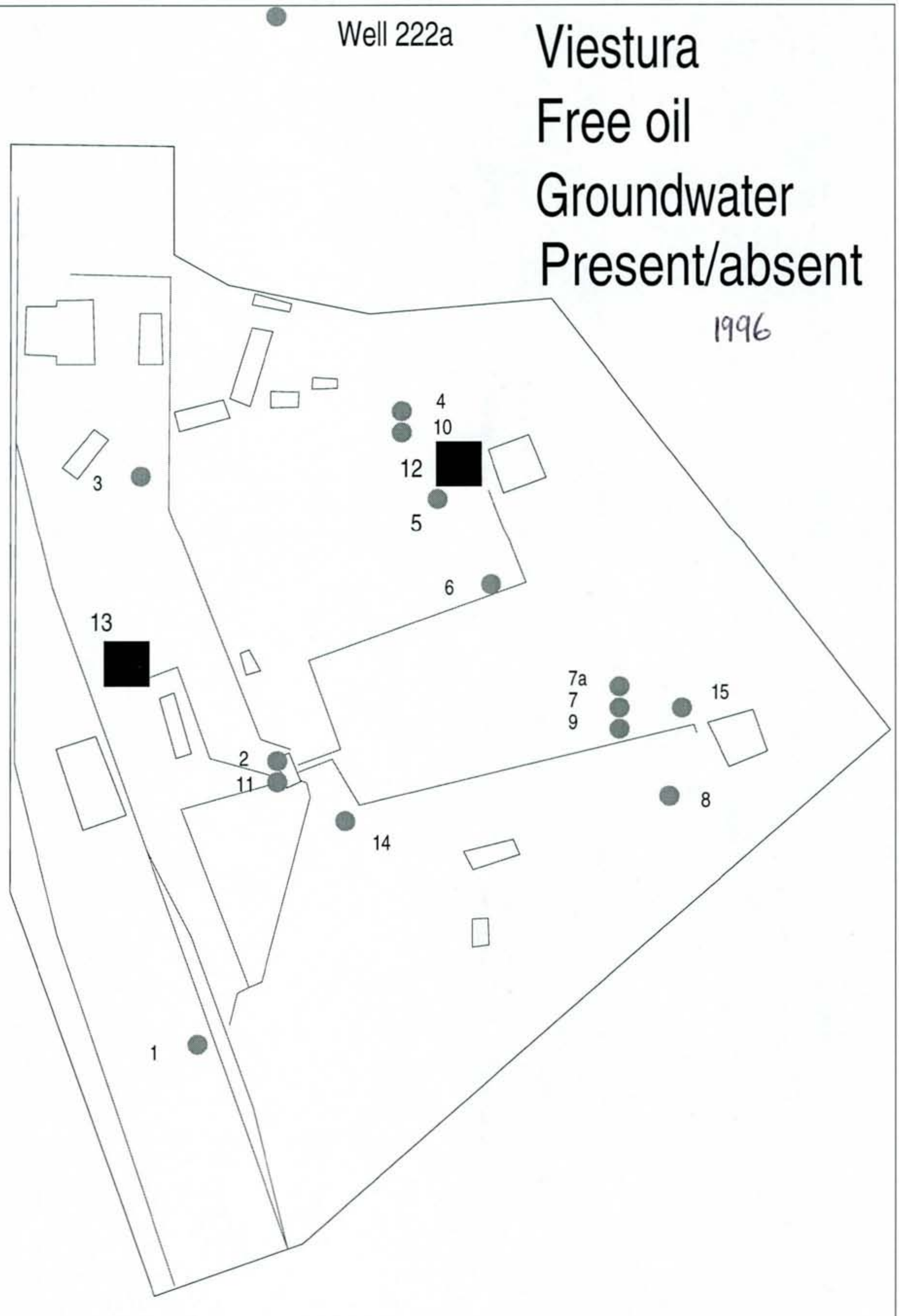


Well 222a
Viestura
NO3 (IC) 1997, NGU
Groundwater
mg/L
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
1.75
0.025
NO397NGU
Detection limit = 0.05 mg/L



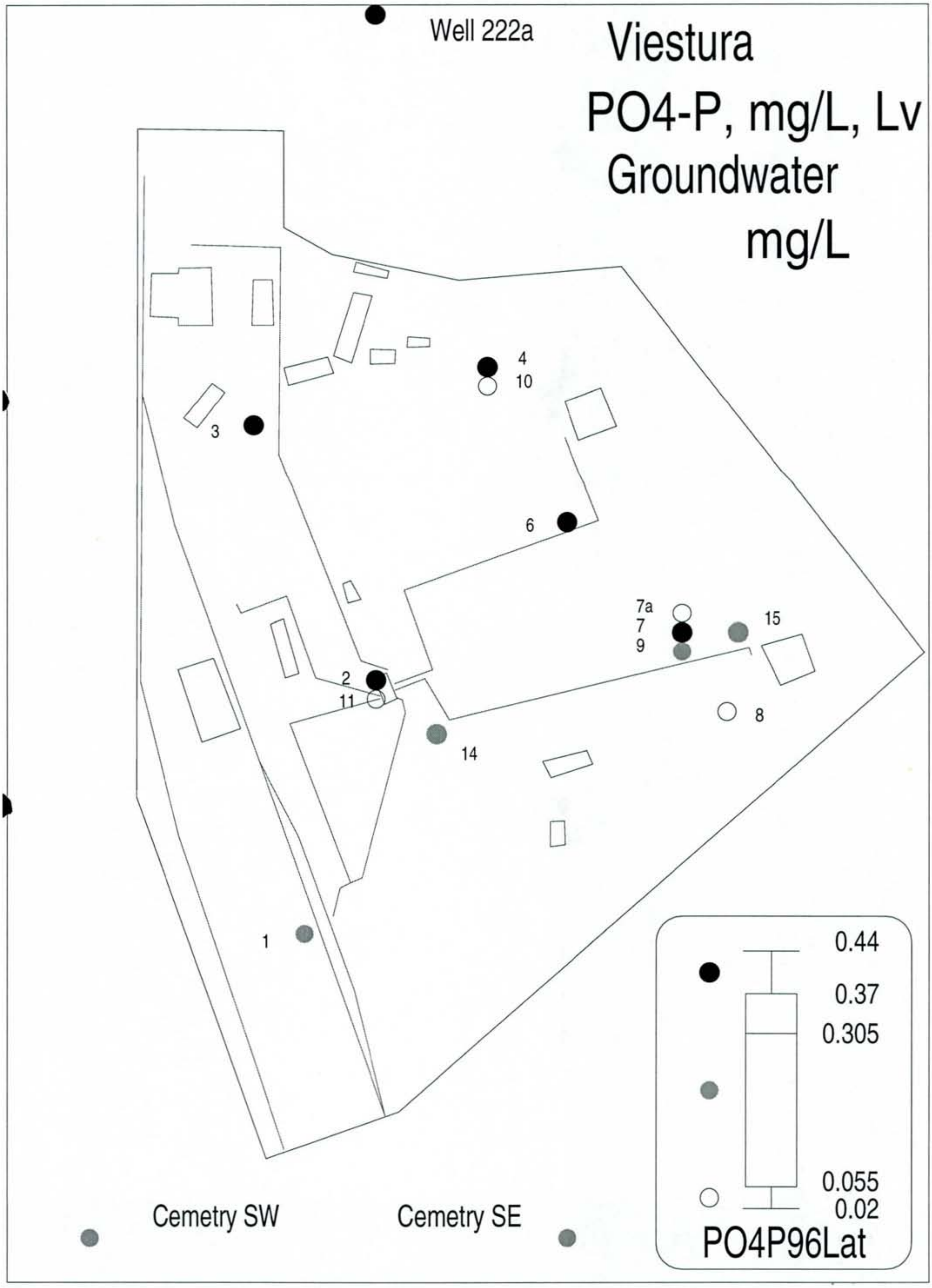
Viestura
Oil, 1994, Lv
Groundwater
mg/L
4
10
7
9
2
11
1.35
0.45
0.44
0.4
0.1
0.05
Oil94


Well 222a
Viestura
Oil 1997, Lv
Groundwater
mg/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
2.5
0.34
0.275
0.19
0.13
0.06
Oil97Lv

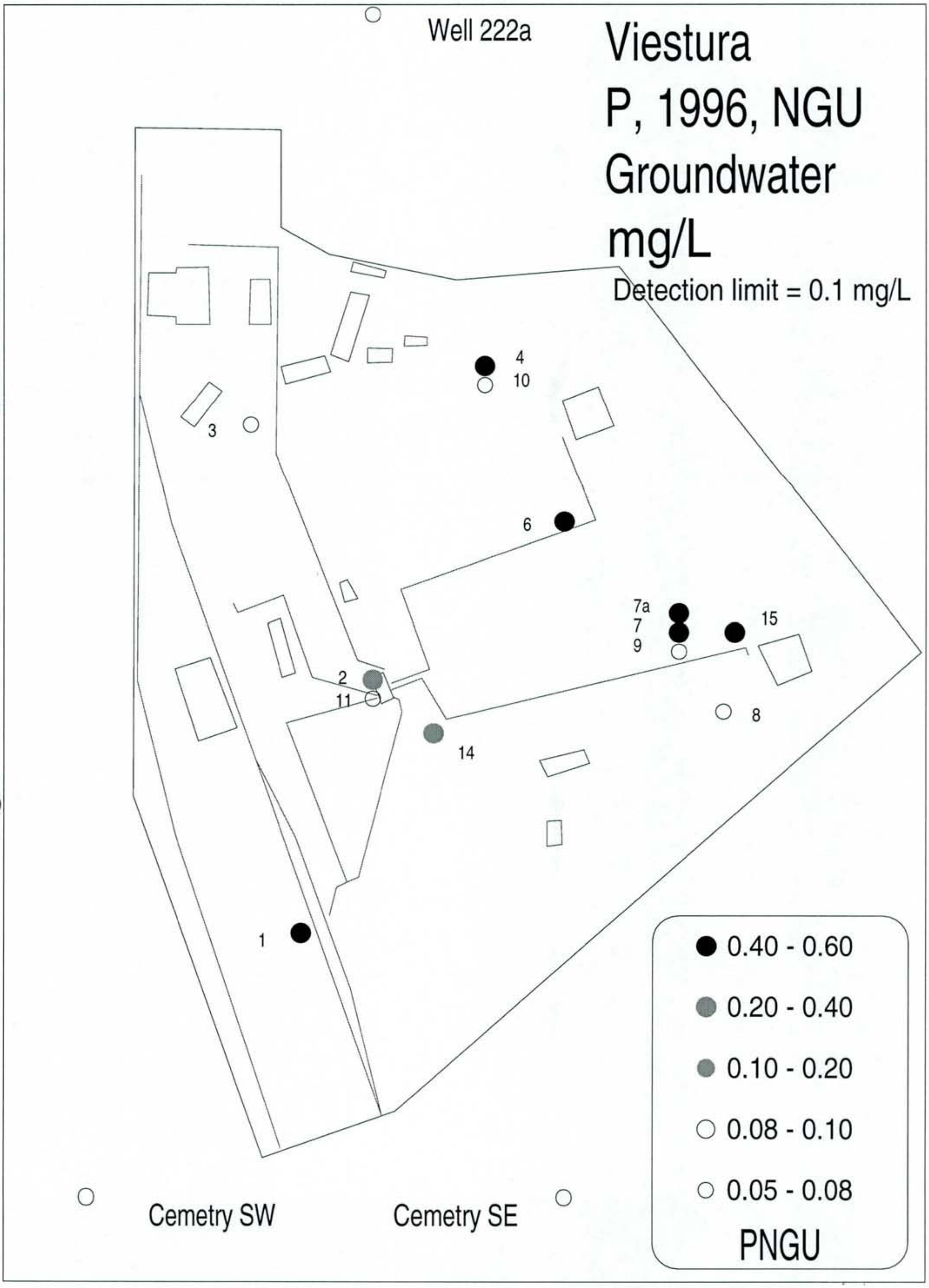


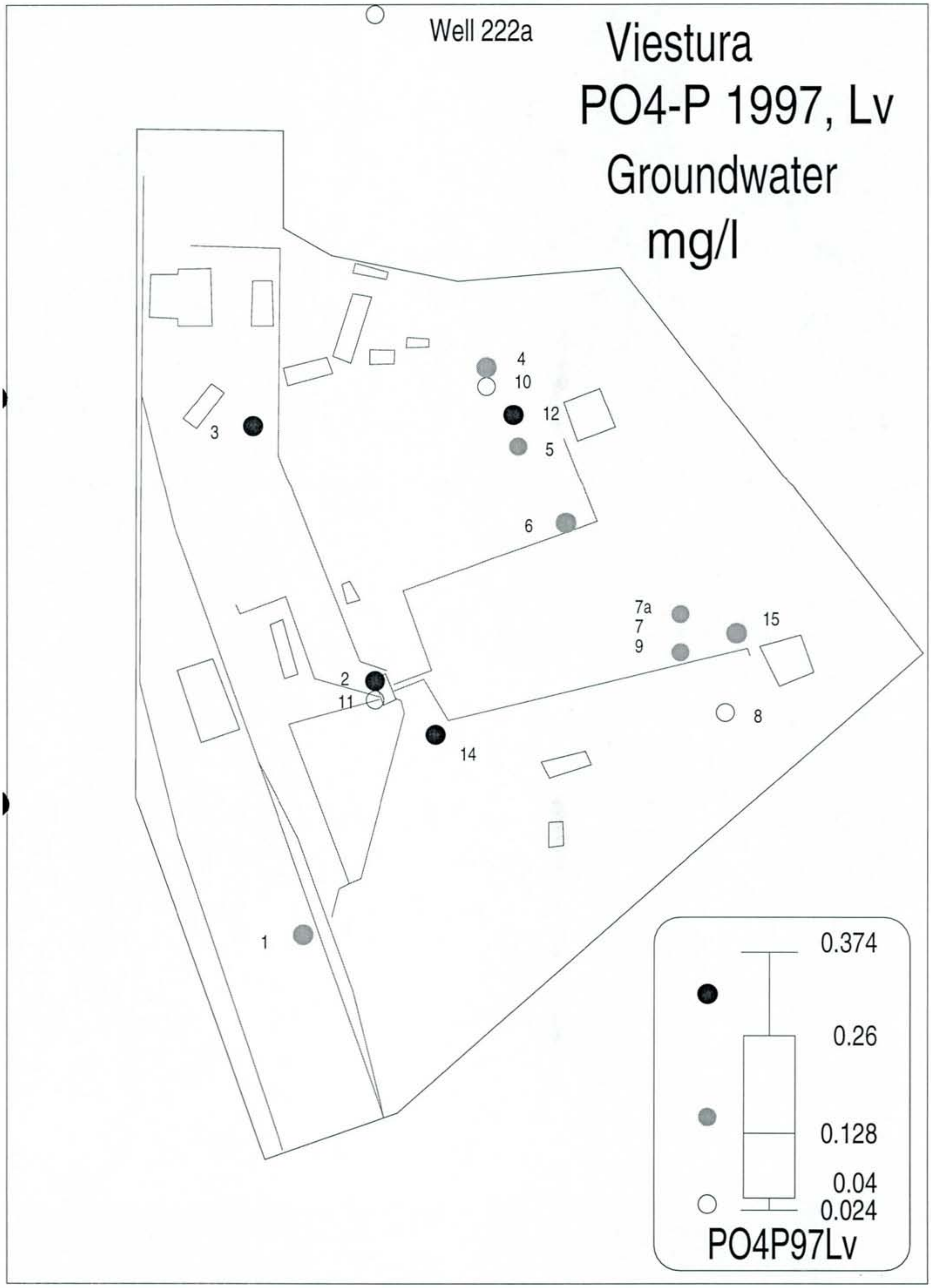
Note that the majority of wells have filters below water table

Wells 12, 13, 14, 15 and 7a have filters in the water table

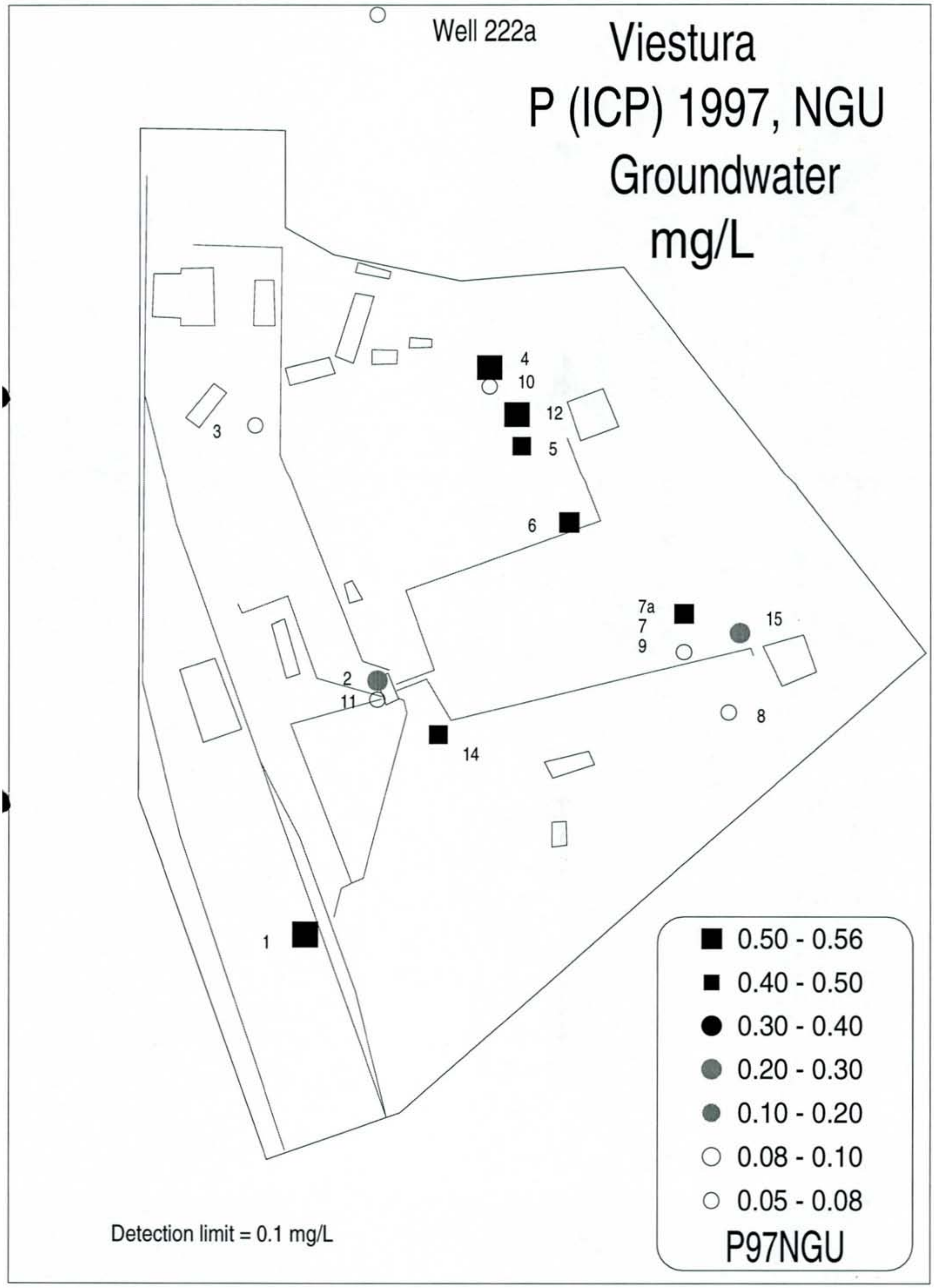


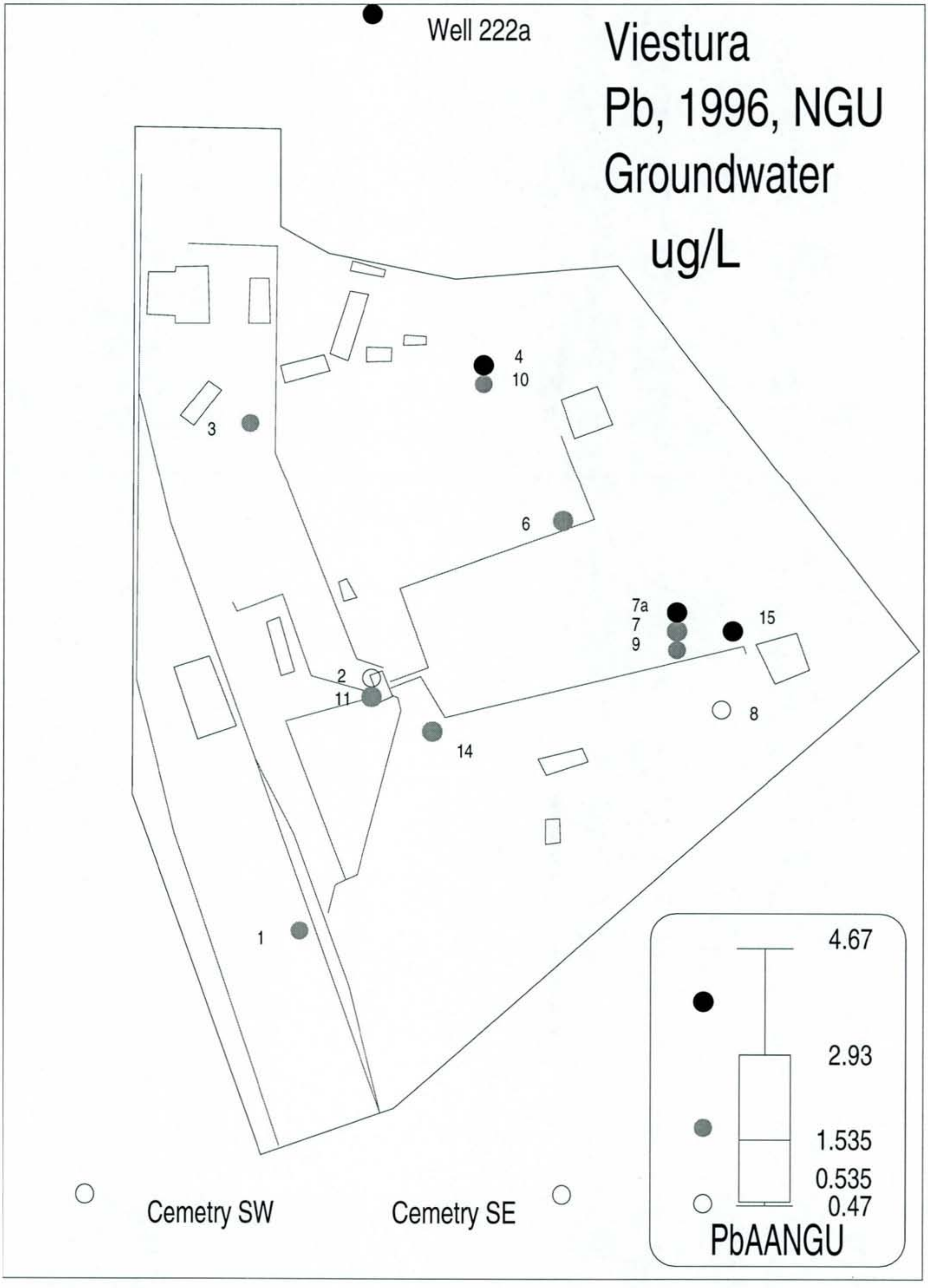
Well 222a
Viestura
PO4-P, mg/L, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.44
0.37
0.305
0.055
0.02
PO4P96Lat
Cemetry SW
Cemetry SE


Well 222a
Viestura
P, 1996, NGU
Groundwater
mg/L
Detection limit = 0.1 mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.40 - 0.60
0.20 - 0.40
0.10 - 0.20
0.08 - 0.10
0.05 - 0.08
PNGU
Cemetry SW
Cemetry SE

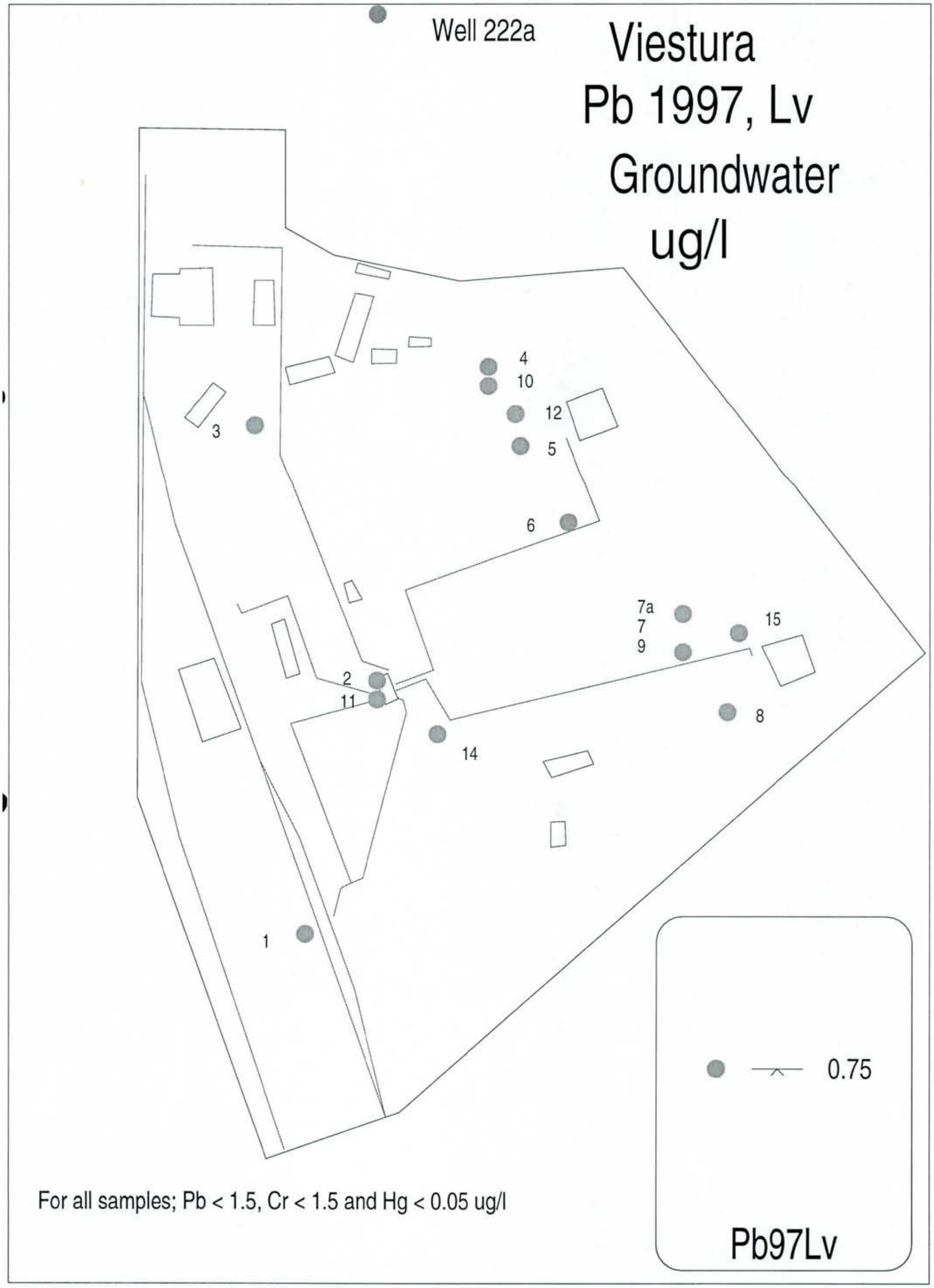


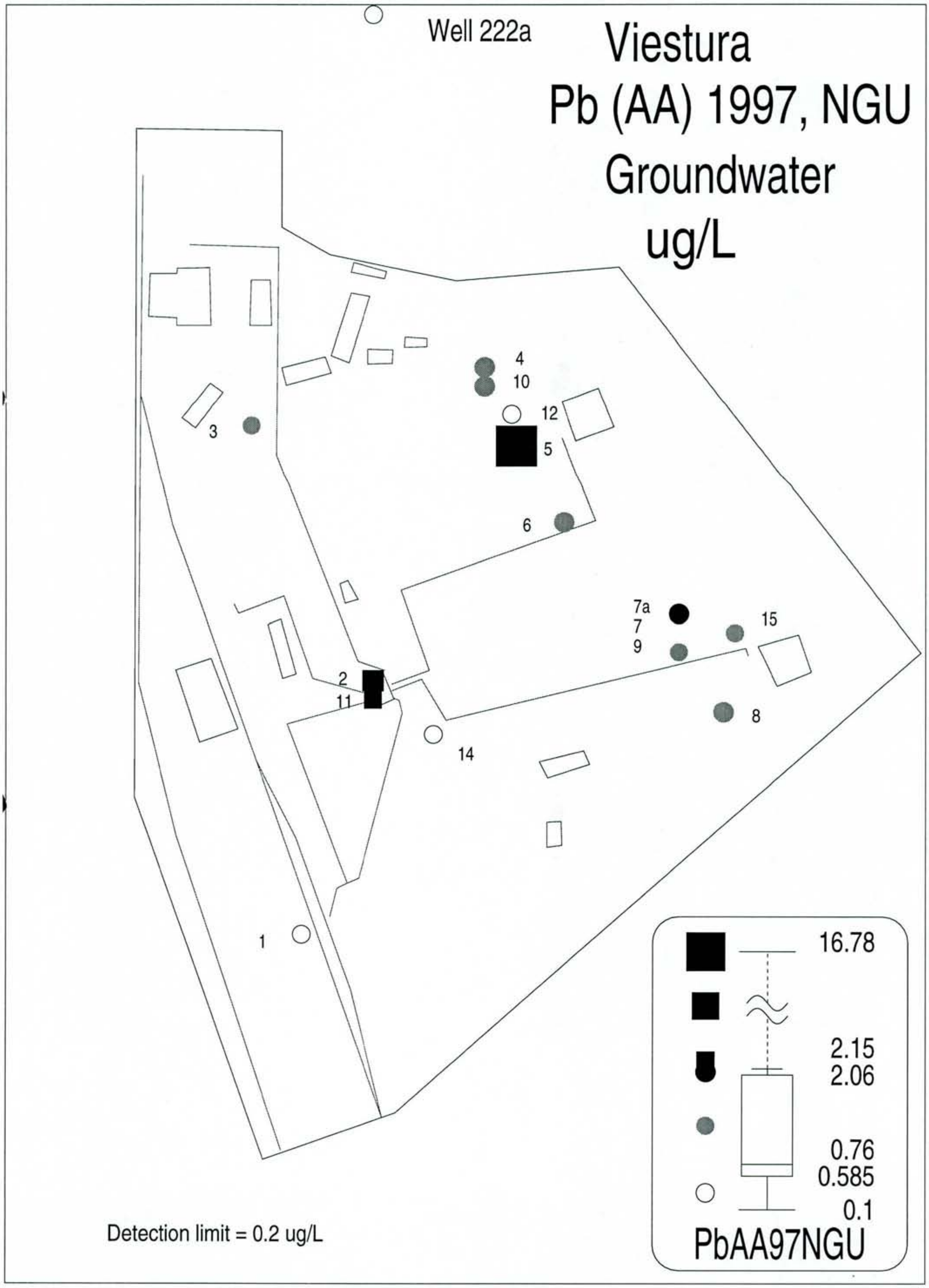
Well 222a
Viestura
PO4-P 1997, Lv
Groundwater
mg/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
0.374
0.26
0.128
0.04
0.024
PO4P97Lv

