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## **Riksantikvaren FoU prosjekt 2005-7 Pæleprosjekt. Piling project. Volum 3**

Report on *Peleprosjektet*, 2005-7

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**Report on *Peleprosjektet* 2005-7, and including part of *Miljøovervåkingsprosjektet*, Bredsgården/Bugården, Bryggen, Bergen, 2004-5**

## **1. Introduction**

### **1.1 The Piling Project (*Peleprosjektet*)**

#### **1.1.1 Background**

In the autumn of 2005 Ann Christensson was seconded from her ordinary duties at *Riksantikvaren's* regional office for West Norway in order to head a 3-month (later prolonged) research project focused on the question of the use of piling as an acceptable foundation method in medieval towns. The project was entitled, naturally enough, the Piling Project (*Peleprosjektet*). In order to investigate on the broadest possible front the problem of piling and its potential impact on archaeological deposits, she arranged for the implementation of a number of subordinate archaeological/geotechnical/geochemical projects both in and outside Norway: namely in Bergen, Trondheim, Tønsberg, Copenhagen (Denmark), and Lund (Sweden).

NIKU (the Norwegian Institute for Cultural Heritage Research) was commissioned to take charge of the archaeological investigations. A. R. Dunlop (an archaeologist from the institute's Bergen office) was the person mainly responsible for NIKU's side of things, including this report.

The project's first fieldwork session took place in Bergen at the end of October 2005, with A. R. Dunlop (an archaeologist from the Bergen office of the Norwegian Institute for Cultural Heritage Research), Jens Peter Ringsted (attached to Denmark's National Museum) and Arild Haukeland (a geotechnical/drilling specialist from the firm of Multiconsult/NOTEBY) participating in the field.

The second fieldwork session took place in Copenhagen from the 5<sup>th</sup> to the 9<sup>th</sup> of December, 2005, with Dunlop, Ringsted, Haukeland, Henning Matthiesen (a conservation specialist from Denmark's National Museum) and Lisbeth L. Poulsen (an archaeologist from Copenhagen's City Museum) participating in the field. Jens Brendstrup (COWI) ably took care of the practical aspects.

The third fieldwork session took place in Lund, South-west Sweden, on the 10<sup>th</sup> of December, 2005, with Dunlop, Haukeland, and Conny Johansson Hervén (an archaeologist at *Kulturen*, Lund) participating in the field.

The fourth fieldwork session took place in Trondheim from the 21<sup>st</sup> to the 22<sup>nd</sup> of August, 2006, with Dunlop, Haukeland, Ann Christensson and Jens Rytter (*Riksantikvaren*), and Chris McLees, Anna Petersén and Ian Reed (NIKU, Trondheim) participating in the field. Multiconsult's local branch handled most of the practical arrangements.

The fifth fieldwork session took place in Tønsberg on the 25<sup>th</sup> of August, 2006, with Dunlop, Haukeland, Christensson, Jan-Erik G. Eriksson (*Riksantikvaren*), Gro Edvardsen (NIKU, Tønsberg) and Vibeke Martens (NIKU, Oslo) participating in the field. Multiconsult's local branch handled most of the practical arrangements.

The sixth fieldwork session took place in Tønsberg from the 29<sup>th</sup> to the 31<sup>st</sup> of May, 2007, with Dunlop, Christensson, Edvardsen, Matthiesen, and Thomas Hartnik (a geochemist from Bioforsk Soil and Environment) participating in the field. Multiconsult's local branch handled most of the practical arrangements, including the drilling.

The reader is also referred to the investigation carried out at Slottsgaten 1, Bergen, at the end of 2005 (Dunlop, 2006; in Norwegian, with English summary). This has a very relevant connection with the Piling Project.

### 1.1.2 Aims and approaches

The aim of the Piling Project was to investigate whether piling can cause damage to surrounding organic cultural deposits – or, more specifically those deposits lying just outside the area directly impacted by the pile itself. The underlying premise is that the insertion of any pile, no matter whether it is installed by driving, drilling or other method, will result in the introduction of air/oxygen, and that this will trigger increased decomposition of organic matter in the penetrated deposits.

The approach was to carry out archaeological, geotechnical and geochemical investigation of cultural deposits around existing piles. The local heritage management authorities and/or archaeologists in the various medieval towns participating in the project were requested to select suitable localities for investigation. Each locality had to fulfil two main criteria:

- Organic deposits had to be present in sufficient quantity
- It had to be accessible for a drilling rig

The idea then was to carry out two (sometimes three) drillings, using a rotating auger to bring the deposits up to the surface for examination by the attending archaeologists and geochemical experts. One drilling was to be as close as possible to the pile (as it turned out, it was seldom possible to manoeuvre the drilling rig to within much less than a metre from the side of a building), with the second drilling between half a metre and a metre further out from the first.

One of the archaeologist's main tasks was to identify and describe the individual strata in each drilling (it was decided to use the term *stratum*, rather than *layer*, for the individual stratigraphic units in the drillings). Each stratum could then be assessed with regard to its state of preservation (see State of Preservation Scale in section 1.1.3), thereby providing the basis for comparison of state of preservation between each pair or triple of drillings.

The process of comparison involved one main principle – the use of corresponding strata. A corresponding stratum is basically the same stratum occurring in both drillings, or – where there three drillings – in at least two out of the three.) It was clear that simply using similar elevation – i.e., strata lying at the same height above/below sea-level – would not necessarily provide meaningful comparisons. Doing so would entail a high risk of comparing totally different strata – strata that never formed part of the same context and that never shared the same state of preservation to begin with. The only valid comparison had to be between corresponding strata, since only then could one be reasonably sure that they had started out with the same state of preservation. Identification of corresponding strata, either during or after fieldwork, was another of the archaeologist's main tasks, and it formed one of the cornerstones of the comparison process.

### 1.1.3 State of preservation Scale

A second cornerstone of the comparison process was the use of a universal scale for characterising the individual stratum's state of preservation. This enabled each stratum to be given a simple, alphanumeric "tag", thereby facilitating speedy comparison.

PRESERVATION SCALE		DEGREE OF PRESERVATION						
		NULL-VALUE	VERY POOR	POOR	MED-IUM	GOOD	VERY GOOD	
POSITION IN RELATION TO GROUNDWATER	OVER	A0	A1	A2	A3	A4	A5	A
	OVER/IN	B0	B1	B2	B3	B4	B5	B
	IN	C0	C1	C2	C3	C4	C5	C
		0	1	2	3	4	5	
"Extreme situations/cases"		D0	D1	D2	D3	D4	D5	D
Fill etc later than ca. 1900		E0	E1	E2	E3	E4	E5	E

### 1.1.4 Archaeological assessment of state of preservation

Archaeological assessment of state of preservation is based on the following principal criteria/indicators:

- Odour type/odour strength
- Colour/rate of colour change
- Amount of force required to snap pieces of wood
- Amount of force required to pull apart a strand of moss
- Sponge reaction of soil block; squashiness of woodchips; springiness of strands of moss or hair/fur
- General appearance (brightness/dullness of colour, visibility of structure) of macroscopic organic components

It is worth stressing two things at this point:

- the archaeological assessment concerns the state of preservation of individual strata, whereas the geochemical analyses are focused more on preservation conditions
- and, in the case of layers exhibiting poor preservation, archaeological assessments cannot really reveal whether this decomposition is due to ongoing processes, or took place at the time of the layer's deposition instead – or even at some point in between. (This applies more to assessments in connection with drillings, rather than with assessments undertaken in connection with excavations, which provide better opportunity to understand the individual layer's formation and subsequent history.)

## 1.2 The Bryggen Monitoring Project: test-trench, 2004

In view of its situation and the fact that it was the first attempt at a kind of pile investigation, the test-trench investigated in November 2004 has been included in the Piling Project report.

Some preliminary background information is probably indicated at this juncture. The site now occupied by the Radisson SAS Hotel was excavated by Asbjørn E. Herteig from 1955 to 1968, with supplementary excavations at intervals during the 1970s. Construction of the encircling wall

of sheet piling – “rediscovered” by the present project – took place right at the end of the 1970s. The sheet piling is anchored by a multitude of metal stays that were drilled downwards and outwards until their ends stuck in the underlying bedrock. This means that the stays penetrate the deposits beneath Bredsgården tenement, so that the perforated/affected zone really extends quite a long way out from the sheet piling itself.

Bredsgården is the northernmost of the complete tenements within the Bryggen complex. Bugården, its neighbour to the north, is really only an amputated stump, two buildings in length, with an isolated small building at the rear of the built-up area. Like the other wooden tenements making up the World Heritage Site of Bryggen, they were built sometime shortly after the major fire of 1702, which razed about seven-eighths of the town. And they are/were separated by a roughly one-metre-wide eavesdrop (of which only part now survives on the ground-surface, of course).

A current measurement programme concerning the buildings and the ground surface at Bryggen has shown that the buildings of particularly the northern Bredsgården tenement are settling at a considerable and alarming rate – up to 8 millimetres per year. The buildings and the ground (surface) seem to go through cycles of movement, each cycle comprising both upward and downward movements. The important thing is that, at the end of every downward movement, the measuring points sink to a point lower than the previous low. It is surmised that the main cause of this settlement has to do with an increased rate of decomposition of the underlying cultural – predominantly organic – deposits, and that this in turn is connected with the fact that the entire area immediately to the north-west of Bredsgården tenement was excavated down to the natural in the 1960–70s.

Towards the end of 2004, *Riksantikvaren* adjudged the time ripe to investigate the question of piling, largely in response to a steadily growing pile of building applications that entailed the use of piles. What was required was an open area containing old piles where it would be possible to dig down alongside one or more piles. Such areas, unfortunately, turned out to be in short supply, so one finally opted for a revisit to the area just behind the Bugården tenement at Bryggen, Bergen. This area had already – November 2002 – been the scene of a small archaeological trial investigation, combined with the initiation of monitoring measures, including the installation of two dipwells with intakes at different depths.

The selected study-area had many things going for it:

- The fieldwork coincided with a seminar/workshop on the topic of Monitoring and documentation of Cultural Deposits, held at Bryggens Museum 11-12.11.2004 and with participants largely drawn from Riksantikvaren, Hordaland County Council, NIKU, and the National Museum of Denmark. David Gregory and Henning Matthiesen, both from the last-named institution, participated in the fieldwork side too
- During the 2002 investigation, a small section of the sheet piling was exposed and plotted in, so that one knew that it could be re-located with little trouble
- By excavating down alongside the sheet piling, it would be possible to assess any damage that it might have inflicted on the archaeological deposits and their contents
- One knew that the sheet piling is anchored by metal stays that had been drilled outwards from near the top of the sheet piling and at a relatively steep angle in under the Bredsgården and Bugården tenements
- It was reckoned that, for the purposes of the present investigation, a slanting stay was just about as good as a vertical pile
- Digging here would also enable recovery of a graphite rod with attached test materials – small tags of wood and iron – that Matthiesen had inserted vertically down into the

deposits in 2002 (Matthiesen, 2002), and which was due for retrieval at the end of 2004 for analysis of the degree of decomposition or corrosion (Gregory & Matthiesen, 2006)

The primary objective was to uncover one of the anchoring stays in order to determine any effects – basically, deformation and decomposition – on the surrounding deposits. This was to be combined with the taking of soil, water and wood samples, along with on-the-spot measurements of various parameters, all of which was carried out by personnel from the National Museum of Denmark (Matthiesen, 2005).

The investigation of the test-trench took place from the 8th to the 15th of November, 2004. Its NIKU project number is 156132903, and the Bryggen Foundation is to be thanked for practical assistance rendered.

## 2. Methods

### 2.1 Test-trench, Bryggen

As regards the test-trench, virtually all the digging was carried out by machine, supplemented by manual cleaning of sections. Documentation/recording adhered to the standard procedures employed by NIKU's Bergen office (though not the context recording sheet – circumstances did not call for its use). For drawing plans and sections, a scale of 1:20 was used exclusively. The photography was done using colour-print film, supplemented by a certain amount of digital photography. The various layers and constructions recorded in the course of the test-trench investigation were numbered sequentially as they were encountered, but using separate sequences (construction numbers have “K” as prefix) and in continuation of the numbering from the investigations in 2002 and 2003. The layers and constructions have not been assigned to successive “phases” or other units of relative chronology; it was felt that this would not be very meaningful, under the circumstances.

No finds were recovered from the test-trench, but numerous soil and wood samples were taken by Gregory and Matthiesen for geochemical analysis (Matthiesen, 2004).

Plan/profile commentaries and detailed information on constructions, finds and layers are to be found in separate tables in an MS-Access database (filename *dba23300000.mdb*), which also contains similar data from the 2002 and 2003 investigations.

### 2.2 Drilling

The same drilling rig and equipment was used for all the drillings. The drilling method employed was rotary (auger) drilling, using a drill whose total “thread” length was one metre. The drill was driven down under rotation one metre at a time, and then retracted without rotation so that the adhering soil could be inspected (after having scraped away the outermost material, which could readily become “contaminated” as a result of contact with higher strata). Stratigraphic sequences with descriptions of the individual strata were noted down in logbooks and, in connection with the investigations in Trondheim and Tønsberg, use was made of the revised context recording sheet as well.

A number of small finds (10 accession numbers in all) were collected from the *Peleprosjekt* drillings in Bergen; these have been registered under the reference number “BRM 618” in accordance with the principles laid down by Bryggens Museum. The artefacts recovered from



the drillings in Tønsberg, Copenhagen and Lund were retained by the respective local archaeologists.

Two radiocarbon dating samples were collected from the Copenhagen drillings (one from PK6, and one from PK7). The datings were carried out by AMS-method at the University of Uppsala in Sweden (the results themselves were reported by the National Dating Laboratory, the Norwegian University of Science and Technology, Trondheim).

## 2.3 Sampling

Three sets of samples – labelled, A, B and C – were taken from all the drillings, apart from Copenhagen and the 2007 investigation in Tønsberg (regarding the latter two, the attending geochemists took extensive soil samples and carried out numerous on-site measurements of oxygen content, conductivity and other parameters). The A-set of samples was intended mainly for loss-on-ignition and moisture content analyses (carried out by Multiconsult in the case of Bryggen, Trondheim and the first investigation in Tønsberg). The B-set comprised samples of organic materials such as wood, animal bone, leather and textile; these await analysis. The C-set was for geochemical analysis of a range of parameters; for various reasons, the C-samples from most of the investigated localities have not yet been analysed.

## 3. Fieldwork results

### 3.1 General remarks

In this report, the stratigraphic sequence in each drilling is presented in tabular form. One of the columns is headed PC, which stands for Preservation Category, and the values in this column are in accordance with the State of Preservation Scale (cf. section 1.1.3).

The abbreviation “masl” stands for “metres above sea-level”. Depths below sea-level are therefore prefixed with a minus sign.

### 3.2 Test-trench, Bryggen, 2004

#### 3.2.1 Observations

In the second week of November 2004 a test-trench was excavated along the Bryggen side of the sheet piling that encircles the hotel site. The trench was situated just a few metres to the north-east of the rear wall of the seaward part of the Bugården tenement, and in this area the sheet piling runs at an angle to the longitudinal axis of the Bryggen tenements. The trench was excavated by machine, using a narrow shovel, and its depth approached three metres.

The scientific work was abetted by several problems:

- Poor light
- A great deal of precipitation
- “Groundwater” that flooded into the trench when the organic deposits over the stay were punctured. The water – probably hundreds of litres per minute – came in from the hotel side of the sheet piling via a hole cut out to accommodate the stay. Gregory and Matthiesen were able by heroic efforts to stop the “leak” enough to allow the trench to be pumped relatively dry for a short while. Personnel from Bergen *kommune*’s Water and Sanitation Department were summoned to the scene, but were unable to detect any breach of waterpipes within the hotel site.

The trench's end-wall towards Bredsgården was drawn (profile 5) by the archaeologist from NIKU, while Gregory and Matthiesen retrieved numerous samples of soil and wood, and took various on-the-spot measurements.

The recorded profile was almost at right angles to the sheet piling. The modern surface was at 1.75 masl, and the top of the sheet piling reached up to 1.34 masl. There was a layer of coarse pebbles and smallish stones down to ca. 0.7 masl.

From ca. 0.7 masl and down to 0 masl was a solid foundation – designated K9 – of horizontal, probably cross-laid logs. The northeastern ends of the upper logs had clearly been truncated in connection with the construction of the sheet piling, but the degree of downward deformation was surprisingly small – which suggests that the logs had been exposed and sawn off prior to the driving of the sheet piling. Furthermore, the timbers right next to the sheet piling were apparently well preserved, at least to the naked eye. Gregory and Matthiesen took samples from the upper surface of the uppermost log at regular intervals proceeding out from the sheet piling, and it is always possible that analysis of the samples will provide a different picture of the log's state of preservation.

Right at the bottom of profile 5 was a worked plank that angled downward towards the sheet piling. However, this inclination did not appear to have resulted from the construction of the sheet piling.

The cultural deposits in profile 5 attained a maximum elevation of 0.4 masl. All in all it seemed to be one and the same layer the whole way, and was designated layer 9. It consisted of dark-grey/brown humus with fine sand and many woodchips (most of which were inclined more or less horizontally), many hazelnut shells, numerous pieces of birch-bark, and a few fragments of red brick/tile and animal bone.

There was, however, a division running just above 0 masl, shown by a horizontal, pricked line on the section drawing. Below this line the soil was relatively compact, and the woodchips were fresh and "natural" in colour, and resisted snapping. The soil above the line, on the other hand, was markedly looser in consistency, and the colour of the woodchips was lot darker. In other words, the lower part of layer 9 seemed to be relatively well preserved, while the properties of the upper part suggest that it has suffered a greater degree of decomposition, and that most of this likely has occurred in quite recent time.