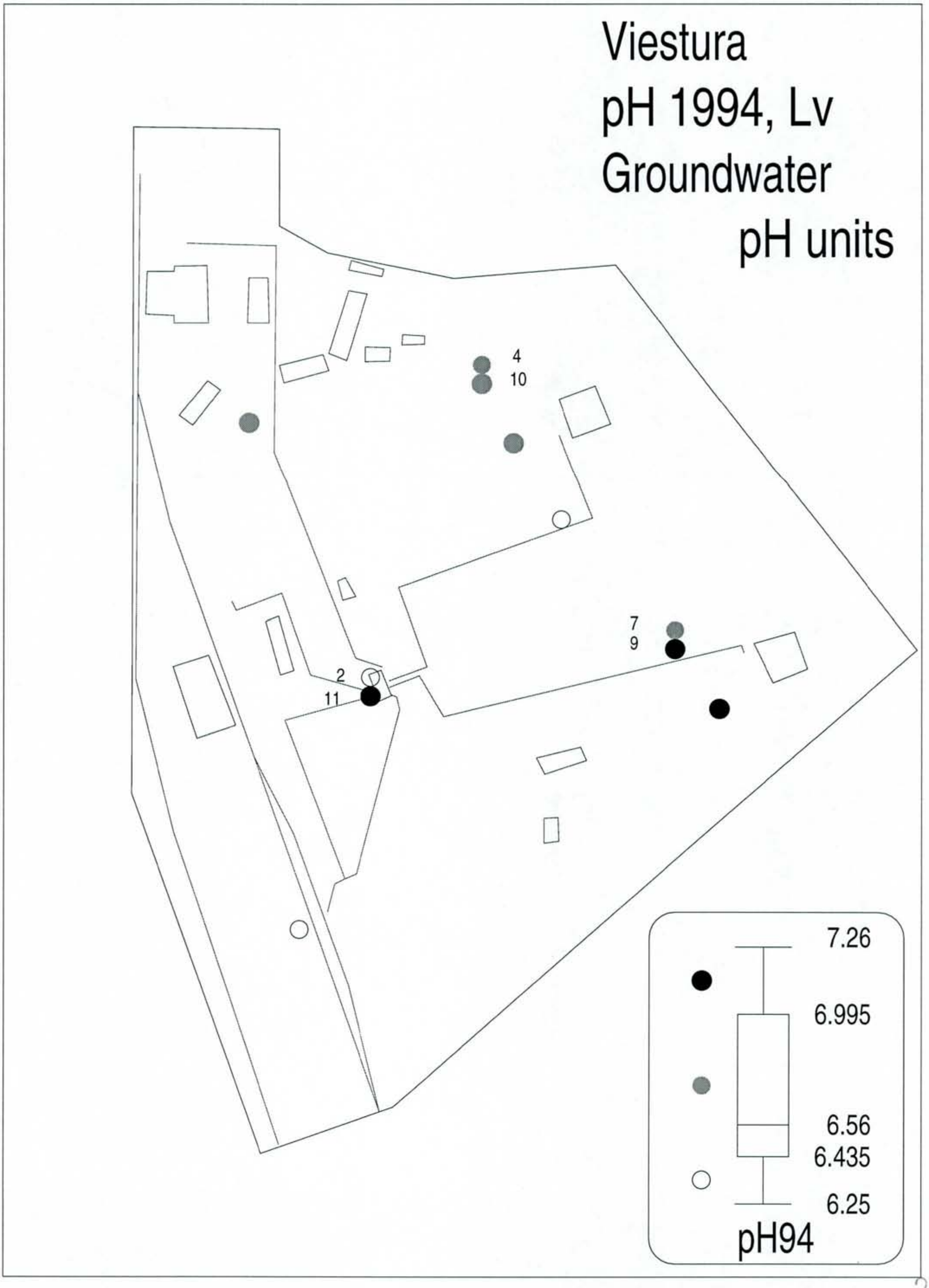

Well 222a
Viestura
P (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
0.50 - 0.56
0.40 - 0.50
0.30 - 0.40
0.20 - 0.30
0.10 - 0.20
0.08 - 0.10
0.05 - 0.08
P97NGU
Detection limit = 0.1 mg/L

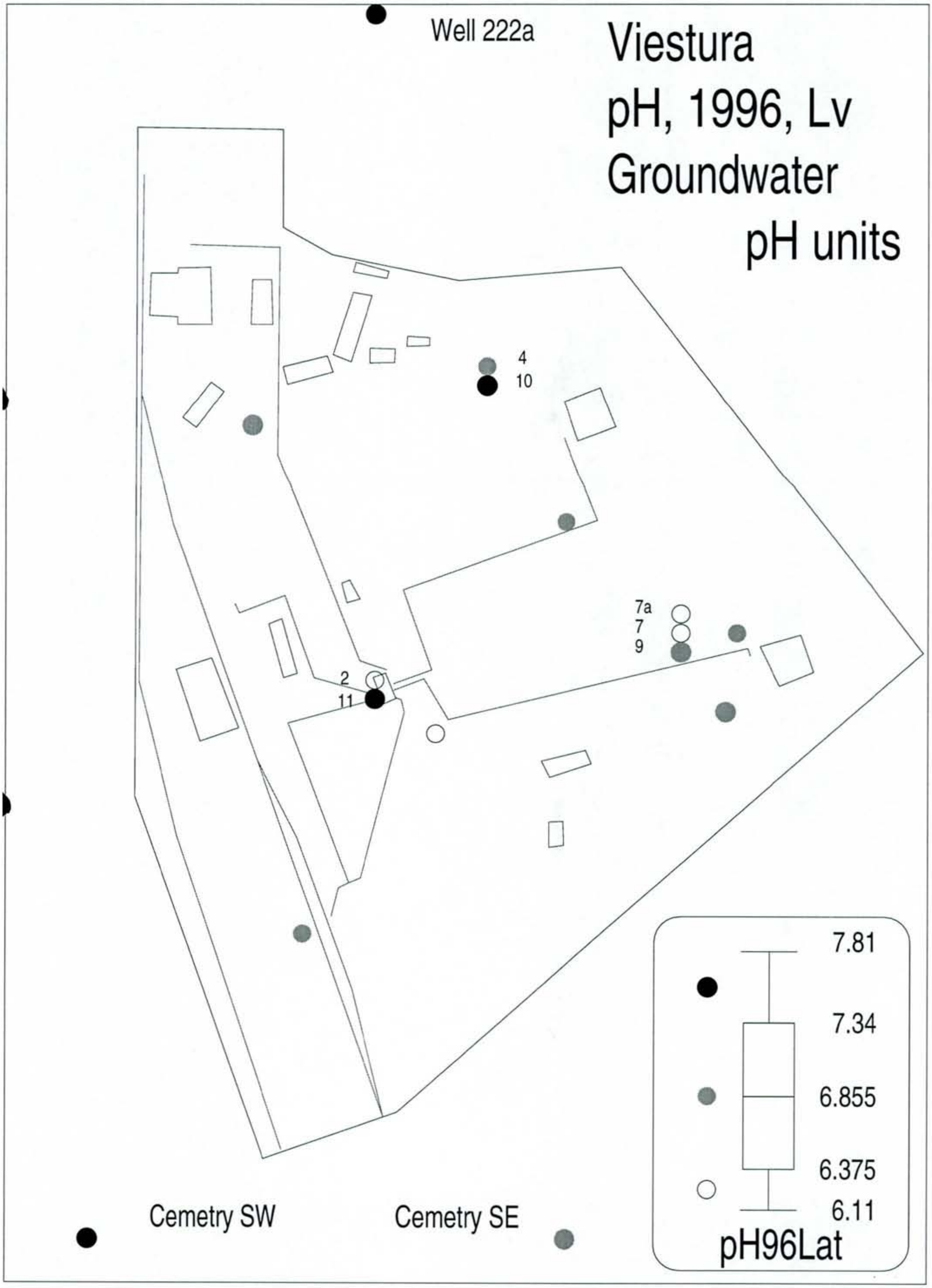


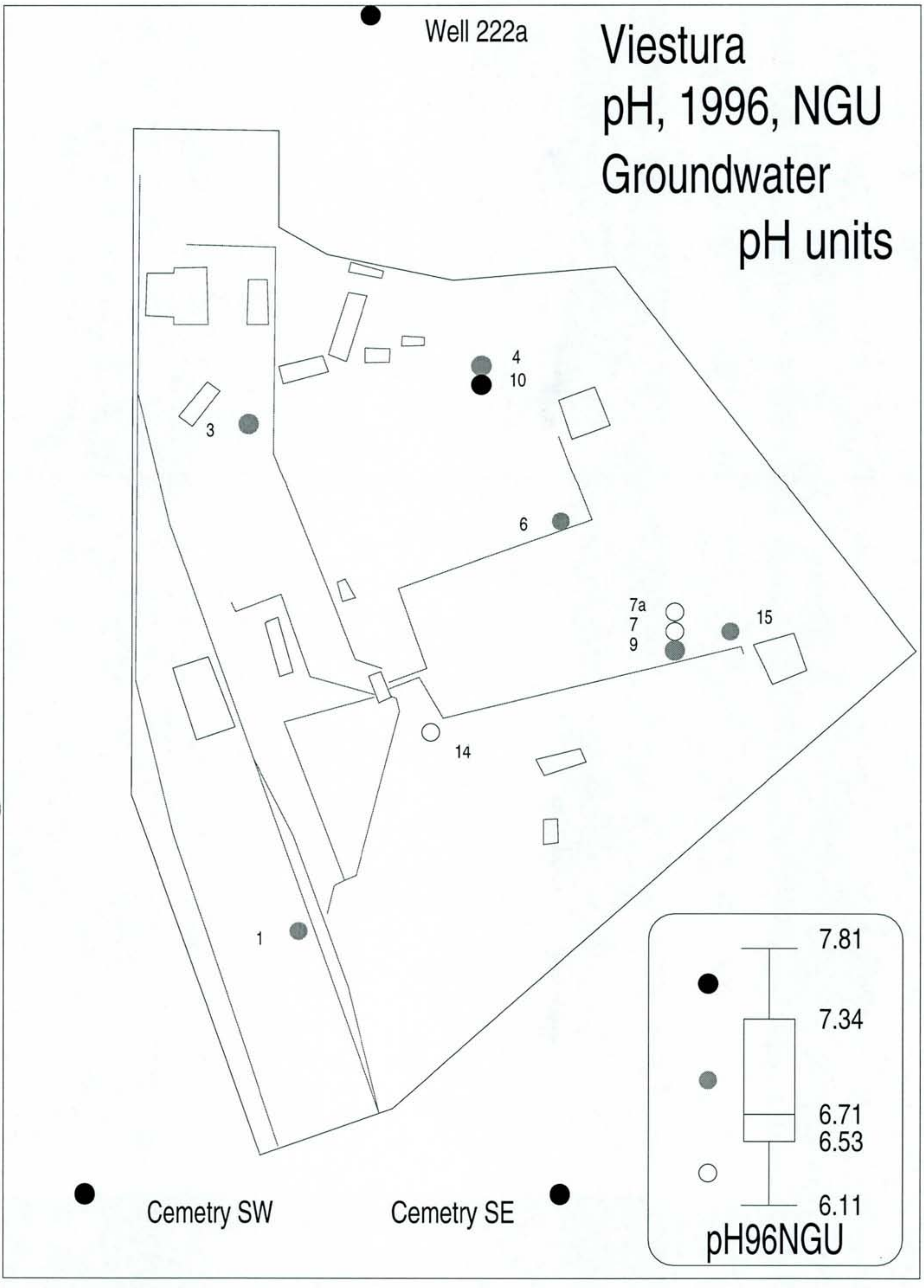
Well 222a
Viestura
Pb, 1996, NGU
Groundwater
ug/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
4.67
2.93
1.535
0.535
0.47
PbAANGU
Cemetry SW
Cemetry SE


Well 222a
Viestura
Pb 1997, Lv
Groundwater
ug/l
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
0.75
For all samples; Pb < 1.5, Cr < 1.5 and Hg < 0.05 ug/l
Pb97Lv

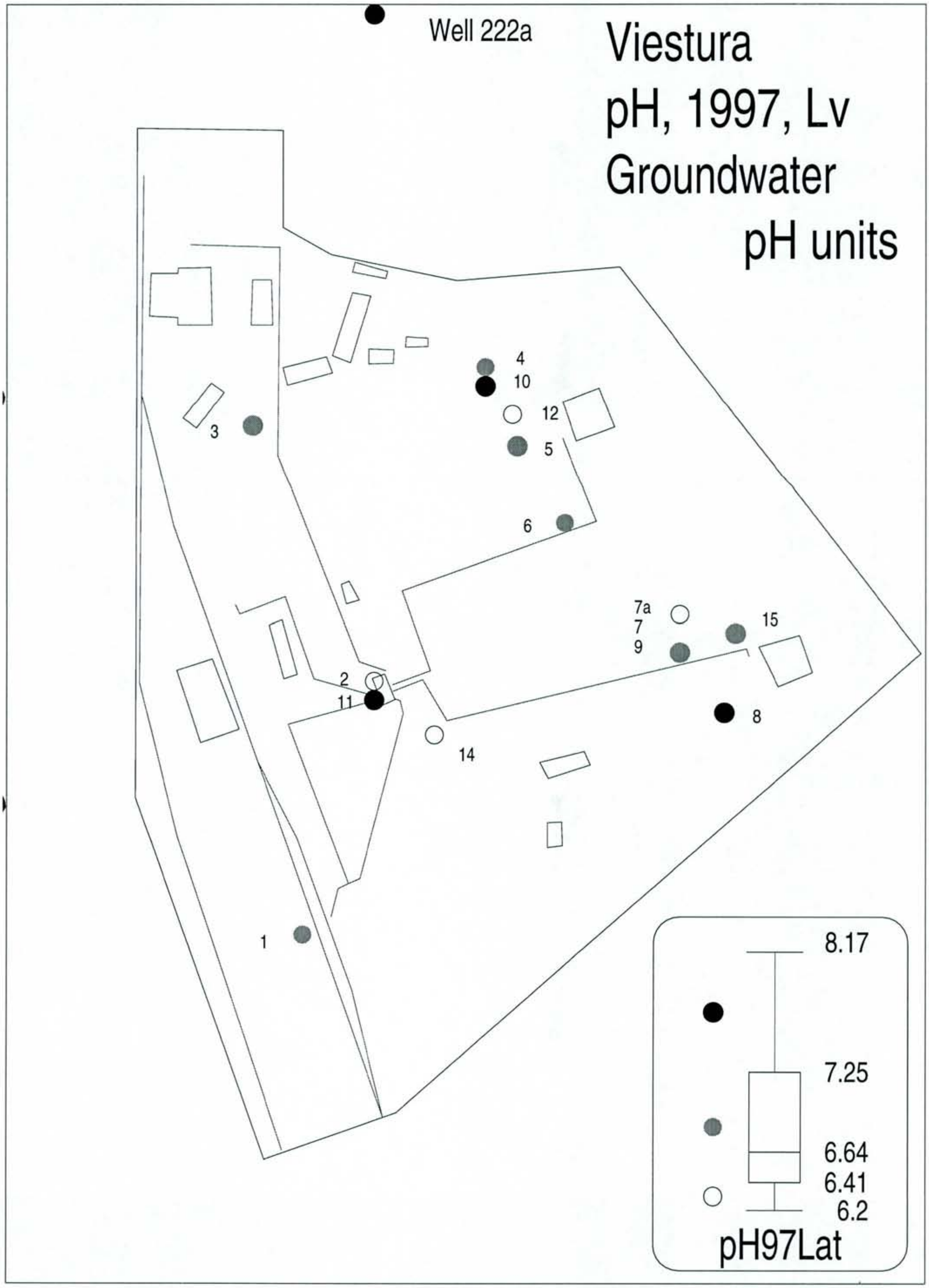

Well 222a
Viestura
Pb (AA) 1997, NGU
Groundwater
ug/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
16.78
2.15
2.06
0.76
0.585
0.1
PbAA97NGU
Detection limit = 0.2 ug/L

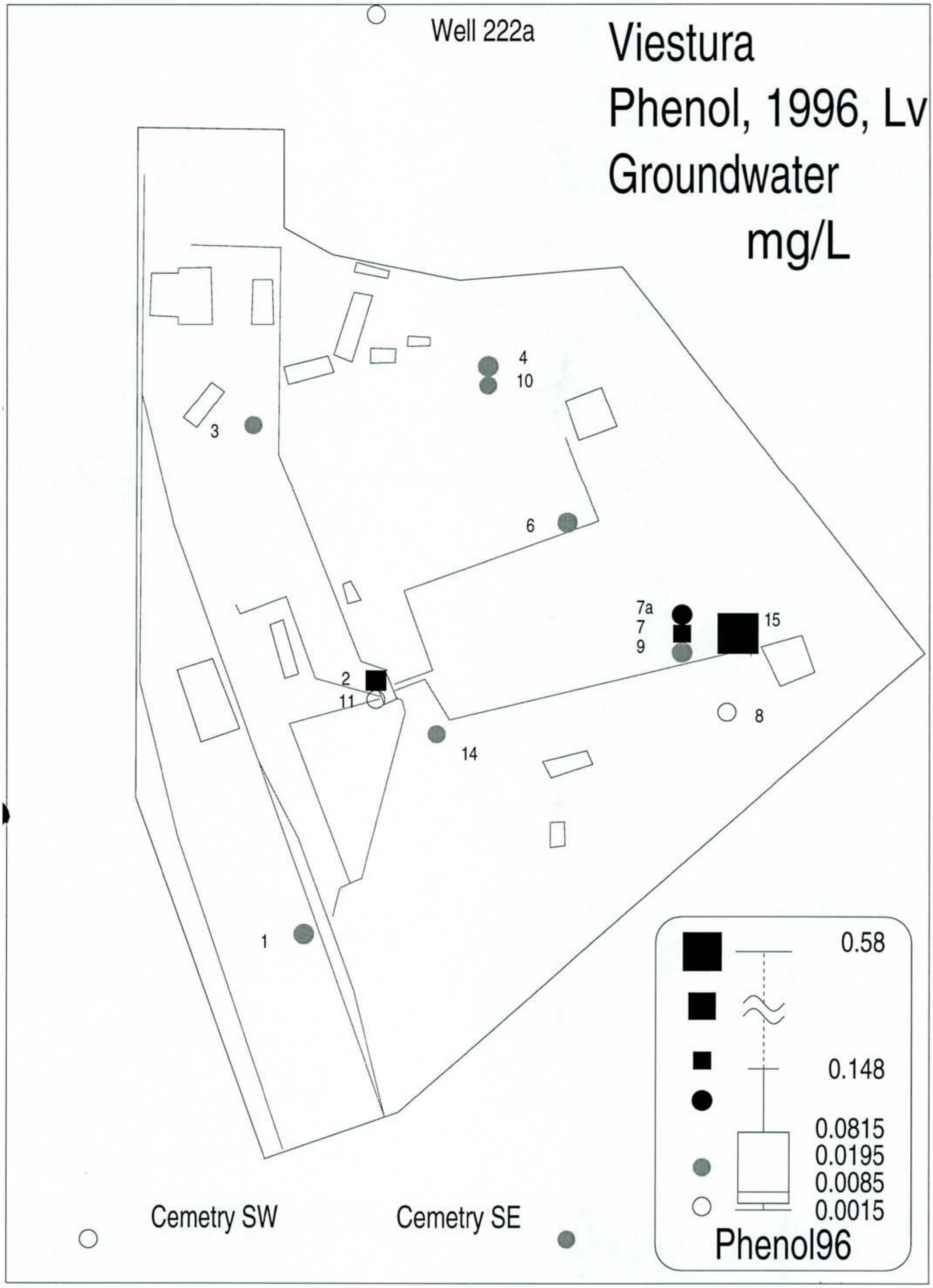

Viestura
pH 1994, Lv
Groundwater
pH units
4
10
7
9
2
11
7.26
6.995
6.56
6.435
6.25
pH94


Well 222a
Viestura
pH, 1996, Lv
Groundwater
pH units
4
10
7a
7
9
2
11
7.81
7.34
6.855
6.375
6.11
pH96Lat
Cemetry SW
Cemetry SE

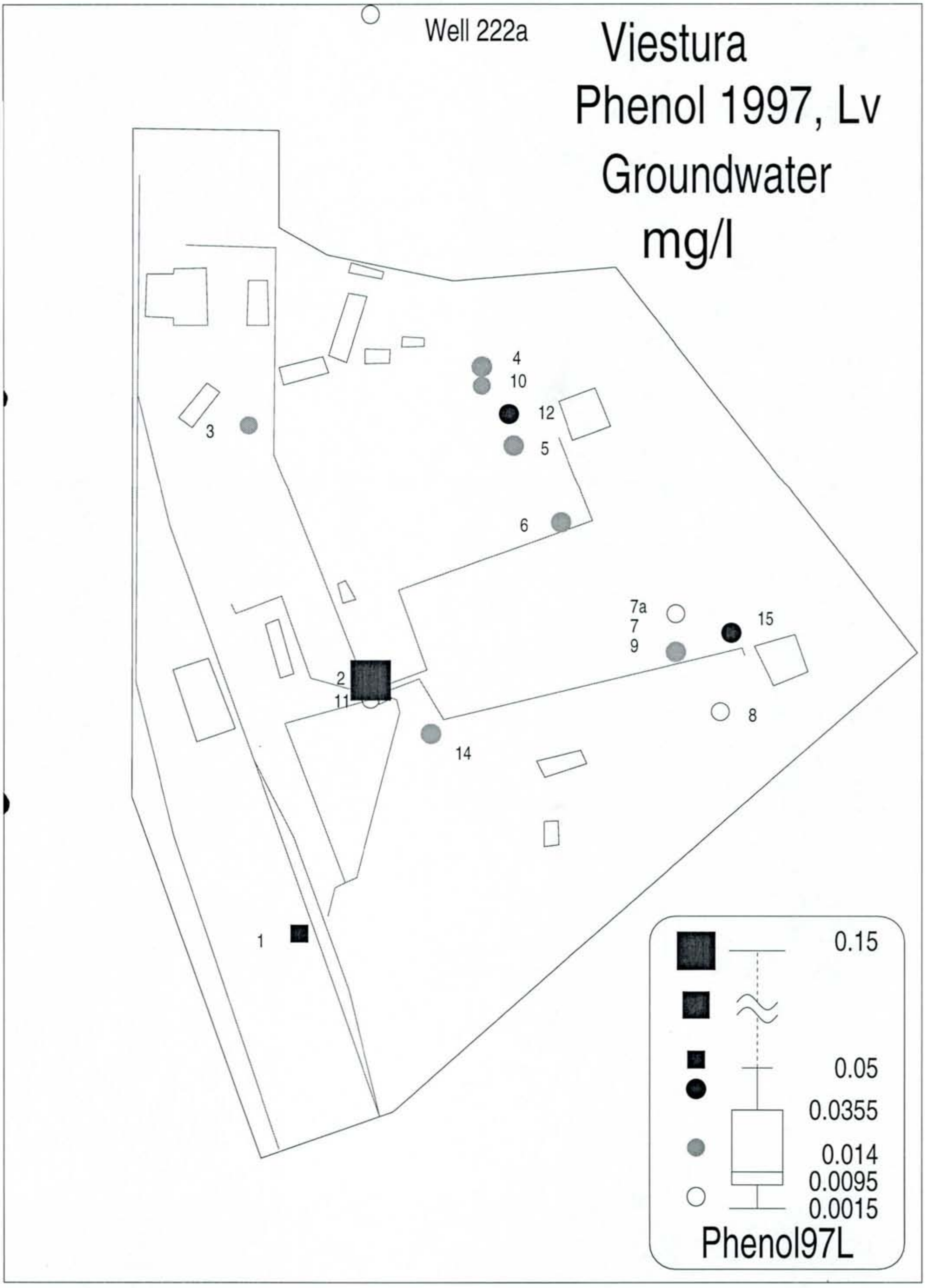


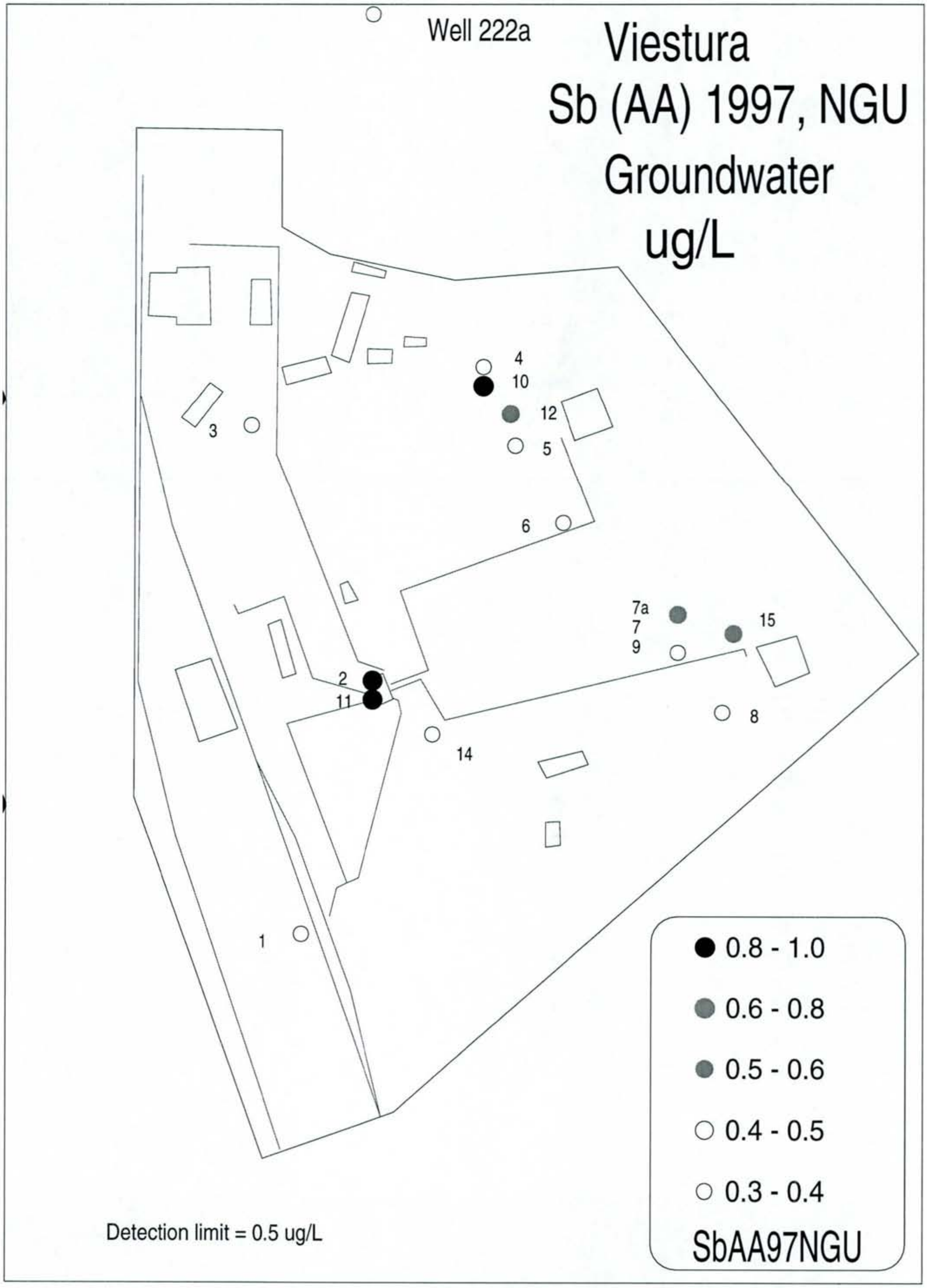
Well 222a
Viestura
pH, 1996, NGU
Groundwater
pH units
4
10
3
6
7a
7
9
15
14
1
7.81
7.34
6.71
6.53
6.11
pH96NGU
Cemetry SW
Cemetry SE


Well 222a
Viestura
pH, 1997, Lv
Groundwater
pH units
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
8.17
7.25
6.64
6.41
6.2
pH97Lat

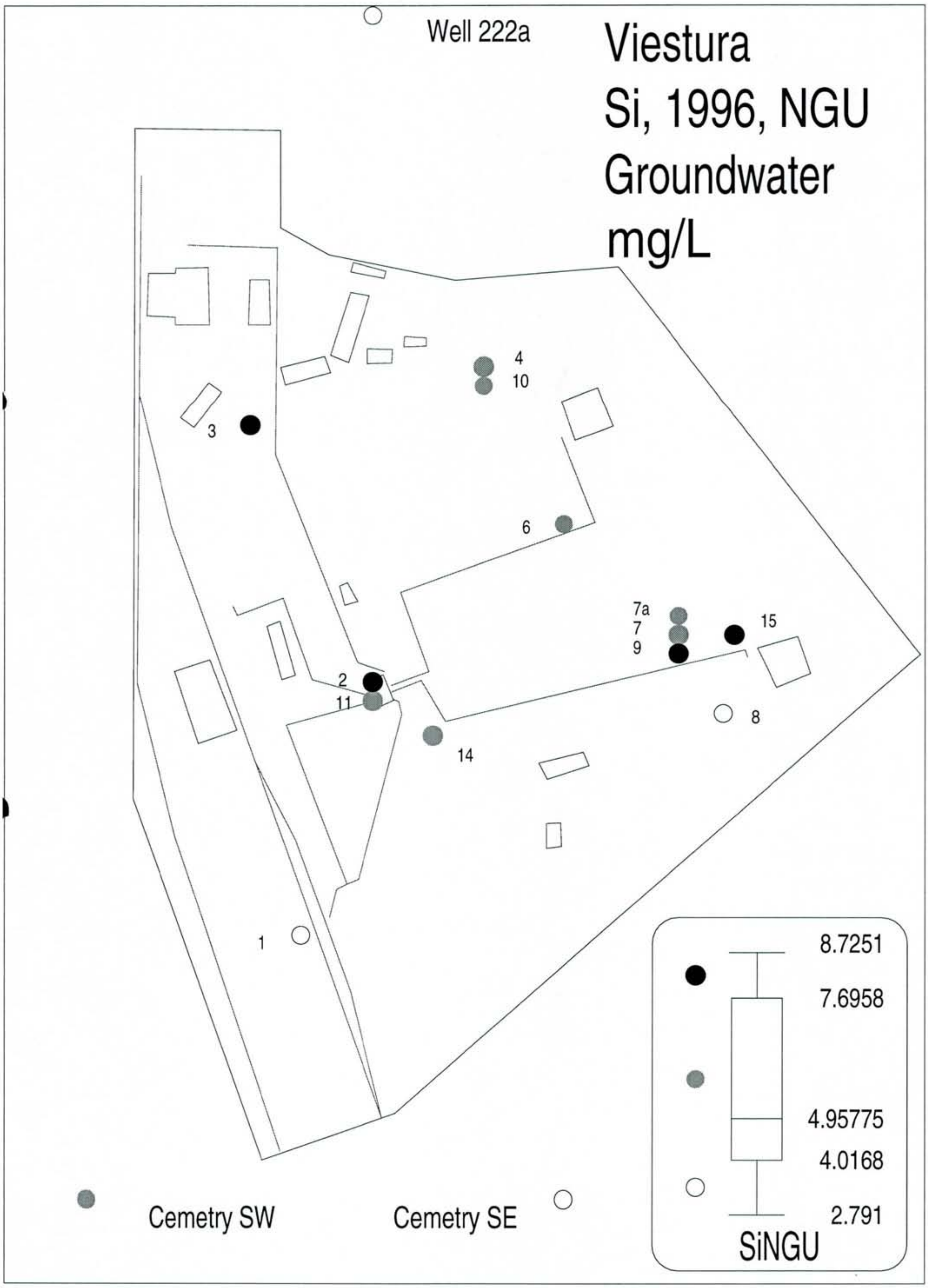


Well 222a
Viestura
Phenol, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.58
0.148
0.0815
0.0195
0.0085
0.0015
Phenol96
Cemetry SW
Cemetry SE

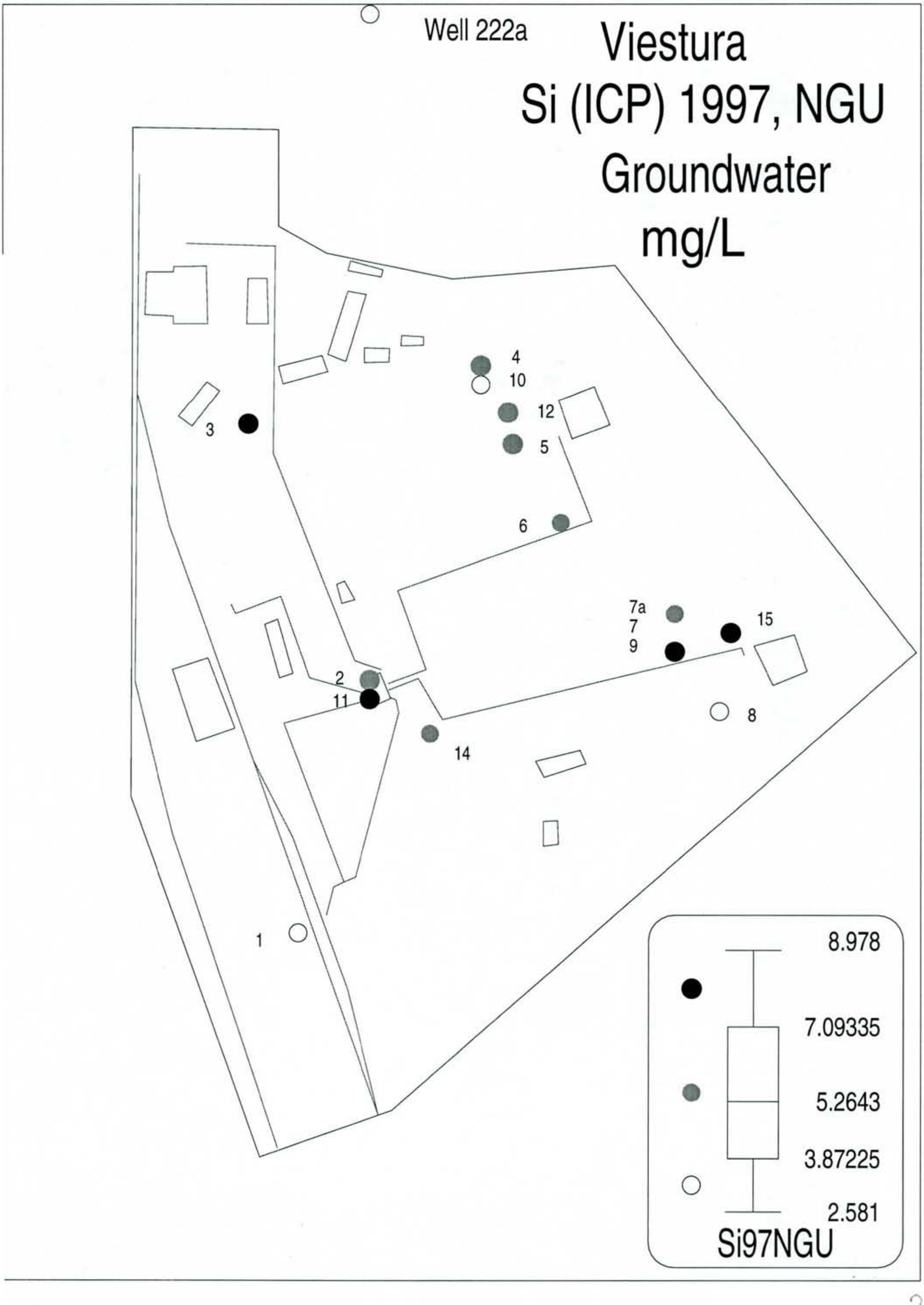

Well 222a
Viestura
Phenol 1997, Lv
Groundwater
mg/l
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
0.15
0.05
0.0355
0.014
0.0095
0.0015
Phenol97L



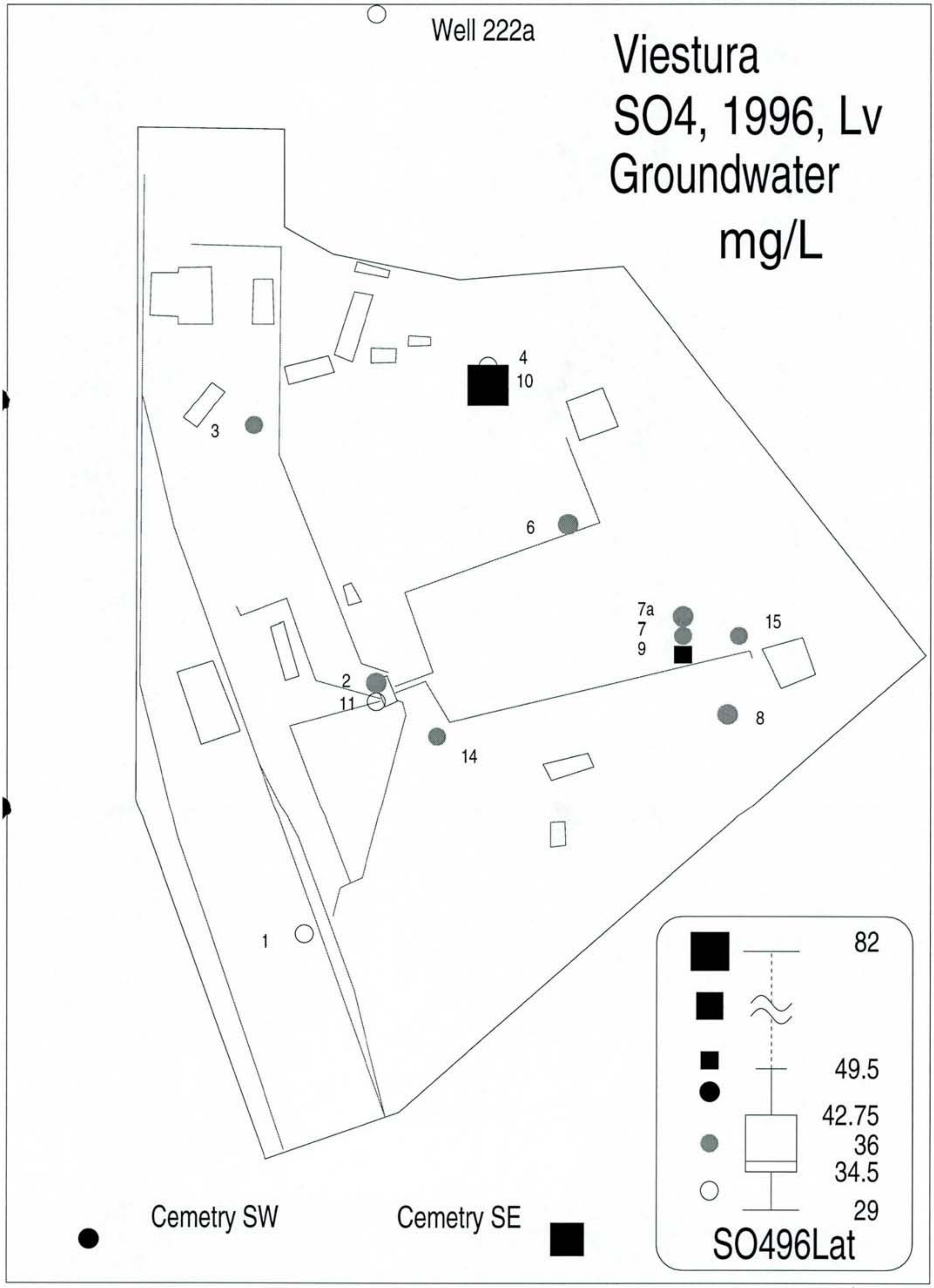
Well 222a
Viestura
Sb (AA) 1997, NGU
Groundwater
ug/L
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
0.8 - 1.0
0.6 - 0.8
0.5 - 0.6
0.4 - 0.5
0.3 - 0.4
SbAA97NGU
Detection limit = 0.5 ug/L



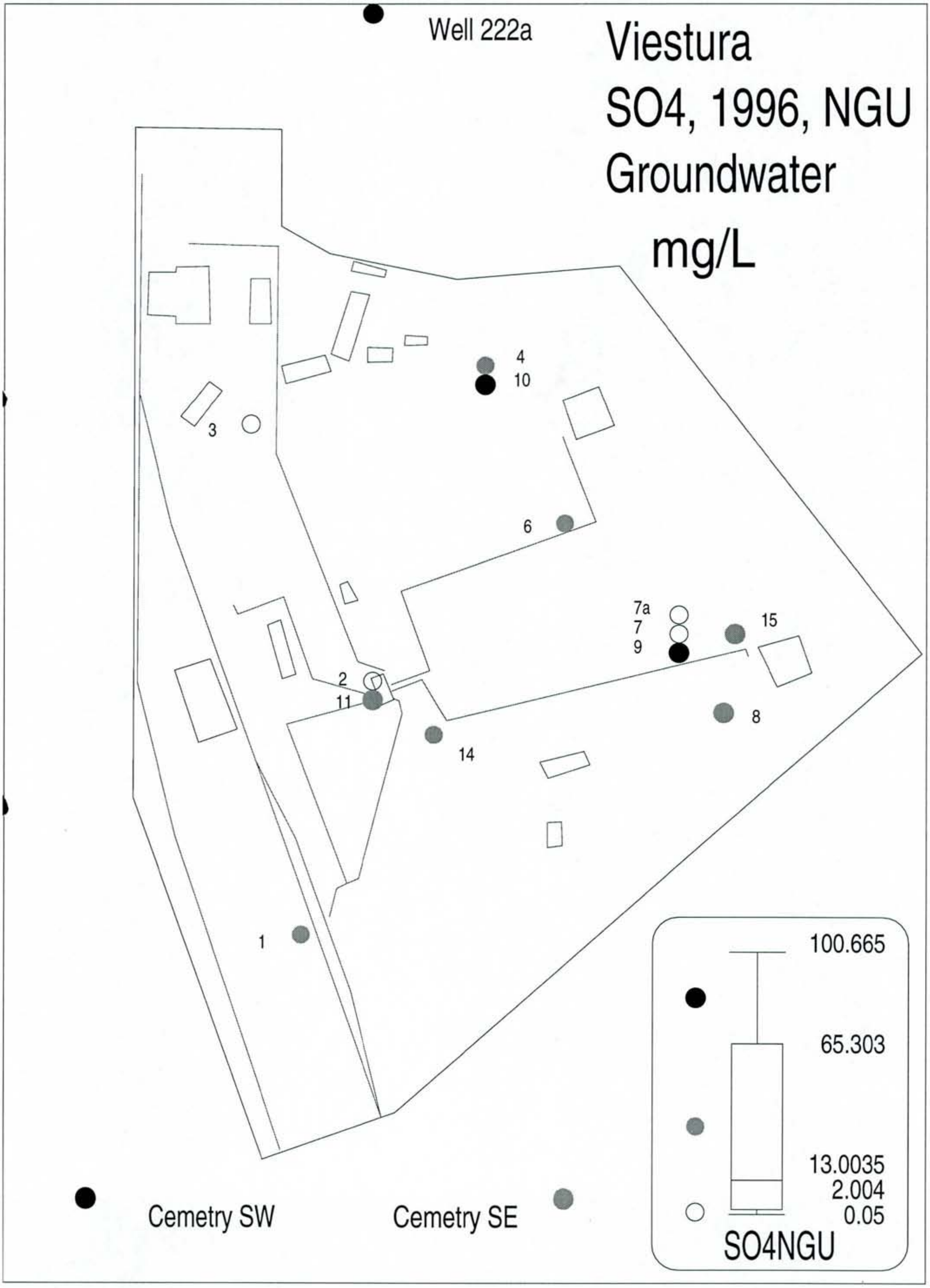
Well 222a
Viestura
Si, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
8.7251
7.6958
4.95775
4.0168
2.791
SiNGU
Cemetry SW
Cemetry SE



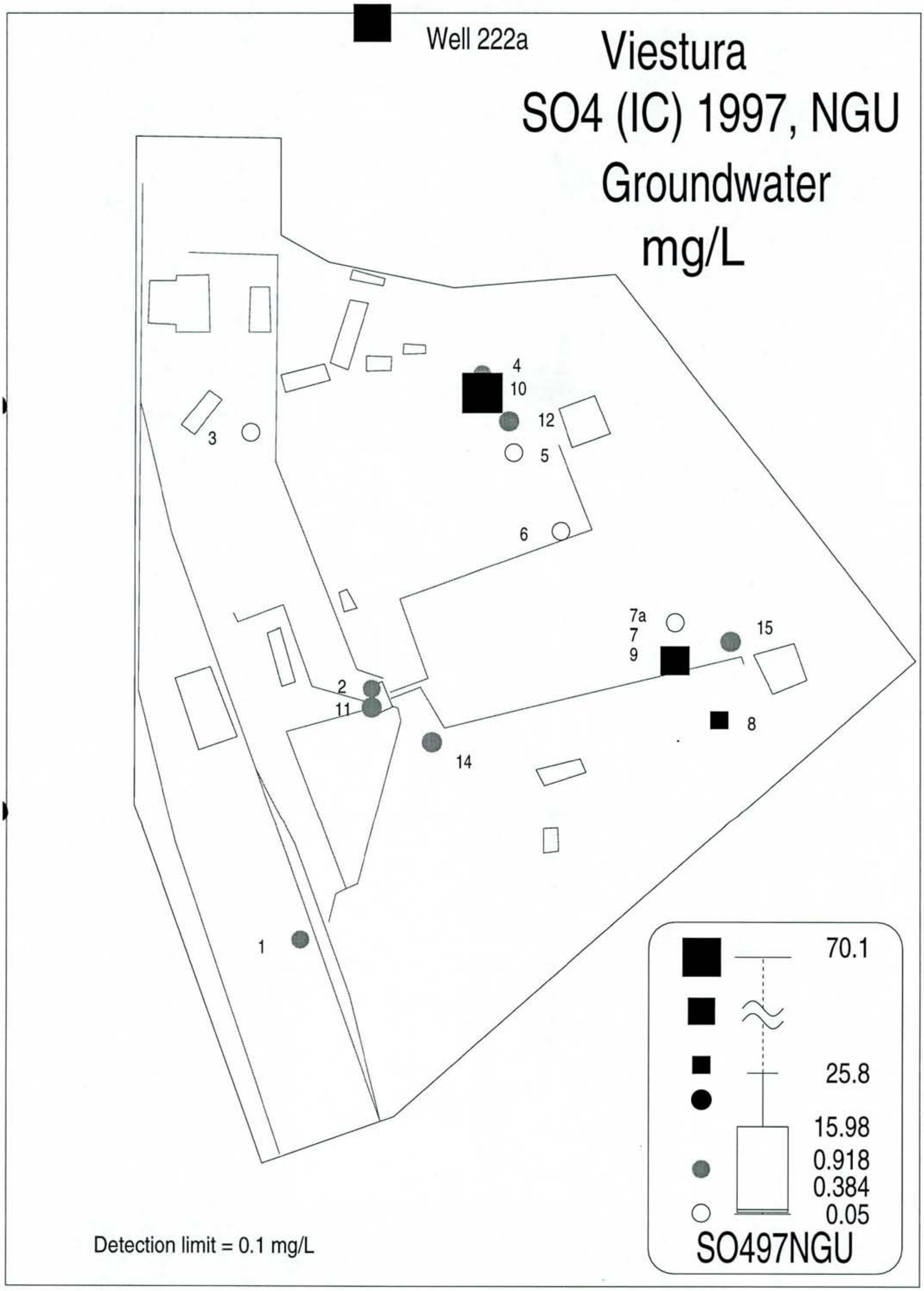
Well 222a
Viestura
Si (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
8.978
7.09335
5.2643
3.87225
2.581
Si97NGU

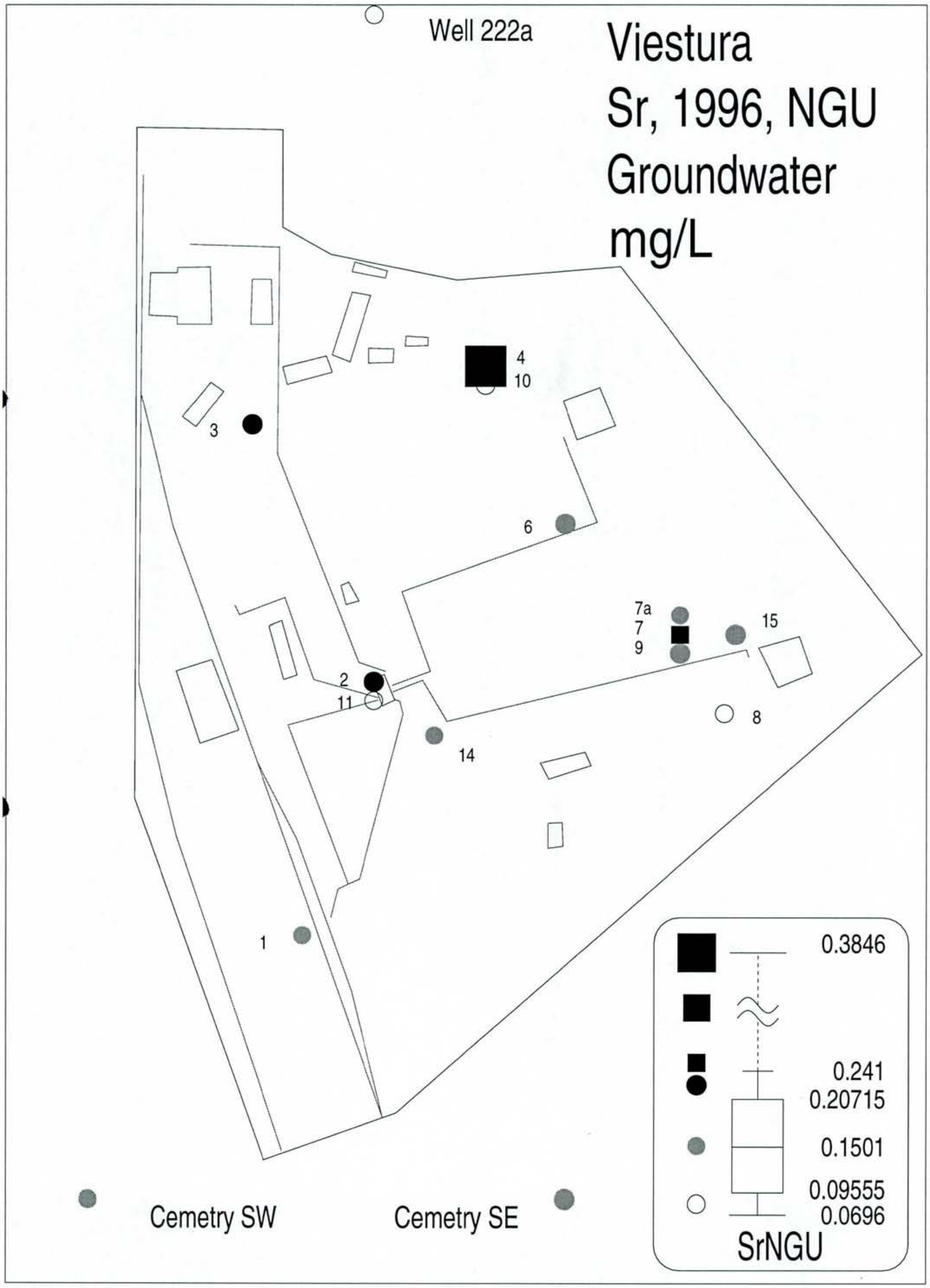


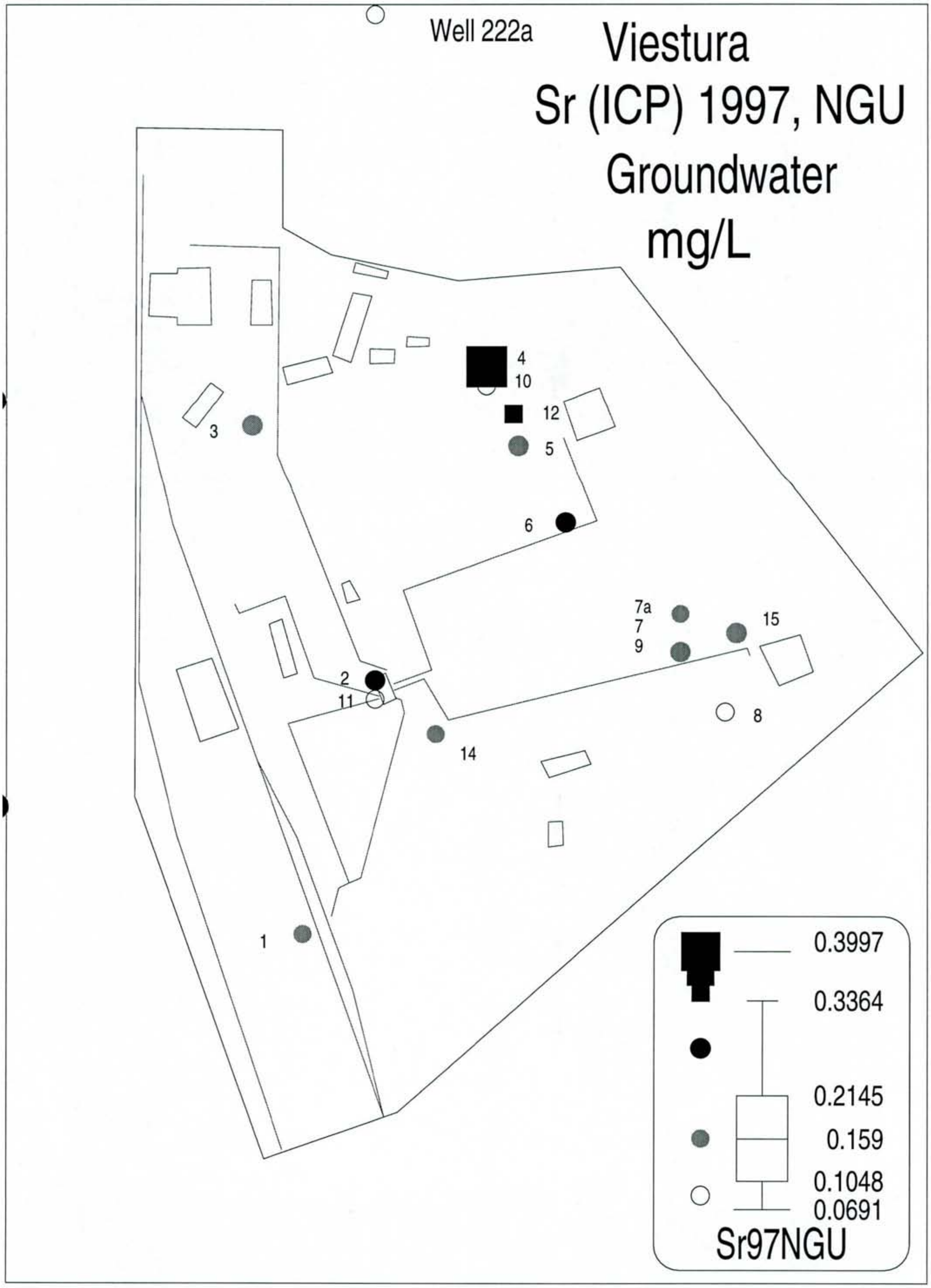
Well 222a
Viestura
SO4, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
82
49.5
42.75
36
34.5
29
SO496Lat
Cemetry SW
Cemetry SE



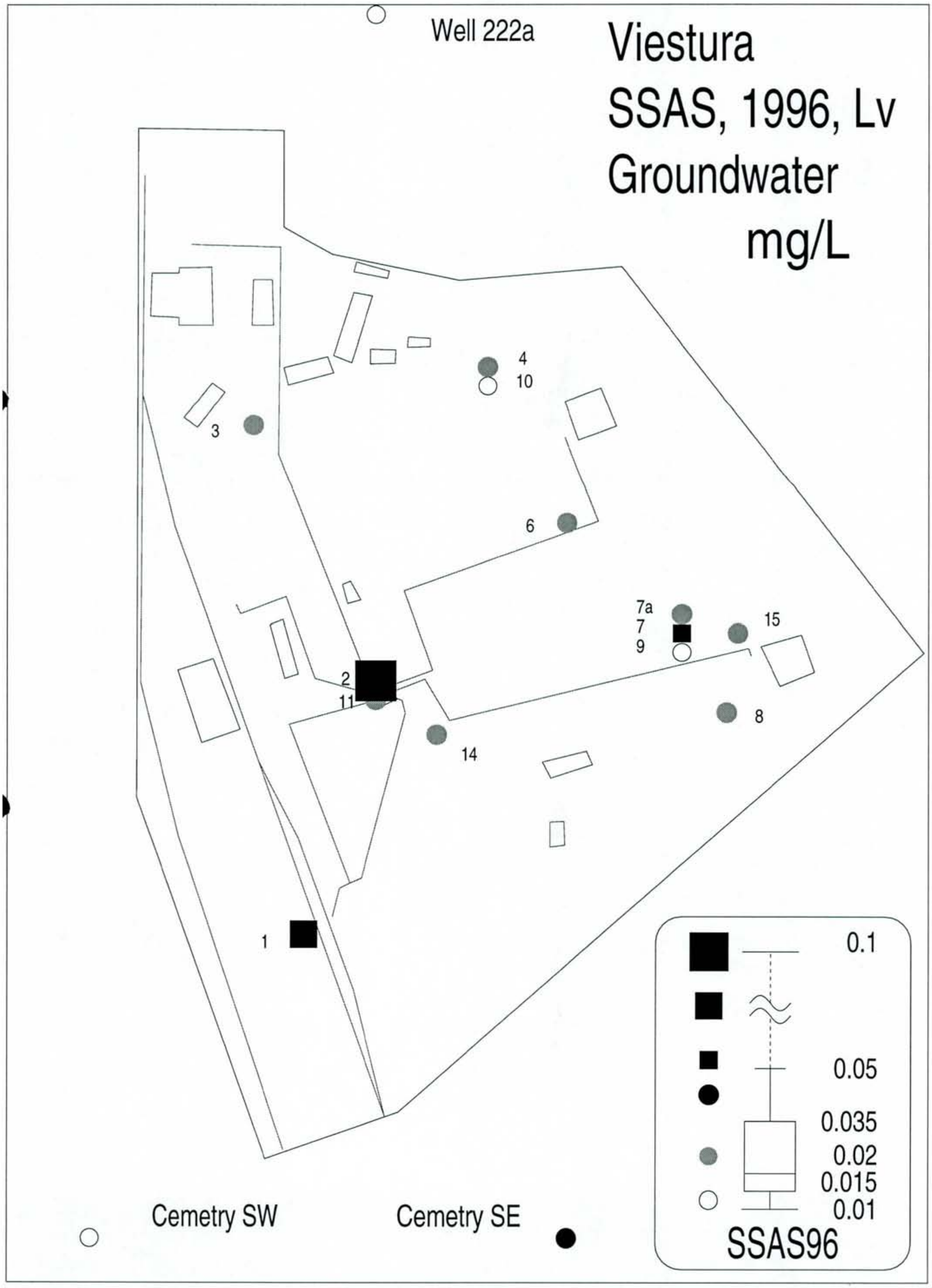
Well 222a
Viestura
SO4, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
100.665
65.303
13.0035
2.004
0.05
SO4NGU
Cemetry SW
Cemetry SE


Well 222a
Viestura
SO4 (IC) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
70.1
25.8
15.98
0.918
0.384
0.05
SO497NGU
Detection limit = 0.1 mg/L

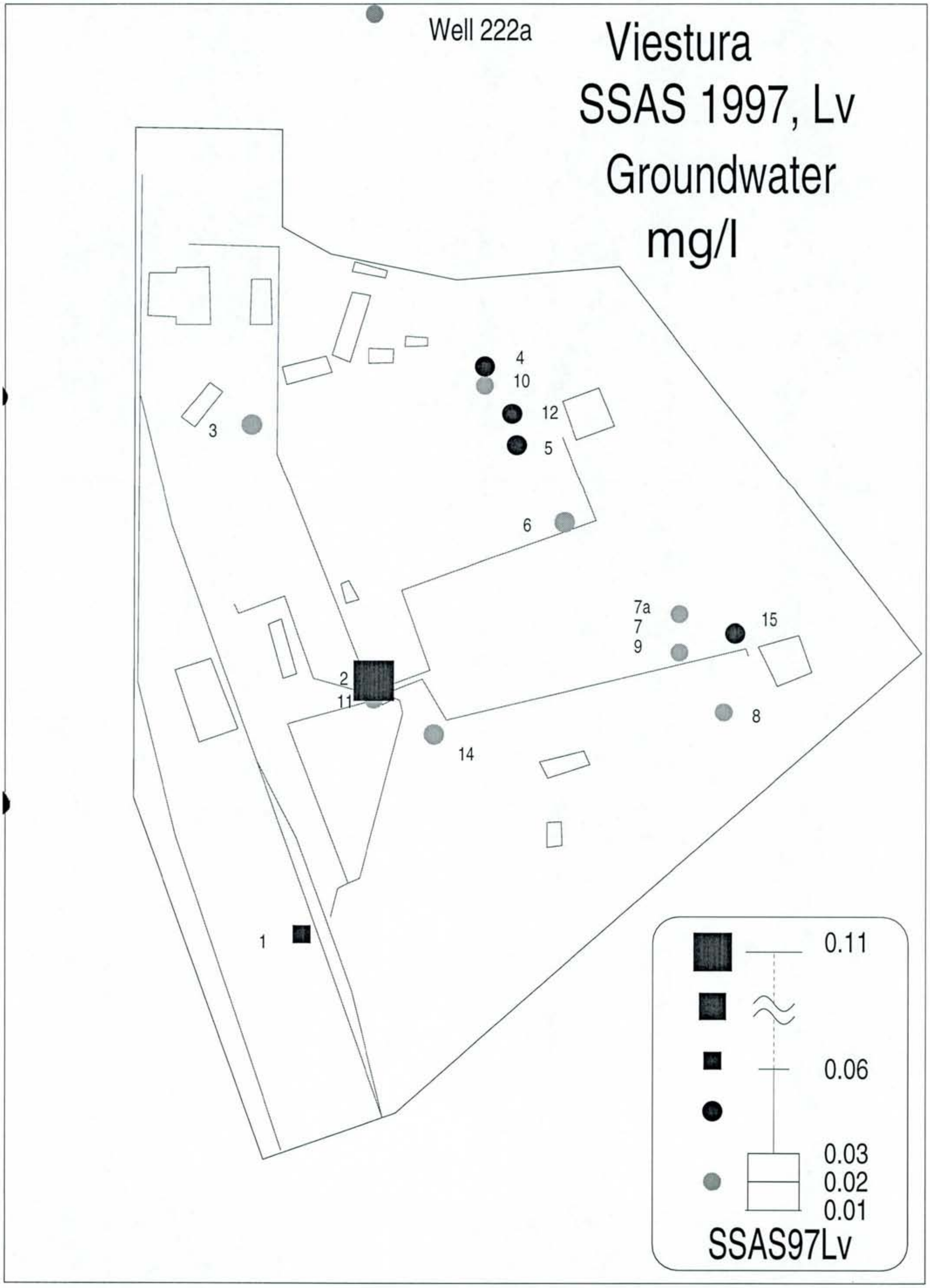

Well 222a
Viestura
Sr, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.3846
0.241
0.20715
0.1501
0.09555
0.0696
SrNGU
Cemetery SW
Cemetery SE