Layer 9 could not be traced all the way in to the sheet piling – although what with all the timbers and with the water flowing incessantly down alongside the sheet piling it was pretty difficult to do a good job of cleaning up the situation. At any rate, it was observed that there was a 10-cm-wide zone of dark-grey sandy soil adjacent to the sheet piling. There were some woodchips visible in this layer, and all of them were inclined almost vertically. From this one may infer that they must have been dragged down as the sheet piling was driven, and were deposited – along with soil from the surface – in small pockets that arose between the sheet piling and the cultural deposits. The soil right next to the sheet piling is therefore interpreted not as an in situ cultural deposit that has suffered severe decomposition, but as a separate – and modern – accumulation.

Gregory and Matthiesen took a series of four soil samples from the bottom of the section. All of the samples were from between 0 masl and -0.10 masl, with one from the modern deposit up against the sheet piling and the others from the well-preserved part of layer 9. The results of the chemical analysis are awaited.

A narrow section of an earth baulk left standing in the recess between two of the sheet piles was also recorded. The situation was the same as in profile 5: the same layer – layer 9 – was present, and was divided into an upper, poorly preserved part and a lower, relatively well-preserved part. Gregory and Matthiesen took three soil samples from the lower part, all of them from between 0 masl and -0.10 masl.

Matthiesen inserted a new graphite rod with tags of test material attached in just about the same place as the retrieved rod, and with its downward point at about the same depth. This rod will be left in place for about 5 years.

### 3.2.2 Finds/dating

No archaeological dating material was recovered, but K9 must be from the building phase immediately prior to the major fire of 1702.

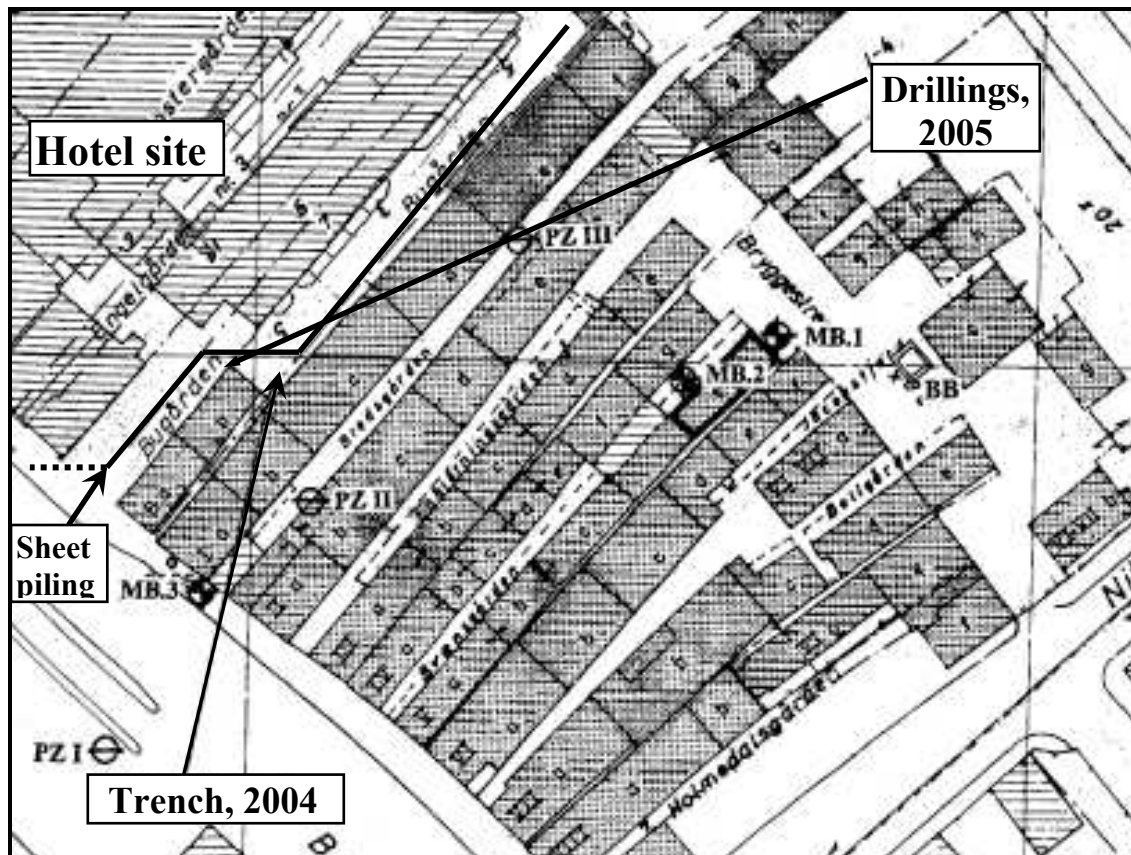


Figure 1. Location of the test-trench and the drillings investigated at Bryggen.

## 3.3 Drillings, Bugården, Bryggen, 2005

### 3.3.1 General remarks

In November 2005 it was decided to return to the area behind Bugården, where the sheet piling forms an angle just by the truncated tenement's northern corner. The plan was to carry out three drillings (all of them on the Bryggen side of the piling): one right next to the sheet piling, the second about 0.5 metres from the sheet piling, and the third about 1 metre from the sheet piling.

No radiocarbon dating samples were collected from the drillings in Bergen; it was thought not necessary, in view of the presence of numerous datable artefacts.

The various strata distinguished in the drillings have been numbered in the following way. First comes “PB0X” (for the drilling in question: P for *Peleprosjekt*, B for Bergen) followed by sequential numbering of the individual stratum (from top to bottom).

### 3.3.2 Drilling 1 (PB1): sediment sequence (visual inspection)

This hole was right next to the sheet piling (coordinates of sheet piling’s top determined by NOTEBY as X67208.75/Y59833.30/1.12masl). NOTEBY determined the hole’s coordinates as X67208.65/Y59833.35, and the modern brick-laid surface was at an elevation of ca. 1.75 masl.

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
1.75	1.05	PB01-01	PB02-01 PB03-01			Mod	E0	Hole dug down through stone/pebble fill to expose top of sheet piling
1.05	-0.40	PB01-02				Mod	E0	Stone and pebble fill Groundwater-level at ca. 0.25 masl
-0.40	-1.05	PB01-03	PB02-04? PB02-05? PB03-03? PB03-04?	Samples: leather scrap and piece of animal bone from ca. -0.65 masl		Mod (?)	C2	Dark-grey, rather loose sandy, gravelly stratum with some humus content and a few half-rotted woodchips (lying at all angles), some hazelnut shells, one twig, one piece of animal bone, and a few small pieces of red brick Poor preservation – may be redeposited cultural deposit
-1.05	-1.80	PB01-04	PB02-06? PB03-05?	Samples: pieces of wood from ca. -1.55 masl		Post med	C2	As PB01-03, but somewhat more compact Poor preservation
-1.80	-3.45	PB01-05	No match in PB2 or PB3	1 wall-sherd of medieval Grimston ware from -2.95 masl	618/1	Post med and med (?)	C2	As PB01-04: apparently a mixture of organic cultural deposit with non-organic material Some differentiation apparent down this drill length, but not possible to distinguish individual strata Poor preservation
-3.45	-3.45	PB01-06	No match in PB2 or PB3			Med	C0	Probably a very thin strip of light-grey fine to medium-fine sand

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
-3.45	-4.75	PB01-07	No apparent match in PB2 or PB3	Samples: piece of animal jaw-bone with tooth from -3.75 masl; pieces of wood from ca. -3.95 masl		Med	C3	(Nothing adhered to the drill from -3.85 to -4.25 masl) Very organic, but not laminated, and still relatively loose: many fresh-looking woodchips, a large quantity of hazelnut shells, some dung/straw patches, and a few animal bones; some sandy humus present between the macroscopic constituents Medium preservation Moist, but not dripping wet
-4.75	-5.05/ -5.40	PB01-08	Top of PB02-16	Sample: leather scrap from -4.95 masl; pieces of wood from ca. -4.85 masl		Med	C4	Very organic, relatively compact and laminated: a good deal of fresh-looking woodchips and hazelnut shells (but less of both than in PB01-07), a good deal of plant matter (moss and straw), some birch-bark pieces and twigs, and some small fragments of mussel Good preservation Moist, but not dripping wet
-5.05	-5.40							Difficult to say where stratum PB01-08 ended, due to lack of adhering material
-5.05/ -5.40	-6.10/ -6.35	PB01-09	PB03-14	Sample: large piece of leather from -5.95 masl		Med (early?)	C3	As PB01-07 for the most part, possibly more sandy, and with greater variation, eg. patches of laminated plant matter present Medium preservation
-6.10	-6.35							Difficult to say where stratum PB01-09 ended, due to lack of adhering material
-6.10/ -6.35	-7.35	PB01-10	PB02-17 PB03-16	1 wall-sherd of medieval cooking-pot, probably an early type, from between -6.25 and -7.25 masl	618/2	Med (early)	C4	Very organic, relatively compact and laminated: a good deal of plant matter (incl. much moss), some twigs, a few hazelnut shells; some silty humus present between the macroscopic constituents Good preservation (but colour was dull, not bright) Digital photo taken

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
-7.35	-8.65	PB01-11	PB02-19 PB03-18			Med (early)	C3	Mixture of dark-brown/grey silty humus and ooze/gyttja with some pebbles and fine sand, some woodchips and hazelnut shells Some sea shell fragments, mainly from -7.45 to -7.55 masl Medium preservation
-8.65	↓	PB01-12	PB03-19					Light-grey sand/silt/clay
								Rotary drilling abandoned at -9.05 masl

### 3.3.3 Drilling 2 (PB2): sediment sequence (visual inspection)

This hole was about 1 metre – by off-set measurement – from the sheet piling. NOTEBY determined its coordinates as X67207.75/Y59834.65, and the modern brick-laid surface was at an elevation of 1.75 masl.

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
1.75	1.35	PB02-01	PB01-01 PB03-01			Mod	E0	Stone and pebble fill under brick-laid surface
1.35	0.65	PB02-02				Mod	E0	Redeposited culture-layer: slightly sandy and humic soil with some stones and pieces of red brick (Very poor preservation)
0.65	-0.35	PB02-03	PB03-02	Sample: leather scrap from 0.20 masl		Mod	E0	As PB02-02, but with a little silt and with greater organic content (severely rotted woodchips and some pieces of charcoal, bark and hazelnut shells); a few interspersed small patches of light-grey clay (Very poor preservation)
-0.35	-0.60	PB02-04	PB03-03 PB01-03?			Post med	C2	Dark-grey/brown silty humus with a little sand and some smallish stones, a few badly rotted woodchips and a few hazelnut shells Poor preservation
-0.60	-1.25 (ca.)	PB02-05	PB03-04 PB01-03?	Sample: fibres from -0.75 masl		Post med	C2	Dark-brown silty, sandy humus with a lot of quite decayed vegetable matter (especially moss) and some half-rotted woodchips, bark pieces, hazelnut shells, twigs and fish bones Poor preservation

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
-1.25 (ca.)	-1.55	PB02-06	PB01-04?  PB03-05			Post med	C2	Dark-grey/brown silty, sandy humus with some rotted woodchips Poor preservation
-1.55	-1.90	PB02-07	PB03-06	Sample: animal rib-bone from -1.80 masl		Post med (?)	C3	Medium-brown vegetable matter, but small degree of lamination: mostly moss and straw with some hazelnut shells, a few animal bones, and probably fish bones too Vegetable matter was partly decayed and loose, but its structure was still well visible Medium preservation
-1.90	-2.35	PB02-08	PB03-07?	Sample: leather scrap from -1.95 masl		Post med (?)	C2	Difficult to say because little soil adhered to the drill: probably humus with stones Poor preservation
-2.35	-2.65	PB02-09	No real match in PB1 or PB3			Post med (?)	C3	Horizontal woodchips and other vegetable matter, including hazelnut shells, in a sand (fine to coarse) and gravel matrix Medium preservation
-2.65	-3.35	PB02-10	PB03-08	Sample: animal bone from -2.90 masl		Med (late)	C3	Loose sand (fine to coarse) and gravel with a little silt, a minor quantity of woodchips and hazelnut shells, single animal bone Medium preservation
-3.35	-3.65	PB02-11	PB03-09	Sample: piece of wood from -3.40 masl		Med (late)	C3	Very sandy brownish humus with a good deal of woodchips and hazelnut shells, some animal bones, and one fragment of sea shell Medium preservation
-3.65	-3.70	PB02-12	No match in PB1 or PB3			Med (late)	C3	Pocket of grey greasy clay with ribbon-like organic matter, possibly hair/fur Medium preservation
-3.70	-3.90	PB02-13	PB03-09?	1 wall-herd of uncertain type, probably late medieval from -3.80 masl Sample: piece of wood-fibre rope from 3.80 masl	618/3	Med (late)	C4	Sandy brownish humus with many woodchips, bark pieces, hazelnut shells and twigs Good preservation

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
-3.90	-4.65	PB02-14	No match in PB1 or PB3	Sample: piece of worked wood from -4.00 masl		Med	C3	Fine to coarse sand and gravel with a little silt, a fair quantity of woodchips and hazelnut shells (probably) Medium preservation
-4.65	-4.80	PB02-15	PB03-13	Sample: leather scrap from -4.75 masl		Med	C3	Dark-grey silty humus with some sand and a few organic constituents Medium preservation
-4.80	-6.40	PB02-16	PB01-08 (partly) PB03-15	Samples: piece of caulking from -5.50 masl; leather scraps from -6.05 masl		Med	C4	Very organic and somewhat laminated: dark-brown silty humus with many woodchips (all sizes), straw, some moss patches, and a few hazelnut shells Some differentiation apparent down this drill length, but not possible to distinguish individual strata Good preservation, mostly
-6.40	-6.95	PB02-17	PB03-16	Samples: animal bone from -6.75 masl; piece of worked wood from -6.90 masl		Med	C4	As PB02-16, but now with more clearly defined alternations of charcoal, hazelnut shells, straw and woodchips, though still not really feasible to distinguish individual strata Good preservation
-6.95	-7.35	PB02-18	No match in PB1 or PB3			Med	C2	Dark-grey to blackish, very silty humus with some roots and a few badly rotted pieces of wood Marked H <sub>2</sub> S odour Poor preservation
-7.35	-7.70	PB02-19	PB01-11 PB03-17 (probably)			Med	C3	Dark-grey/brown, very sandy humus with silt, some stones and some half-rotted pieces of wood Medium preservation
-7.70	↓	PB02-20	PB01-11 PB03-18 (probably)			Med	C0	Thin lenses of grey, very silty humus with some gravel, hazelnut shells and straw, alternating with thin lenses of slightly gravelly, clayey sand with traces of calcium carbonate (from sea shells) Probably some kind of seabed deposit Preservation indefinable
								Rotary drilling abandoned at -8.05 masl (possibly because of stone block)



### 3.3.4 Drilling 3 (PB3): sediment sequence (visual inspection)

This hole was about 0.5 metre – by off-set measurement – from the sheet piling. Its coordinates were later determined by triangulation as X67208.40/Y59834.40, and the modern brick-laid surface was at an elevation of ca. 1.75 masl.

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
1.75	0.55	PB03-01	PB01-01 PB02-01			Mod	E0	Stone and pebble fill under brick-laid surface
0.55	-0.35	PB03-02	PB02-03			Mod	E0	Redeposited culture-layer, very humified with severely rotted woodchips, some pieces of charcoal and red brick; a few interspersed small patches of light-grey clay (Very poor preservation)
-0.35	-0.55	PB03-03	PB01-03?  PB02-04			Recent	C2	Dark-grey/brown silty humus with a little sand and some smallish stones, a few badly rotted woodchips and a few hazelnut shells Poor preservation
-0.55	-1.25 (ca.)	PB03-04	PB01-03?  PB02-05			Post med	C2	Dark-brown silty, sandy humus with a lot of quite decayed vegetable matter (especially moss) and some half-rotted woodchips, bark pieces, hazelnut shells, twigs and fish bones Soil sample 1 Poor preservation
-1.25 (ca.)	-1.65	PB03-05	PB01-04?  PB02-06			Post med	C1	Loose, dark-grey/brown silty, sandy humus with some rotted woodchips No colour change Very poor preservation
-1.65	-1.85	PB03-06	PB02-07			Post med	C3	Medium-brown vegetable matter, but small degree of lamination: mostly moss and straw with some hazelnut shells, a few animal bones, and probably fish bones too, a minor quantity of fine to coarse sand present Vegetable matter was partly decayed and loose, but its structure was still well visible  Sample 2 (bone) from -1.70 masl No colour change Medium preservation

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
-1.85	-2.25	PB03-07	PB02-08?			Post med	C2	Loose, dark-grey/brown humus with some stones and large, half-rotted woodchips, a few hazelnut shells and pieces of charcoal Sample 3 (woodchip) from -1.90 masl Weak smell of hydrocarbons at around -1.95 masl No colour change Poor preservation
-2.25	-3.25 (ca.)	PB03-08	PB02-10			Post med and med (?)	C2	Loose, grey sand (fine to coarse) and gravel with a little silt, a minor quantity of woodchips and hazelnut shells, some smallish pieces of animal bone, a few sea shell fragments Small fragments of red brick down to -2.50 masl Sample 4 (bone) from -2.60 masl No colour change Poor preservation
-3.25 (ca.)	-3.95	PB03-09	PB02-11 PB02-13?			Med	C3	As above, but increasing quantity of woodchips (fresher in colour but still easily snapped), hazelnut shells and animal bones Sample 5 (leather) from -3.40 masl Sample 6 (bone) from -3.70 to -3.80 masl Sample 7 (leather) from -3.90 masl Sample 8 (soil) from -3.55 masl No colour change Medium preservation
-3.95	-4.05	PB03-10	No match in PB1 or PB2			Med	C3	Possible timber (large wood pieces came up on drill, and greater resistance noted)
-4.05	-4.25							Nothing adhered to the drill