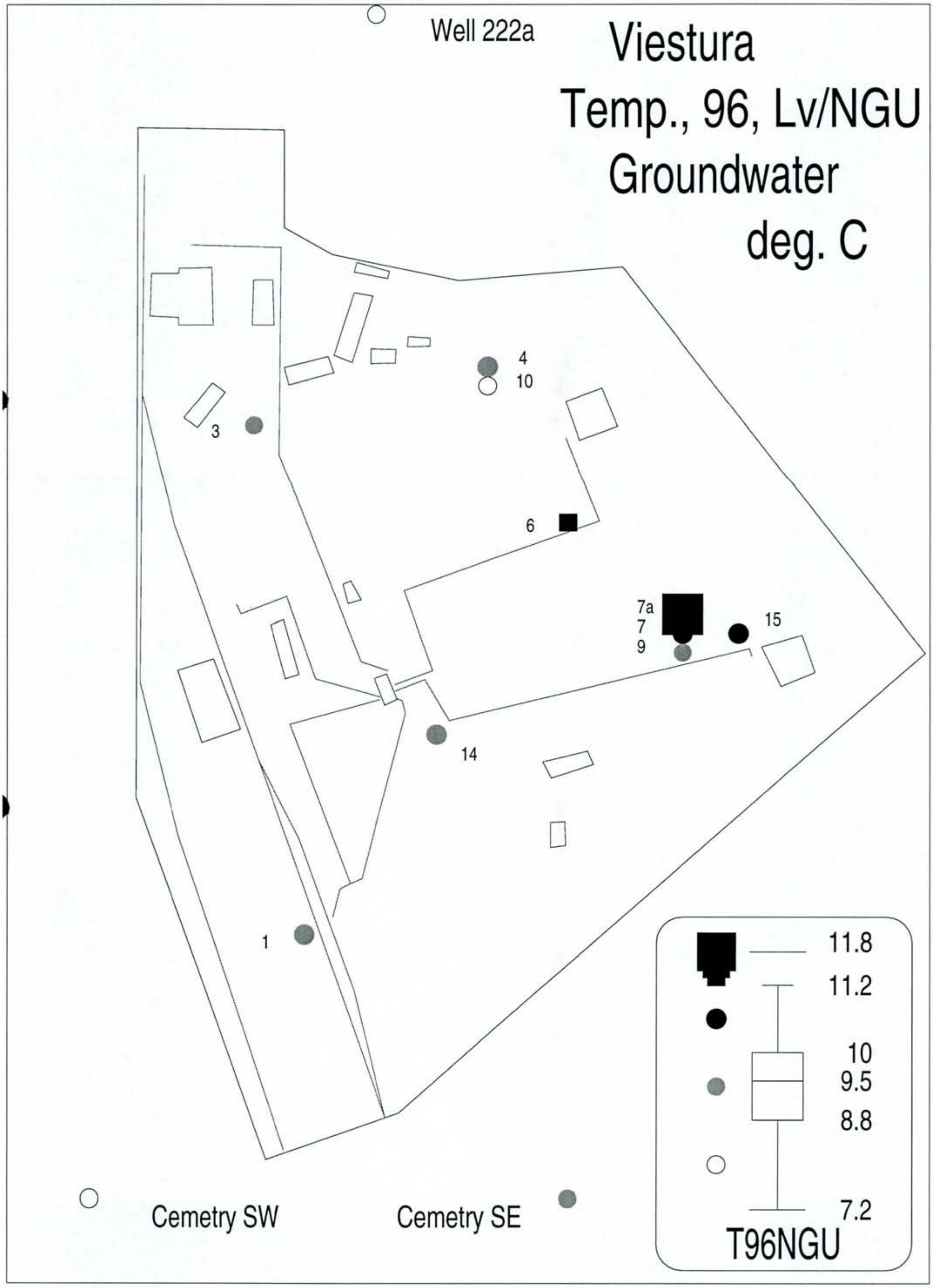


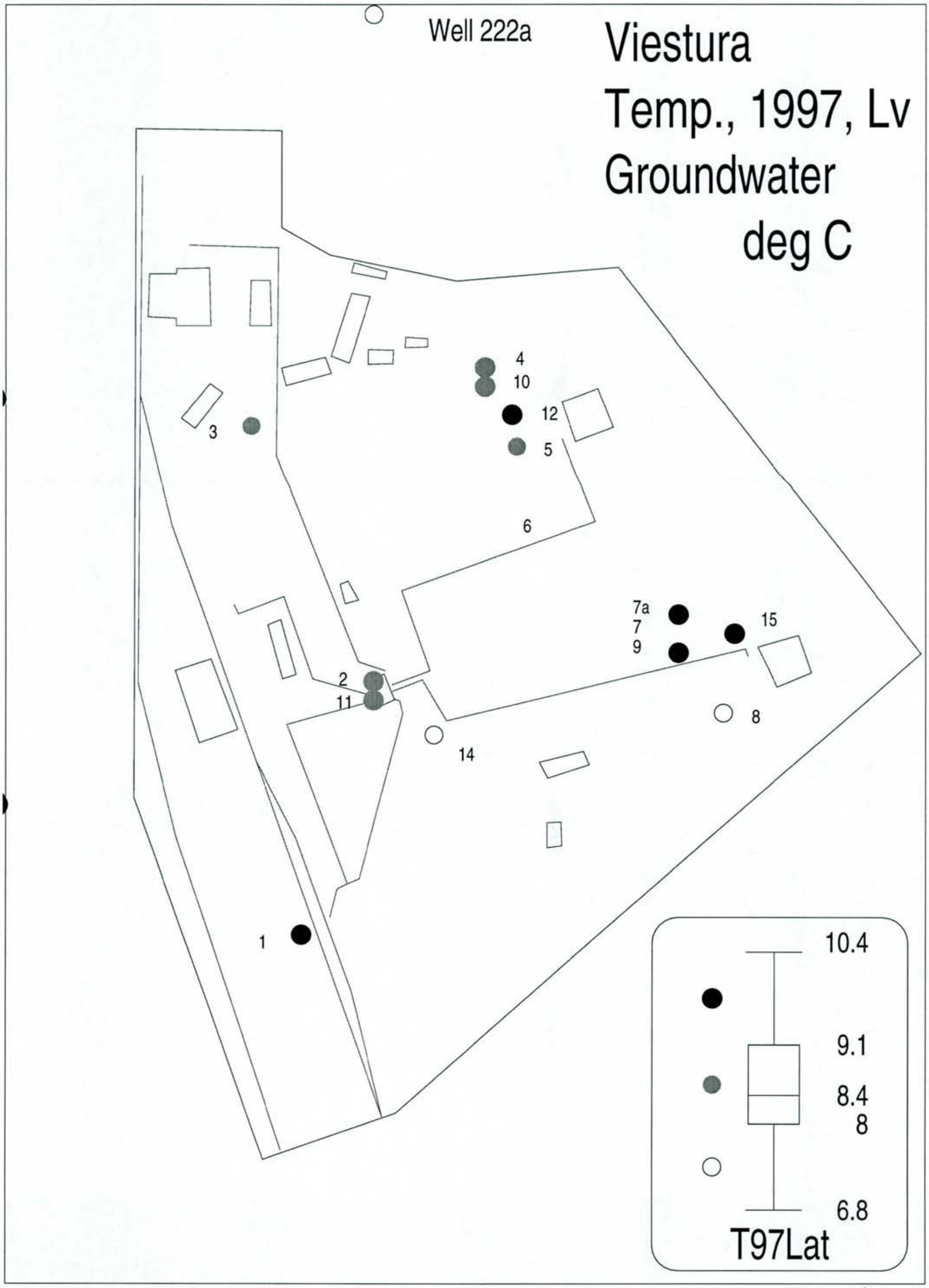
Well 222a
Viestura
Sr (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
0.3997
0.3364
0.2145
0.159
0.1048
0.0691
Sr97NGU

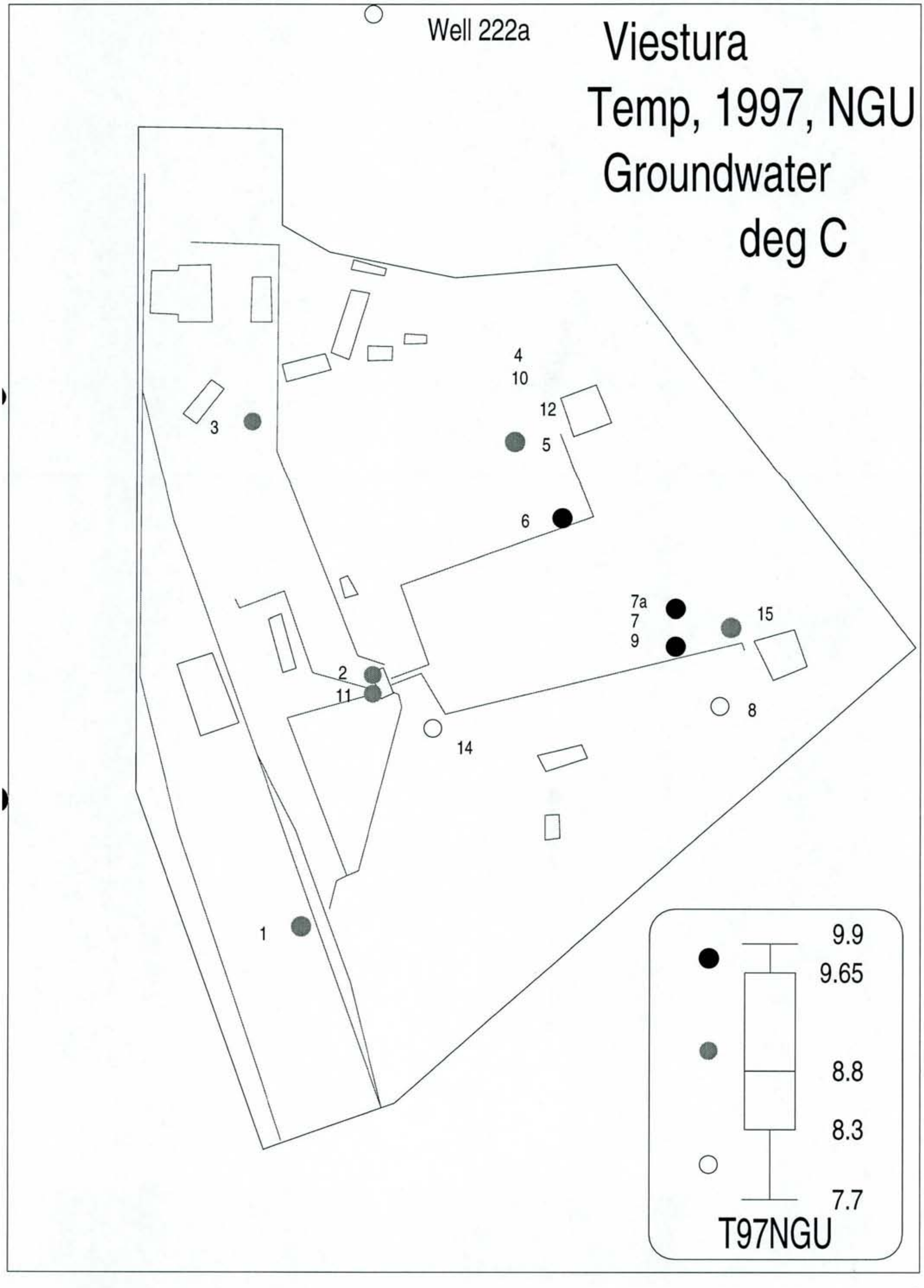


Well 222a
Viestura
SSAS, 1996, Lv
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.1
0.05
0.035
0.02
0.015
0.01
SSAS96
Cemetry SW
Cemetry SE

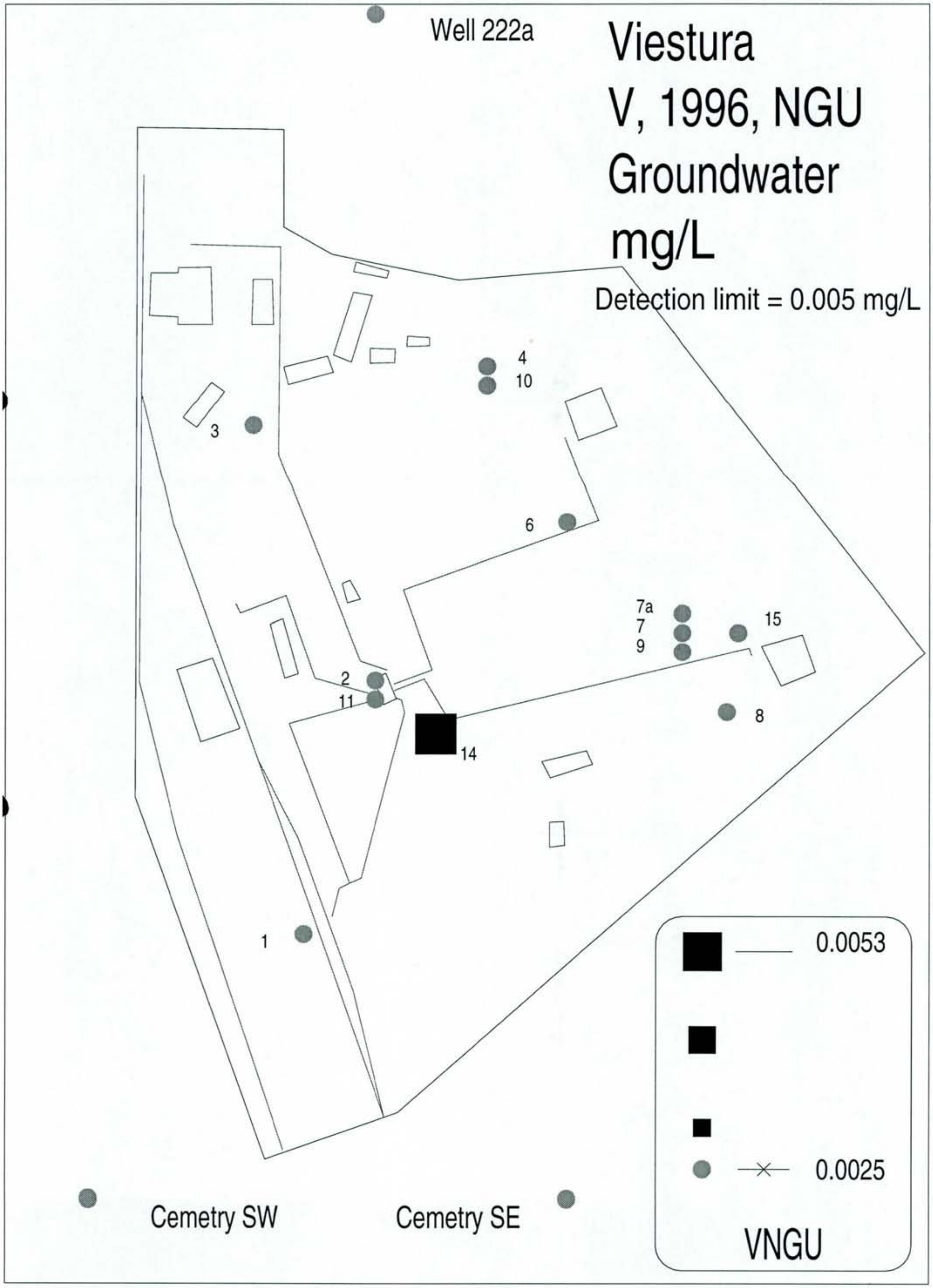

Well 222a
Viestura
SSAS 1997, Lv
Groundwater
mg/l
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
0.11
0.06
0.03
0.02
0.01
SSAS97Lv


Well 222a
Viestura
Temp., 96, Lv/NGU
Groundwater
deg. C
4
10
3
6
7a
7
9
15
14
1
11.8
11.2
10
9.5
8.8
7.2
T96NGU
Cemetry SW
Cemetry SE

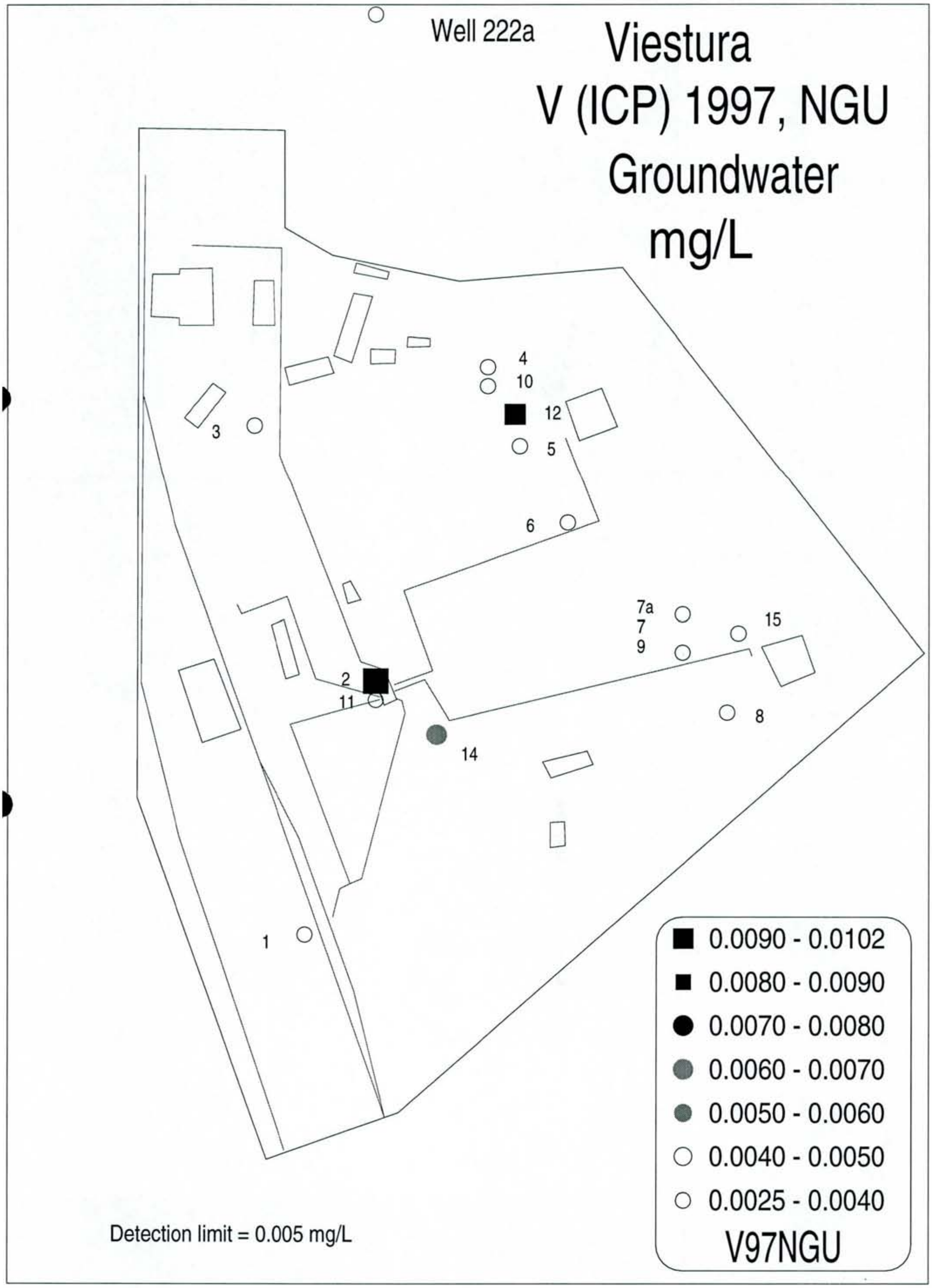

Well 222a
Viestura
Temp., 1997, Lv
Groundwater
deg C
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
10.4
9.1
8.4
8
6.8
T97Lat



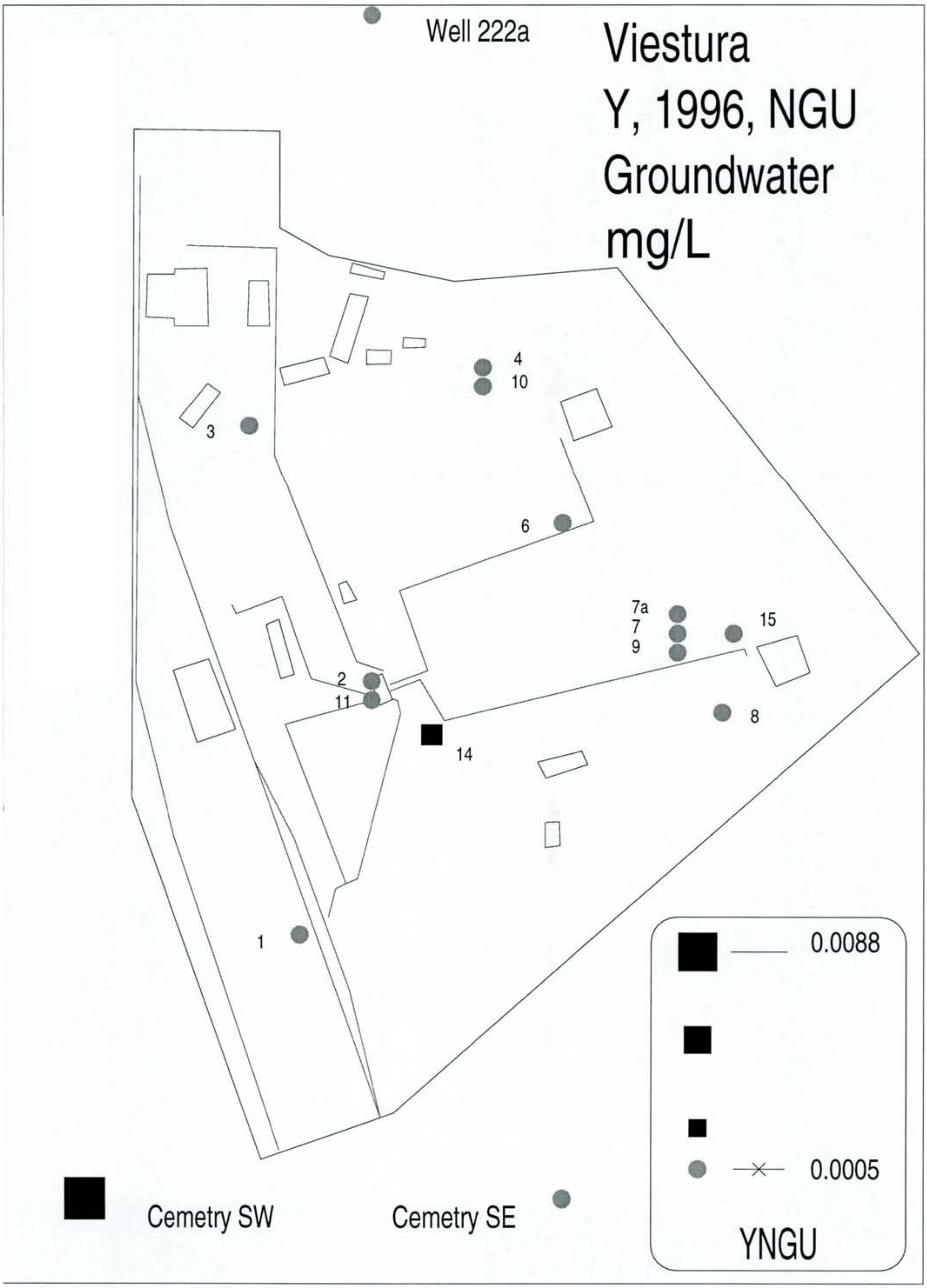
Well 222a
Viestura
Temp, 1997, NGU
Groundwater
deg C
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
9.9
9.65
8.8
8.3
7.7
T97NGU

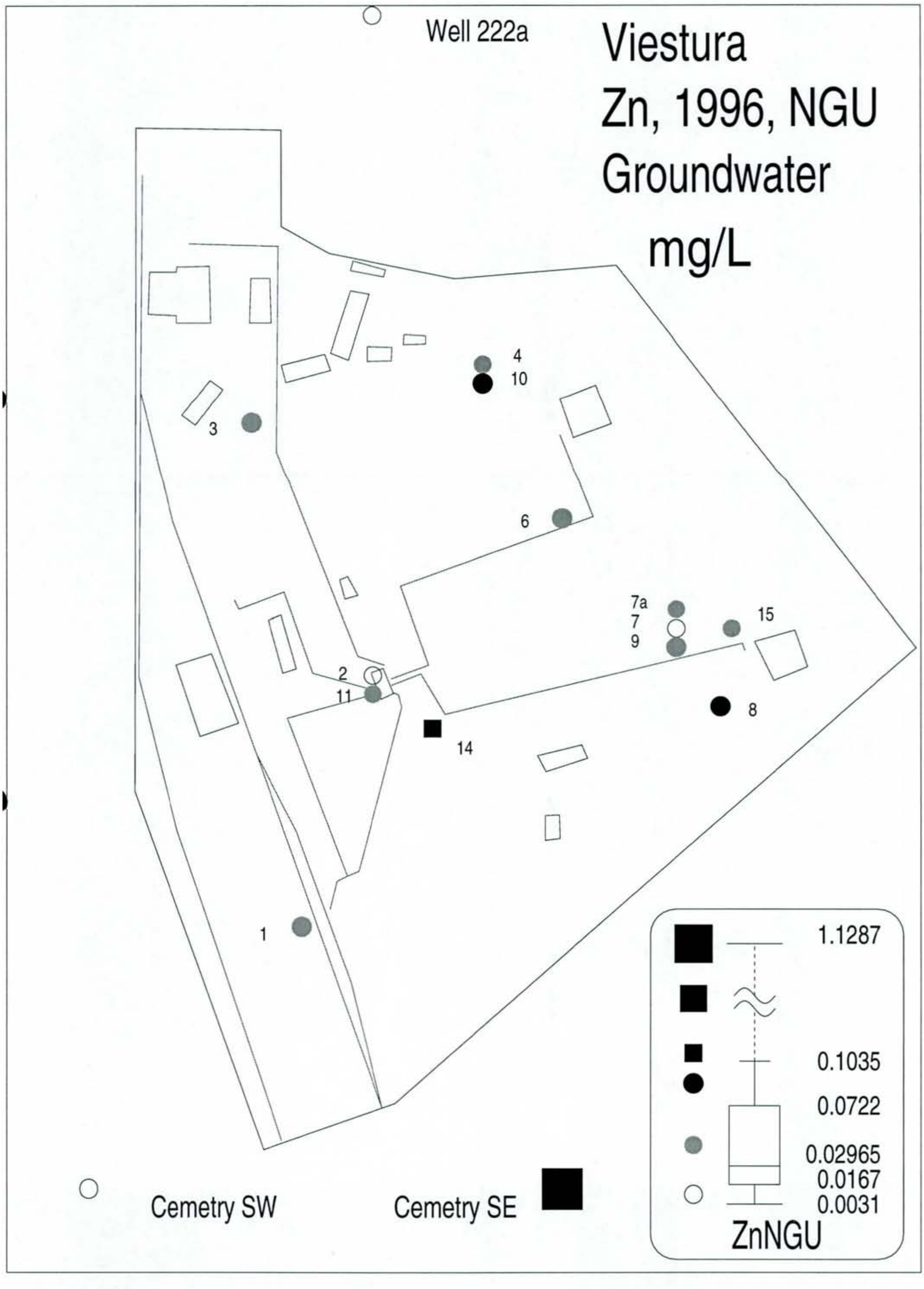


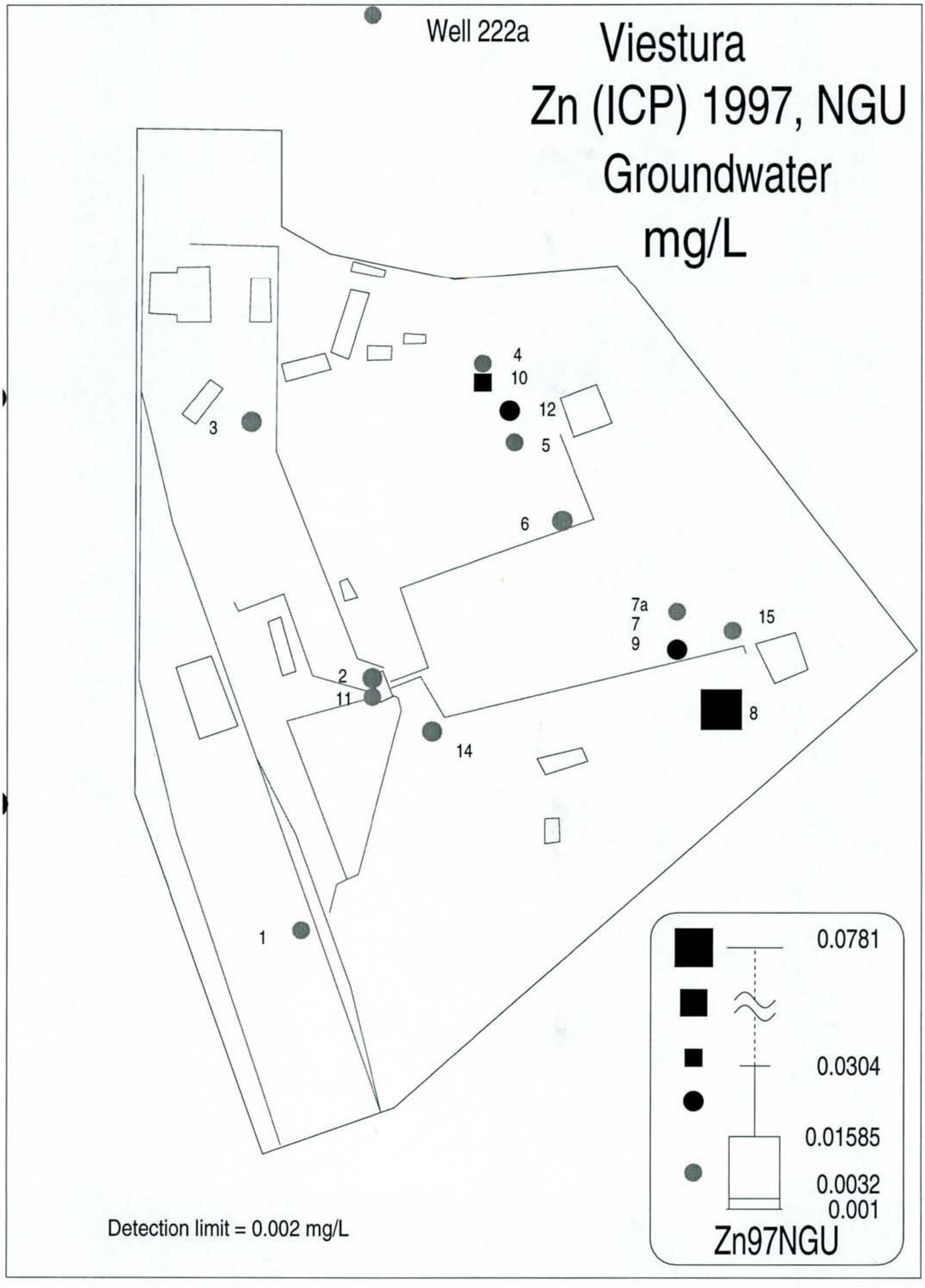
Well 222a
Viestura
V, 1996, NGU
Groundwater
mg/L
Detection limit = 0.005 mg/L
4
10
3
6
7a
7
9
15
2
11
14
8
1
0.0053
0.0025
Cemetery SW
Cemetery SE
VNGU

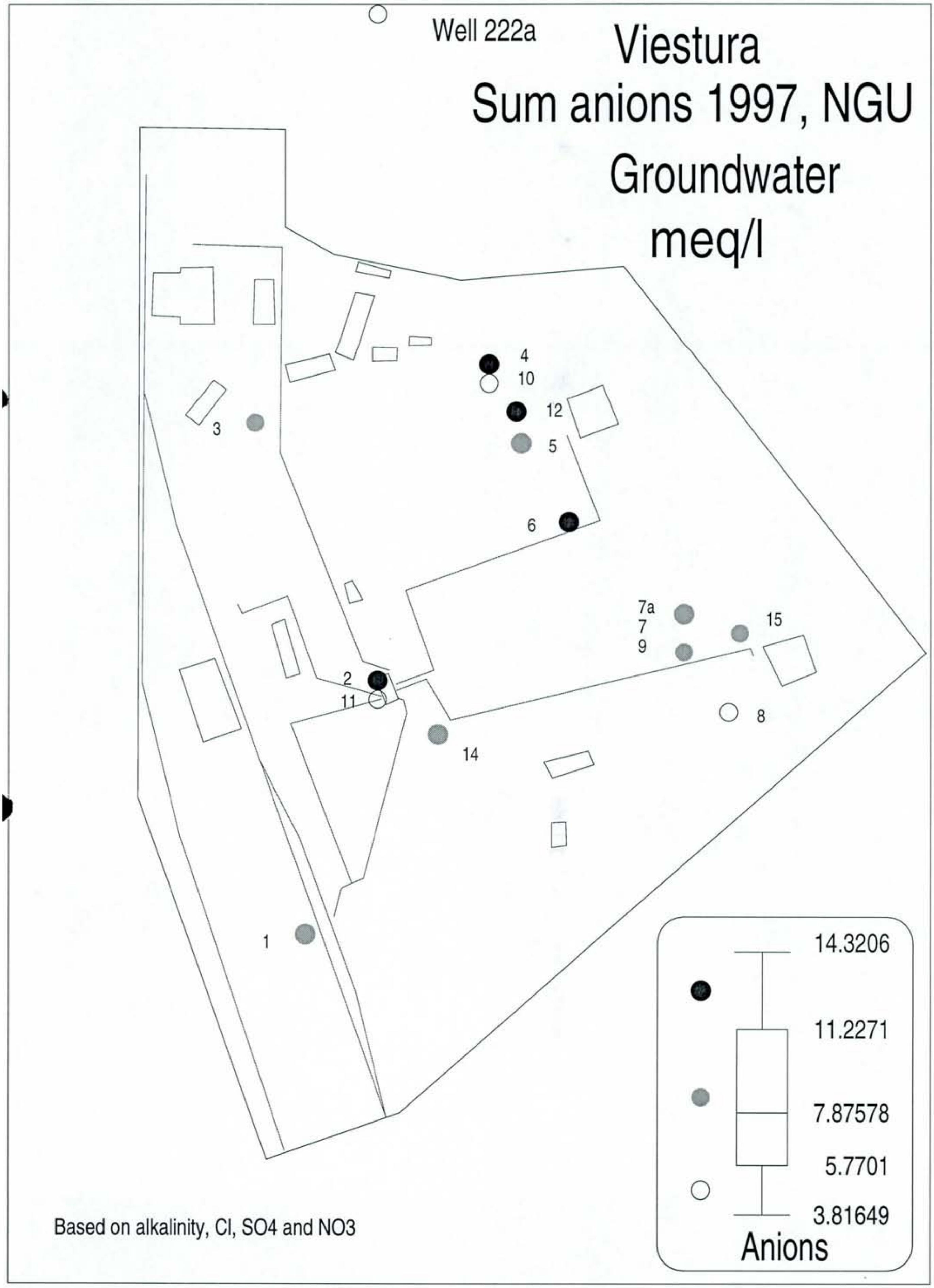


Well 222a
Viestura
V (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
5
6
3
7a
7
9
15
2
11
8
14
1
0.0090 - 0.0102
0.0080 - 0.0090
0.0070 - 0.0080
0.0060 - 0.0070
0.0050 - 0.0060
0.0040 - 0.0050
0.0025 - 0.0040
V97NGU
Detection limit = 0.005 mg/L

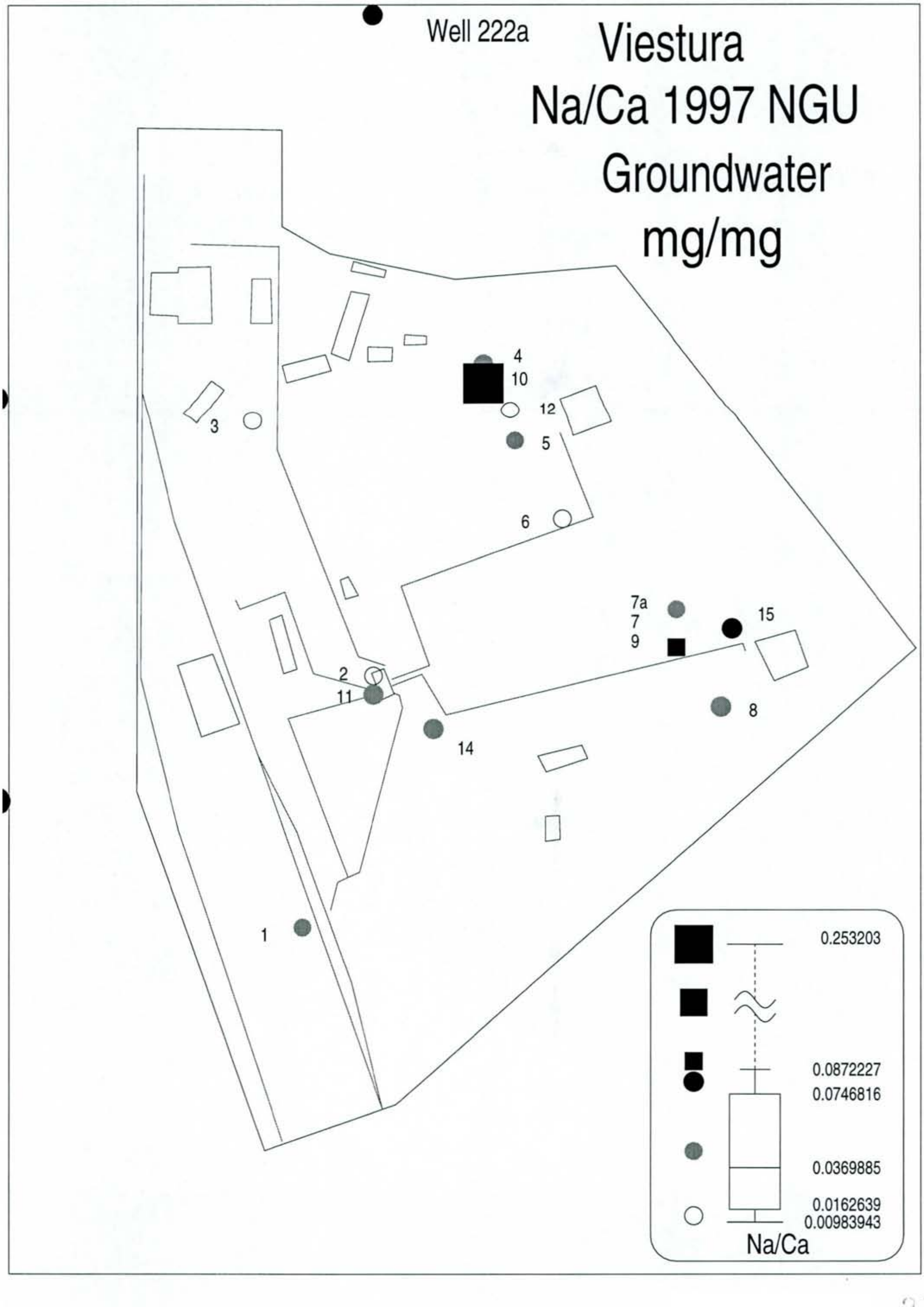

Viestura
Y, 1996, NGU
Groundwater
mg/L
Well 222a
4
10
3
6
7a
7
9
15
2
11
8
14
1
0.0088
0.0005
YNGU
Cemetry SW
Cemetry SE

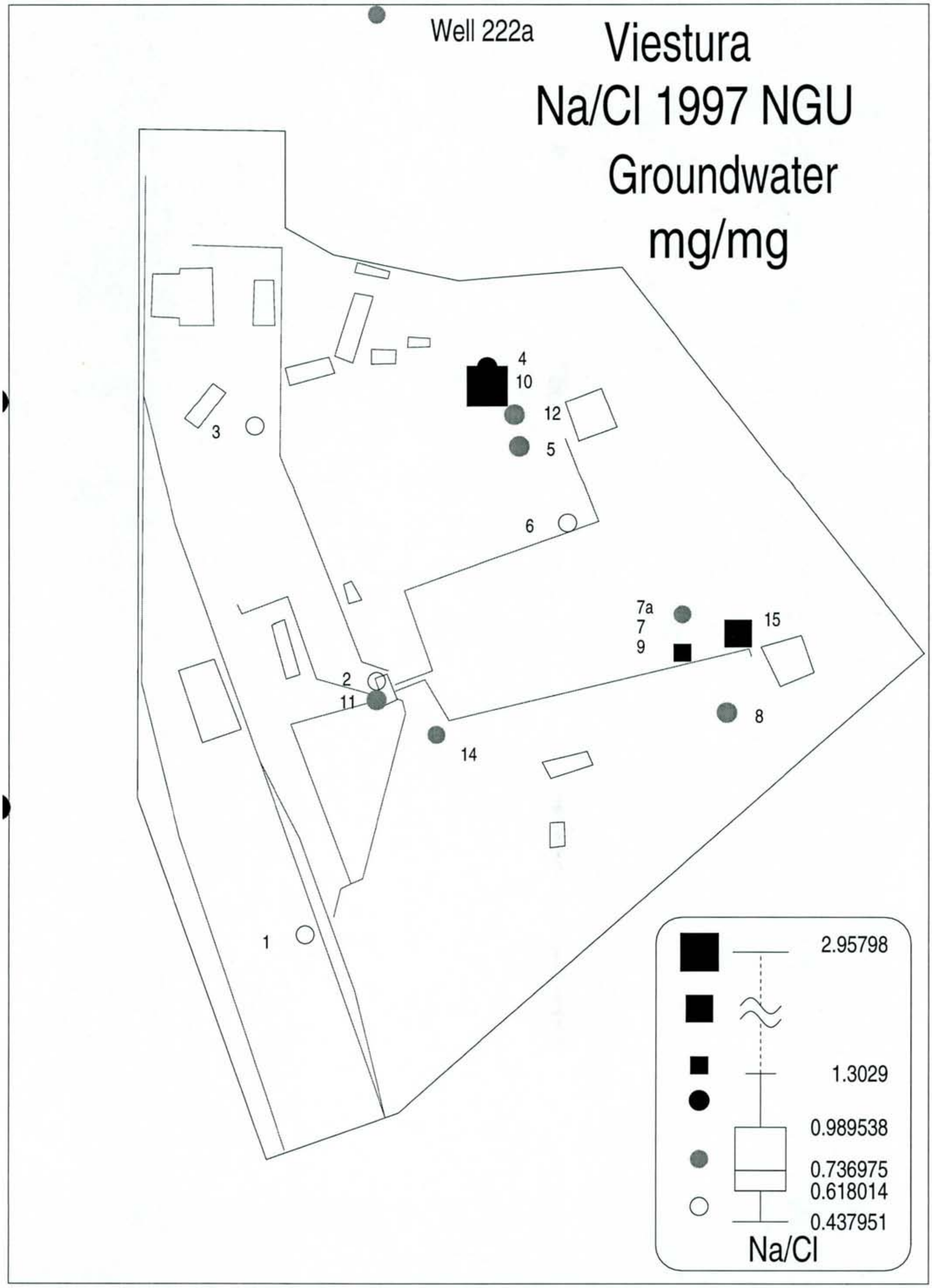

Well 222a
Viestura
Zn, 1996, NGU
Groundwater
mg/L
4
10
3
6
7a
7
9
15
2
11
8
14
1
1.1287
0.1035
0.0722
0.02965
0.0167
0.0031
ZnNGU
Cemetry SW
Cemetry SE


Well 222a
Viestura
Zn (ICP) 1997, NGU
Groundwater
mg/L
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
0.0781
0.0304
0.01585
0.0032
0.001
Zn97NGU
Detection limit = 0.002 mg/L

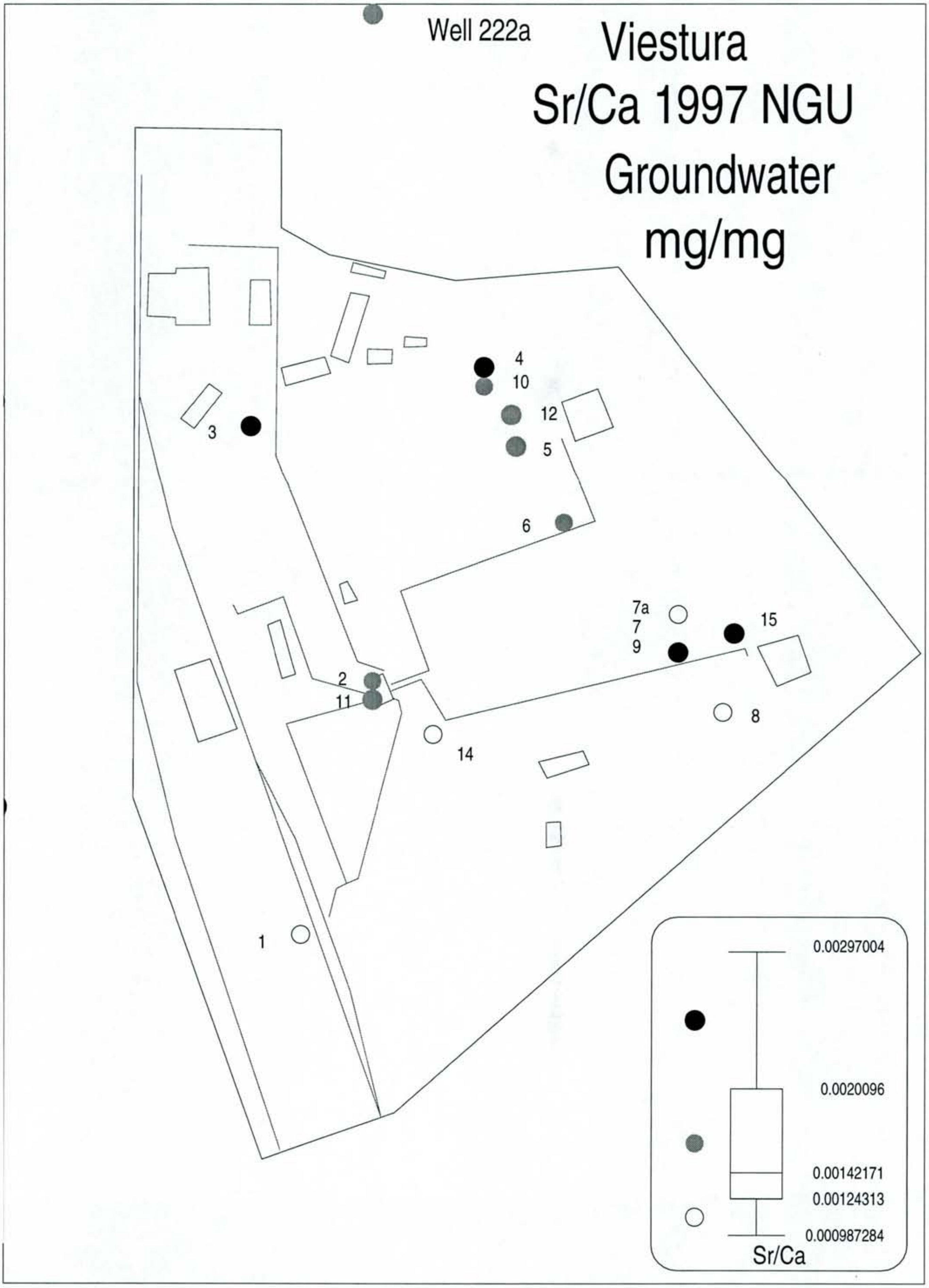


Well 222a
Viestura
Sum anions 1997, NGU
Groundwater
meq/l
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
14.3206
11.2271
7.87578
5.7701
3.81649
Anions
Based on alkalinity, Cl, SO4 and NO3


Well 222a
Viestura
Na/Ca 1997 NGU
Groundwater
mg/mg
4
10
12
3
5
6
7a
7
9
15
2
11
8
14
1
0.253203
0.0872227
0.0746816
0.0369885
0.0162639
0.00983943
Na/Ca



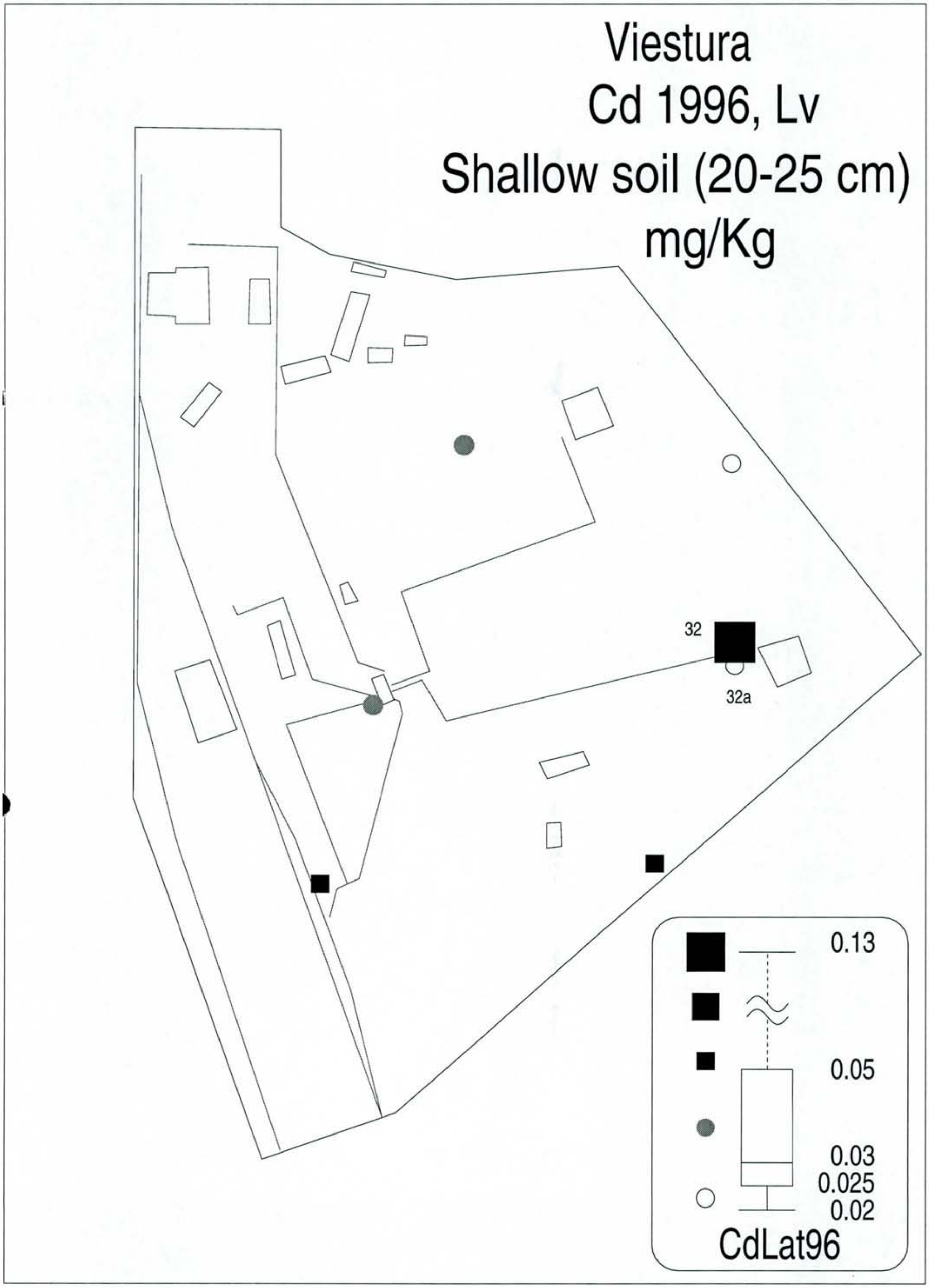
Well 222a
Viestura
Na/Cl 1997 NGU
Groundwater
mg/mg
4
10
12
5
3
6
7a
7
9
15
2
11
8
14
1
2.95798
1.3029
0.989538
0.736975
0.618014
0.437951
Na/Cl

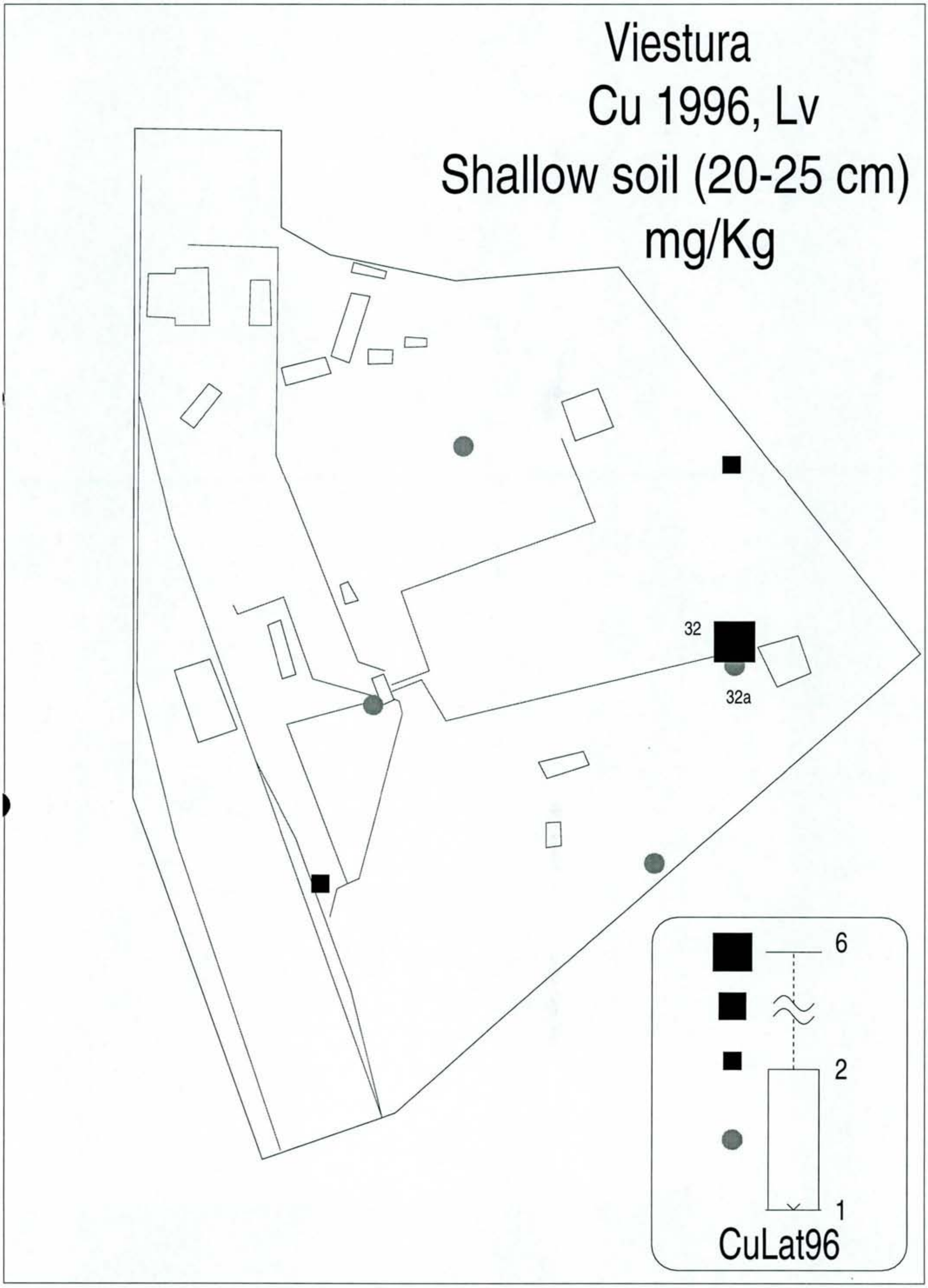


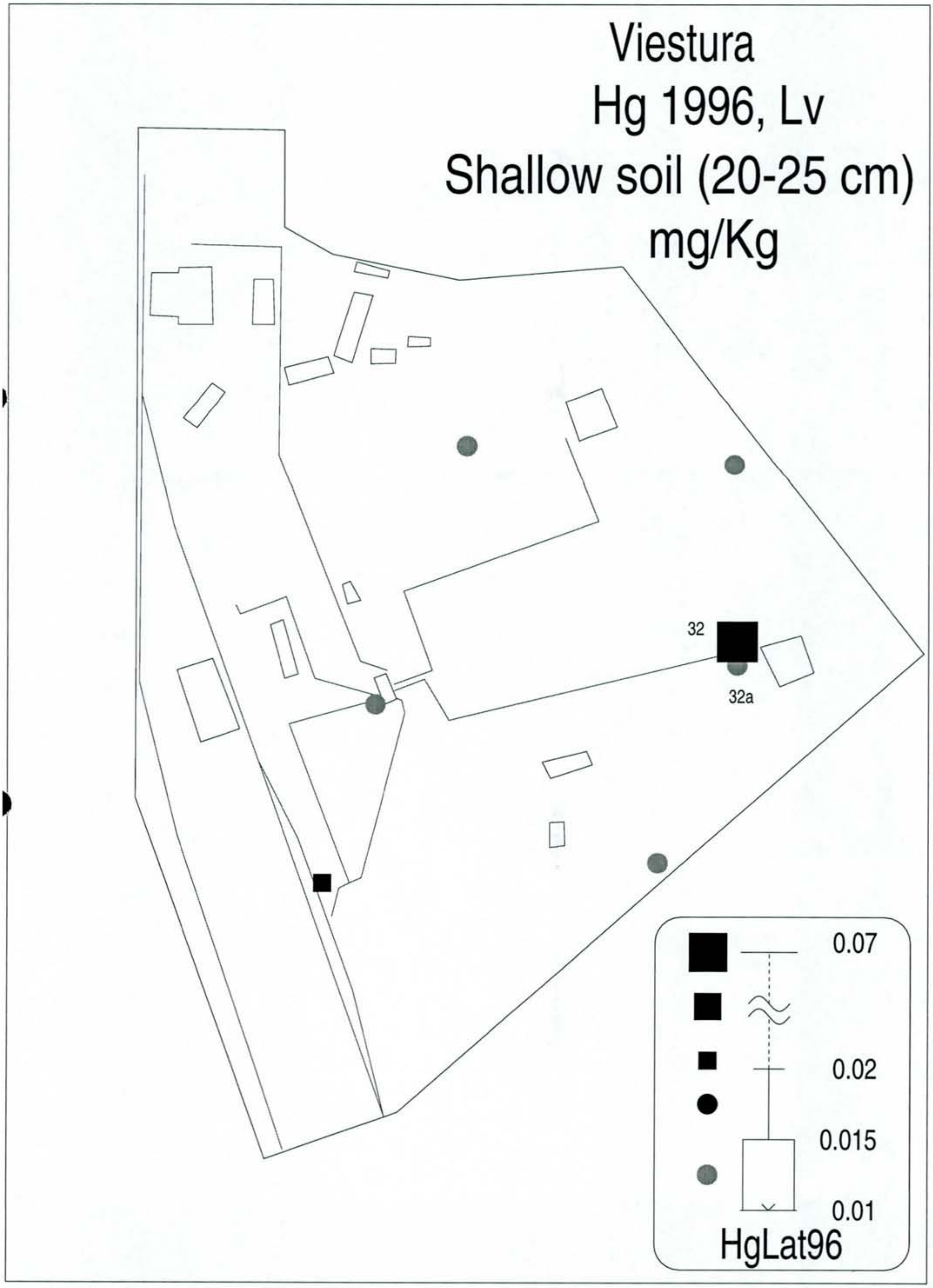
Well 222a
Viestura
Sr/Ca 1997 NGU
Groundwater
mg/mg
1
2
3
4
5
6
7a
7
8
9
10
11
12
14
15
0.00297004
0.0020096
0.00142171
0.00124313
0.000987284
Sr/Ca

Appendix 8:

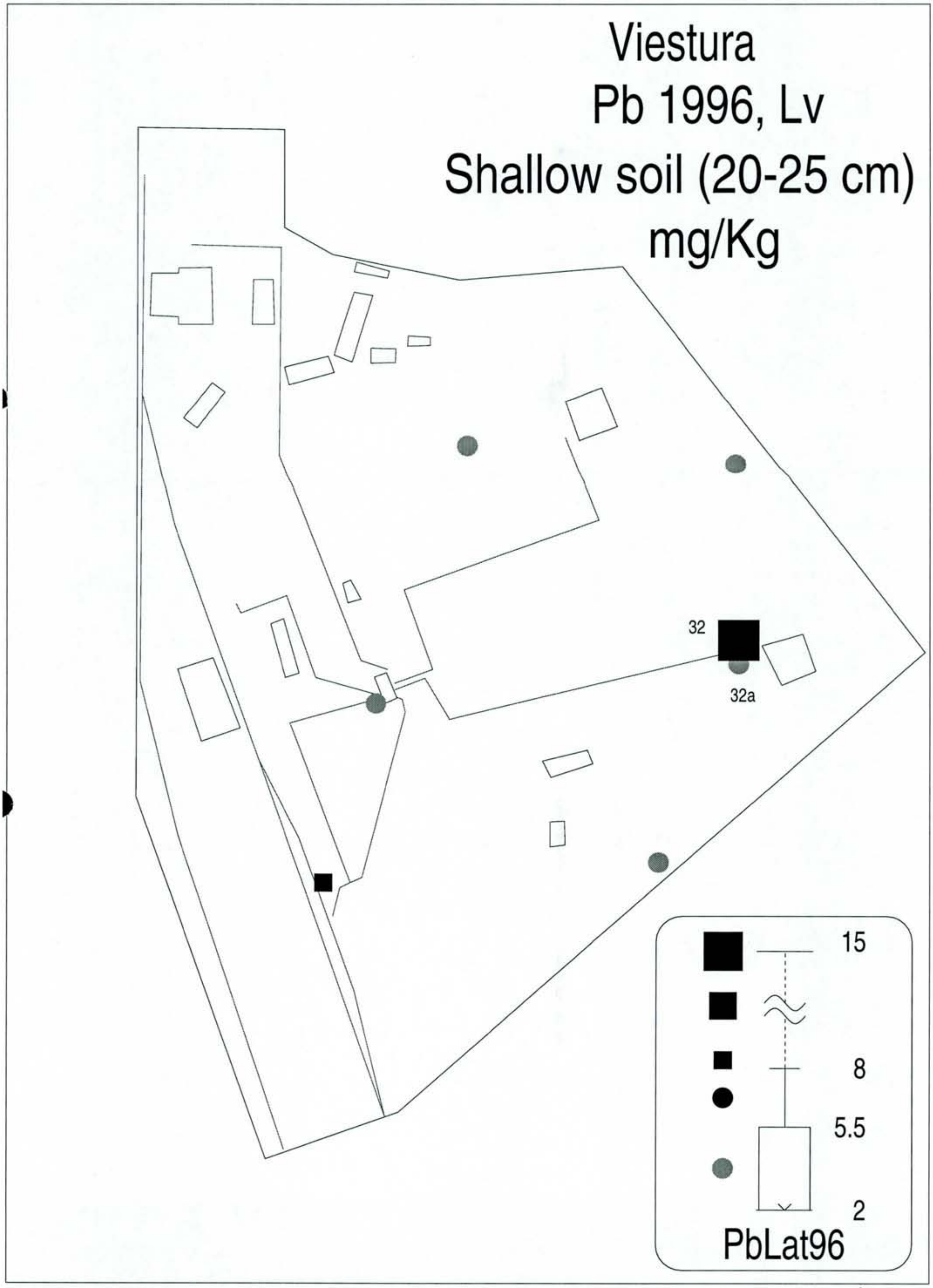
Maps of the Viestura Prospekts site showing concentrations of analysed parameters in soils.

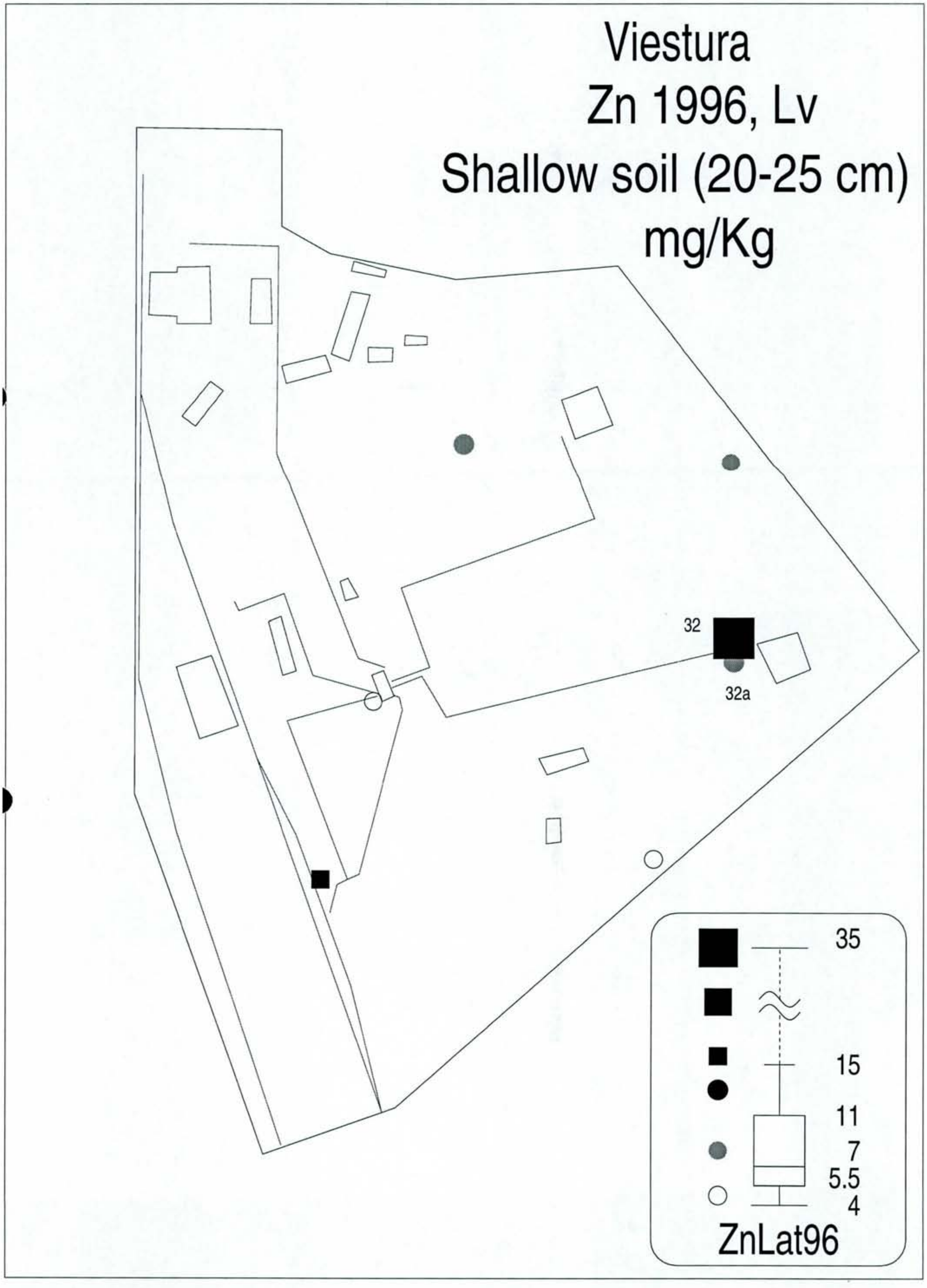

Viestura
Cd 1996, Lv
Shallow soil (20-25 cm)
mg/Kg
32
32a
0.13
0.05
0.03
0.025
0.02
CdLat96


Viestura
Cu 1996, Lv
Shallow soil (20-25 cm)
mg/Kg
32
32a
6
2
1
CuLat96



Viestura
Hg 1996, Lv
Shallow soil (20-25 cm)
mg/Kg
32
32a
0.07
0.02
0.015
0.01
HgLat96


Viestura
Pb 1996, Lv
Shallow soil (20-25 cm)
mg/Kg
32
32a
15
8
5.5
2
PbLat96



Viestura
Zn 1996, Lv
Shallow soil (20-25 cm)
mg/Kg
32
32a
35
15
11
7
5.5
4
ZnLat96

Appendix 9:

Results and interpretation of slug tests performed at Viestura Prospekts

Data from A. Misund and D. Banks collected during fieldwork in Riga, Sept. - Oct. 1996.