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
-4.25	-4.65	PB03-11	No match in PB1 or PB2			Med	C4	Very sandy, medium-grey humus, more compact than overlying strata, with a good deal of fresh-looking woodchips, hazelnut shells, some animal bones, and small fragments of sea shell Sample 9 (woodchip) from -4.65 masl Slight darkening in colour Good preservation
-4.65	-4.85	PB03-12	Top of PB01-08			Med	C3	Concentration of laminated vegetable matter, mostly straw Sample 10 (soil) from -4.80 masl Medium preservation
-4.85	-5.25 (ca.)	PB03-13	PB02-15			Med	C0	Loose, stony, sandy dark-grey humus, only a few organic constituents Preservation indefinable
-5.25 (ca.)	-5.65	PB03-14	PB01-09	1 rim-sherd of Paffrath ware from -5.40 masl	618/4	Med (early?)	C3	Very sandy, relatively compact, medium-grey humus with a good deal of fresh-looking woodchips, hazelnut shells and vegetable matter, some animal bones, and small fragments of sea shell Sample 11 (leather) from -5.40 masl Slight darkening in colour Medium preservation
-5.65	-6.05	PB03-15	PB01-09 PB02-16			Med (early)	C4	Relatively compact and laminated vegetable matter with some silty, sandy humus, many fresh-looking woodchips and larger pieces of wood (most resisted snapping), some twigs and pieces of bark, a few hazelnut shells, no animal bones visible Sample 12 (wood) from -5.75 masl Good preservation
-6.05	-6.25							Nothing adhered to the drill

Masl		Stratum number	Same as stratum no.	Finds	Accession number	Period	PC	Description
From	To							
-6.25	-7.05	PB03-16	PB01-10 PB02-17	1 wall-herd of glazed Grimston ware from -6.75 masl	618/11	Med (early)	C4	As PB03-15, but fewer large pieces of wood; some fish bones, a single animal bone Somewhat loose from -6.65 to -6.75 masl, quite compact and laminated otherwise Sample 13 (soil) from -6.65 to -6.75 masl Sample 14 (soil) from -6.85 to -6.95 masl Sample 15 (leather) from ca. -6.55 masl Relatively rapid deposition Good preservation
-7.05	-7.25 (ca.)							Nothing adhered to the drill
-7.25 (ca.)	-7.65 (ca.)	PB03-17	PB02-19 (probably)			Med (early)	C3	Looser (but still relatively compact), mostly dark-grey silty, homogeneous humus, some woodchips and larger pieces of wood, a few hazelnut shells and some animal bones, one small scrap of leather (sample?), many pebbles Soil quite dry Medium preservation
-7.65 (ca.)	-8.45	PB03-18	PB01-11 PB02-20 (probably)	6 wall-sherds of (early) medieval cooking-pot wares from ca. -7.90 masl	618/5-618/10	Med (early)	C0	As PB03-16, but now more ooze-like and grey/brown in colour, with some sea shell fragments Sample 16 (soil) from -7.85 to -7.95 masl Soil quite dry to touch Preservation indefinable
-8.45	↓	PB03-19	PB01-12					Light-grey fine sand/silt Most of the soil was washed off the drill on retraction
								Rotary drilling abandoned at -8.85 masl

### 3.3.5 Finds/dating

PB1: archaeological material

- from -2.95 masl came 1 sherd of medieval glazed Grimston ware (accession number 618/1)
- from between -6.25 and -7.25 masl came 1 sherd of medieval cooking-pot (accession number 618/2)

PB2: archaeological material

- from -3.80 masl came 1 sherd of uncertain type, probably late medieval (accession number 618/3)

PB3: archaeological material

- from -5.40 masl came 1 rim-sherd of Paffrath ware, early medieval (accession number 618/4)
- from -6.75 masl came 1 sherd of medieval glazed Grimston ware (accession number 618/11)
- from between -7.85 and -7.95 masl came 6 sherds of (early) medieval cooking-pot (accession numbers 618/5-/10)

All things considered, it is probable that the transition to medieval deposits occurs somewhere between -2.50 and -3.00 masl.

### 3.3.6 PB1-PB3: state of preservation comments and general discussion

As Matthiesen has rightly pointed out, there is a relatively lengthy section in PB1 – from -1.80 to -4.75 masl – where it was not possible to match up the strata to the strata in PB2 or PB3. The question is: what is this due to? Matthiesen has asked Dunlop to evaluate three possibilities: 1) that the apparent lack of correspondence is due to differences in state of preservation; 2) that there is a real stratigraphic/depositional difference (i.e., difference in context); and 3) that the driving of the sheet piling caused a physical disturbance in this section of PB1 in particular, with the original strata being either replaced or mixed with foreign material.

As regards explanation model 1, reference to table 1 will quickly reveal that the state of preservation in the relevant sections of PB1 and PB3 is quite similar. Model 1 thus seems not so plausible.

As for model 2, there certainly are archaeological situations where one finds very little horizontal separation between dissimilar strata. One such case – a case, furthermore, that is widespread in the Bryggen area – is the box-like raft of interlocking logs used as a foundation for quays and buildings (Norw.: *bolverkskar*). The deposits inside and outside such rafts can be completely different, even though at the same elevation. This is undeniably a possibility – but to verify it would mean excavating down to a depth of at least 5 metres, which is not really on the cards.

However, and all things being equal etc etc, the author's money would have to be on – and, being Scottish, the author is careful with his money! – explanation model 3: a local disturbance right next to the sheet piling, most likely caused by the sheet piling's hitting a stone or timber and forcing it downwards for some way.

Comparing the elevation of the natural in PB1 and PB3, there is definitely evidence that the ramming down of the sheet piling has also resulted in a local downward deformation of the natural surface.

There was felt to be a qualitative difference between the sequences in PB1-PB3 and those found in Rotary drilling 1 and MB4 investigated in 2002; these two drillings were situated only about 3.5 metres to the south-east of PB2. However, the soil colours in PB1-PB3 were less bright, and the consistency of the soil was generally less firm. Table 1 attempts to present the state of preservation situation in the five drillings carried out in this area.

**Table 1:** Tabular comparative presentation of deposit “health” in various drillings at Bugården, Bryggen, Norway (table format developed from Christensson). Shaded column denotes drilling closest to the sheet piling. Each symbol represents a length of about 20 centimetres, with depth increasing towards the right.

Rotary drilling 1 (2002)	MB4 (coring, 2002)	PB1	PB3	PB2	Masl
		0000	0000	0000	2.0 – 1.0
?XXXX	XXXXX	?????	00???	?????	1.0 – 0.0
XXXXX	?????	??XXX	??XXX	??XXX	0.0 – -1.0
XXXXX	?????	XXXXX	XXXXX	XXXXX	-1.0 – -2.0
?XXXX	?????	XXXXX	XXXXX	00XXX	-2.0 – -3.0
XXXXX	XXXXX	XXXX	XXXXX	XXXXX	-3.0 – -4.0
XXXXX	?????	XXXX	0XXX?	XXXXX	-4.0 – -5.0
XXXXX	XXXXX	XXX	?XXXX	XXXXX	-5.0 – -6.0
XXXXX	??X	XXX	0XXXX	XXXXX	-6.0 – -7.0
XX???		XXXXX	0XX??	XXXX?	-7.0 – -8.0
XXXXX		XXXN	??N		-8.0 – -9.0
XXN					-9.0 – -10.0
Increasing depth within each 1 m length —>					

SYMBOLS	
X - VERY POOR	X - VERY GOOD
X - POOR	? - INDEFINABLE
X - MEDIUM	0 - NO SOIL RECOVERED
X - GOOD	N - NATURAL

### 3.4 Rotary drillings, Copenhagen, 2005

#### 3.4.1 General remarks

In early December 2005, eight auger drillings were carried out in the centre of Copenhagen, distributed among three separate locations: Pilestræde 63 (2 drillings), Amaliegade 41 (4 drillings), and Knabrostræde 16 (2 drillings).

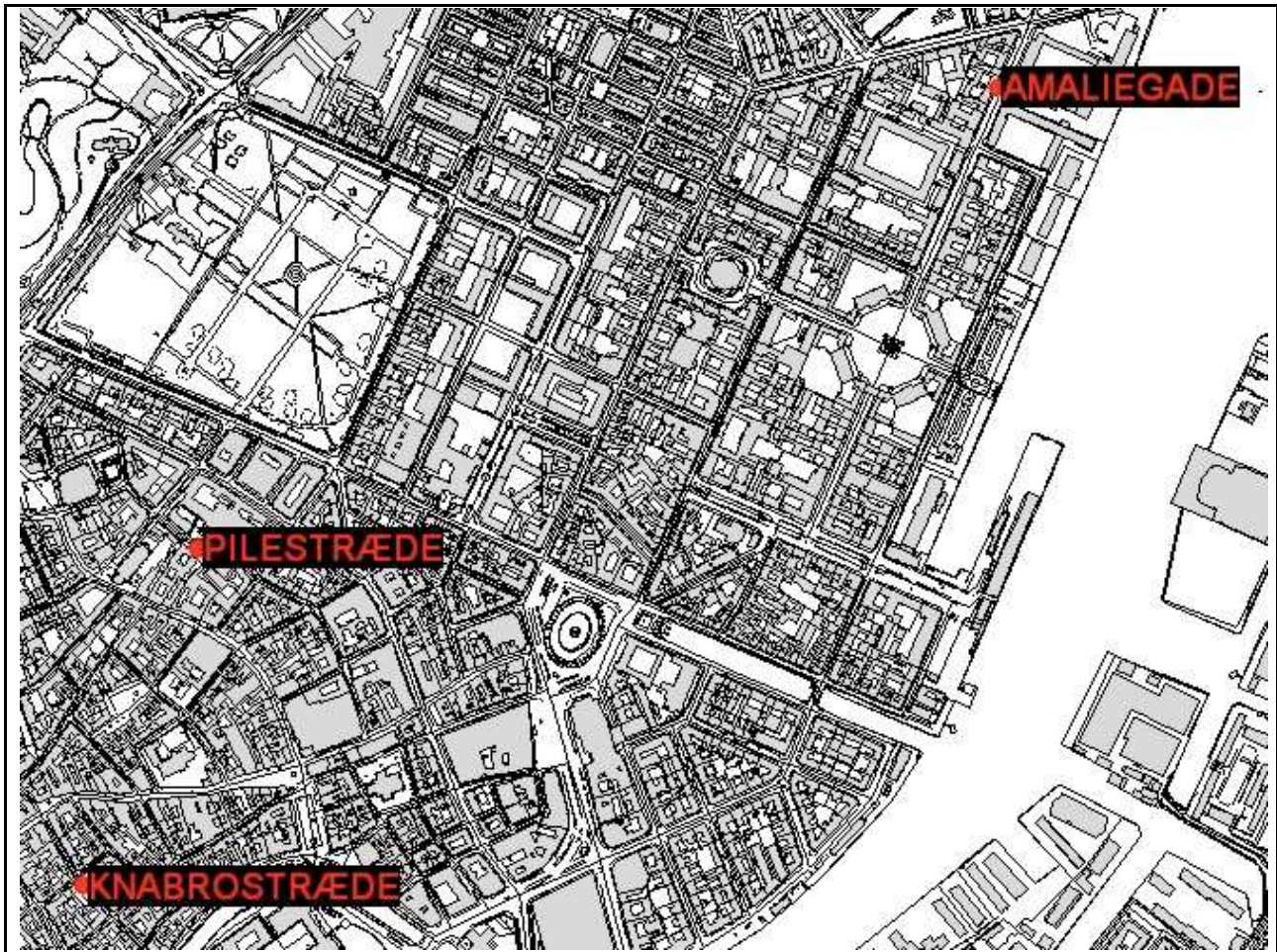


Figure 2. Location of the three drilling sites in Copenhagen (after Poulsen, 2005).

The various strata distinguished in the drillings have been numbered in the following way. First comes “PK0X” (for the drilling in question: P for *Peleprosjekt*, K for København – Copenhagen), followed by sequential numbering of the individual stratum (from top to bottom).

### 3.4.2 Pilestræde 63

The investigated pile was installed in 1989. Attention is drawn to the fact that PK1 – or at least its upper part – lay inside the building pit, so that most of the deposits down to ca. 4.00 KNN were very likely redeposited soil.

Weather conditions during recording of the Pilestrædet drillings were poor, with persistent rain/drizzle and bad light.

Drilling 1 (PK1): sediment sequence (visual inspection)

This hole was 1.0 metre from the side of the building, and the modern surface was at an elevation of ca. 6.00 KNN (KNN stands for the local ordnance datum).

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating /finds	Accession number	Period	PC	Description
From	To							
6.00	4.90	PK01-01				Mod	E0	Hole dug down through modern deposits to ensure avoidance of power cables etc

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating /finds	Accession number	Period	PC	Description
From	To							
4.90	4.50	PK01-02				Mod	E0	Grey, sticky, clayey soil with a lot of mortar and many pieces of light-coloured brick, some pebbles and a few pieces of charcoal Possibly demolition deposit, or possibly backfill in the building pit 1 sherd of modern window-pane from 1.35 m depth
4.50	4.25	PK01-03				Mod	E0	Grey clay with some small pieces of red brick/tile and charcoal, a little gravel and a few pebbles No odour
4.25	4.15	PK01-04				Mod	E0	Medium-grey fine sand
4.15	4.00 (?)	PK01-05	PK02-02?			Mod (?)	?	Trace of dark-grey soil with some humus, all organic matter practically entirely degraded Very faint H <sub>2</sub> S odour The stratum's downward extension never materialized, so perhaps it just represents soil redeposited as part of backfill in building pit
4.00 (?)	3.80 (?)	PK01-06				(?)	?	As PK01-03, but without the pieces of brick/tile Possible levelling deposit
3.80 (?)	3.50	PK01-07				(?)	?	As PK01-06, but slightly more homogeneous and fewer pieces of charcoal Darker than PK01-06, perhaps because of downward transport of dissolved carbon from charcoal Possibly accumulated in a swampy depression
3.50	↓	PK01-08						The natural: light-grey clay

Drilling was abandoned at 4.00 metres depth. Two digital photos were taken of the length from 4.00 to 3.00 KNN.

Drilling 2 (PK2): sediment sequence (visual inspection)

This hole was 1.5 metres from the side of the building, and the modern surface was at an elevation of ca. 6.00 KNN (KNN stands for the local ordnance datum).

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating /finds	Accession number	Period	PC	Description
From	To							
6.00	4.85	PK02-01				Mod	E0	Hole dug down through modern deposits to ensure avoidance of power cables etc



KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating /finds	Accession number	Period	PC	Description
From	To							
4.85	4.75	PK02-02	PK01-05?			Mod (?)	?	Dark-grey sandy humus with some silt and clay, and some small pieces of charcoal, mortar and red brick/tile Very faint H <sub>2</sub> S odour
4.75	4.40	PK02-03				Mod (?)	?	As PK02-02, but now with clay as principal constituent Very faint H <sub>2</sub> S odour Piece of animal bone from 4.55 KNN
4.40	-0.85 (?)	PK02-04		Red brick/tile down to at least 0.10 KNN		Mod (?)	?	Light-grey clay, some gravel and pebbles (including a lot of chalk), a few small pieces of red brick/tile, alternating with pockets/lenses of grey, chalky sand No real stratum differentiation possible (or necessary) Small fragments of rotted wood from 2.65 KNN Fragment of rotted, fibrous wood from 1.10 KNN Fragments of rotted, fibrous wood from 0.30 KNN Stratum became more visibly moist below 2.00 KNN, and quite wet from 1.00 KNN and on down
-0.85 (?)	-1.50	PK02-05				Mod (?)	?	More compact light-grey clay with quite a lot of sand Relatively well-preserved fragment of wood from -0.90 KNN
-1.50	↓	PK02-06						Presumed natural: at least an impenetrable deposit

Drilling was abandoned at 7.50 metres depth (-1.50 KNN). One digital photo was taken of the length from 1.00 to 0 KNN.

The marked stratigraphic and topographic differences between PK1 and PK2 cannot be accounted for at present. These two drillings will not be discussed further, since they have nothing to contribute to the problem being addressed.

### 3.4.3 Amaliegade 41

The site almost directly across the street from Amaliegade 41 was partially investigated by means of exploratory trenches in 2003, and should be consulted for supplementary archaeological information (Høst-Madsen, 2003). Archaeological investigations have also been carried out at Amaliegade 37 and 39, and are referred to in Høst-Madsen's report.

The investigated pile was a driven pile installed in 1957. Attention is drawn to the fact that PK3 and PK6 – or at least their upper parts – lay inside the building pit, so that most of the deposits down to ca. 0.20 and 0.40 KNN respectively were very likely redeposited soil.

Weather conditions during recording of the Amaliegade drillings were good, somewhat cold but dry and sunny.

Drilling 3 (PK3): sediment sequence (visual inspection)

This hole was 0.5 metres from the side of the building, and the modern surface was at an elevation of ca. 2.10 KNN (KNN stands for the local ordnance datum).

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating /finds	Accession number	Period	PC	Description
From	To							
2.10	0.60	PK03-01				Mod	E0	Hole dug down through modern deposits to ensure avoidance of power cables etc Soil with a lot of organic matter (including animal bones) visible, and numerous sherds of Delft Preservation indefinable
0.60	0.20	PK03-02				?	-	Soil lost because a concrete block became wedged between drill and pipe lining the hole
0.20	0.10	PK03-03	PK04-02? PK06-03?			?	-	Trace of dark-brown fine sand with humus, a little coarse sand/gravel, a few small pieces of red brick/tile, and a couple of small, badly preserved woodchips Preservation indefinable
0.10	-0.10	PK03-04				?	B0	Grey fine sand with some gravel and pebbles, and a few small pieces of charcoal Groundwater-level at ca. 0.05 KNN
-0.10	-0.35	PK03-05	PK04-05 PK05-07 PK06-05			Pre-historic	C1	Light-grey/brown fine sand with some horizontal flecks/lenses of brownish humus-like matter (probably decayed wood), a couple of small, very badly preserved pieces of wood, and one piece of flint Stratum became coarser from -0.25 to -0.35 KNN Very poor preservation
-0.35	-0.60	PK03-06	PK04-06 PK05-08					Top of the natural: light-grey/bluish clay and fine sand, some gravel and pebbles

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating /finds	Accession number	Period	PC	Description
From	To							
-0.60	-1.60	PK03-07	PK04-07 PK05-09					Light-grey/bluish clay with a very small amount of silt and fine sand, some pebbles (both rounded and irregular, and including some chalk), a few small pieces of sea shell, and a few patches of decayed wood or other vegetable matter
-1.60	↓	PK03-08	-					Light-brown/grey clay, silt and fine sand

Drilling was abandoned at 4.00 metres depth (-1.90 KNN). One digital photo was taken of the length from 0.10 to -0.90 KNN.