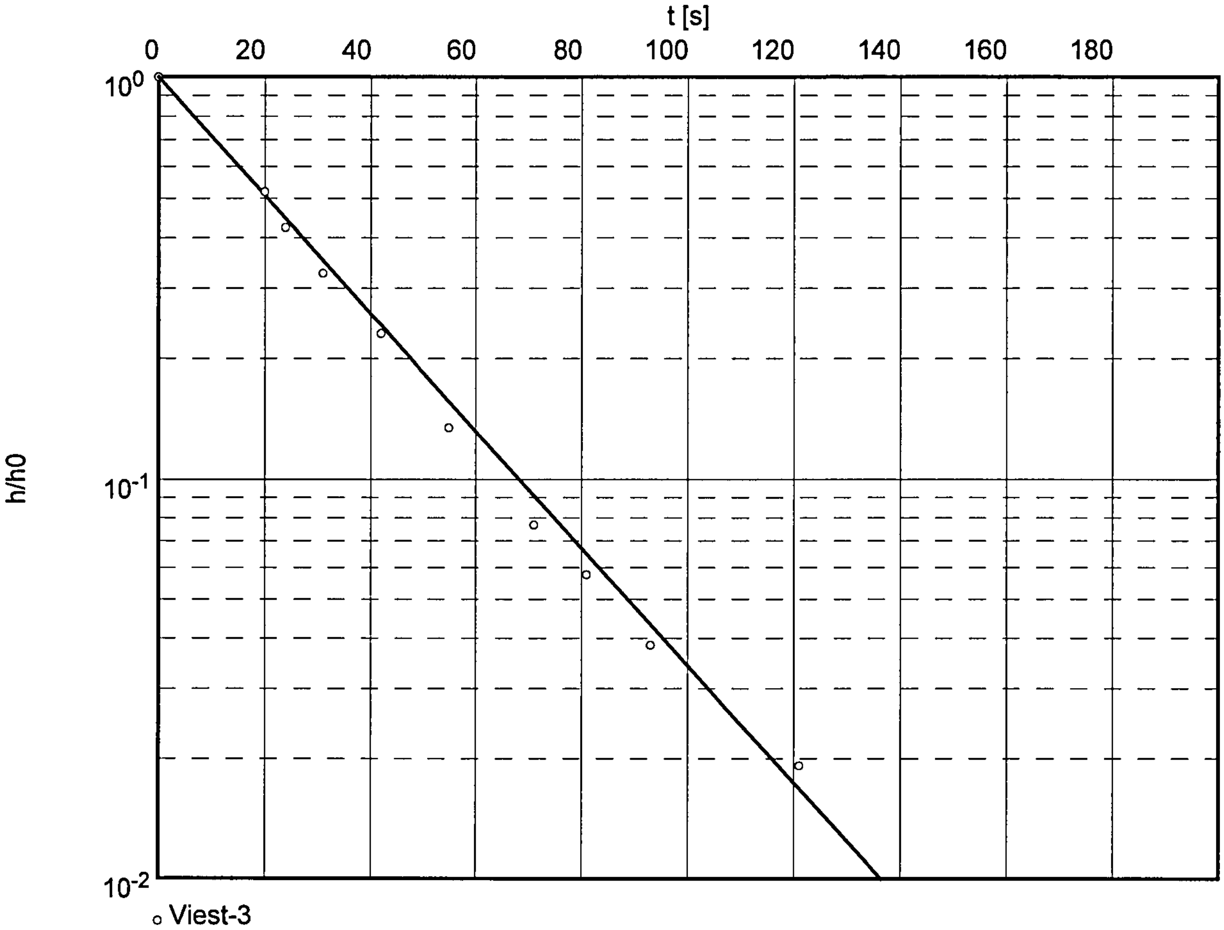
SLUGTESTS

Withdrawal of 5 - 6 bailers, each containing approx. 650 ml. Time in seconds after withdrawal of 5 - 6 bailers. Level in meters from welltop.

Well	**3**		**4**		**6**		**8**		**10**	
	Time	Level	Time	Level	Time	Level	Time	Level	Time	Level
Before test		4.28		3.56		4.13		3.90		3.52
	20	4.55	17	3.75	30	4.17	30	3.91	30	3.57
	24	4.50	23	3.70	60	4.15	90	3.90	60	3.56
	31	4.45	31	3.65	120	4.14			70	3.55
	42	4.40	40	3.62	300	4.13			80	3.54
	55	4.35	47	3.60					120	3.53
	71	4.32	54	3.59						
	81	4.31	63	3.58						
	93	4.30	78	3.57						
	121	4.29								

NGU Postboks 3006 Lade N 7002 TRONDHEIM Norway Tel: +47-73904011	slug/bail test analysis BOUWER-RICE's method	Diam = 2", Screen = 1 m, Page 1 Project: Viestura Prospekts Evaluated by: DB/A Date: 28.02.1997

Pumping Test No. Slug test	Test conducted on: Sept./Oct. 1996
Borehole 3	



Hydraulic conductivity [m/s]: 2.86×10^{-5}

NGU
Postboks 3006 Lade
N 7002 TRONDHEIM Norway
Tel: +47-73904011

slug/bail test analysis
BOUWER-RICE's method

Diam = 2", Screen = 1 m, Page 2

Project: Viestura Prospekts

Evaluated by: DB/A Date: 28.02.1997

Pumping Test No. Slug test

Test conducted on: Sept./Oct. 1996

Borehole 3

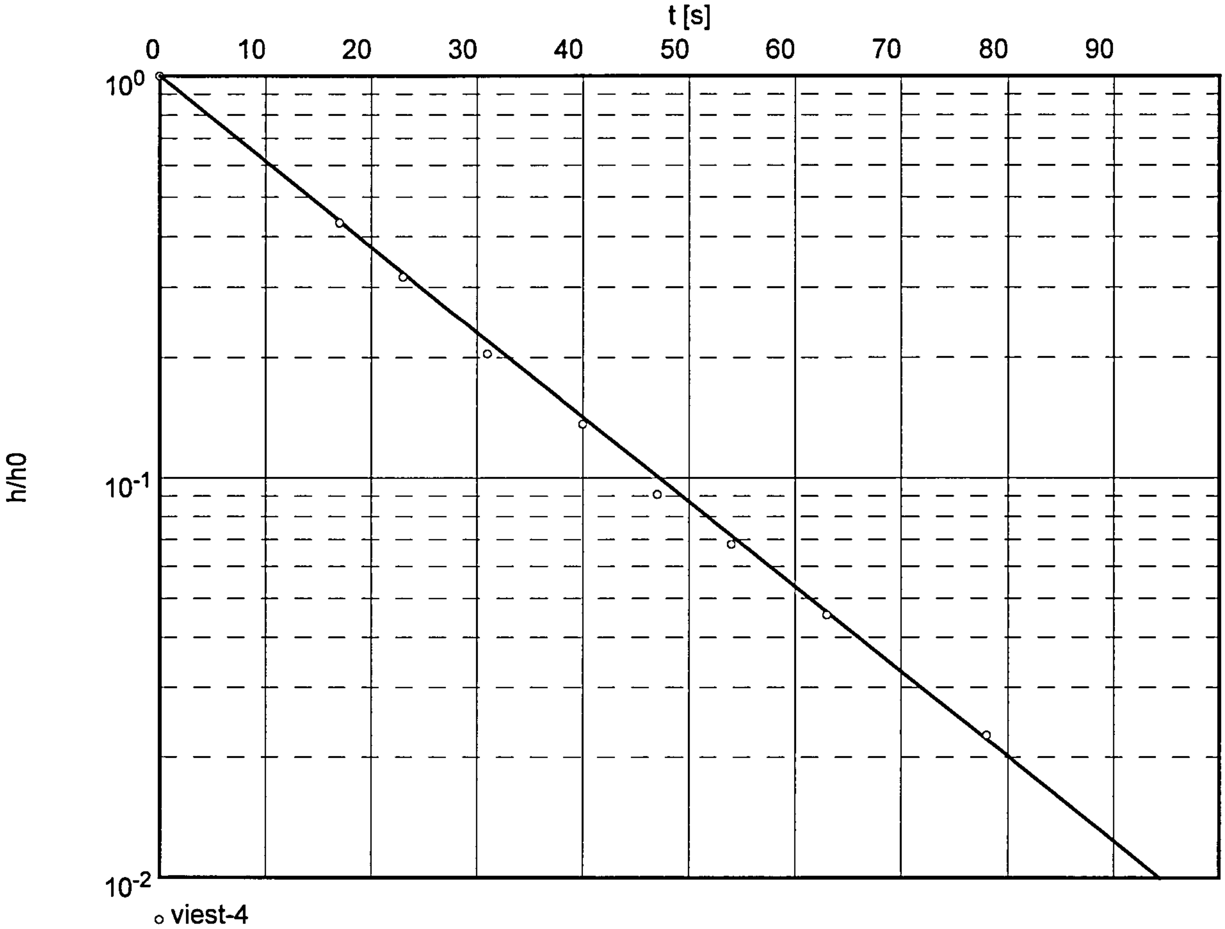
Viest-3

Static water level: 4.280 m below datum

	Pumping test duration [s]	Water level [m]	Drawdown [m]	
1	0	4.800	0.520	
2	20	4.550	0.270	
3	24	4.500	0.220	
4	31	4.450	0.170	
5	42	4.400	0.120	
6	55	4.350	0.070	
7	71	4.320	0.040	
8	81	4.310	0.030	
9	93	4.300	0.020	
10	121	4.290	0.010	

NGU Postboks 3006 Lade N 7002 TRONDHEIM Norway Tel: +47-73904011	slug/bail test analysis BOUWER-RICE's method	Diam. = 2", Screen = 1 m, Page 1 Project: Viestura Prospekts Evaluated by: AM/I Date: 28.02.1997

Pumping Test No. Slug test	Test conducted on: Sept./Oct. 1996
Borehole 4	



Hydraulic conductivity [m/s]: 3.61×10^{-5}

NGU
Postboks 3006 Lade
N 7002 TRONDHEIM Norway
Tel: +47-73904011

slug/bail test analysis
BOUWER-RICE's method

Diam. = 2", Screen = 1 m, Page 2

Project: Viestura Prospekts

Evaluated by: AM/[Date: 28.02.1997

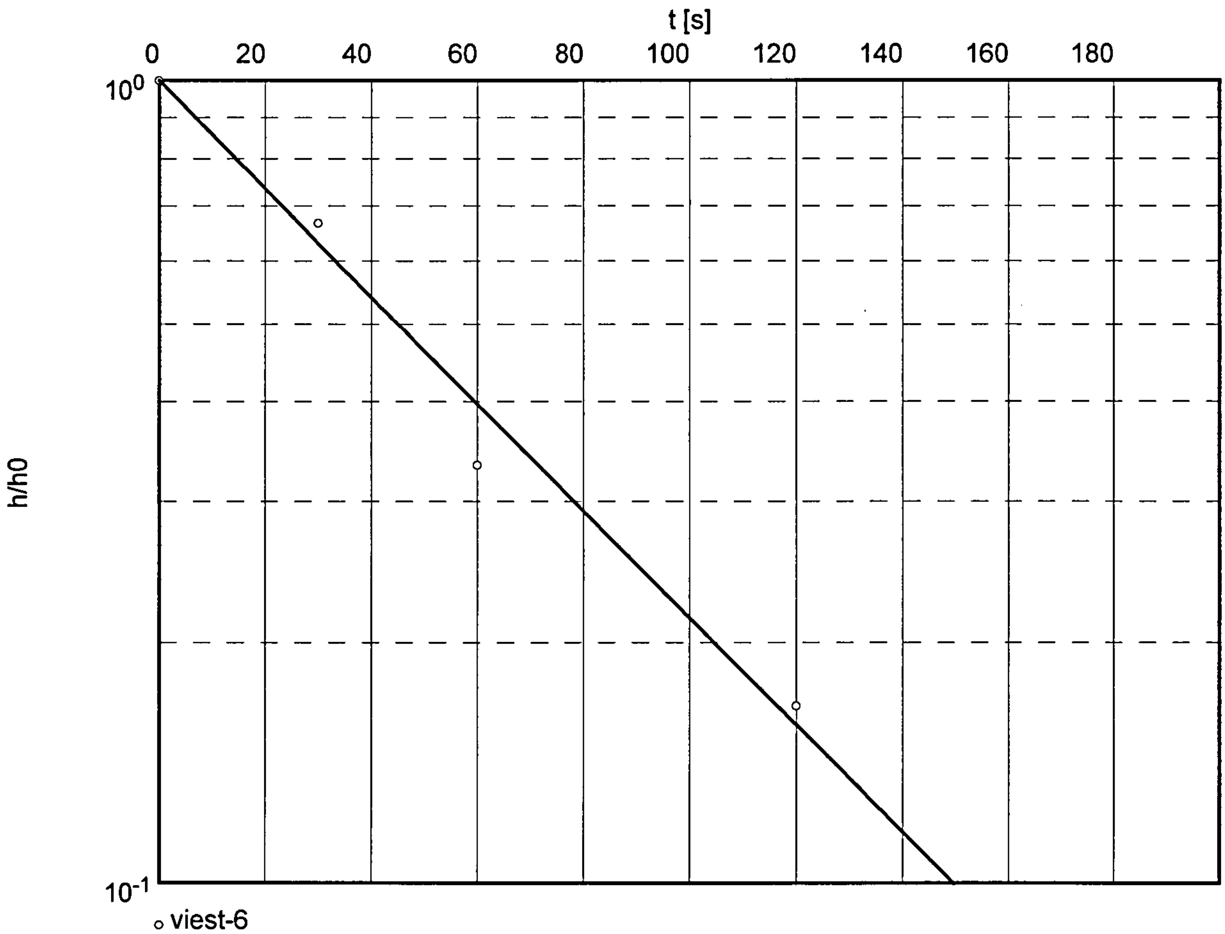
Pumping Test No. Slug test	Test conducted on: Sept./Oct. 1996
Borehole 4	viest-4

Static water level: 3.560 m below datum

	Pumping test duration [s]	Water level [m]	Drawdown [m]	
1	0	4.000	0.440	
2	17	3.750	0.190	
3	23	3.700	0.140	
4	31	3.650	0.090	
5	40	3.620	0.060	
6	47	3.600	0.040	
7	54	3.590	0.030	
8	63	3.580	0.020	
9	78	3.570	0.010	

NGU Postboks 3006 Lade N 7002 TRONDHEIM Norway Tel: +47-73904011	slug/bail test analysis BOUWER-RICE's method	Diam. = 2", Screen = 1 m, Page 1 Project: Viestura Prospekts Evaluated by: AM/I Date: 28.02.1997

Pumping Test No. Slug test	Test conducted on: Sept./Oct. 1996
Borehole 6	



Hydraulic conductivity [m/s]: 1.12×10^{-5}

NGU
Postboks 3006 Lade
N 7002 TRONDHEIM Norway
Tel: +47-73904011

slug/bail test analysis
BOUWER-RICE's method

Diam. = 2", Screen = 1 m, Page 2

Project: Viestura Prospekts

Evaluated by: AM/[Date: 28.02.1997

Pumping Test No. Slug test | Test conducted on: Sept./Oct. 1996

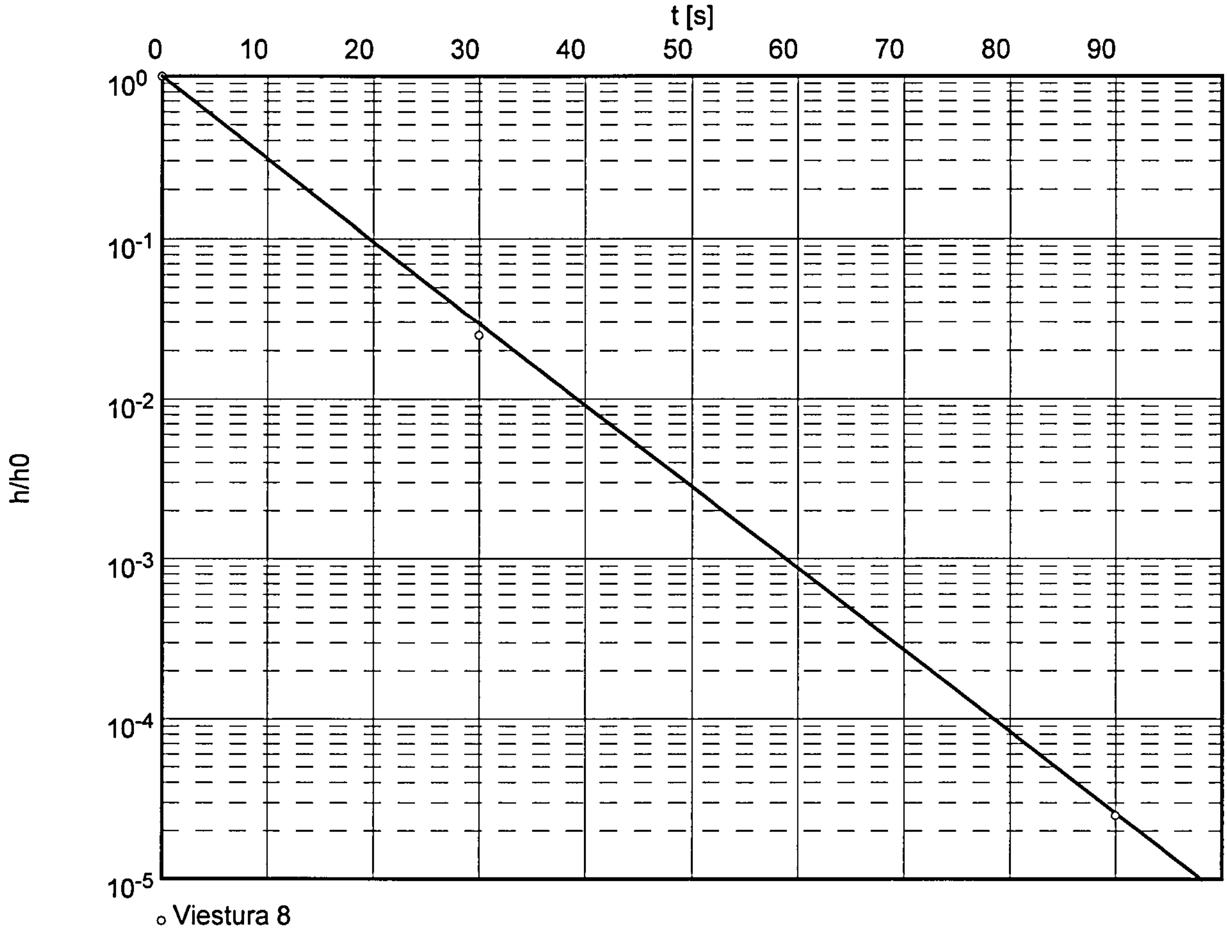
Borehole 6 | viest-6

Static water level: 4.130 m below datum

	Pumping test duration [s]	Water level [m]	Drawdown [m]	
1	0	4.190	0.060	
2	30	4.170	0.040	
3	60	4.150	0.020	
4	120	4.140	0.010	

NGU Postboks 3006 Lade N 7002 TRONDHEIM Norway Tel: +47-73904011	slug/bail test analysis BOUWER-RICE's method	Page 1 Project: Evaluated by: Date: 01.08.1997

Pumping Test No.	Test conducted on:



Hydraulic conductivity [m/s]: 9.29×10^{-5}

NGU
Postboks 3006 Lade
N 7002 TRONDHEIM Norway
Tel: +47-73904011

slug/bail test analysis
BOUWER-RICE's method

Project:

Evaluated by: | Date: 01.08.1997

Pumping Test No. | Test conducted on:

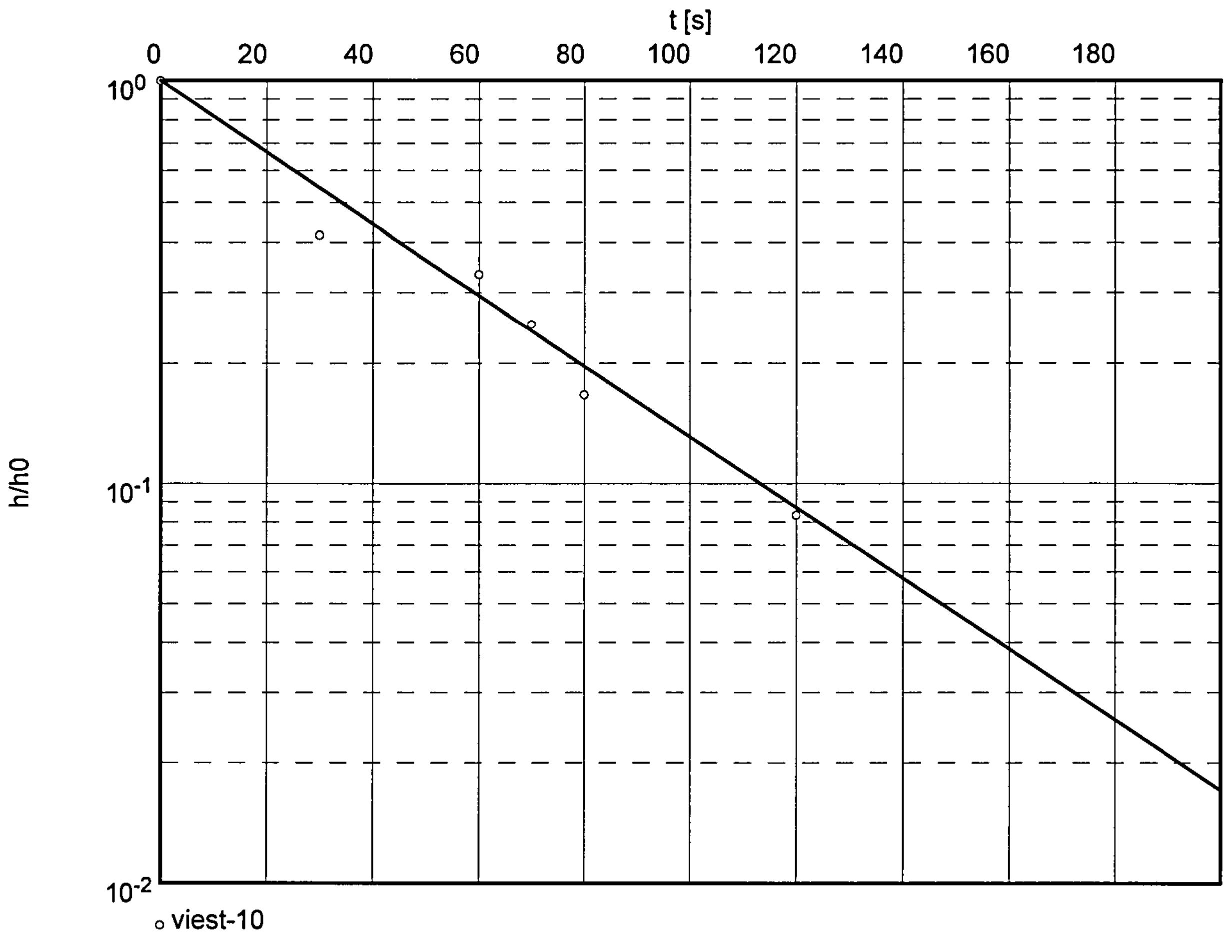
Viestura 8

Static water level: 3.900 m below datum

	Pumping test duration [s]	Water level [m]	Drawdown [m]	
1	0	3.500	-0.400	
2	30	3.910	0.010	
3	90	3.900	0.000	

NGU Postboks 3006 Lade N 7002 TRONDHEIM Norway Tel: +47-73904011	slug/bail test analysis BOUWER-RICE's method	Diam = 2", Screen = 1 m, Page 1 Project: Viestura Prospekts Evaluated by: AM/[Date: 28.02.1997

Pumping Test No. Slug test	Test conducted on: Sept./Oct. 1996
Bore 10	



Hydraulic conductivity [m/s]: 1.90×10^{-5}

NGU Postboks 3006 Lade N 7002 TRONDHEIM Norway Tel: +47-73904011	slug/bail test analysis BOUWER-RICE's method	Diam = 2", Screen = 1 m, Page 2 Project: Viestura Prospekts Evaluated by: AM/[Date: 28.02.1997

Pumping Test No. Slug test	Test conducted on: Sept./Oct. 1996
Bore 10	viest-10

Static water level: 3.520 m below datum

	Pumping test duration [s]	Water level [m]	Drawdown [m]	
1	0	3.640	0.120	
2	30	3.570	0.050	
3	60	3.560	0.040	
4	70	3.550	0.030	
5	80	3.540	0.020	
6	120	3.530	0.010	

Appendix 10:

Interpretation of grain-size analyses at Viestura Prospekts

011-96

NORGES GEOLOGISKE UNDERSØKELSE
SEDIMENTLABORATORIET

PRØVEJOURNAL

1996.0240

2699.00 / . . .

BELAST KONTO NR (DRIFTSREGNSKAP)

ANT. PRØVER I SERIEN: [ ] SIDE: [ ] ANT. SIDER I SERIEN: [ ]

ANFØRTE PRØVER SKAL: ANALYSERES: [ ] FOREL. LAGRES [ ] BRUK BLYANT!

(ANALYSE-OG LAGRINGSPRØVER MÅ IKKE BLANDES I SAMME SKJEMASERIE)

KART NR. (M 711): XXX

KARTBLAD NAVN: XXX

KOMM. NR.:

INNLEVERT AV: DAVID BANKS

PROBLEMSTILLING/SPES.KRAV TIL ANAL.METODE:

FYLLES UT AV INNSENDER

FYLLES NORMALT UT AV LABORATORIET MED MINDRE INNSENDERS PROBLEMSTILLING KREVER SPESIELLE ANALYSEMETODER.

ANALYSER: SKAL UTFØRES: X ER UTFØRT: O

PRØVEMRK I FELT	UTM-KOORDINATER	DYP (cm)	AVSETNINGSTYPE	KASSE/SEKK NR.		JOURNAL NR. (for lab.)	A TØRRSIKTING	B VÅTSIKTING	C HYDROMETER	PIPETTE	HUMUS-SLAM	OXALSYREV.	STORPRØVE						M UTTAK GEOKJEMI	N FRAKSJ. PAKKES SEPARAT
LvS1 = Viestura prospekt, Soil sample 31					3	960489		⊗												
LvS2 = Valmieras, borehole 3 @ 5.5 m					4	960490		⊗												
LvS3 = Valmieras, borehole 4 @ 3.1 m					5	960491		⊗												
					6															
					7															
					8															
					9															
					10															
					11															
					12															
					13															
					14															
					15															

STEMPLINGSHAL:

NGU 158-07 79

FOR LAB: SIKTING: NORMAL SATS [ ] SPESIELL SATS [ ]

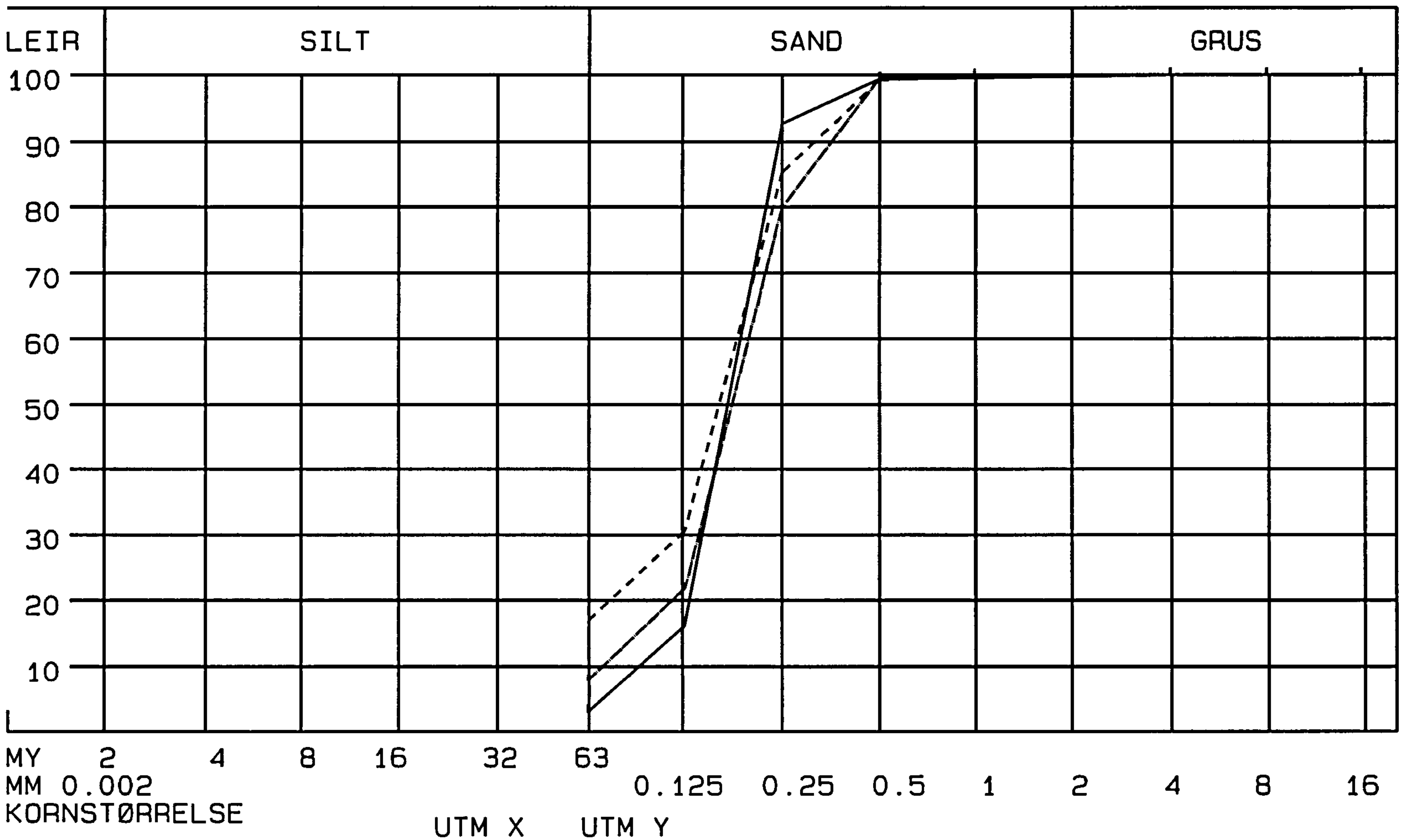
REGISTRERT: ______ DATO ______ SIGN.

PUNCHET: 1/11-96 DATO A.N. SIGN.

NORGES GEOLOGISKE UNDERSØKELSE
SEDIMENTLABORATORIET

KORNFORDELINGSKURVE

XXX XXX



		UTM X	UTM Y
————————	960489	0	0
- - - - - - - - - -	960490	0	0
— — — — — —	960491	0	0

NGU
SEDIMENTLABORATORIET.

P R Ø V E J O U R N A L.

KARTBLADNR M711	: XXX	KONTONR DRIFTSREGNSKAP	: 2699.00
KARTBLADNAVN	: XXX	SERIENUMMER	: 011-96
KOMMUNENR	:	SERIEINTERVALL	: 960489-960491
INNLEVERT AV	: David Banks		

UTM-KOORDINATER		DYP	AVSETNINGSTYPE	JOURNALNR	A	B	C	D	E	F	G	H	I	J	K	L	M	N
0	0	0		960489		B												
0	0	0		960490		B												
0	0	0		960491		B												
			ANTALL PRØVER :	3														

KORNFORDELINGSANALYSE

JOURNALNR:960489 STED: XXX KARTBLADNR: XXX KOORD: 0 0

DYP: 0 CM TYPE:

TOTALVEKT AV MAT.: 117.5 GR
19.00 MM: .0 GR, SOM ER .00 % AV TOTALVEKT

NETTOVEKT 117.5 GR
SVINN: .0 GR, SOM ER .00 % AV NETTOVEKT

BENYTTET VEKT: 117.5 GR

SIKTING

VEKT I GR.	KORNST. I MM	KORNST. I PHI	FREKV. %	KUMULATIV %
.0	16.0000	-4.00	.00	100.00
.0	8.0000	-3.00	.00	100.00
.0	4.0000	-2.00	.00	100.00
.2	2.0000	-1.00	.17	99.83
.2	1.0000	.00	.17	99.66
.3	.5000	1.00	.26	99.40
7.9	.2500	2.00	6.72	92.68
90.1	.1250	3.00	76.68	16.00
15.2	.0625	4.00	12.94	3.06
3.6	< .0625	> 4.00	3.06	.00

CALCULATED GRAIN-DIAMETERS FOR 9 CONSTANT ORDINATES:

	MD	5%	10%	16%	25%	75%	84%	90%	95%
MM :	.1700	.0693	.0906	.1250	.1356	.2131	.2311	.2440	.3175
PHI:	2.56	3.85	3.46	3.00	2.88	2.23	2.11	2.03	1.66

SEDIMENTOLOGICAL PARAMETERS:

TRASK 1932:		SO(SQRT Q75/25)= 1.25	SK(Q75,Q25,MD) = 1.00	KT(P75,25,90,10)= .25
SELMER-OLSEN 1954:		SO(LOG Q75/Q25)= .20	SK(LOG SK(TRASK)) = .00	
INMAN 1952:	M(1/2(084+16))= 2.56	SO(1/2(084-16))= .44	SK(084,016,SO) = .00	KT(084,16,95,5) = 1.48
			SK(095,05,MD,SO) = .44	M - MD = .00
FOLK & WARD 1957:	MZ(016,50,84) = 2.56	SO(-16,84,5,95)= .55	SK(05,16,50,84,95)= .09	KG(05,95,25,75) = 1.38
MOMENT :	M0 = 2.61	SD0 = .60	SK0 = .04	KT0 = 5.98

MAIN FRACTIONS % :

CLAY(<2MI): .00 SILT(2-62.5MI): .00 SAND(62.5MI-2MM): 96.77 GRAVEL(2-19.0MM): .17
PELITE(<62.5MI): 3.06
CLAY(<4MI): .00 SILT(4-62.5MI): .00

960489

```
 FREQUENCY :
     .00   .00   .00   .00   .00   .00   .00 12.94 76.68 6.72  .26   .17   .17   .00   .00   .00
77%                                               I*****I
73%                                               I*****I
69%                                               I*****I
65%                                               I*****I
61%                                               I*****I
57%                                               I*****I
53%                                               I*****I
49%                                               I*****I
45%                                               I*****I
41%                                               I*****I
37%                                               I*****I
33%                                               I*****I
29%                                               I*****I
25%                                               I*****I
21%                                               I*****I
17%                                               I*****I
13%                                         I*****I*****I
 9%                                         I*****I*****I
 5%                                         I*****I*****I*****I
 1%                                         I*****I*****I*****I
 0%*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I
      10     9     8     7     6     5     4     3     2     1     0    -1    -2    -3    -4    -5
       .001  .002  .004  .008  .016  .032 .0625  .125  .25   .5    1.    2.    4.    8.   16.   32.
GRAIN SIZE(MM);
```

KORNFORDELINGSANALYSE

JOURNALNR:960490 STED: XXX KARTBLADNR: XXX KOORD: 0 0

DYP: 0 CM TYPE:

TOTALVEKT AV MAT.: 110.5 GR
19.00 MM: .0 GR, SOM ER .00 % AV TOTALVEKT

NETTOVEKT 110.5 GR
SVINN: .0 GR, SOM ER .00 % AV NETTOVEKT

BENYTTET VEKT: 110.5 GR

SIKTING

VEKT I GR.	KORNST. I MM	KORNST. I PHI	FREKV. %	KUMULATIV %
.0	16.0000	-4.00	.00	100.00
.0	8.0000	-3.00	.00	100.00
.0	4.0000	-2.00	.00	100.00
.0	2.0000	-1.00	.00	100.00
.1	1.0000	.00	.09	99.91
.8	.5000	1.00	.72	99.19
15.4	.2500	2.00	13.94	85.25
60.5	.1250	3.00	54.75	30.50
15.0	.0625	4.00	13.57	16.92
18.7	< .0625	> 4.00	16.92	-.00

CALCULATED GRAIN-DIAMETERS FOR 9 CONSTANT ORDINATES:
MM : MD = .1600 5%: .0340 10%: .0439 16%: .0596 25%: .0944 75%: .2196 84%: .2461 90%: .3166 95%: .4060
PHI: MD = 2.64 5%: 4.88 10%: 4.51 16%: 4.07 25%: 3.40 75%: 2.19 84%: 2.02 90%: 1.66 95%: 1.30

SEDIMENTOLOGICAL PARAMETERS:

TRASK	1932:		SO(SQRT Q75/25)= 1.53	SK(Q75,Q25,MD) = .81	KT(P75,25,90,10)= .23
SELMER-OLSEN	1954:		SO(LOG Q75/Q25)= .37	SK(LOG SK(TRASK)) = -.05	
INMAN	1952:	M(1/2(084+16))= 3.05	SO(1/2(084-16))= 1.02	SK(084,016,SO) = .39	KT(084,16,95,5) = .75
				SK(095,05,MD,SO) = .44	M - MD = .40
FOLK & WARD	1957:	MZ(016,50,84) = 2.91	SO(-16,84,5,95)= 1.05	SK(05,16,50,84,95)= .32	KG(05,95,25,75) = 1.20
MOMENT	:	M0 = 2.82	SD0 = .94	SK0 = .23	KT0 = 10.42

MAIN FRACTIONS % :

CLAY(<2MI): .00 SILT(2-62.5MI): .00 SAND(62.5MI-2MM): 83.08 GRAVEL(2-19.0MM): .00
PELITE(<62.5MI): 16.92
CLAY(<4MI): .00 SILT(4-62.5MI): .00

960490

```
  FREQUENCY :
     .00   .00   .00   .00   .00   .00   .00 13.57 54.75 13.94  .72   .09   .00   .00   .00   .00
55%                                               I*****I
52%                                               I*****I
49%                                               I*****I
46%                                               I*****I
43%                                               I*****I
40%                                               I*****I
37%                                               I*****I
34%                                               I*****I
31%                                               I*****I
28%                                               I*****I
25%                                               I*****I
22%                                               I*****I
19%                                               I*****I
16%                                               I*****I
13%                                         I*****I*****I*****I
10%                                         I*****I*****I*****I
 7%                                         I*****I*****I*****I
 4%                                         I*****I*****I*****I
 1%                                         I*****I*****I*****I*****I
 0%*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I
      10     9     8     7     6     5     4     3     2     1     0    -1    -2    -3    -4    -5
      .001  .002  .004  .008  .016  .032 .0625  .125  .25    .5    1.    2.    4.    8.   16.   32.
GRAIN SIZE(MM);
```

KORNFORDELINGSANALYSE

JOURNALNR:960491 STED: XXX KARTBLADNR: XXX KOORD: 0 0

DYP: 0 CM TYPE:

TOTALVEKT AV MAT.: 99.4 GR
19.00 MM: .0 GR, SOM ER .00 % AV TOTALVEKT

NETTOVEKT 99.4 GR
SVINN: .0 GR, SOM ER .00 % AV NETTOVEKT

BENYTTET VEKT: 99.4 GR

SIKTING

VEKT I GR.	KORNST. I MM	KORNST. I PHI	FREKV. %	KUMULATIV %
.0	16.0000	-4.00	.00	100.00
.0	8.0000	-3.00	.00	100.00
.0	4.0000	-2.00	.00	100.00
.0	2.0000	-1.00	.00	100.00
.1	1.0000	.00	.10	99.90
.4	.5000	1.00	.40	99.50
19.3	.2500	2.00	19.42	80.08
58.1	.1250	3.00	58.45	21.63
13.7	.0625	4.00	13.78	7.85
7.8	< .0625	> 4.00	7.85	-.00

CALCULATED GRAIN-DIAMETERS FOR 9 CONSTANT ORDINATES:
MM : MD = .1750 5%: .0542 10%: .0696 16%: .0942 25%: .1301 75%: .2354 84%: .2875 90%: .3562 95%: .4258
PHI: MD = 2.51 5%: 4.21 10%: 3.84 16%: 3.41 25%: 2.94 75%: 2.09 84%: 1.80 90%: 1.49 95%: 1.23

SEDIMENTOLOGICAL PARAMETERS:

TRASK 1932:		SO(SQRT Q75/25)= 1.35	SK(Q75,Q25,MD) = 1.00	KT(P75,25,90,10)= .18
SELMER-OLSEN 1954:		SO(LOG Q75/Q25)= .26	SK(LOG SK(TRASK)) = .00	
INMAN 1952:	M(1/2(084+16))= 2.60	SO(1/2(084-16))= .81	SK(084,016,SO) = .11	KT(084,16,95,5) = .85
			SK(095,05,MD,SO) = .25	M - MD = .09
FOLK & WARD 1957:	MZ(016,50,84) = 2.57	SO(-16,84,5,95)= .85	SK(05,16,50,84,95)= .12	KG(05,95,25,75) = 1.43
MOMENT :	MO = 2.59	SDO = .81	SKO = .31	KTO = .47

MAIN FRACTIONS % :

CLAY(<2MI): .00 SILT(2-62.5MI): .00 SAND(62.5MI-2MM): 92.15 GRAVEL(2-19.0MM): .00
PELITE(<62.5MI): 7.85
CLAY(<4MI): .00 SILT(4-62.5MI): .00