Drilling 4 (PK4): sediment sequence (visual inspection)

This hole was 2.75 metres from the side of the building, and the modern surface was at an elevation of ca. 2.00 KNN (KNN stands for the local ordnance datum).

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating /finds	Accession number	Period	PC	Description
From	To							
2.00	0.50	PK04-01				Mod	E0	Hole dug down through modern deposits to ensure avoidance of power cables etc Soil with a lot of organic matter (including animal bones) visible Preservation indefinable
0.50	0.20	PK04-02	PK03-03? PK06-03?			mid 17 <sup>th</sup> - mid 18 <sup>th</sup> C(?)	A2	Dark-brown/(grey) humus, a little fine sand, one half-rotted woodchip, some soft pieces of charcoal, some thin hairs or fur Some relatively large, black, animal bone fragments from 0.35 KNN (taken for analysis by Matthiesen) Marked H <sub>2</sub> S odour No colour change Slight sponge reaction under compression Poor preservation
0.20	0 (?)	PK04-03					-	Obstruction, probably a large stone (drilled through)
0 (?)	-0.10 (?)	PK04-04				mid 17 <sup>th</sup> - mid 18 <sup>th</sup> C(?)	?	Possible continuation of PK04-02, possibly just soil from PK04-02 pushed down in front of the drill

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating /finds	Accession number	Period	PC	Description
From	To							
-0.10 (?)	-0.45	PK04-05	PK03-05  PK05-07  PK06-05			Pre-historic	C1	Light-grey/brown fine sand with some horizontal flecks/lenses of brownish humus-like matter (probably decayed wood), a couple of small, very badly preserved pieces of wood, and four relatively large pieces of flint Stratum became coarser from -0.35 to -0.45 KNN Stratum was slightly more organic and slightly better-preserved than PK03-05 Very poor preservation
-0.45	-0.70	PK04-06	PK03-06  PK05-08					Top of the natural: light-grey/bluish clay and fine sand, some gravel and pebbles
-0.70	-1.80 (?)	PK04-07	PK03-07  PK05-09					Light-grey/brownish(/bluish) clay with a very small amount of silt and fine sand, numerous pebbles (both rounded and irregular, and including some chalk), a few small pieces of sea shell, and a few patches of decayed wood or other vegetable matter Very compact, and saturated (though seemingly dry to the naked eye)
-1.80 (?)	↓	PK04-08	PK03-08					Light-grey/blue clay, silt and fine sand Visibly more moist than PK04-07 Softer and more silty than PK03-08

Drilling was abandoned at 4.00 metres depth (-2.00 KNN). Two digital photos were taken of the length from 0.50 to 0.20 KNN, and one digital photo of the length from 0 to -1.00 KNN.

Drilling 5 (PK5): sediment sequence (visual inspection)

This hole was 2.75 metres from the side of the building, and the modern surface was at an elevation of ca. 2.00 KNN (KNN stands for the local ordnance datum).

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
2.00	0.45	PK05-01				Mod	E0	Hole dug down through modern deposits to ensure avoidance of power cables etc Soil with a lot of organic matter (including animal bones) visible Preservation indefinable
0.45	0.35	PK05-02		1 wall-sherd of post-medieval/relatively modern red-ware from 0.35 KNN		mid 17 <sup>th</sup> -mid 18 <sup>th</sup> C(?)	A0	Light-brown fine to coarse sand
0.35	0.20	PK05-03				mid 17 <sup>th</sup> -mid 18 <sup>th</sup> C(?)	A3	Highly organic: dark-yellow/brown/green, laminated animal dung and straw/vegetable matter, compact A few black, animal bone fragments Marked H <sub>2</sub> S odour Slight, slow colour change Medium preservation (but not as well preserved as similar layers found at Bryggen)
0.20	0.17 (ca.)	PK05-04					A0	Probable streak/pocket of light-grey fine sand, somewhat coloured by leached humus
0.17 (ca.)	-0.05	PK05-05		Sherd of post-medieval/relatively modern glass from ca. 0.10 KNN		mid 17 <sup>th</sup> -mid 18 <sup>th</sup> C(?)	B3	Highly organic: as PK05-03, but possibly a little more sandy Marked H <sub>2</sub> S odour Medium preservation Groundwater-level at ca. 0.05 KNN
-0.05	-0.12	PK05-06	PK06-04			mid 17 <sup>th</sup> -mid 18 <sup>th</sup> C(?)	C0	Light-grey fine sand with numerous fragments of sea shell
-0.12	-0.45	PK05-07	PK03-05 PK04-05 PK06-05			Pre-historic	C1	Light-grey/brown fine sand with some horizontal flecks/lenses of brownish humus-like matter (probably decayed wood), a couple of small, very badly preserved pieces of wood, and four relatively large pieces of flint Stratum became coarser from -0.35 to -0.45 KNN Very poor preservation

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
-0.45	-0.70	PK05-08	PK04-06					Top of the natural: light-grey/bluish clay and fine sand, some gravel and pebbles
-0.70	-1.45	PK05-09	PK04-07					Light-grey/brownish(/bluish) clay with a very small amount of silt and fine sand, numerous pebbles (both rounded and irregular, and including some chalk), a few small pieces of sea shell, and a few patches of decayed wood or other vegetable matter Very compact, and saturated (though seemingly dry to the naked eye)
-1.45	↓	PK05-10	-					As PK05-09, but lesser amount of clay Relatively friable, and thus hard to roll out into strips

Drilling was abandoned at 4.00 metres depth (-2.00 KNN). One digital photo was taken of the length from 0.50 to 0 KNN, and two digital photos of the length from 0 to -1.00 KNN (one detail of the upper half).

Drilling 6 (PK6): sediment sequence (visual inspection)

This hole was 0.5 metres from the side of the building, and therefore probably lay within the building pit. The modern surface was at an elevation of ca. 2.10 KNN (KNN stands for the local ordnance datum).

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
2.10	0.50	PK06-01				Mod	E0	Hole dug down through modern deposits to ensure avoidance of power cables etc Soil with a lot of organic matter (including animal bones) visible Preservation indefinable
0.50	0.40	PK06-02				Mod (?)	?	Grey, fine to medium-fine sand with a small amount of charcoal, brick/tile, and pebbles

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
0.40	-0.05	PK06-03	PK03-03?  PK04-02?			Mod (?)	A2 / B2	Dark-grey(/brown) fine sand with some humus, a couple of small, quite rotted wood-chips, some pieces of charcoal, and some small pieces of red brick/tile and chalk One animal bone fragment from 0.35 KNN (taken for analysis by Matthiesen) Faint H <sub>2</sub> S odour No colour change, but stratum became gradually darker with depth Increasing amount of humus and organic matter with depth Poor preservation
-0.05	-0.10	PK06-04	PK05-06			mid 17 <sup>th</sup> -mid 18 <sup>th</sup> C(?)	C0	Light-grey fine sand with numerous fragments of sea shell
-0.10	-0.35	PK06-05	PK03-05 PK04-05 PK05-07	<sup>14</sup> C-dating: 5600-5525BC		Pre-historic	C1	Light-grey/brown fine sand with some horizontal flecks/lenses of brownish humus-like matter (probably decayed wood), a couple of small, very badly preserved pieces of wood, and one piece of flint Stratum became coarser from -0.25 to -0.35 KNN Radiocarbon dating sample taken from -0.15 to -0.20 KNN Very poor preservation
-0.35	-0.65 (ca.)	PK06-06	PK03-06					Top of the natural: light-grey/bluish clay and fine sand, some gravel and pebbles
-0.65 (ca.)	-1.15	PK06-07	PK05-09					Light-grey/brownish(/bluish) clay with a very small amount of silt and fine sand, numerous pebbles (both rounded and irregular, and including some chalk), a few small pieces of sea shell, and a few patches of decayed wood or other vegetable matter Very compact, and saturated (though seemingly dry to the naked eye)

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
-1.15	-1.70 (ca.)	PK06-08	PK05-10					As PK06-07, but lesser amount of clay Relatively friable, and thus hard to roll out into strips
-1.70	↓	PK06-09	-					Grey sand with many fragments of sea shell

Drilling was abandoned at 4.00 metres depth (-1.90 KNN). One digital photo was taken of the length from 0.50 to 0.10 KNN.

### 3.4.4 Knabrostræde 16

The property Brolæggerstræde 9 – which is actually the same as Knabrostræde 16 – was partially investigated by means of numerous trial pits in 2003, and should be consulted for supplementary archaeological information (Poulsen, 2003).

The investigated pile was a cylindrical, concrete pile installed by driving in 2003.

Weather conditions during recording of the Knabrostræde drillings were good, somewhat cold but sunny.

Drilling 7 (PK7): sediment sequence (visual inspection)

This hole was 2.10 metres from the side of the building. The modern surface was at an elevation of ca. 3.55 KNN (KNN stands for the local ordnance datum).

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
3.55	2.30	PK07-01				Mod and post med	-	Hole dug down through modern deposits to ensure avoidance of power cables etc Perhaps some demolition deposit from after the fire of 1728 present in the bottom 10 cms Preservation indefinable
2.30	1.95	PK07-02	PK08-03			Post med	A0	Yellow-brown compact, tacky clay with some sand and gravel (but still easy to roll out into strips), some charcoal, red brick/tile, and mortar lumps (especially in the upper portion) Probably levelling layer, according to Poulsen
1.95	1.90	PK07-03	PK08-04			Post med	A0	Light-grey fine sand with a few pebbles, and perhaps a few pieces of decayed bone
1.90	1.85	PK07-04	PK08-05			Post med	A0	(Light-)grey clay, very homogeneous, sticky and “fatty”, with a few soft pieces of charcoal



KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
1.85	1.25	PK07-05	PK08-06			Med (?)	A1 B1	Dark-grey (with slight brown tone), sticky humus with some fine sand and a few small clay flecks, some small pieces of charcoal or burnt wood and a few fragments of animal bone Groundwater at 1.45 KNN Stratum became browner with depth Slight, slow colour change Faint H <sub>2</sub> S odour Very poor preservation
1.25	1.20	PK07-06	PK08-07			Med (?)	C0	Light-blue/grey clay
1.20	0.70	PK07-07	PK08-08	3 wall-sherds of medieval grey ware from 0.90 KNN  <sup>14</sup> C-dating: AD1055-1215		Med	C3	As PK07-05, but brown rather than grey, and somewhat more compact and homogeneous, numerous small pieces of wood or woodchips (half-rotted and mostly horizontal), some bones (both animal and fish) Radiocarbon dating sample taken 0.75 KNN Soil was friable, and blocks broke easily under pressure Stratum became more sandy in the bottom 10 cms Slight, slow colour change Marked H <sub>2</sub> S odour Medium preservation
0.70	0.30	PK07-08					C2	Dark-brown clayey humus with some woodchips and a few small clay flecks More medium-grey/brown from 0.55 to 0.40 KNN Poor preservation
0.30	0.25	PK07-09	PK08-10				-	Top of the natural: grey clay, slightly sandy but otherwise pretty homogeneous
0.25	0.00	PK07-10	PK08-11				-	Unstructured mixture of all kinds of mineral components: clay, sand (all particle sizes), gravel and pebbles (including quite a lot of chalk)
0.00	-0.05	PK07-11	PK08-12				-	Light-grey/yellow fine to medium-fine sand

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
-0.05	↓	PK07-12	PK08-13				-	Grey, relatively well-sorted coarse sand (many reddish grains) Possibly beach sand Turned gradually more dark-brown with depth

Drilling was abandoned at 5.00 metres depth (-1.45 KNN). Two digital photos were taken of the length from 2.30 to 1.55 KNN (one a detail of 1.95 to 1.55 KNN), three digital photos of the length from 1.55 to 0.55 KNN (one of the whole length, plus one close-up of each half), and two digital photos of the length from 0.55 to -0.45 KNN (one a detail of 0.55 to 0.05 KNN).

Drilling 8 (PK8): sediment sequence (visual inspection)

This hole was 0.95 metres from the side of the building. The modern surface was at an elevation of ca. 3.60 KNN (KNN stands for the local ordnance datum).

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession no.	Period	PC	Description
From	To							
3.60	2.60	PK08-01				Mod	-	Hole dug down through modern deposits to ensure avoidance of power cables etc Preservation indefinable
2.60	2.50	PK08-02				Post med	A0	Sandy soil with quite a lot of smashed red brick/tile, a little charcoal and a few mortar lumps Probably a demolition deposit from after the fire of 1728
2.50	2.30	PK08-03	PK07-02			Post med	A0	Light-green/yellow/grey tacky, compact clay with a slight amount of sand and gravel (but still easy to roll out into strips), some charcoal, small pieces of red brick/tile, and mortar lumps (especially in the upper portion) Probably levelling layer, according to Poulsen
2.30	2.25	PK08-04				Post med	A0	As PK08-03, but now more brown than yellow
2.25	1.95	PK08-05	PK07-04			Post med	A0	(Light-)grey clay, very homogeneous, sticky and "fatty", with numerous soft pieces of charcoal (especially in stratum's lower half), and increasingly darker with depth

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession no.	Period	PC	Description
From	To							
1.95	1.30	PK08-06	PK07-05			Med (?)	A1 B1	Dark-grey (with slight brown tone), sticky humus with some fine sand and a few small clay flecks, some small pieces of charcoal or burnt wood and a few fragments of animal bone (Section from 1.60 to 1.30 KNN was lost due to a stone obstruction) Stratum became browner with depth Slight, slow colour change Faint H <sub>2</sub> S odour Very poor preservation
1.30	1.20	PK08-07	PK07-06			Med (?)	C0	Light-blue/grey clay
1.20	0.85	PK08-08	PK07-07			Med	C3	As PK08-06, but brown rather than grey, and somewhat more compact and homogeneous, numerous small pieces of wood or woodchips (half-rotted and mostly horizontal), some bones (both animal and fish) Soil was friable, and blocks broke easily under pressure Stratum became more sandy in the bottom 10 cms Slight, slow colour change Marked H <sub>2</sub> S odour Medium preservation
0.85	0.35	PK08-09				Med	C4	Relatively homogeneous stratum, rich-brown in colour – possibly sawdust, little humus Medium-fast colour change Marked H <sub>2</sub> S odour Good preservation, mostly [Pocket of possible laminated vegetable matter, badly decomposed, from 0.75 to 0.70 KNN (medium-grey/-brown in colour, only slight, slow colour change)]
0.35	0.25	PK08-10	PK07-09				-	Top of the natural: grey clay, slightly sandy but otherwise pretty homogeneous

KNN		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession no.	Period	PC	Description
From	To							
0.25	0.00	PK08-11	PK07-10				-	Unstructured mixture of all kinds of mineral components: clay, sand (all particle sizes), gravel and pebbles (including quite a lot of chalk)
0.00	-0.05	PK08-12	PK07-11				-	Light-grey/yellow fine to medium-fine sand
-0.05	↓	PK08-13	PK07-12				-	Grey, relatively well-sorted coarse sand (many reddish grains) Possibly beach sand Turned gradually more dark-brown with depth

Drilling was abandoned at 4.00 metres depth (-0.40 KNN). Two digital photos were taken of the length from 2.60 to 1.60 KNN (one a detail of the length's middle section), two digital photos of the length from 1.60 to 0.60 KNN (one a detail of 0.95 to 0.60 KNN), and one digital photo of the length from 0.60 to -0.40 KNN.

### 3.4.5 Finds/dating

#### Pilestræde

According to Poulsen, culture-layers found during previous investigations in the Pilestræde area are from the medieval period, without being able to date them more precisely. It is, however, very doubtful whether the drillings in 2005 encountered any intact culture-layers, and no finds were recovered from either drilling.

#### Amaliegade

##### PK5: archaeological material

- 1 small wall-herd of post-medieval/relatively modern red earthenware from ca. 0.35 KNN
- 1 sherd of post-medieval/relatively modern glass (window-pane) from ca. 0.10 KNN

##### PK6: radiocarbon dating

- radiocarbon dating of charcoal from stratum PK06-05 yielded a result of 6700±50 BP, calibrated to 5,600-5,525 BC (dating number TUa-5691) – which is somewhat earlier than expected!

According to Poulsen, culture-layers in the Amaliegade area should be mainly from the mid-17<sup>th</sup> to the mid-18<sup>th</sup> century. The finds from PK5 fit well with this, but the radiocarbon dating from PK6 most definitely does not. This will have to be investigated by excavation at some other time.

#### Knabrostræde

##### PK7: archaeological material

- 3 wall-sherds of medieval grey earthenware from 0.90 KNN (stratum PK07-07)

**PK7: radiocarbon dating**

- radiocarbon dating of charcoal from stratum PK07-07 yielded a result of 890±35 BP, calibrated to AD 1055-1215 (dating number TUa-5690) – which fits quite well with Poulsen’s archaeological datings.

According to Poulsen, the organic deposits at Knabrostræde 16 were formed in the 13<sup>th</sup> and 14<sup>th</sup> centuries (this means the deposits found slightly below 2.00 KNN and down to the natural). Both the finds and the radiocarbon dating from PK7 are in agreement with this dating.

**3.4.6 State of preservation comments**

Pilestræde can be disregarded in the context of the aims of the Piling Project, and Amaliegade has very little to contribute. Knabrostræde shows significant variation in state of preservation of the bottom of the two drillings – but with the better-preserved deposits being found in the drilling situated closer to the pile.

**Table 2:** Tabular comparative presentation of deposit “health” in eight drillings in Copenhagen, Denmark. Shaded columns denote drillings closest to existing piles. Each symbol represents a length of about 20 centimetres, with depth increasing towards the right.

PK1	PK2	PK3	PK4	PK5	PK6	PK7	PK8	KNN
00000	00000							6.0 – 5.0
?????X	0????							5.0 – 4.0
???N	?????					000	000	4.0 – 3.0
	?????					000??	???	3.0 – 2.0
	?????	00000	00000	00000	00000	?XXXX	XXXXX	2.0 – 1.0
	?????	000?	00XX?	000XX	000XX	XXXN	XXXN	1.0 – 0.0
	?????	XXN	XXN	?XN	XXN			0.0 – -1.0
	???N							-1.0 – -2.0
Increasing depth within each 1 m length —>								

SYMBOLS	
X - VERY POOR	X - VERY GOOD
X - POOR	? - INDEFINABLE
X - MEDIUM	0 - NO SOIL RECOVERED
X - GOOD	N - NATURAL

### 3.5 Rotary drillings, Lund, 2005

#### 3.5.1 General remarks

In early December 2005, two auger drillings were carried out in a courtyard right next to the site of Maria Minor Church in the centre of Lund (quarter of Minor Minor 4, address Vårfrugatan 8a). A number of soil samples for geochemical analysis were collected from the drillings in Lund, but none for radiocarbon dating.

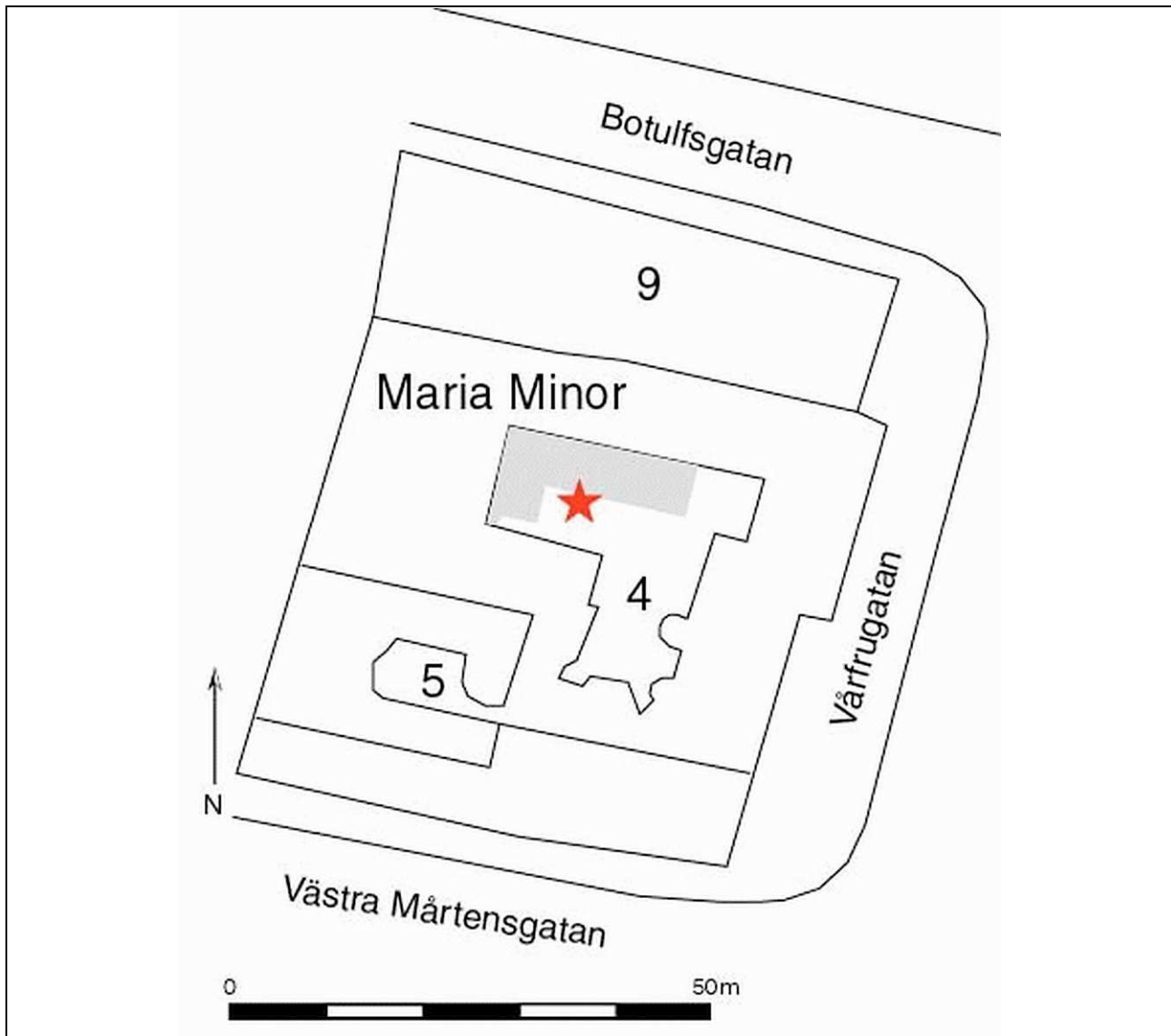


Figure 3. Location of investigation area (star) in Lund.

The investigated pile was one of in all 35 piles that were installed by drilling in late October and early November 1995. The piles were of concrete with titanium cores, and most had a diameter of 90 millimetres.

Owing to various factors, it was not possible to get as close to the chosen pile as one would have wanted, but the closer of the two boreholes was probably not more than about one metre from the pile.

The various strata distinguished in the drillings have been numbered in the following way. First comes “PLOX” (for the drilling in question: P for *Peleprosjekt*, L for Lund) followed by sequential numbering of the individual stratum (from top to bottom).

According to a local geotechnician, the water-table in this area can be assumed with confidence to coincide with the transition to the boulder clay underlying the cultural deposits.

Weather conditions during recording of the Lund drillings were good, somewhat cold but dry and with adequate light.

### 3.5.2 Drilling 1 (PL1): sediment sequence (visual inspection)

This hole was 0.9 metres from the side of the building, and the modern surface was at an elevation of ca. 37.65 masl.

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
37.65	37.35	PL01-01	PL02-01			Mod	E0	Surfacing over pebble/sand fill
37.35	37.20	PL01-02	PL02-02	1 sherd of porcelain		Mod	E0	Grey soil with sand, gravel and some clay, a few larger stones, some pieces of brick (red and yellow), and a few pieces of charcoal Levelling deposit, possibly redeposited soil
37.20	37.05	PL01-03	PL02-03			Mod	?	Light-yellow/brown clay, slight amount of sand, with some small pieces of red brick/tile and charcoal; relatively homogeneous Possibly redeposited soil
37.05	36.20	PL01-04 basal 5cm =	PL02-04 PL02-05	Iron nail from ca. 36.45 masl		17 <sup>th</sup> C.? Med (basal part?)	A2	Grey, unstructured, very clayey soil with a lot of charcoal (very decayed), some small pieces of red brick/tile and mortar, one piece of flint, and one sherd of modern window-pane from 36.95 masl (probably result of contamination) Very charcoal-rich from 36.25 to 36.20 masl (must correspond to PL02-05) Sample 1 from 36.30 to 36.20 masl Very probably a demolition deposit, apart from basal 5cm, which must be from firelayer

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
36.20	34.90	PL01-05	PL02-12	1 small metal needle from between 36.05 and 35.75 masl		Med	A2	Grey to dark-grey with brownish patches, clayey humus with numerous badly rotted pieces of wood (quantity increasing with depth) and fibrous wood; little in the way of charcoal, brick/tile and mortar Faint H <sub>2</sub> S odour No colour change A couple of patches of somewhat laminated and very decayed vegetable matter Piece of wood from 35.80 masl Sample 2 from 35.85 to 35.75 masl Sample 3 from 35.45 to 35.35 masl (only for analysis, no duplicate for storage) The length from 35.65 to 34.65 masl was very contaminated with material from higher up, making it difficult to identify strata clearly
34.90	34.80	PL01-06	PL02-13			Med	-	Blue-grey, plastic, wet, sandy clay, must be natural dug up and redeposited in connection with an older disturbance
34.80	34.55	PL01-07	PL02-14			Med	A2	Basically as PL01-05, but probably greater proportion of clay
34.55	↓	PL01-08	PL02-15				-	The natural: blue-grey, plastic, wet, sandy clay Sample 4 from 34.40 to 34.35 masl (only for analysis, no duplicate for storage)

Drilling was abandoned at 4 metres depth. One digital photo was taken of the length from 37.65 to 36.65 masl, two digital photos of the length from 36.65 to 35.65 masl (one a detail of 36.15 to 35.75 masl), and one digital photo of the length from 35.65 to 34.65 masl.

### 3.5.3 Drilling 2 (PL2): sediment sequence (visual inspection)

This hole was 1.9 metres from the side of the building, and the modern surface was at an elevation of ca. 37.65 masl. The uppermost metre was investigated only cursorily so as to save time; the depths of the transitions in this first metre must therefore be regarded as approximate.

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
37.65	37.35	PL02-01	PL01-01			Mod	E0	Surfacing over pebble/sand fill



Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
37.35	37.20	PL02-02	PL01-02			Mod	E0	Grey soil with sand, gravel and some clay, a few larger stones, some pieces of brick (red and yellow), and a few pieces of charcoal Levelling deposit, possibly redeposited soil
37.20	37.05	PL02-03	PL01-03			Mod	?	Light-yellow/brown clay, slight amount of sand, with some small pieces of red brick/tile and charcoal; relatively homogeneous Possibly redeposited soil
37.05	36.20	PL02-04	PL01-04	1 sherd of 17 <sup>th</sup> century drinking-glass from 36.30 masl		17 <sup>th</sup> C.?	A1	Grey, unstructured, very clayey soil with some charcoal (very decayed), a good deal of red brick/tile, mortar and stones Very probably a demolition deposit Very poor preservation
36.20	36.15	PL02-05	(Basal part of PL01-04)			Med	A2	Charcoal dominated Unstructured, probably remains of a firelayer Sample 5 from 36.20 to 36.15 masl
36.15	36.05	PL02-06				Med	A2	Dark-brown humus with some pieces of very decayed wood No odour No colour change Organic occupation deposit Poor preservation
36.05	36.00	PL02-07				Med	-	Yellow/brown clay with some sand, some pieces of brick/tile (red and yellow), and a little mortar/lime Very probably earth floor
36.00	35.95	PL02-08				Med	A2	Dark-brown/(grey) humus with some pieces of very decayed wood and a few of charcoal No odour No colour change Organic occupation deposit Poor preservation
35.95	35.90	PL02-09				Med	-	Yellow/brown clay with some sand, some pieces of brick/tile (red and yellow), and a little mortar/lime Very probably earth floor

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds	Accession number	Period	PC	Description
From	To							
35.90	35.85	PL02-10				Med	A2	Dark-brown/(grey) humus with some pieces of very decayed wood and a few of charcoal No odour No colour change Organic occupation deposit Sample 6 from 35.90 to 35.85 masl Poor preservation
35.85	35.65 (ca.)	PL02-11				Med	-	Yellow/brown clay with some sand, some pieces of brick/tile (red and yellow), and a little mortar/lime Very probably earth floor
35.65 (ca.)	34.95	PL02-12	PL01-05			Med	A2	Grey to dark-grey with brownish patches, clayey humus with numerous badly rotted pieces of wood (quantity increasing with depth) and fibrous wood; little in the way of charcoal, brick/tile and mortar Possibly more humus than in PL01-05 Faint H <sub>2</sub> S odour No colour change A couple of patches of somewhat laminated and very decayed vegetable matter Sample 7 from 35.05 to 34.95 masl Poor preservation
34.95	34.65 (?)	PL02-13	PL01-06			Med	-	Blue-grey, plastic, wet, sandy clay, must be natural dug up and redeposited in connection with an older disturbance
34.65 (?)	34.55	PL02-14	PL01-07			Med	A2	Bottom of cultural-deposit sequence (probably clayey humus with a little wood, but little material adhered to the drill) Poor preservation
34.55	↓	PL02-15	PL01-08				-	The natural: blue-grey, plastic, wet, sandy clay

Drilling was abandoned at 4 metres depth (ca. 33.5 masl). Two digital photos were taken of the length from 35.65 to 34.65 masl.

### 3.5.4 Finds/dating

PL1: archaeological material

- 1 sherd of porcelain from stratum PL01-02
- 1 sherd of modern window-pane from 36.95 masl (very likely result of contamination during drill retraction)
- 1 iron nail from ca. 36.45 masl
- 1 small metal needle (probably medieval) from between 36.05 and 35.75 masl

PL2: archaeological material

- sherd of 17<sup>th</sup> century glass beaker from 36.30 masl

It is likely that the transition to medieval deposits occurs at around 36.20 masl.

### 3.5.5 Archaeological interpretation

The soil sequences in the two drillings are relatively similar down to about 36.15 masl (ca. 1.5 m below the surface), implying similar depositional history and similar use of the immediate area. From this level and down to about 35.65 masl, however, there is a marked dissimilarity, reflecting two different archaeological situations.

The interpretation is as follows. In PL2, we have evidence of several successive occupation phases – three, altogether – of a building, with clay floors (strata PL02-06, PL02-08 and PL02-10, from youngest to oldest) and overlying occupation deposits (strata PL02-07, PL02-09 and PL02-11, from youngest to oldest), and with a destruction deposit (stratum PL02-05) marking the end of the third and final phase. In PL1, the charcoal concentration forming the basal part of stratum PL01-04 must correspond to stratum PL02-05, and this charcoal concentration must surely have been deposited outside the building (on the basis of the complete absence in PL1 of the successive building-occupation levels observed in PL2).

### 3.5.6 State of preservation comments

One half-metre section of PL2 displays a definite difference in archaeological context from PL1 – specifically, the above-mentioned building with clay floors and organic occupation deposits. Apart from this, the sequences are quite similar, and – as table 3 shows – there is very little difference between the two drillings in respect of the overall state-of-preservation picture, which is generally poor. Even the organic occupation deposits in PL2 – deposits that were sandwiched between layers of clay – are characterised as poorly preserved. The conclusion in this particular case is that the poor preservation must be the result of contemporary decomposition, i.e., while the layer was lying exposed during the occupation phase.

**Table 3:** Tabular comparative presentation of deposit “health” in two drillings in Lund, Sweden. Shaded column denotes drilling closer to existing pile. Each symbol represents a length of about 20 centimetres, with depth increasing towards the right.

PL1	PL2	Masl	Symbols
???	???	38.0 – 37.0	X - VERY POOR
XXXXX	XXXXX	37.0 – 36.0	X - POOR
XXXXX	XXXXX	36.0 – 35.0	? - INDEFINABLE
?XN	?XN	35.0 – 34.0	N - NATURAL
Increasing depth within each 1 m length →			

## 3.6 Rotary drillings, Trondheim, 2006

### 3.6.1 General remarks

In late August 2006, a series of auger drillings was carried out in Peter Egges Plass, where sheet piling had been erected around the Public Library site in 1991. Prior to drilling, a narrow trench was dug by machine and by hand perpendicularly outwards from the edge of the sheet piling so as to ensure that the sub-surface heating cables in this area were not damaged by the drill, and a local construction firm was hired to dig the trench, and to fill it in and re-lay the cobbles afterwards.

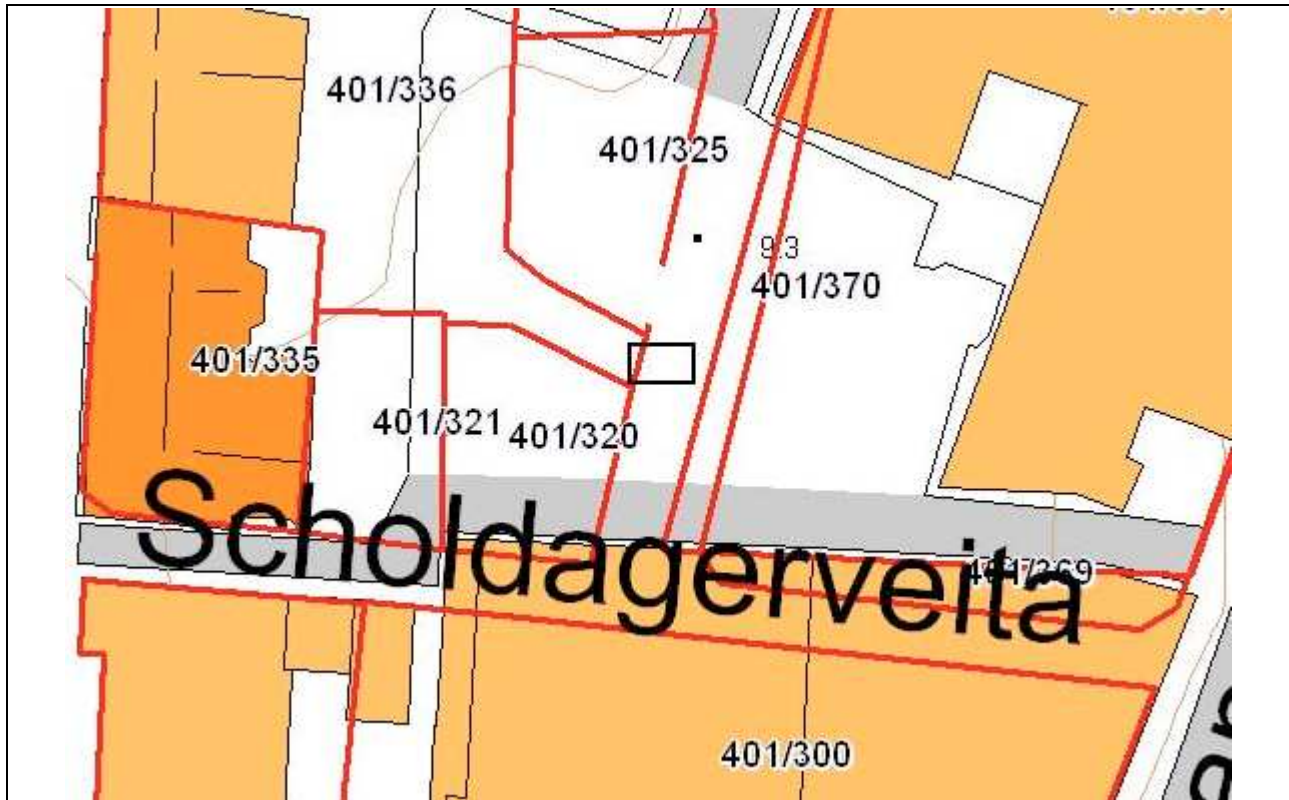


Figure 4. Location of investigation area (black-outlined rectangle) in Trondheim.