960491

```
 FREQUENCY :
     .00   .00   .00   .00   .00   .00   .00 13.78 58.45 19.42   .40   .10   .00   .00   .00   .00
59%
56%                                              I*****I
53%                                              I*****I
50%                                              I*****I
47%                                              I*****I
44%                                              I*****I
41%                                              I*****I
38%                                              I*****I
35%                                              I*****I
32%                                              I*****I
29%                                              I*****I
26%                                              I*****I
23%                                              I*****I
20%                                              I*****I
17%                                              I*****I*****I
14%                                        I*****I*****I*****I
11%                                        I*****I*****I*****I
 8%                                        I*****I*****I*****I
 5%                                        I*****I*****I*****I
 2%                                        I*****I*****I*****I
0%*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I*****I
      10     9     8     7     6     5     4     3     2     1     0    -1    -2    -3    -4    -5
       .001  .002  .004  .008  .016  .032  .0625 .125  .25   .5   1.    2.    4.    8.    16.   32.
GRAIN SIZE(MM);
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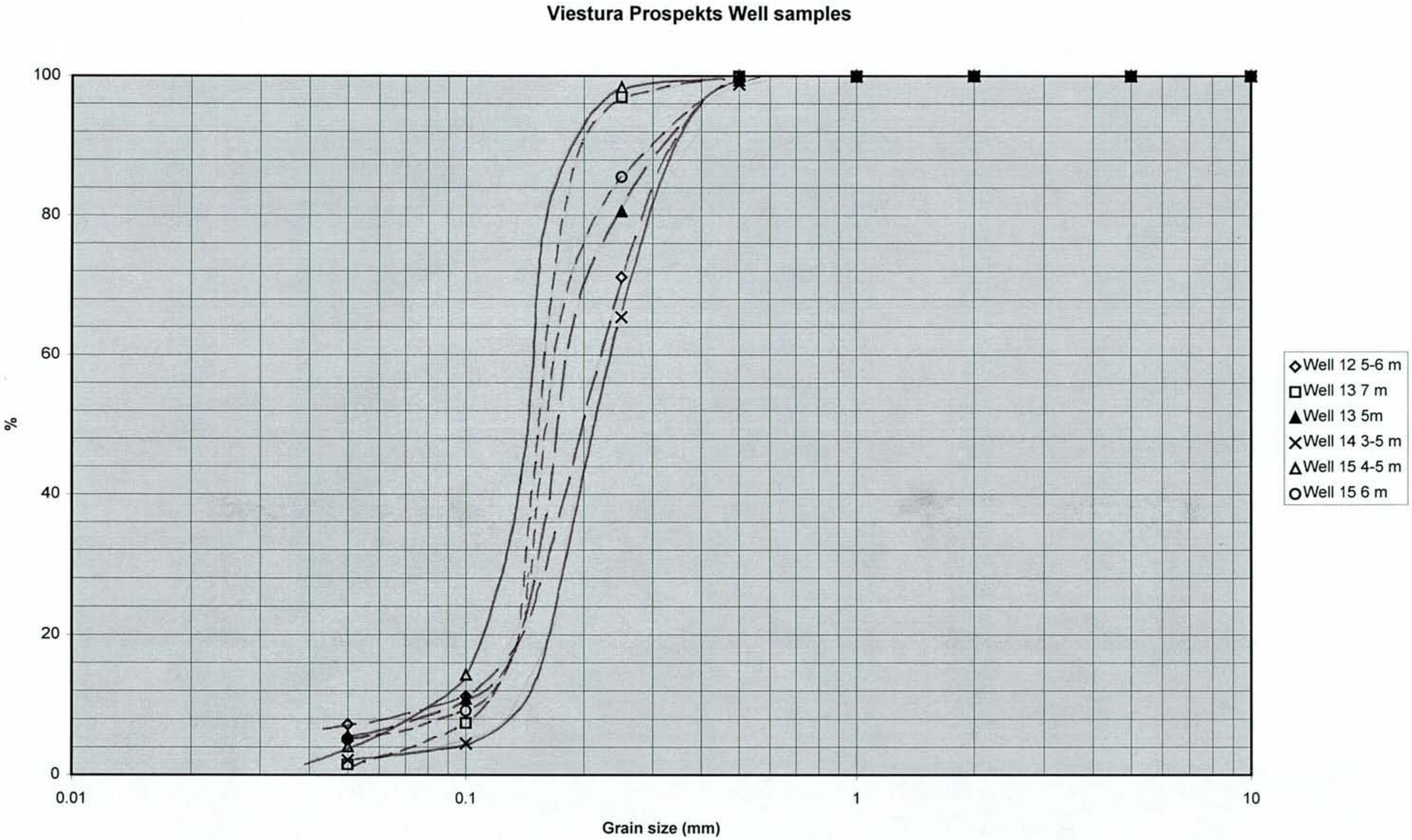
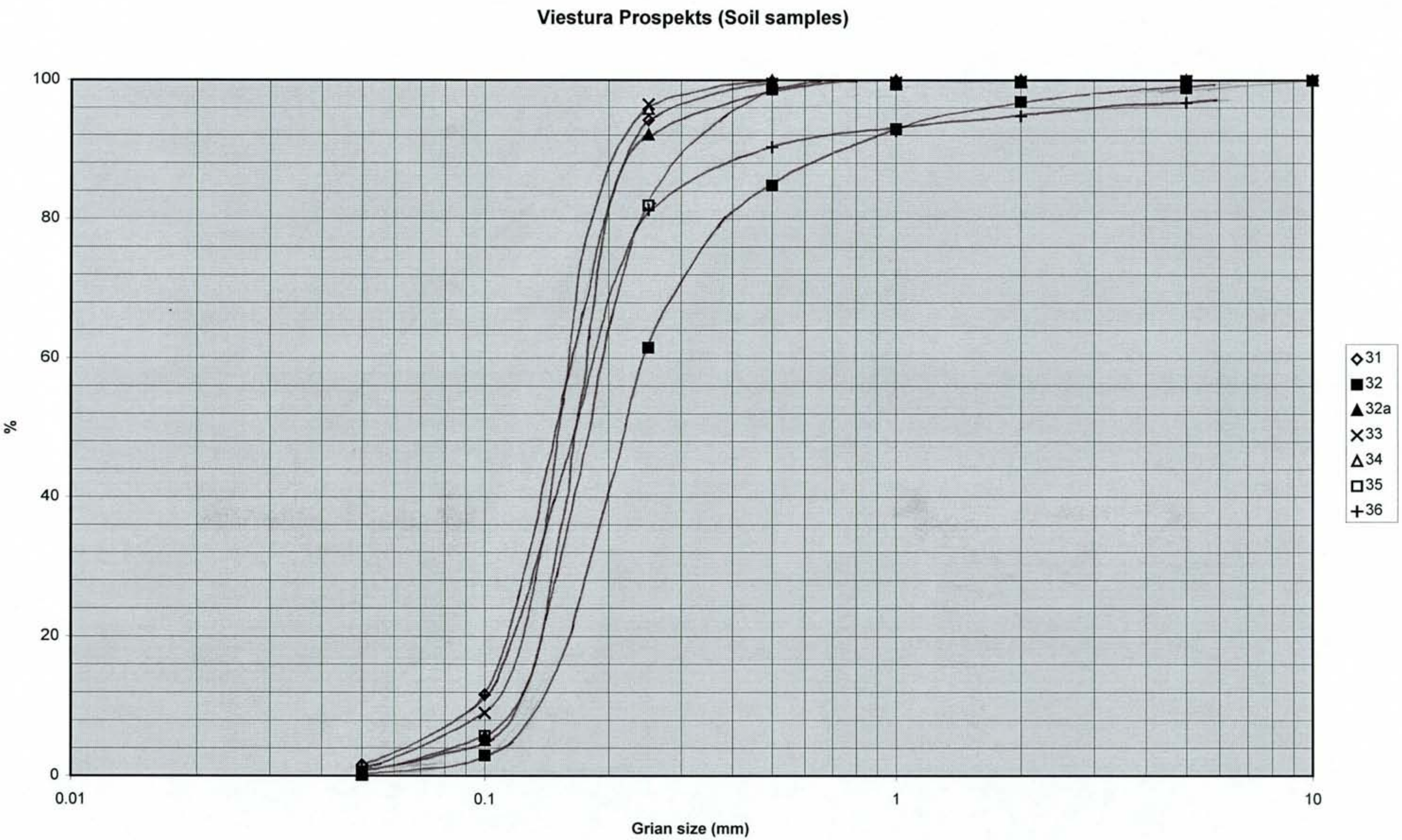

Viestura Prospekts Well samples
100
80
60
40
20
0
%
0.01
0.1
1
10
Grain size (mm)
Well 12 5-6 m
Well 13 7 m
Well 13 5m
Well 14 3-5 m
Well 15 4-5 m
Well 15 6 m

Ark1 Diagram 3



Appendix 11:

Paper presented at NATO Workshop, Vilnius, Oct. 1997 (Banks et al. 1997).

HOW TO MAP HYDROCARBON CONTAMINATION OF GROUNDWATER WITHOUT ANALYSING FOR ORGANICS

A Study of Oil Contamination of Soil and Groundwater at Viestura Prospekts Former Military Fuel Storage Depot, Riga, Latvia.

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Abstract

The Geological Surveys of Latvia and Norway and the Norwegian Defence Research Establishment have undertaken a risk-based investigation and assessment of a former Soviet military oil depot at Viestura Prospekts, Riga, using the firms Dames & Moore (U.K.) and Geo-Konsultants as subcontractors.

The site lies on homogeneous fine-medium grained Baltic Ice Lake sands containing a shallow unconfined water table. Georadar, calibrated against monitoring boreholes, has been used to map the north-westward gradient of the water table.

16 monitoring boreholes have been employed to assess groundwater contamination. Free phase oil has been proven in boreholes near fuel storage bunkers and at the oil-transfer railhead.

Vertical electric sounding profiling (VES), a geophysical technique measuring the apparent resistivity of the sediments, has been employed at the site. VES showed two plumes of low resistivity leading away from the bunker area and the railhead in a NW direction. These may represent plumes of groundwater with high ionic content.

Oil degradation releases CO_2, which enhances weathering of carbonate and silicate mineral phases in the aquifer, releasing alkalinity and several cations and elevating the water's electrical conductivity (EC), explaining the VES map. Additionally, degradation consumes O_2 and other electron acceptors, promoting reducing conditions and releasing dissolved iron. Thus, a combination of high Fe, alkalinity, ion content, EC and low oxygen, sulphate and nitrate, may be used as low-cost inorganic indicators of hydrocarbon contamination.

1. Introduction

The Geological Survey of Norway (NGU), the Geological Survey of Latvia (GSL) and the Norwegian Defence Research Establishment (FFI) are currently carrying out a risk-based site investigation and assessment of a former Soviet military fuel storage depot at Viestura Prospekts, Riga, Latvia. The main partners in the project have also contracted out parts of the project to sub-consultants, namely; Dames and Moore (U.K.) who have carried out the risk assessment of the site, and Geo-Konsultants (Latvia) who have carried out the geophysical investigations. The project has been financed by the Ministry of Foreign Affairs in Norway and the Ministry of Environment in Latvia.

1.1. SITE LOCATION AND TOPOGRAPHY

The site is located on the eastern side of Viestura Prospekts in the Meza Parks area of northern Riga. The site has a total area of ca. 20.5 Ha. A small part of the north of the site is currently in use by a private fuel management firm for daily operations including vehicle refuelling and repair. The remainder of the area is used by the firm for oil off-loading (from rail), pumping and storage, but is fenced off and declared a customs zone.

The site has an elevation of between 5 and 12 m above sea level (a.s.l.). The terrain is hummocky. While some of these hummocks may be related to excavated materials during installation of the fuel bunkers, the terrain in the surrounding Meza Parks is similar, suggesting that most of the hummocks are natural. They may represent wind blown dunes in the sandy deposits of the Baltic Ice Lake, which constitute the underlying sediments. The topography is dominated by the two fuel storage bunker complexes in the east of the site. These consist of groups of steel tanks encased in concrete bunkers. Low bunds of natural materials have been constructed around the bunkers. Within the bunds the ground is natural (i.e. sandy). While the bunds may have been effective at hindering spreading of surficial oil contamination, they would not have been effective at preventing ground and groundwater contamination.

1.2. SITE HISTORY

The Viestura Prospekts site was in use from 1941 until 1992 as a fuel storage depot for the Soviet (later, Russian) Army (Figure 1). Estimates of the total volume of fuel storage at the site vary from 4,400 m^3 (GSL) to 13,200 m^3[1]. There exist a railhead, a road tanker loading bay and a pipeline to Riga port (following the course of Viestura Prospekts). It is believed that fuel arrived by rail and was distributed throughout the Soviet Union and Warsaw Pact lands by road and sea. At a similar, though larger and more strategically central, locality in Lithuania (Valciunai [2]), fuel also entered by rail. In the event of a critical situation, fuel could be freighted by road to a number of sub-depots and recipients.

Following the withdrawal of the Russian/Soviet Army in 1992, the site has been in use by a commercial fuel handling company who operate along the same lines as the Soviet Army, but on a much smaller scale. The site is bordered on the north and east by Meza Parks, one of Riga's main park areas.

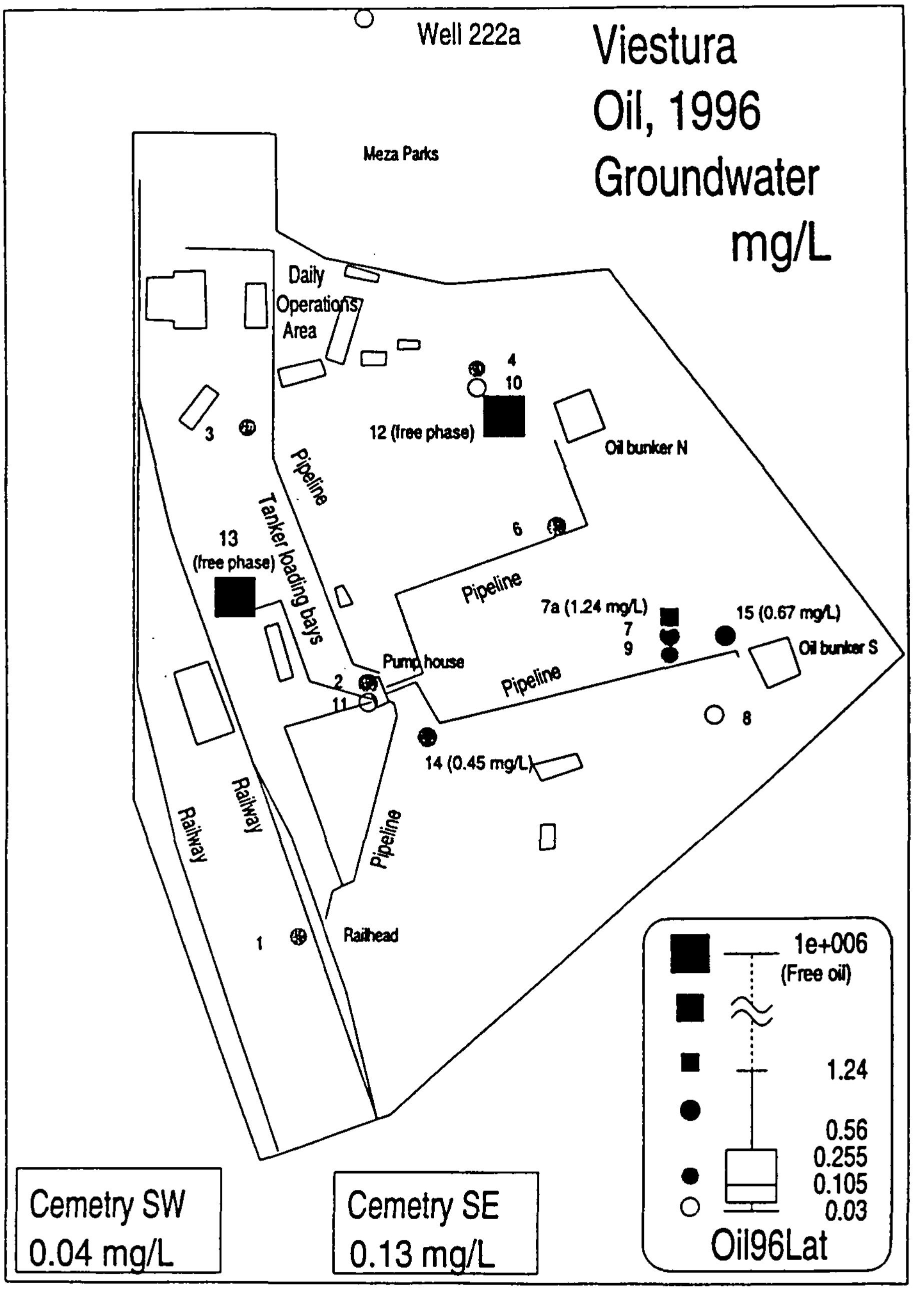


Figure 1. Map of the Viestura Prospekts site, showing concentrations of oil in groundwater (mg/L) in 1996. Numbers on the map are borehole numbers.

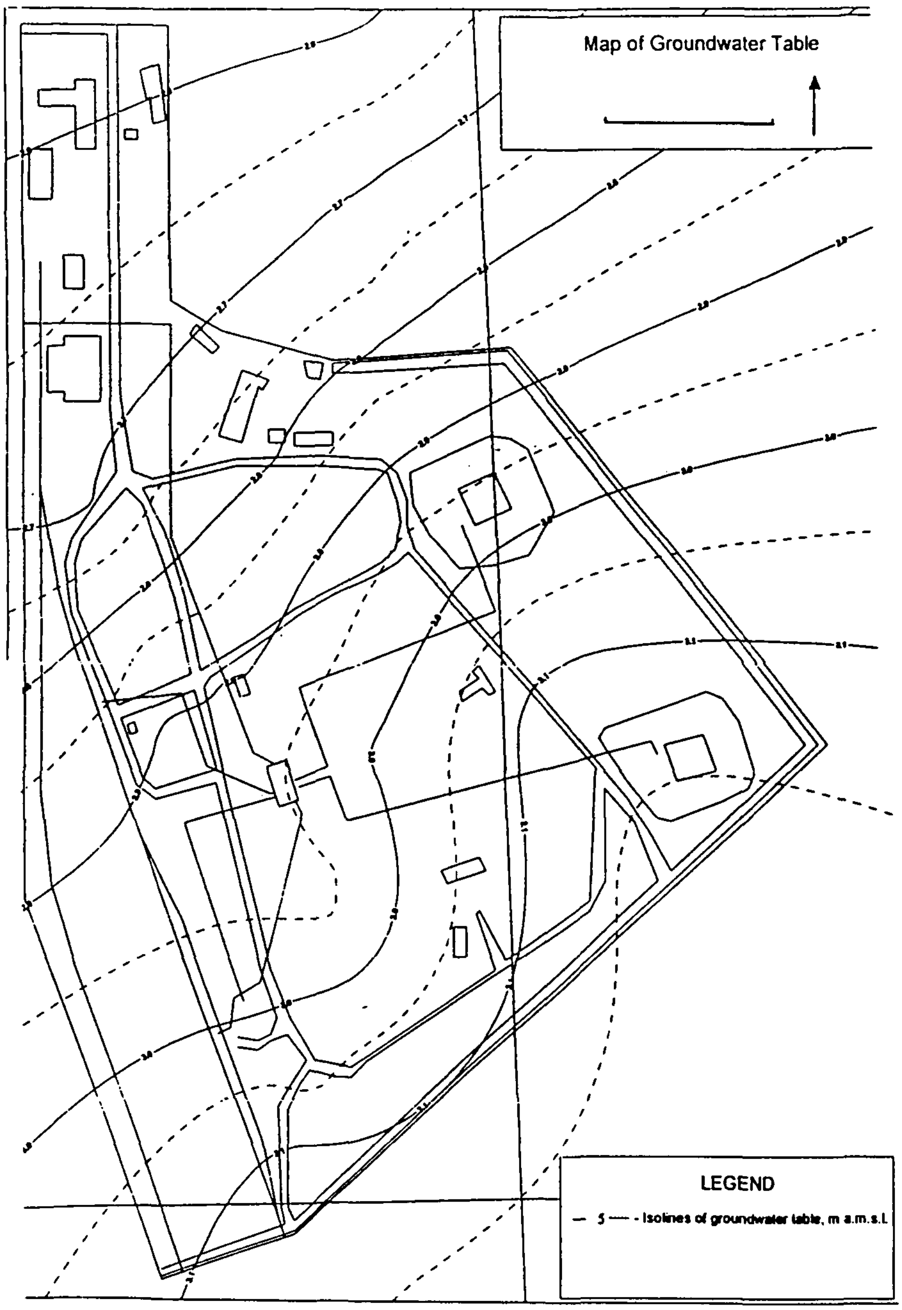


Figure 2. Map of Viestura Prospekts site showing contours on water table deduced by georadar (m above sea level). Scale bar is 100 m.

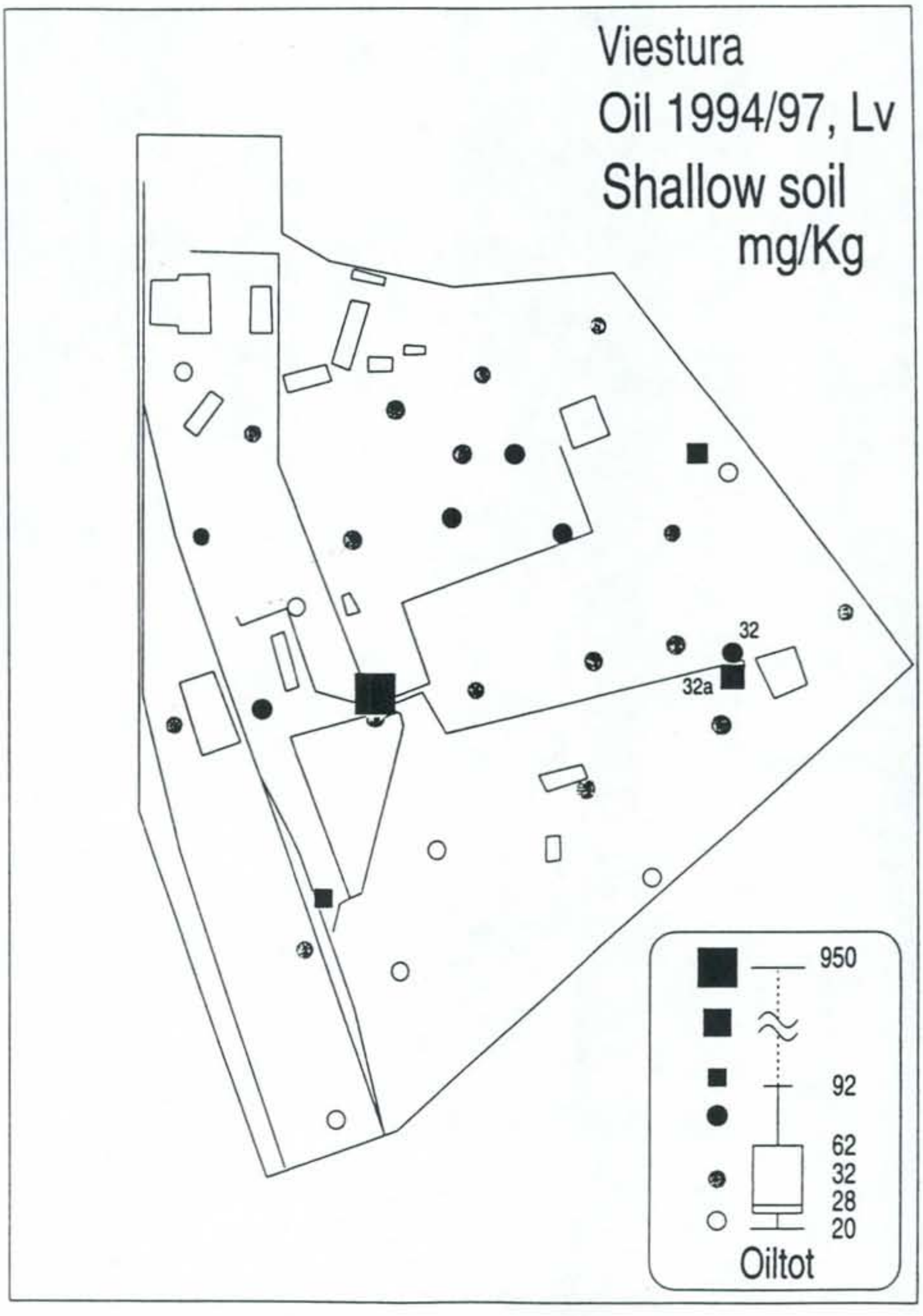


Figure 3. Concentrations of mineral oil in topsoil (ca. 20-25 cm depth) at the Viestura Prospekts site, according to samples collected in 1994 and 1997.

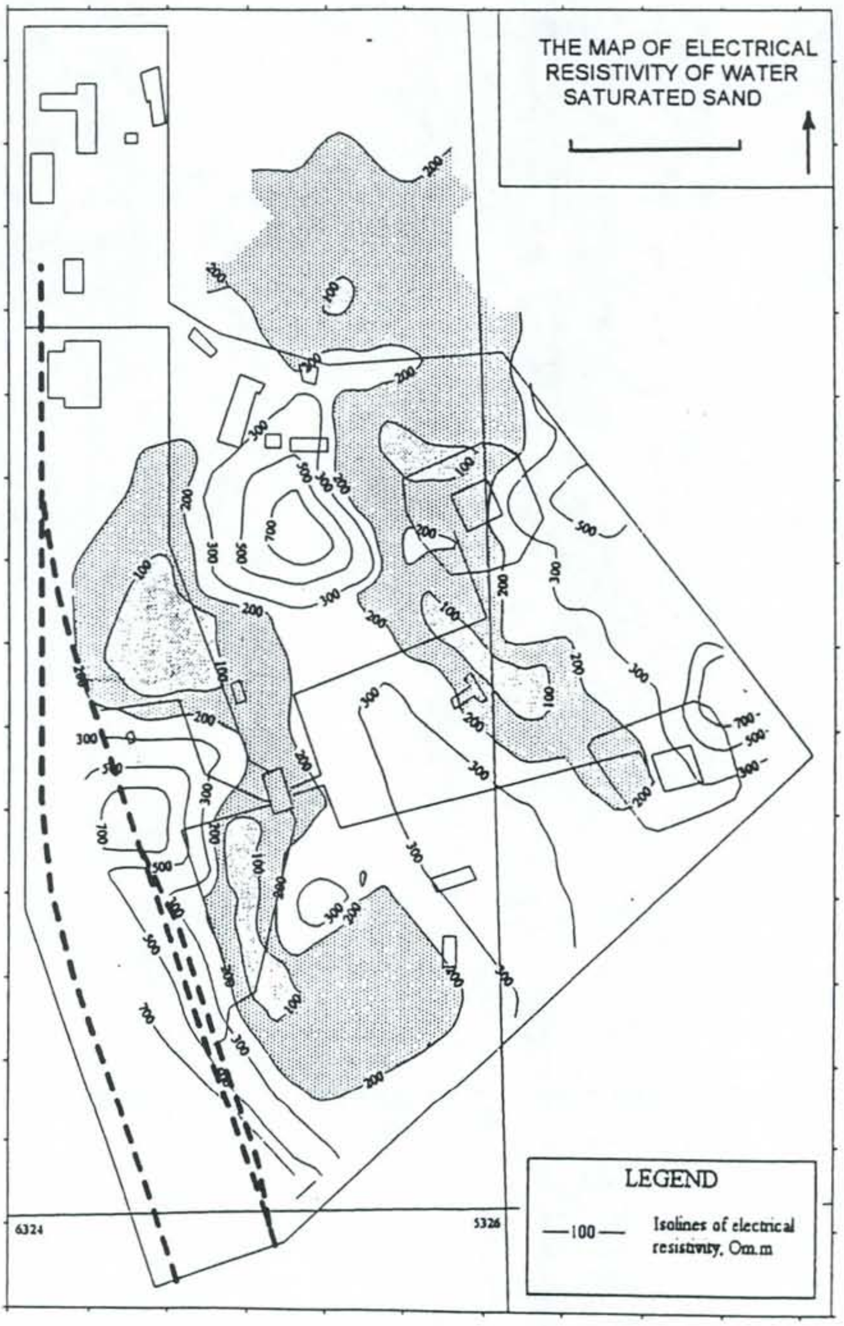


Figure 4. Electrical resistivity of water-saturated sand (ohm.m) deduced by VES profiling. Shaded areas show low resistivity. Scale bar = 100 m.

1.3. CONTAMINANT SOURCES

The main likely contaminant sources are assumed to be as follows:

- Leakage / spillage from the two main bunker complexes.
- Leakage from pipelines or pump-house.
- Leakage from numerous smaller buried or half-buried oil storage tanks. These tend to be located along the railhead or along the road comprising the tanker loading bays.
- Spillage during on- or off-loading of rail or road tankers.
- Contamination associated with storage or filling activities in the currently active part of the site.

As regards contaminants of concern, four classes can be named:

- Hydrocarbon fuel - this is believed to be dominantly diesel (possibly jet fuel / paraffin).
- Natural inorganic fuel components - much Soviet oil is, for example, known to be rich in vanadium
- Fuel additives.
- Natural components mobilised from the aquifer matrix as a result of oil contamination and biodegradation.

2. Geology and Hydrogeology

The geology of the Riga area broadly consists of Quaternary glacial, limnoglacial and interglacial deposits overlying a Devonian sequence of alternating aquifers and aquitards. A detailed description may be found in Gosk *et al.* [3].

Below a thin organic soil zone at Viestura Prospekts, occur fine-medium sand deposits of the Quaternary Baltic Ice Lake, with probably wind-blown dune sands forming hummocky areas of topography. The Baltic Ice Lake sediments appear to be rather homogeneous although it is reported that interlayering of fine and medium grained sands may occur. The thickness of the Baltic Ice Lake sand sequence is estimated at 21 m by the Latvian Geological Survey (or 30 - 40 m according to Levins and Sichovs [1]). GSL also estimate a hydraulic conductivity in the range 8 - 10 m/d for the sands, although this is essentially an educated guess (although a rather good one, as hydraulic tests were to prove).

Below the Baltic Ice Lake sands sequence occur tills comprising sandy clays with gravel/pebble clasts (with possibly also some clayey / silty limnoglacial deposits). The thickness of this lower permeability Lower Quaternary sequence is reported by the Geological Survey of Latvia as some 28 m, giving a total Quaternary thickness of some 49 m.

The Quaternary deposits overlie sedimentary rocks of the Upper Devonian Gauja Formation comprising sandstone with silty interlayers. This is an important aquifer for water supply in the Riga area.

The hydrogeology at the contaminated site thus essentially consists of two aquifer horizons, the Baltic Ice Lake sands and the Devonian Gauja Sandstone, separated by a ca. 28 m thick aquitard sequence of sandy silts and clays.

Rising head tests were performed in 5 boreholes in the Baltic Ice Lake Sands at the Viestura Prospekts site, yielding values of 1 - c. 8 m/d for hydraulic conductivity (K). Estimates of K based on grain size yield values of 6 - 20 m/d.

Georadar profiles carried out at the site were able to identify the water table in the Baltic Ice Lake Sands, and this was calibrated against water levels in monitoring boreholes to yield the map shown in Figure 2. The water table exhibits a north-westerly gradient oriented towards the mouth of the River Daugava.

Meteorological records from the station at the University of Latvia (Merkela street, Riga) indicate an annual average precipitation of some 705 mm. Of this, GSL suggest that at least 400 mm/a is evapotranspired, leaving a potential 300 mm to recharge or run-off.

3. Site Investigations

3.1. SOIL SAMPLING

In 1994 samples of soil at ca. 20 cm depth and subsoil were taken at a network of sampling points and analysed for total mineral oil content. Samples were composites of five sampling points, 1 m apart, at the corners and centre of square grid at each locality.

Seven supplementary samples were taken in 1997 and were additionally analysed for content of selected heavy metals. Samples were also taken for duplicate analyses by FFI and NGU. The results for oil are compiled and presented in Figure 3. Note that sample 32A is a spot sample of the most contaminated horizon of soil and is a single component of the bulk composite sample 32.

The median oil concentration is 32 mg/Kg and the contaminated samples are dominantly in the central part of the site around the bunkers, pipelines, pump-house and railhead. The maximum is at the site of borehole 2 (950 mg/Kg), by the pump-house. Two samples of shallow (20-25 cm) soil taken, as part of another study, from grass roadside verges near a factory site at Valmieras iela in central Riga returned oil concentrations of 60 and 72 mg/Kg. The majority of the Viestura Prospekts site thus returned oil concentrations lower than what might be regarded as an urban background.

Concentrations exceed the Norwegian trigger level requiring a site specific risk assessment (100 mg/Kg - [4]) in only a few samples. No sample exceeds the Dutch Action Level of 5000 mg/Kg [5]. Concentrations of the heavy metals Zn, Cu, Pb, Hg and Cd do not exceed Norwegian trigger values.

3.2. GROUNDWATER SAMPLING

Site investigations of contamination at the site were undertaken in 1994, 1996 and 1997. In 1994, boreholes 1 to 8 were drilled with (typically) a 1 m long well-screen fully below the water table. At three sites (2, 4 and 7), a second borehole was drilled with a filter at a deeper level in the sand aquifer (at depths of around 8-10 m). These deep boreholes were named 9, 10 and 11. In all boreholes, the well screen was fully submerged: the wells were thus designed to sample dissolved contamination, rather than light non-aqueous phase liquid (LNAPL - i.e. free oil) contamination.

To supplement this network, four new wells were installed in 1996 (numbers 12-15), with well screens straddling the water table, rendering them suitable for LNAPL monitoring. The casing in well 7 was pulled up so that it too straddled the water table (referred to as well 7a). A pre-existing monitoring borehole (number 222a - with well screen at 8.6-10.6 m) was also incorporated into the network. Additionally, two wells at cemeteries (used for tending plants at graves) some 500-800 m SSW and SSE of the oil depot were sampled in an attempt to establish "background" groundwater chemistry.

Sampling rounds were carried out in 1994, 1996 and 1997. Samples were analysed for organic parameters in Latvia, while duplicate control samples were taken for inorganic analysis at NGU and organic analysis at FFI. Latvian laboratories yielded the most reproducible values for organic parameters, while NGU's laboratories returned the most reproducible values for the majority of inorganic parameters.

Free phase oil was found in only two wells; well 12, near the northernmost fuel bunker, and well 13, near the railhead.

4. Geophysical Investigations

Ground penetrating radar (Georadar), calibrated against water level measurements in existing boreholes, was used to produce a map of the water table, showing a north-westerly groundwater gradient.

Vertical electrical resistivity sounding (VES) was also used to produce a map of electrical resistivity of the aquifer below the site. In such flat, relatively homogeneous geology, variations in resistivity will be mainly attributable to variations in groundwater conductivity. The resistivity map is presented in Figure 4. It appears to show two elongated areas of low resistivity. These could be interpreted as plumes of high conductivity groundwater moving north-westward away from the fuel bunker area and the railhead area. Initially, these results were perplexing: the high conductivity water might represent contamination, but hydrocarbons are not themselves electrically conductive, nor do they dissolve to yield high concentrations of charged species.

5. Results: Groundwater Chemistry

Free phase oil was found in wells 12 and 13, both of which lie within the high-conductivity plumes detected in the VES survey.

Figure 1 shows the distribution of dissolved (or possibly emulsified) oil concentrations found in groundwaters during the 1996 sampling round. For reference, the Norwegian drinking water limit for oil is 0.01 mg/L [6], while the Dutch background and action levels are 0.05 and 0.6 mg/L, respectively [5].

Three points are noteworthy. Firstly, the highest concentrations coincide with resistivity lows on the VES map. Secondly, the concentrations decrease with depth (see the well triplet 7a,7,9 and the pairs 4,10 and 2,11). Contamination is almost absent from the deep monitoring well 222a (though this does not imply that contamination is not present in shallow groundwater at that point). Thirdly, significant oil concentrations were detected at the SE cemetery well, suggesting that there are other sources of contamination to the aquifer than the oil depot (e.g. road run-off). The median oil concentration at the contaminated site was 0.26 mg/L.

A plot of iron in groundwater shows a not-dissimilar distribution (Figure 5), with extremely high concentrations being reached in some of the shallow wells (maximum over 50 mg/L). Low iron concentrations were recorded in little-contaminated shallow wells (well 8) and deep wells such as wells 10 and 222a. Nitrate and sulphate (Figures 6 and 7) show an inverse trend, however, with high concentrations in the "background" (cemetery) and uncontaminated wells (8 and 222a) and a tendency to increasing concentrations with depth. Three tentative conclusions are thus drawn from the results:

- that vertical groundwater quality stratification is highly significant at this site, the oil-contaminated layer maybe being only ca. 2 metres thick. This has important implications for design of monitoring well networks and for estimating the total volume of contaminated water which may require treatment.
- that oil concentrations show some correlation with groundwater conductivity and dissolved ionic content.
- that oil concentrations show clear relationships with redox parameters such as Fe, SO_4^{2-} and NO_3^-.

6. Organic and Inorganic Chemistry: A Close Relationship

Why should oil concentrations have such a major impact on inorganic groundwater chemistry ? When oil begins to biodegrade it alters two fundamental chemical equilibrium systems of the groundwater environment: the redox system and the acid-base system. For example, the idealised hypothetical full degradation of octane to CO_2:

$$2C_8H_{18} + 25O_2 = 16CO_2 + 18H_2O$$

6.1. OIL AND THE REDOX SYSTEM

Firstly, degradation of hydrocarbons consumes oxygen and lowers the redox potential of the groundwater. When oxygen is consumed, biodegradation may continue, using oxidised species of iron (aquifer matrix Fe_2O_3), nitrate and sulphate as electron acceptors. This will result in increased concentrations of reduced, soluble iron (Fe^{++}), and reduced S and N-species, and decreased concentrations of sulphate and nitrate. This is indeed observed: Figures 8 and 9 illustrate the positive correlation between iron and oil concentrations and the negative one between iron and sulphate/nitrate. Previous investigations also suggest a correlation between oil and ammonium concentrations [1].

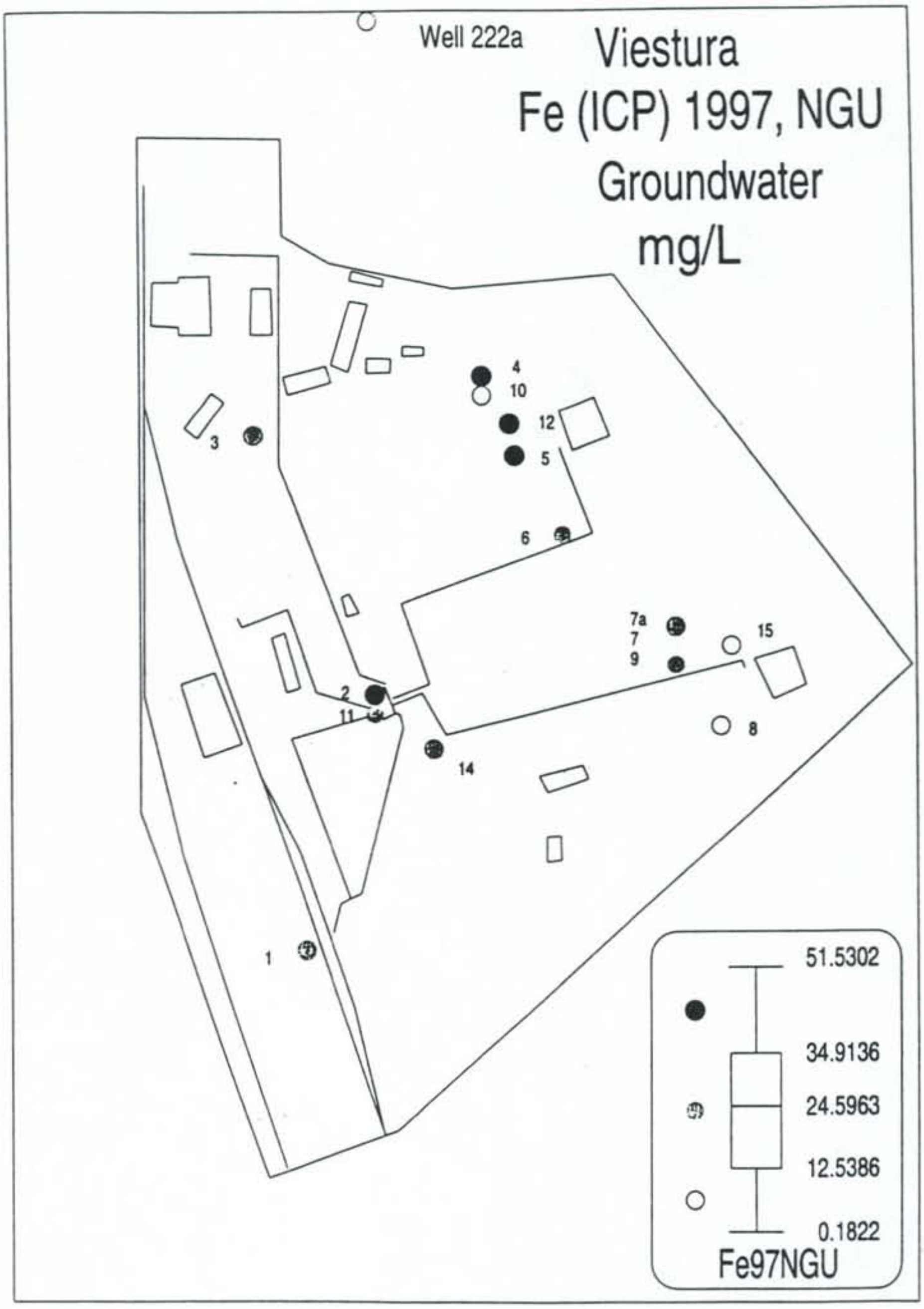
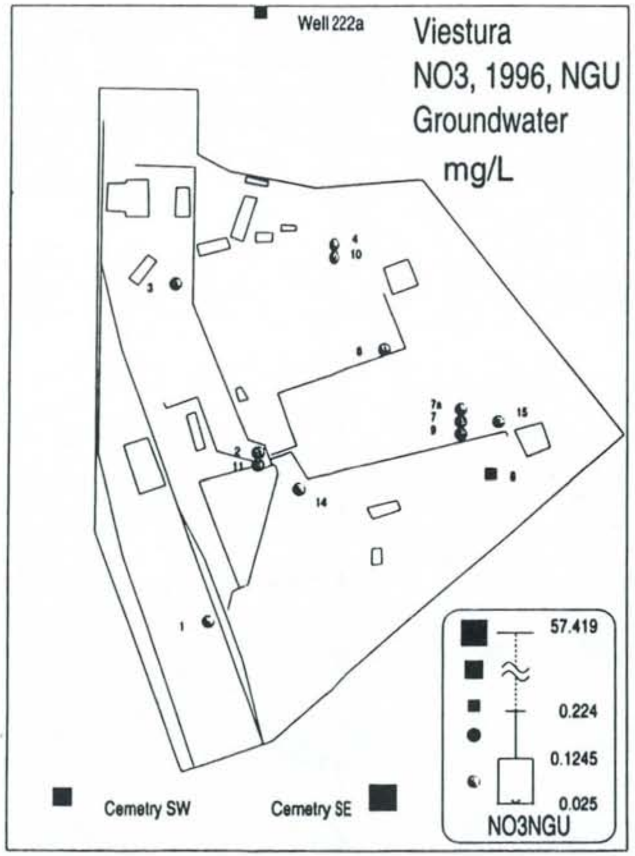


Figure 5. Concentrations of dissolved iron in groundwater (mg/L) at the Viestura Prospekts site (1997). Numbers on map refer to monitoring wells.



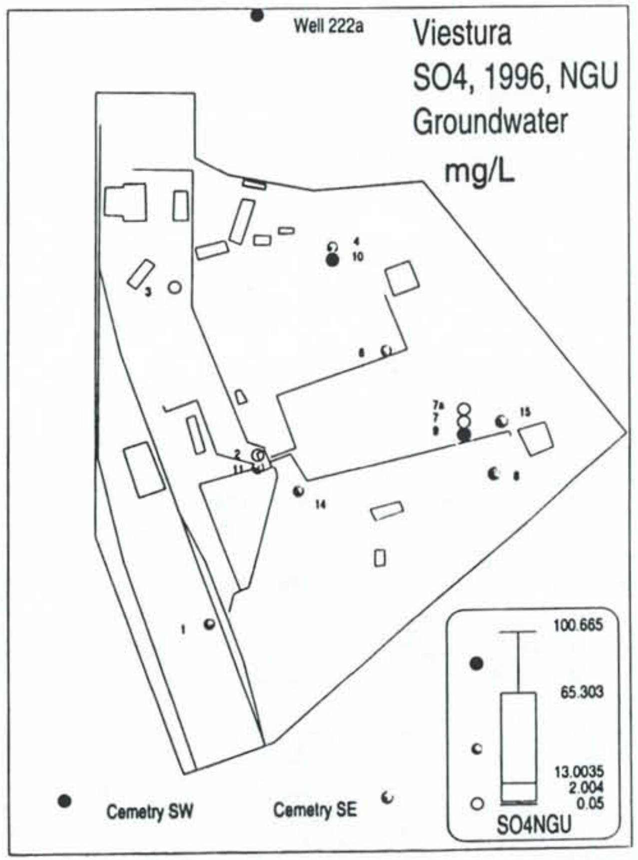


Figure 6 (left) and Figure 7 (right). **Concentrations of nitrate and sulphate in groundwater at the Viestura Prospekts site (mg/L), as measured in 1996.**

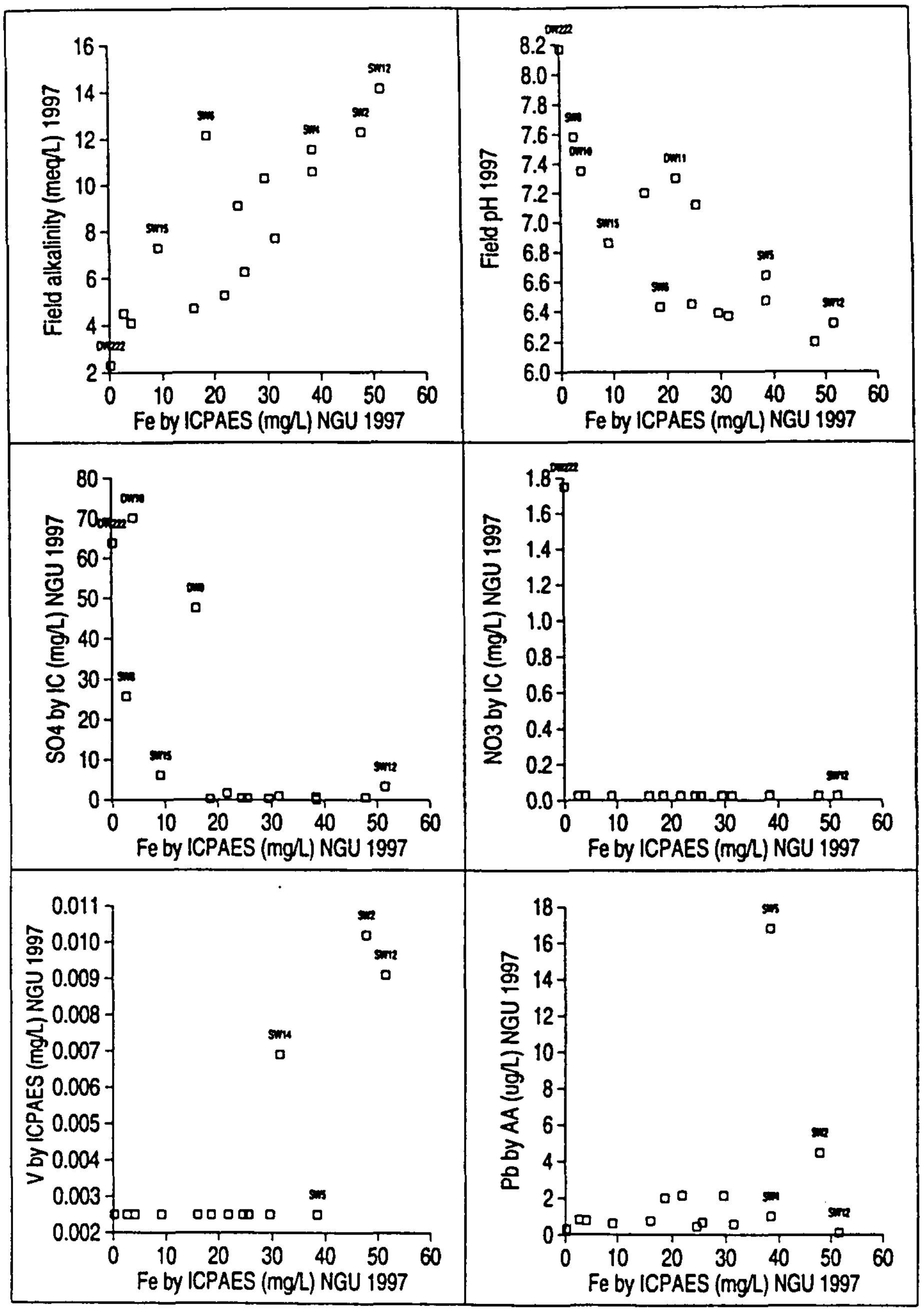


Figure 8. Relationship of alkalinity, pH, sulphate, nitrate, vanadium and lead to dissolved iron in groundwater at Viestura Prospekts. 1997 samples. Concentrations less than analytical detection limit are plotted at half the detection limit.

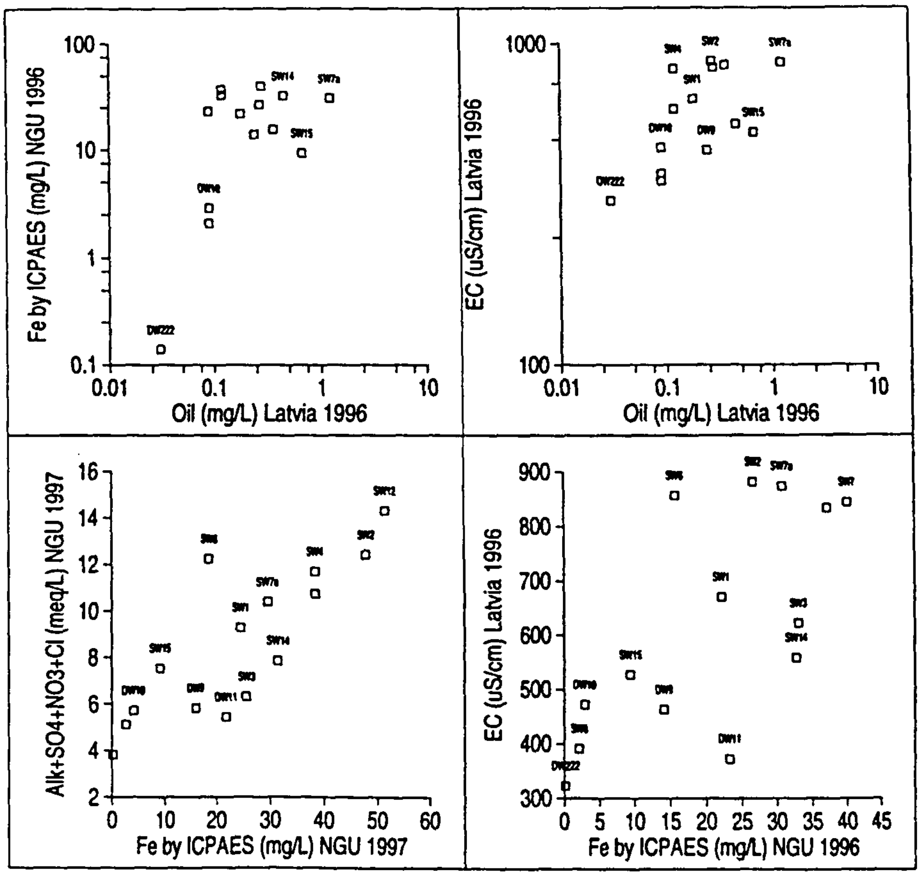


Figure 9. The relationship of dissolved oil to Fe and EC in groundwater and of Fe to anion sum and EC.

Dissolved iron may thus be a stable, easily samplable and cheap indicator of hydrocarbon contamination. It avoids the difficulties of reproducibility of oil analyses due to the potential for entraining of emulsified oil phase in the sampled water.

6.2. OIL AND THE ACID-BASE SYSTEM

Secondly, the reaction generates carbon dioxide which, when dissolved in water, acts as an acid and can attack and weather both carbonate and feldspar minerals, such as calcite:

$H_2O + CO_2 + CaCO_3 = Ca^{++} + 2HCO_3^-$

or sodium feldspar:

$2NaAlSi_3O_8 + 2CO_2 + 3H_2O = 2Na^+ + 2HCO_3^- + 4SiO_2 + Al_2Si_2O_5(OH)_4$

These reactions release alkalinity, dissolved silica and cations. Figures 8 and 9 confirm that positive correlations do indeed exist between oil and electrical conductivity (a measure of ionic content) and between Fe and ionic sum and alkalinity.

6.3. TRACE METALS - A CURIOSITY

Figure 9 indicates that, while the majority of sampled groundwaters display concentrations of < 5 μg/L vanadium (here, as on all figures, concentrations less than the analytical detection limit are plotted at a value of half the detection limit), several of the most iron rich (and oil-contaminated) groundwaters display concentrations of up to 10 μg/L. It is conceivable that the vanadium has been mobilised from the aquifer matrix by pH/redox changes during oil degradation, but it is also known that many Soviet oil resources are typically rich in vanadium [7].

The same observation applies, although less clearly, to lead. It is conceivable that lead may have been used as an additive to some fuels formerly stored on the site.

7. Conclusions

Contamination of groundwater due to hydrocarbon spillages, far from being merely the province of the organic chemist, offers much food for thought for the inorganic hydrochemist. This is not a new observation, but has been tackled in detail by the work of Mary-Jo Baedecker and her colleagues [8,9,10,11]. This study provides clear indications that oil contamination in groundwater may be positively correlated with total ion content, alkalinity, electrical conductivity and iron, and negatively correlated with redox indicators such as sulphate and nitrate. These species thus offer low cost alternatives to hydrocarbon analyses for monitoring of oil contamination. Organic analyses are expensive, crave extremely high standards of purity in sampling techniques and are often less reproducible than inorganic analyses due to problems with entrainment of emulsified oil phase. Such inorganic parameters may also allow some assessment to be made of the contamination's degradation status.

Secondly, the correlation of oil concentrations with electrical conductivity appears to allow contamination plume migration to be identified with geophysical techniques such as VES.

Thirdly, it has been shown that the distribution of oil contamination in the aquifer at Viestura Prospekts is highly vertically stratified and confined to within the upper few metres below the water table. This has important implications for design of monitoring networks.

The message is clear: contamination specialists should avoid a philosophy which involves peppering a site with monitoring boreholes and analysing sampled waters merely for the contaminants under question.

Rather, the use of geophysics can assist in reducing the number of necessary observation boreholes, and in locating them most efficiently. A monitoring network should not just aim to achieve maximum areal coverage, but to obtain information on the three-dimensional distribution of contaminants. Analytical programs should place more emphasis on characterising major ionic chemistry. Such a philosophy may save money on costly organic chemical analyses.

9. References

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