The idea was to carry out two drillings, one as close as possible to the sheet piling and the other at a distance of about one metre from the first hole. In the event, drilling was carried out/attempted at six points along the trench, but cultural deposits were encountered in only two of the holes (designated PTr3 and PTr6), due to the unexpected fact that the excavated area extended at least two metres out from the sheet piling. Not only that but there turned out to be much more severe vertical truncation of the deposits than expected, resulting in a reduction of the thickness of the cultural deposits to no more than 1.5 metres at the most.

A large number of soil samples for geochemical analysis were collected from the drillings in Trondheim, and one sample for radiocarbon dating.

The various strata distinguished in the drillings have been numbered in the following way. First comes "PTrX" (for the drilling in question: P for *Peleprosjekt*, Tr for Trondheim) followed by sequential numbering of the individual strata (from top to bottom).

As regards the elevation of the water-table, it is a matter of established fact that the water-table in the medieval urban area of Trondheim is to be found beneath the cultural deposits.

Weather conditions during recording of the Trondheim drillings were good, dry and mostly quite sunny.

### 3.6.2 Drilling 1 (PTr3): sediment sequence (visual inspection)

This hole was 2.65 metres from the edge of the sheet piling, and the modern cobbled surface was at an elevation of 9.40 masl.

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
9.40	7.70					Mod	E0	Cobbled surface over sand/-gravel/pebble fill (with underground heating cables 20 cm below cobbles) No sign of brick/tile pieces One piece of rotted wood at 7.90 masl, presumably re-deposited
7.70	7.50	PTr3-01				Mod	-	Dark-grey sandy soil with some humus and a few pieces of charcoal: transitional stratum between modern fill and culture-layers?
7.50	7.30	PTr3-02		PTr3-C Pose 0: 7.50-7.40 masl		?	-	Dark-grey soil with coarse sand, gravel, some pebbles, a slight amount of humus, and a few pieces of soft, quite decomposed charcoal No odour No colour change Preservation indefinable
7.30	7.15	PTr3-03	PTr6-01	PTr3-A Pose 1: 7.30-7.20 masl PTr3-C Pose 1		?	A2	Dark-grey sandy, gravelly soil with a little humus, some pebbles, and numerous large pieces of charcoal: possible disturbed/-spread firelayer No odour No colour change Poor preservation
7.15	6.95	PTr3-04		PTr3-C Pose 2		?	A1	Dark-brownish humus with many rotted woodchips and a few small pieces of birch-bark; some sand, gravel and pebbles Faint H <sub>2</sub> S odour No colour change Very poor preservation

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
6.95	6.80	PTr3-05		PTr3-A Pose 2: 6.90-6.80 masl PTr3-B Pose 1 (bone): 6.85 masl PTr3-C Pose 3		?	A2	Compact, dark-brownish humus with numerous rotted woodchips, some hazelnut shells and a few small pieces of birch-bark; some sand, gravel and pebbles Faint H <sub>2</sub> S odour Medium-fast darkening Poor preservation
6.80	6.75	PTr3-06	PTr6-03			?	-	Red-orange ash/sand with a lot of charcoal: probably an in situ firelayer No odour Preservation indefinable
6.75	6.65	PTr3-07	PTr6-05?	PTr3-C Pose 4		Med	A2	Compact, dark-brownish humus with a few rotted woodchips, some hazelnut shells and a few small pieces of birch-bark; some sand, gravel and pebbles Faint H <sub>2</sub> S odour Slow darkening Poor preservation
6.65	6.65	PTr3-08				Med	A3	Ca. 1-cm-thick lens of probable excrement; red-brown, some moss visible Medium preservation
6.65	6.50	PTr3-09		PTr3-A Pose 3: 6.55-6.50 masl PTr3-C Pose 5: 6.65-6.55 masl		Med	A2	Compact dark-brownish, relatively homogeneous humus with a few rotted woodchips, some hazelnut shells and a few small pieces of birch-bark; some sand, gravel and pebbles Faint H <sub>2</sub> S odour Slow darkening Hazelnut shells collected for <sup>14</sup> C-dating Poor preservation
6.50	6.15	PTr3-10	PTr6-07	PTr3-A Pose 4: 6.35-6.25 masl PTr3-B Pose 2 (bone): 6.20 masl PTr3-C Pose 6: 6.25-6.15 masl		Med	A3	Highly organic stratum: compact, dark-grey/-brown humus with many half-rotted woodchips (randomly inclined), numerous hazelnut shells and a few pieces of animal bone (at 6.20 masl) Faint H <sub>2</sub> S odour No colour change Poor preservation

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
6.15	6.05	PTr3-11	PTr6-10?	PTr3-C Pose 7: 6.15-6.05 masl		Viking Age ?	-	Medium-grey (with brownish tints) fine to coarse sand, gravel and pebbles, and a few poorly preserved woodchips No odour Preservation indefinable
6.05	6.05	PTr3-12				Viking Age ?	-	Possible very thin lens of dark-grey sand and gravel, possibly with charcoal/ash and a very few poorly preserved woodchips No odour Preservation indefinable
6.05	5.65	PTr3-13	PTr6-11	PTr3-A Pose 5: 5.90-5.80 masl PTr3-C Pose 8: 6.00-5.90 masl		Viking Age ?	-	Somewhat moist, light-grey/-brown coarse sand with some gravel and pebbles Top of the natural? Or part of building platform?
5.65	5.15	PTr3-14	PTr6-12				-	Light-grey silty clay with a few coarse sand grains and rounded pebbles A small quantity of naturally deposited organic matter (mostly in upper part)
5.15	↓	PTr3-15					-	Light-grey coarse sand, gravel and pebbles

Drilling was abandoned at 4.5 metres depth (4.90 masl). Two digital photos were taken of the length from 2 to 3 m depth, and four digital photos of the length from 3 to 4 m depth.

The following table presents the results of the analysis of the A-set soil samples from drilling PTr3.

Sample no.	Stratum no.	Masl	Moisture content (%)	Organic matter (%)	Soil description
1	PTr3-03	7.30-7.20	12.1	5.3	Sand/gravel with humus
2	PTr3-05	6.90-6.80	126.8	26.0	Culture-layer with sand and pieces of wood
3	PTr3-09	6.55-6.50	136.8	41.5	Culture-layer with sand and pieces of wood
4	PTr3-10	6.35-6.25	125.2	35.5	Culture-layer with wood
5	PTr3-13	5.90-5.80	9.8	2.7	Sand/gravel

### 3.6.3 Drilling 2 (PTr6): sediment sequence (visual inspection)

This hole was 3.40 metres from the edge of the sheet piling, and the modern cobbled surface was at an elevation of 9.40 masl.

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
9.40	7.15					Mod	E0	Cobbled surface over sand/-gravel/pebble fill (with underground heating cables 20 cm below cobbles) No sign of brick/tile pieces Geotextile at 7.25 masl
7.15	7.10 (ca.)	PTr6-01	PTr3-03	PTr6-C Pose 1		?	A2	Dark-grey soil with sand, gravel, some pebbles, and numerous large pieces of charcoal, along with dark-grey sandy humus: possible disturbed/spread firelayer, but not as distinct as PTr3-03 No odour No colour change Poor preservation
7.10 (ca.)	6.95	PTr6-02		PTr6-A Pose 1: 7.00-6.95 masl PTr6-C Pose 2: 7.10-7.00 masl		?	A1	Dark-grey soil with sand, gravel, some pebbles and stones, a slight amount of humus, and a few very decomposed woodchips One piece of burnt clay Just earthy odour No colour change Very poor preservation
6.95	6.85	PTr6-03	PTr3-06			?	-	Red-orange ash/sand with a lot of charcoal: probably an in situ firelayer, but less distinct than PTr3-06 (fewer large charcoal pieces, more sand, less orange in colour) Just earthy odour Preservation indefinable
6.85	6.80	PTr6-04				Med ?	A2	Charcoal (all sizes) and humus with some pieces of wood Just earthy odour No colour change Poor preservation
6.80	6.70	PTr6-05	PTr3-07?	PTr6-C Pose 3		Med	A2	Somewhat soggy, dark-brownish humus with a very few rotted woodchips; some sand and stones Just earthy odour Slow darkening Poor preservation



Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
6.70	6.55	PTr6-06		PTr6-C Pose 4: 6.65-6.55 masl		Med	A2	Dark-grey humus with numerous rotted woodchips, some fish-bones and a few pieces of charcoal; quite a lot of sand and some gravel Just earthy odour No colour change Poor preservation
6.55	6.40	PTr6-07	PTr3-10	PTr6-C Pose 5: 6.50-6.40 masl		Med	A2	Highly organic stratum: medium-brown humus with many half-rotted woodchips (randomly inclined) and numerous hazelnut shells; some sand, gravel and pebbles Resembled PTr3-10 in most respects, but was much less compact Just earthy odour No colour change Poor preservation
6.40	6.25	PTr6-08		PTr6-A Pose 2: 6.40-6.25 masl		Viking Age ?	A2	Grey/black silty sand with some gravel, some charcoal with a little ash/sand Possibly a disturbed fire-layer, or a hearth deposit
6.25	6.20	PTr6-09				Viking?	-	Light-grey clay, possibly a clay floor
6.20	6.10	PTr6-10	PTr3-11?			Viking?	-	Dark-grey humus with much sand, gravel and pebbles, and a few poorly preserved woodchips Just earthy odour No colour change Preservation indefinable
6.10	5.65	PTr6-11	PTr3-13			Viking?	-	Somewhat moist, light-grey/-brown coarse sand with some gravel and pebbles Top of the natural? Or part of building platform?
5.65	↓	PTr6-12	PTr3-14				-	Light-grey silty clay with a few coarse sand grains and rounded pebbles Some more brownish lenses at top of stratum, probably naturally deposited organic matter

Drilling was abandoned at 4 metres depth (5.40 masl). Three digital photos were taken of the length from 2 to 3 m depth, and two digital photos of the length from 3 to 4 m depth.

The following table presents the results of the analysis of the A-set soil samples from drilling PTr6.

Sample no.	Stratum no.	Masi	Moisture content (%)	Organic matter (%)	Soil description
1	PTr6-02	7.00-6.95	44.9	11.7	Sand/gravel with a little humus
2	PTr6-08	6.40-6.25	52.7	17.7	Silt/sand and some charcoal

### 3.6.4 Archaeological interpretation

The investigated locality lies in an area that was occupied by settlement from as early as the late Viking Age (from latter half of 10<sup>th</sup> century) and onwards, as the extensive excavations on the neighbouring Public Library site (*Folkebibliotekstomten*: excavated 1973-85) have shown. The drilling spot would have been on the western side of a blunt, southward-pointing promontory that was bounded by the River Nid to the east and by an inlet to the west. At the start of the 11<sup>th</sup> century, settlement started to expand into the inlet, with the construction of large platforms consisting of gravel and sand reinforced with wattle, and with solid, multi-room, timber buildings erected on the platforms. It is possible that strata nos. PTr3-13 and PTr6-11 represent such a gravel/sand platform, and strata nos. PTr6-09 and PTr6-08 may represent a clay floor and a hearth deposit respectively.

So, as regards the dating of the soil sequence, the deepest culture-layers are very likely from the late Viking Age, while the bulk of the overlying deposits are from the Middle Ages. The local archaeologists think it possible that modern excavation has resulted in truncation of the sequence down to more or less the top of the medieval deposits. Unfortunately, no finds were recovered from either drilling, so it is difficult to corroborate this hypothesis.

### 3.6.5 State of preservation comments

Where ascertainable, the state of preservation in the investigated deposits was generally poor, as table 4 reveals. By contrast, Anna Petersén from NIKU's Trondheim office has stated that conditions on the neighbouring Public Library site were very good, with appreciable cultural deposits containing a large proportion of organic matter in places, and where timbers and other wooden elements had remained quite intact, retaining their size, shape and structure.

One factor that is worth bearing in mind is that the sheet piling here – just like that around the SAS Hotel site at Bryggen, Bergen – is anchored by metal stays that were drilled downwards and outwards from the sheet piling. These stays are at intervals of only one metre, which means that the surrounding deposits have been punctured to a considerable degree – and this may have contributed to accelerated decomposition of the organic deposits lying in a zone stretching up to five metres outwards from the sheet piling.

**Table 4:** Tabular comparative presentation of deposit “health” in two drillings in Trondheim, Norway. Shaded column denotes drilling closer to existing sheet piling.

PTr3	PTr6	Masi	SYMBOLS	
??	??	10.0 – 9.0	X - VERY POOR	X - VERY GOOD
?????	?????	9.0 – 8.0	X - POOR	? - INDEFINABLE
???XX	????X	8.0 – 7.0	X - MEDIUM	0 - NO SOIL RECOVERED
XXXX?	?XXX?	7.0 – 6.0	X - GOOD	N - NATURAL
N	N	6.0 – 5.0		
Increasing depth within each 1 m length →				

## 3.7 Rotary drillings, Tønsberg, 2006

### 3.7.1 General remarks

In late August 2006, two auger drillings was carried out in Tollbodgaten at a point close to the southern corner of the property Storgaten 48. The southernmost part of this building had its foundations completely renewed in 1991, with the installation by drilling of 26 steel-core concrete piles that were topped by reinforced concrete pile caps that in turn supported the building's existing concrete strip footing. For the investigation in 2006, the idea was to carry out two drillings, one as close as possible to one of the exterior piles (pile no. 24 was chosen in the end), and the other at a distance of about one metre from the first hole.

Prior to drilling, a trench was dug by machine and by hand perpendicularly outwards from the side of the building so as to ensure that the electricity cables in this area were not damaged by the drill. The digging work was carried out by Haukeland from Multiconsult.

A large number of soil samples for geochemical analysis were collected from the drillings in Tønsberg, but no samples for radiocarbon dating.

The various strata distinguished in the drillings have been numbered in the following way. First comes "PTØX" (for the drilling in question: P for *Peleprosjekt*, Tø for Tønsberg) followed by sequential numbering of the individual strata (from top to bottom).

Weather conditions during recording of the Tønsberg drillings were changeable, with some occasional heavy showers, but the light was mostly good.

### 3.7.2 Drilling 1 (PTØ1): sediment sequence (visual inspection)

This hole was ca. 0.5 metres from the pile (coordinates X141183.40/Y-17857.65; surveyed by total station), and the modern pavement was at an elevation of ca. 7.50 masl.

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
7.50	5.85					Mod	E	Asphalt over stone/pebble/sand fill Excavated by machine
5.85	5.65	PTØ1-01 (layer 1)		PTØ1-A Pose 1: 5.75-5.65 masl PTØ1-C Pose 1: 5.85-5.70 masl		Post med (?)	A2	Redeposited organic stratum with a quantity of fine vegetable matter (probably some myrtle), some poorly preserved woodchips, some sandy humus and pebbles Poor preservation
5.65	5.35	PTØ1-02 (layer 2)	PTØ2-05 (?) PTØ3-04	PTØ1-B Pose 1: 5.65-5.55 masl		Post med (?)	A2	Poorly preserved timber

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
5.35	5.25	PTø1-03 (layer 3)	(PTø2-04) PTø2-06 PTø3-05			Post med (?)	A2	Not much soil adhered to the drill Probably grey/brown humus with a large quantity of poorly preserved wood pieces and woodchips, along with some birch-bark pieces Faint H <sub>2</sub> S odour No colour change Poor preservation
5.25	5.00	PTø1-04 (layer 4)	-	PTø1-B Pose 2		Post med (?)	A3	Medium preserved timber
5.00	4.95	PTø1-05 (layer 5)	PTø2-07 PTø3-06	PTø1-C Pose 2		Med (?)	A3	Dung, some small woodchips, some burnt bone Faint odour of dung Slow colour change Medium preservation
4.95	4.10	PTø1-06 (layer 6)	PTø2-08 (?) PTø3-07	PTø1-A Pose 2: 4.75-4.65 masl PTø1-C Pose 3: 4.85-4.75 masl		Med	A3	Lenses with high content of organic matter, incl. dung and hazelnut shells Medium preservation
4.10	3.90	PTø1-07 (layer 7)	-	PTø1-C Pose 4		Med	A3	Refuse stratum dominated by woodchips, medium-well preserved, with some hazelnut shells and pieces of birch-bark Stratum displayed a somewhat indefinable character Medium preservation
3.90	3.30 (ca.)	PTø1-08 (layer 8)	PTø2-10 PTø3-12	PTø1-A Pose 3: 3.75-3.65 masl PTø1-C Pose 5: 3.85-3.75 masl		Med	A3	Wet, medium-brown refuse stratum with a lot of dung and numerous relatively well-preserved woodchips and wood pieces Medium preservation
3.30 (ca.)	3.05	PTø1-09 (layer 9)	PTø2-11	PTø1-A Pose 4: 3.25-3.15 masl PTø1-C Pose 6: 3.15-3.05 masl		Med	A3	Moss, laminated, with some small woodchips and twigs in humus, and spots of silt/fine sand in between
3.05	2.90	PTø1-10 (layer 10)	PTø2-12 PTø3-13				-	Sand with some weathered stone, and one pocket of organic matter Natural deposit, with organic matter admixed later
2.90	↓	PTø1-11 (layer 11)	PTø2-13 PTø3-14				-	Grey clay

Drilling was abandoned at 5 metres depth (ca. 2.50 masl). According to the drilling undertaken for pile no. 24 in 1991, bedrock lies at ca. -7.80 masl. Five digital photos were taken of the length from 1 to 2 m depth, five digital photos of the length from 2 to 3 m depth, five digital photos of the length from 3 to 4 m depth, and five digital photos of the length from 4 to 5 m depth.

### 3.7.3 Drilling 2 (PTø2): sediment sequence (visual inspection)

This hole was ca. 1.1 metres from the pile (approximate coordinates triangulated to X141183.00/Y-17857.20; not surveyed by total station), and the modern pavement was at an elevation of ca. 7.40 masl.

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
7.40	6.30					Mod	E	Asphalt over stone/pebble/sand fill Excavated by machine
6.30	6.15	PTø2-01 (layer 12)	PTø3-01			Post med	-	Firelayer, probably in situ Preservation indefinable
6.15	5.80	PTø2-02 (layer 13)	PTø3-02			Post med (?)	A2	Brown humus with a large quantity of poorly preserved wood pieces and woodchips, along with some birch-bark pieces Faint H <sub>2</sub> S odour No colour change Extremely rotten wood at the bottom of the stratum Poor preservation
5.80	5.75	PTø2-03 (layer 14)	PTø3-03			Post med (?)	-	Possible firelayer, very sandy Preservation indefinable
5.75	5.60	PTø2-04	(PTø1-03)	PTø2-A Pose 1: 5.65-5.60 masl		Post med (?)	A2	Grey/brown humus with a large quantity of poorly preserved wood pieces and woodchips, along with some birch-bark pieces Faint H <sub>2</sub> S odour No colour change Poor preservation = layer 3
5.60	5.40 (ca.)	PTø2-05	PTø1-02 (?) PTø3-04	PTø2-B Pose 1: 5.60-5.50 masl		Post med (?)	A2	Poorly preserved timber = layer 2 (probably)
5.40 (ca.)	5.25	PTø2-06	PTø1-03 PTø3-05			Post med (?)	A2	= layer 3
5.25	5.20	PTø2-07	PTø1-05 PTø3-06	PTø2-C Pose 1		Med (?)	A3	Dung, some small woodchips, some burnt bone Faint odour of dung Slow colour change Medium preservation = layer 5

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
5.20	4.60	PTø2-08	PTø1-06 PTø3-07	PTø2-A Pose 2: 5.15-5.05 masl PTø2-C Pose 2: 5.05-4.95 PTø2-A Pose 3: 4.65-4.60		Med	A3	Highly organic stratum with dung, hazelnut shells, twigs, some birch-bark pieces and woodchips (fresh in colour) Medium preservation = layer 6 (but more concentrated)
4.60	4.15	PTø2-09 (layer 15)	PTø3-08 (partly)			Med	-	Large quantity of charcoal and ash, possibly refuse from mortar production Preservation indefinable
4.15	3.10 (ca.)	PTø2-10 (layer 16)	PTø1-08 PTø3-12	PTø2-A Pose 4: 4.15-4.05 masl PTø2-C Pose 3: 4.00-3.80 PTø2-A Pose 5: 3.65-3.55 PTø2-C Pose 4: 3.65-3.55 PTø2-A Pose 6: 3.20-3.10 PTø2-B Pose 2: 3.10 (bone)		Med	A4	Resembled layer 8 in PTø1, but better preserved stratum Dominated by woodchips in upper part, and with a large concentration of dung at 3.55-3.45 masl Large twigs (wattle?), and numerous visible pieces of sea-shell Strong H <sub>2</sub> S odour Darkened slowly Good preservation
3.10 (ca.)	2.95	PTø2-11	PTø1-09	PTø2-C Pose 5: 3.05-2.95 masl		Med	A3	Moss, laminated, with some small woodchips and twigs in humus, and spots of silt/fine sand in between Medium preservation = layer 9
2.95	2.85	PTø2-12	PTø1-10 PTø3-13				-	Sand with some weathered stone, and one pocket of organic matter Natural deposit, with organic matter admixed later = layer 10
2.85	↓	PTø2-13	PTø1-11 PTø3-14				-	Grey clay = layer 11

Drilling was abandoned at 5 metres depth (ca. 2.40 masl). Three digital photos were taken of the length from 1 to 2 m depth, three digital photos of the length from 2 to 3 m depth, three digital photos of the length from 3 to 4 m depth, and three digital photos of the length from 4 to 5 m depth.

### 3.7.4 Archaeological interpretation and groundwater situation

The drilling spot lies in an important and central part of the medieval town of Tønsberg, but unfortunately there is little in the way of detailed archaeological information about the immediate area. The local archaeologists believe, however, that it is probably crossed by the original shoreline, and that the strata sequence would start with fill and occupation deposits from the early Middle Ages, or possibly even from the late Viking Age.

As it turned out, the archaeological deposits in the vicinity of the drilling spot were shown to be 3-3.5 metres thick, which corresponds well with the results from the few prior observations in the area. And the results from the drillings – though no finds were recovered from either, regrettably – certainly would not refute the presence of early medieval deposits at the bottom of the sequence.

As regards groundwater-level, there is, unfortunately, no information on this concerning the immediate area. It is possible that the complete excavation of the neighbouring property – Hotell Klubben – has resulted in the water-table's being lowered to a level below the deepest cultural deposits. There were plans, back in 1999, to install a dipwell in the middle of the parking area to the south-east of Storgaten 48 (and roughly at the same distance from the sea as the 2006 drilling spot), but installation was cancelled due to the fact that, when the hole had been drilled, there was apparently no sign of groundwater.

### 3.7.5 State of preservation comments

Regarding the “health” of the deposits in PTø1, there appears to be – on visual inspection at least – only the one zone where the state of preservation can be classified as poor. And not surprisingly, the poorly preserved zone comprises the uppermost part of the sequence, from 5.85 down to 5.25 masl. Below this, the strata are all assessed as being medium-well preserved.

Regarding the “health” of the deposits in PTø2, we again find that the uppermost zone – from 6.15 down to 5.25 masl – exhibits poor preservation. Below this, there is a gradual transition over the next metre to much better preservation starting at 4.15 masl and down to the natural.

The interesting aspect appears when the two drillings are compared (table 5). For the first time, we find a situation where one stratum (PTø1-08) in the drilling located closer to the pile seems to display a clearly worse state of preservation than its counterpart (PTø2-10) in the drilling further away from the pile.

Although only a single stratum is involved, it nevertheless represents quite an appreciable proportion of the deposits' overall thickness: PTø1-08 was some 60 centimetres thick, while PTø2-10 was about 1 metre thick (so that the latter made up a little less than a third of the total deposit thickness).

This finding prompted a return to Tønsberg in May 2007 in order to carry out a second, more detailed investigation in the same area (cf. section 3.8).

**Table 5:** Tabular comparative presentation of deposit “health” in the first two drillings in Tønsberg, Norway. Shaded column denotes drilling closer to existing pile. Each symbol represents a length of about 20 centimetres, with depth increasing towards the right.

PTø1	PTø2	Masl	SYMBOLS	
???	??	8.0 – 7.0	X - VERY POOR	X - VERY GOOD
?????	????X	7.0 – 6.0	X - POOR	? - INDEFINABLE
?XXXX	XXXXX	6.0 – 5.0	X - MEDIUM	0 - NO SOIL RECOVERED
XXXXX	XX??X	5.0 – 4.0	X - GOOD	N - NATURAL
XXXXX	XXXXX	4.0 – 3.0		
N	N	3.0 – 2.0		
Increasing depth within each 1 m length →				

## 3.8 Tønsberg, 2007

### 3.8.1 General remarks

As mentioned just above, the findings from the Tønsberg drillings in 2006 prompted *Riksantikvaren* to commission a more detailed follow-up investigation in the very same area. The investigation was to be two-pronged. First, a third drilling (designated PTø3) would be undertaken, and then a small test-pit would be excavated by machine as far down as it was possible to go.

It was hoped to drill down somewhere between the first two drillings, but the presence of power cables meant, regrettably, that the third drilling had to be carried out even further from the pile than PTø2.

Only the archaeology in the drilling will be described here. The archaeology in the test-pit is described in a separate report (Dunlop, in prep.). (The western section can in any case be discounted from an archaeological point of view, since it did not contain intact cultural deposits.)

### 3.8.2 Drilling 3 (PTø3): sediment sequence (visual inspection)

This hole was ca. 2.0 metres from the pile (coordinates X141182.35/Y-17856.35; surveyed by total station), and the modern pavement was at an elevation of ca. 7.35 masl.

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
7.35	6.30					Mod	E	Asphalt over stone/pebble/sand fill Excavated by machine
6.30	6.15	PTø3-01 (layer 12)	PTø2-01			Post med	-	Firelayer, probably in situ Preservation indefinable
6.15	5.80	PTø3-02 (layer 13)	PTø2-02	PTø3-A Pose 1: 6.10-6.00 masl		Post med (?)	A2	Brown humus with a large quantity of poorly preserved wood pieces and woodchips, along with some birch-bark pieces Faint H <sub>2</sub> S odour No colour change Poorly preserved timber in the middle part of the stratum Poor preservation
5.80	5.75	PTø3-03 (layer 14)	PTø2-03			Post med (?)	-	Possible firelayer, very sandy Preservation indefinable
5.75	5.45	PTø3-04	PTø1-02 (?) PTø2-05			Post med (?)	A2	Poorly preserved timber = layer 2
5.45	5.23	PTø3-05	PTø1-03 PTø2-06	PTø3-A Pose 2: 5.45-5.35 masl		Post med (?)	A2	Grey/brown humus with a large quantity of poorly preserved wood pieces and woodchips, along with some birch-bark pieces Faint H <sub>2</sub> S odour No colour change Poor preservation = layer 3



Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
5.23	5.18	PTø3-06	PTø1-05 PTø2-07			Med (?)	A3	Dung, some small woodchips, some burnt bone Faint odour of dung Darkened quickly Medium preservation = layer 5
5.18	4.50	PTø3-07	PTø1-06 PTø2-08	PTø3-A Pose 3: 4.95-4.85 masl		Med	A4	Highly organic stratum with dung, hazelnut shells, twigs, some birch-bark pieces and woodchips (fresh in colour, resisted snapping) Good preservation = layer 6
4.50	3.85	PTø3-08 (layer 17)	PTø2-09 (partly)	PTø3-A Pose 4: 4.45-4.35 masl PTø3-A Pose 5: 3.95-3.85 masl		Med	A2 A3	Somewhat jumbled deposit, probably comprising mixed, mostly redeposited material deriving from different kinds of household activities Alternated between strata consisting of humus, woodchips and hazelnut shells, and strata consisting of largely of charcoal and ash along with some sand, woodchips and hazelnut shells, and a few fragments of sea-shell (mussel) The latter strata may correspond to PTø2-09 The woodchips were mostly dull in colour and snapped easily A lot of the organic material must have been exposed and started to decay prior to final deposition Medium H <sub>2</sub> S odour Darkened very slowly Varied from poor to medium preservation
3.85	3.70	PTø3-09 (layer 18)	-			Med	A4	Concentration of reddish-brown to yellowish excrement/dung Compact, but not laminated Some woodchips and other vegetable matter in the lower part of the stratum Medium odour of dung Medium-fast darkening Good preservation

Masl		Stratum number	Same as stratum no.	<sup>14</sup> C-dating/ finds/ samples	Accession number	Period	PC	Description
From	To							
3.70	3.60	PTø3-10 (layer 19)	-			Med	A3	Moist, dark-grey (with brownish hints) moss and finely chopped vegetable matter Medium H <sub>2</sub> S odour No darkening Medium preservation Appeared to have been exposed to oxidisation in situ
3.60	3.55	PTø3-11 (layer 20)	-			Med	-	Grey, fine to medium-fine sand with a small amount of organic matter Preservation indefinable
3.55	3.00	PTø3-12	PTø1-08 PTø2-10	PTø3-A Pose 6: 3.45-3.35 masl		Med	A4	= layer 16 (and layer 8) Good preservation
3.00	2.90	PTø3-13	PTø1-10 PTø2-12				-	Sand with some weathered stone, and one pocket of organic matter Natural deposit, with organic matter admixed later = layer 10
2.90	↓	PTø3-14	PTø1-11 PTø2-13				-	Grey clay = layer 11

Drilling was abandoned at 4.80 metres depth (ca. 2.55 masl). Three digital photos were taken of the length from 5.55 to 4.55 masl, five digital photos of the length from 4.55 to 3.55 masl (one taken before the auger was cleaned in order to illustrate the before and after situations), and three digital photos of the length from 3.55 to 2.55 masl.

### 3.8.3 Test-pit, 2007

A more detailed description of the foundation work carried out in 1991 would probably enhance understanding of the situation. It had become apparent that the southernmost part of the property was suffering from subsidence, and that the existing foundations – which consisted of relatively narrow strip footings of concrete or brick – would have to be shored up in some way. Roughly speaking, the chosen method involved the insertion of pairs of piles at various intervals along the existing foundations, with one pile on either side. The piles did not themselves support the existing foundations. Instead, they supported pile caps – large, concrete blocks placed in excavated trenches on either side of the foundations. The pile caps had flanges that fitted into slots chiselled into the existing foundations, and it was this arrangement that supported the building's footings.

The trench for the pile cap supported by pile no. 24 was dug to a depth of at least 2.2 metres. It was in excess of 1 metre wide at the surface, tapering to about 0.7 metres at the bottom. After the construction of the pile cap, the trench was backfilled with a relatively loose, permeable deposit of mostly large pieces of crushed stone of a shale-like nature. In addition, examination of the test-pit's western section revealed that concrete slurry had pooled in the bottom of the trench, under the base of the pile cap, and had mixed with disturbed deposits and material from the surrounding deposits. The test-pit's western section therefore contained no intact cultural deposits.

The test-pit measured about 2.5 metres to a side at the surface, narrowing to about 2 metres to a side at the bottom. The northern side was dug to coincide more or less with the line formed by the three drillings, while the western side followed the eastern edge of the pile cap. Working conditions were not favourable: among other things, two sets of power cables ran inconveniently across the test-pit from northeast to southwest.

The pit was dug mostly by machine, while the sections were cleaned up manually. In the end, it proved impossible to dig down as far as one would have wished, because of the risk of weakening the foundations. The bottom of the test-pit was therefore only about 2.2-2.3 metres below pavement level (about 5.3 masl), which means that it was about level with the **top** of the pile.

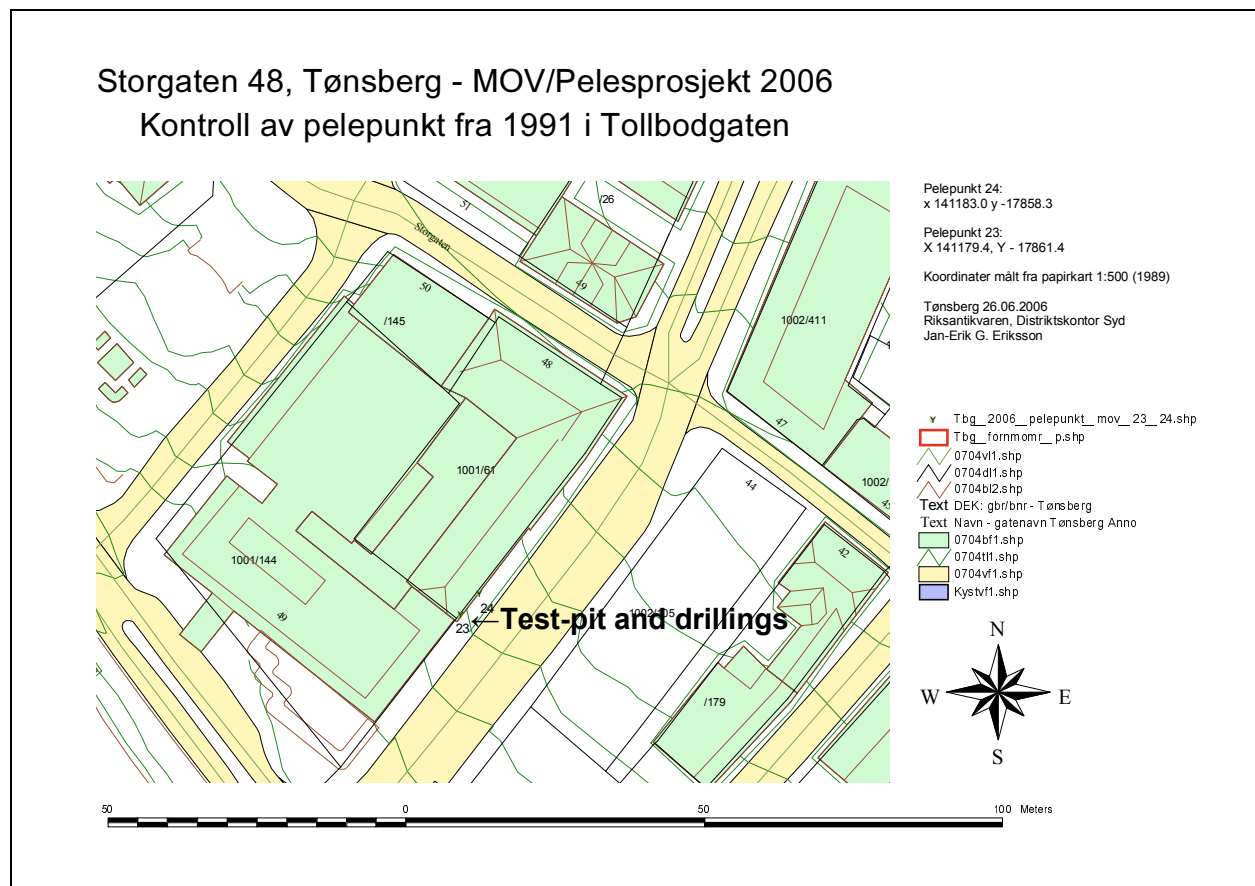


Figure 5. Location of the test-pit and drillings investigated in Tønsberg.

### 3.8.4 State of preservation comments

#### Drilling PTØ3

The situation in the upper half of PTØ3 was very similar to that in the upper half of PTØ2. From about 5.0 masl, differences started to appear. Good preservation was encountered in PTØ3 at an elevation one metre higher than in PTØ2, but the lower half of PTØ3 nevertheless exhibited quite large variations in state of preservation, as table 6 reveals.

It is very difficult to argue that these findings are evidence of damage caused by the pile. Rather, when we look at the overall picture as displayed in table 6, two possible alternative explanations present themselves:

1. the impact of the trench/permeable backfill

2. drainage of groundwater; it is reported that the deep cellar under Hotel Klubben – the neighbouring building that lies to the south of and downslope from Storgaten 48 – may be at least partly responsible for drainage of groundwater from the deposits in the higher-lying area to the north (Edvardsen, pers. comm.)

And it is always conceivable, of course, that the observed situation results from a combination of both factors.

**Table 6:** Tabular comparative presentation of deposit “health” in the three drillings in Tønsberg, Norway. Shaded column denotes drilling closest to existing pile. Each symbol represents a length of about 20 centimetres, with depth increasing towards the right.

PTø1	PTø2	PTø3	Masl	SYMBOLS	
???	??	??	8.0 – 7.0	X - VERY POOR	X - VERY GOOD
?????	????X	????X	7.0 – 6.0	X - POOR	? - INDEFINABLE
?XXXX	XXXXX	XXXXX	6.0 – 5.0	X - MEDIUM	0 - NO SOIL RECOVERED
XXXXX	XX??X	XXXXX	5.0 – 4.0	X - GOOD	N - NATURAL
XXXXX	XXXXX	XXXXX	4.0 – 3.0		
N	N	N	3.0 – 2.0		
Increasing depth within each 1 m length →					

#### Test-pit

The state of preservation situation in the test-pit’s northern section exclusively reflects the impact of the trench excavated in 1991, and this is treated in admirable detail in the geochemical report (Hartnik & Matthiesen, 2007). The archaeological observations are in complete agreement with the geochemical results – it was quite clear to the naked how eye how much more poorly preserved were the deposits and timbers along the western side of the northern section in comparison with those lying further east. Both the geochemical and archaeological results clearly document the damaging effect of the trench with its permeable backfill.

There is a corroborating piece of evidence from the report on the archaeological investigation of the trench’s excavation (Jahnsen, 1991). A number of short posts were found in the upper part of the deposits, with their crowns reaching up to the bottom of the inorganic modern deposits. Their condition was described in 1991 as “well-preserved”, but similar posts found in the test-pit’s northern section were characterised as “poorly preserved”. This reflects the extent of damage done in the space of no more than 16 years.

As regards the western section, some geochemical measurements were taken in the area below the pile cap, but when these are to be interpreted one must allow for the fact that this area consisted of trench backfill and disturbed deposits. The results will therefore reflect only local – and somewhat artificial – preservation conditions.

As stated elsewhere, the test-pit sheds no direct light on the piling-damage question, because the bottom of the pit lay at roughly the same elevation as the **top** of the pile. The trench with its permeable backfill can have had no direct impact on the lower-lying deposits around the pile. However – and the following remarks must be treated as conjecture for the time being – the question is: can it have had an *indirect* impact? One can easily imagine how the trench/backfill combination could lead oxygen-rich rainwater down to the pile, which could in turn lead this water down into the lower-lying deposits. This is a conceivable mechanism – but testing it will probably prove quite difficult.

## 4. Results

### 4.1 Evaluation of the individual investigations' usefulness

Before proceeding to a presentation of the results of the various drilling investigations, it is necessary to evaluate their usefulness and informational value in relation to the aims of the Piling Project, and specifically in relation to two criteria:

- presence of organic deposits
- presence of corresponding strata

The evaluations can be summed up as follows:

Bugården, Bergen: useful – even though it was a section of sheet piling, not a pile, that was investigated, and despite the fact that much of the upper part of the closest drilling lacked strata that corresponded with strata in the other two drillings (due to a local disturbance right next to the sheet piling, most likely caused by the sheet piling's hitting a stone or timber and forcing it downwards, leaving a cavity that became filled with unrepresentative soil)

Peter Egges Plass, Trondheim: borderline – not so much because it was a section of sheet piling, not a pile, that was investigated, but because the distance from the closer drilling to the sheet piling was all of 2.65 metres (as a result of greater-than-expected excavation outwith the area enclosed by the sheet piling)

Tollbodgaten, Tønsberg: 2006 – useful  
2007 – the results do not shed further light on the issue of whether piling causes damage

Pilestræde 63, København: not useful – no corresponding strata (and virtually no organic strata either)

Amaliegade 41, København: not useful – it transpired that the two closer drillings lay partly within the excavated building pit, and there were not enough corresponding strata for meaningful comparison

Knabrostræde 16, København: borderline – very few corresponding organic strata

Vårfrugatan 8a, Lund: useful

Based on these evaluations, it becomes apparent that only three of the investigated localities – Bugården, Bergen; Tollbodgaten, Tønsberg (2006); and Vårfrugatan 8a, Lund – yielded results that fit the bill in the context of the aims of the Piling Project. Another two – Peter Egges Plass, Trondheim and Knabrostræde 16, København – are regarded as borderline, but will be included for discussion anyway.

### 4.2 Presentation of results

#### Clarifications

The tables that follow below present the results from the individual localities, and only from the corresponding strata. The value in the column headed *PC* is the archaeological assessment of the individual stratum's state of preservation, classified in accordance with the State of Preservation Scale. The value in the column headed *LOI value* derives from the analysis of the soil sample and represents the amount of organic matter in the stratum.

#### Bugården, Bryggen

Two drillings were carried out here, designated PB01, PB02 and PB03. PB01 was only 15-20 cm from the sheet piling, PB03 was ca. 0.5 metres from the sheet piling, and PB02 was ca. 1 metre

from the sheet piling. PB02 has been used as the yardstick for purposes of comparison, since this is the drilling where one would expect to find the best state of preservation.

Stratum number PB01	PC	LOI value	Stratum number PB03	PC	LOI value	Stratum number PB02	PC	LOI value
PB01-03 (possibly)	C2	-	PB03-03	C2	-	PB02-04	C2	-
PB01-03 (possibly)	C2	24,4	PB03-04	C2	29,5	PB02-05	C2	36,3
PB01-04 (possibly)	C2	16,6	PB03-05	C1	31,4	PB02-06	C2	27,9
			PB03-06	C3	37,6	PB02-07	C3	28,8
			PB03-07 (possibly)	C2	22,6	PB02-08	C2	27,4
			PB03-08	C2	23,5	PB02-10	C3	8,9 19,4
			PB03-09	C3	18,3	PB02-11	C3	-
			PB03-09 (possibly)	C3	22,1	PB02-13	C4	22,2
PB01-08 (partly)	C4	28,1 25,0	PB03-15	C4	41,9	PB02-16	C4	23,2 48,8 47,6
PB01-10	C4	45,0	PB03-16	C4	61,2	PB02-17	C4	58,2
PB01-11	C3	-	PB03-17 (probably)	C3	-	PB02-19	C3	-

#### Knabrostræde 16, København

Two drillings were carried out here, designated PK07 and PK08. PK07 was ca. 2.1 metres from the pile, and PK08 was ca. 0.95 metres from the pile.

Stratum number PK08	PC	LOI value	Stratum number PK07	PC	LOI value
PK08-06	A1/B1	12	PK07-05	A1/B1	12
PK08-08	C3	25	PK07-07	C3	21

#### Vårfrugatan 8a, Lund

Two drillings were carried out here, designated PL01 and PL02. PL01 was ca. 0.9 metres from the pile, and PL02 was ca. 1.9 metres from the pile.

Stratum number PL01	PC	LOI value	Stratum number PL02	PC	LOI value
PL01-04	A2	-	PL02-04	A1	-
PL01-05	A2	20	PL02-12	A2	20
PL01-07	A2	-	PL02-14	A2	-

Peter Egges Plass, Trondheim

Two drillings were carried out here, designated PTr3 and PTr6. PTr3 was ca. 2.65 metres from the sheet piling, and PTr6 was ca. 3.4 metres from the sheet piling.

Stratum number PTr3	PC	LOI value	Stratum number PTr6	PC	LOI value
PTr3-03	A2	5,3	PTr6-01	A2	-
PTr3-07	A2	-	PTr6-05 (probably)	A2	-
PTr3-10	A3	35,5	PTr6-07	<b>A2</b>	-

Tollbodgaten, Tønsberg (2006)

Two drillings were carried out here in 2006, designated PTø1 and PTø2. PTø1 was ca. 0.5 metres from the pile, and PTø2 was ca. 1.1 metres from the pile.

Stratum number PTø1	PC	LOI value	Stratum number PTø2	PC	LOI value
PTø1-03	A2	-	PTø2-06	A2	-
PTø1-05	A3	-	PTø2-07	A3	-
PTø1-06	A3	39,9	PTø2-08	A3	56,6 58,8
PTø1-08	<b>A3</b>	41,2	PTø2-10	A4	57,3 21,4 37,6
PTø1-09	A3	15,4	PTø2-11	A3	-

### 4.3 Evaluation of results

Bugården, Bryggen

Going by the comparison of the state of preservation of corresponding strata, there are no grounds for claiming that the sheet piling has exerted a consistent damaging effect on the deposits in the zone lying less than ca. 1 metre from the sheet piling. It is the middle drilling, PB03 – not the closest one, PB01 – that exhibits poorer state of preservation, but only in a few of the corresponding strata (hatched cells). As regards the six corresponding strata in drillings PB01 and PB02 – the closest and the furthest drillings, respectively – we find no differences (though admittedly some of the identifications of correspondence are not entirely certain).

On the other hand, when one looks at the LOI values for corresponding strata, it is noticeable that the lowest values show up consistently in PB01, the drilling closest to the sheet piling. This would seem to suggest that some loss of organic matter is taking place in a narrow zone immediately adjacent to the sheet piling – but in a way that apparently does not affect the archaeological assessment of state of preservation. Resolution of this problem will probably have to be left to the geochemists.

Knabrostræde 16, København

Knabrostræde 16 was one of the two borderline localities. There were only two corresponding strata, but together they made up a substantial proportion of the deposit thickness. Neither displayed differences in state of preservation, and the LOI values are relatively similar. Thus it cannot be claimed that the pile has had any detrimental effect outwith the zone that was directly damaged when the pile was driven in place (not unless the detrimental effect extends outwards for more than 2 metres from the pile). On the other hand, it may still be too early to say for sure – after all, the investigation took place only 2 years after the pile's insertion.

#### Vårfrugatan 8a, Lund

There were three corresponding strata in the pair of drillings in Lund. Two exhibited the same state of preservation, while the third was deemed to be more poorly preserved in the drilling further from the pile (hatched cell). As regards the one stratum that was analysed for organic content, the LOI value was the same in both drillings. There are no grounds for claiming that the pile – which was inserted 10 years prior to the investigation – has led to a worsening in the state of preservation of the organic deposits immediately adjacent to the pile.

#### Peter Egges Plass, Trondheim

The Trondheim drillings yielded the same kind of results as the ones in Lund: namely, that out of three corresponding strata two exhibited the same state of preservation, while the third was deemed to be more poorly preserved in the drilling further from the sheet piling (hatched cell). As such, there are no grounds for claiming that the sheet piling has led to a worsening in the state of preservation of the adjacent organic deposits. However, the distance from the closer drilling to the sheet piling was no less than 2.65 metres, and the trench between the sheet piling and the edge of the deposits was found to be backfilled with a porous mixture of sand, gravel and crushed stone. In view of this, it would be very dubious to claim that the sheet piling itself could have exerted any direct effect whatsoever on the intact deposits.

There is no further information to be derived from the LOI values.

#### Tollbodgaten, Tønsberg (2006)

There were no less than five corresponding strata in the pair of drillings carried out in 2006 (in fact, there were two others in addition, but both were at elevations too high to have been directly affected by the pile). Four strata exhibited the same state of preservation in the closer drilling as in the further, while the fifth was deemed to be more poorly preserved in the drilling closer to the pile (hatched cell). This constitutes the only case that provides an indication that the pile may have adversely affected the organic deposits in its immediate vicinity. The impact has, however, been relatively limited, since four other strata were apparently not similarly affected – and, what's more, three of these four were lying above the stratum in question.

As at Bryggen, comparison of the LOI values for corresponding strata indicate that the lowest values show up in PT01, the drilling closer to the sheet piling. Again, this suggests that some loss of organic matter may be taking place in a narrow zone immediately adjacent to the sheet piling, though this cannot be corroborated archaeologically.

The drilling carried out in 2007 cast no further light on the piling-damage question, and neither did the test-pit.

## 4.4 Conclusions

Out of a total of 20 corresponding strata from five investigation sites, only one provides a case – and a marginal case, at best – where one finds a worse state of preservation in the drilling closer to the pile. All in all, the study has produced no real support for the hypothesis that piling can cause damage to organic deposits lying outwith the zone that is directly impacted by the pile's insertion.

Does this necessarily mean that piling can now become a totally acceptable foundation method? This report does not seek to answer this question, though it may be part of the answer. It must be addressed by the heritage management authority, *Riksantikvaren*, whose assessment must be based on all the available evidence that the present project (and other investigations) has amassed. The important issues will include determining the least damaging methods of piling, and finding ways of reducing the density of piles in relation to the building's area and – probably more importantly – in relation to the volume of the underlying cultural deposits within the



targeted area. Even so, each building application that involves the use of piling will have to be evaluated separately on the basis of its individual pros and cons.

#### 4.5 Recommendations

*Riksantikvaren* should give serious thought to ordering re-excavation of the trench in Tollbodgaten, Tønsberg, and replacement of the fill with an impermeable mixture that will prevent drainage.

Further work ought to be put in at some stage on the question of loss-on-ignition values vis-à-vis archaeological assessments of state of preservation. Perhaps – once enough samples have been analysed – it will be possible for the geochemists to produce some kind of rough “calibration”, but one will always have to check the archaeological description carefully, since it is quite conceivable to encounter contexts that contain very little organic material, but with what there is of that material assessed as well preserved.

### 5. References

- Dunlop, A.R., 2003. Miljøovervåkingsprosjektet Bredsgården, Bryggen, Bergen, 2002-3. – Arkivrapport, NIKU distriktskontor Bergen.
- Dunlop, A.R., 2006. Slottsgaten 1, Bergen: Arkeologisk undersøkelse og registrering av grunnboringer, 2005. – Arkivrapport 5-2006, NIKU distriktskontor Bergen.
- Dunlop, in prep. Tollbodgaten, Tønsberg, 2007: Arkeologisk undersøkelse av en grunnboring og et prøvehull. – Rapport Arkeologiske utgravninger, NIKU.
- Gregory, D. & Matthiesen, H., 2006. On the use of modern samples to study preservation conditions in the cultural layers below Bryggen in Bergen. – Copenhagen: National Museum of Denmark, Department of Conservation. Report no. 10832-0008-1.
- Hartnik, T. & Matthiesen, H., 2007. The effect of piling on the preservation of cultural layers - physical-chemical assessment in a soil profile adjacent to a pile. – Bioforsk Rapport Nr. 94/2007. Ås, Norway.
- Høst-Madsen, L., 2003. Beretning for den arkæologiske prøvegravning af KBM 2307 Mærsk Hovedsæde. – Københavns Bymuseum.
- Jahnsen, K., 1991. Innberetning over de arkeologiske undersøkelsene i Storgaten 48, Klub- og balselskabet Harmonien, Tønsberg 12.-16. august 1991. – Arkivrapport, Riksantikvarens Utgravningskontor for Tønsberg.
- Matthiesen, H., 2002. Field work on Bryggen, 6th - 8th of November 2002. – Copenhagen: National Museum of Denmark, Department of Conservation. Report no. 10832-0004-1.
- Matthiesen, H., 2004. State of preservation and possible settling of cultural layers below Bredsgården and Bugården tenements, Bryggen, Bergen. – Copenhagen: National Museum of Denmark, Department of Conservation. Report no. 10832-0004-3.

Matthiesen, H., 2005. Influence of piling on cultural deposits at Bryggen, Bergen. – Copenhagen: National Museum of Denmark, Department of Conservation. Report no. 10832-0007-1.

Poulsen. L.L., 2003. Arkæologiske undersøgelser i Brolæggerstræde 9. – Københavns Bymuseum 2003-4.

Poulsen. L.L., 2006. KBM 3290 boreprøver på tre lokaliteter i København. Projekt ”bygging på kulturlag”. Int. Nr. 1102.

## 6. Documentation (NIKU)

### 2004

- 2 section drawings
- 11 colour photos, 1 digital photo

### 2005

- Soil sequences noted down in *Boreprøvebok* (drilling logbook) 4

### 2006

- Soil sequences noted down in separate *Boreprøvebok* (drilling logbook)
- Layer recording forms
- 61 digital photos

### 2007

- Soil sequences noted down in separate *Boreprøvebok* (drilling logbook)
- Layer recording forms
- 16 digital photos, plus numerous orthophotos