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Resultats from new dipwells MB 15, 30, 31, 32 and MB 33 installed in 2009

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*Department of Conservation*

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REPORT no
11031041

*June 2010*

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Case: 11031041
Date: 10th June 2010

Title:
Preservation conditions in the area bordering the sheet piling at Bryggen, Bergen: Results from new dipwells MB15, 30, 31, 32 and 33 installed in 2009.

Author:
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Summary:
Five new dipwells have been installed at Schøtstuene and near the sheet piling at Bryggen in Bergen, in order to evaluate the preservation conditions for the cultural deposits. In this report the results are discussed, including a review of earlier studies and reports from the area. Two main threats are discussed: drainage, and increased through-flow of water.
The extent of the drained area has been better documented through the new dipwells, and the presence of medieval cultural layers above the groundwater level has been shown near Schøtstuene. Some of the layers above the groundwater level are surprisingly well preserved, possibly due to a thick layer of "garden soil" above, which may function as an oxygen scavenger and protect the layers underneath. The different soil layers still have a high organic content and a large settling potential. Continuous measurements in four soil strata above the groundwater level show a slow decrease in water content since 2006. The preservation conditions in the area are considered critical and the groundwater level should be raised.
The area alongside the sheet piling has been investigated in terms of horizontal and vertical waterflow and its consequences for the preservation conditions. The horizontal waterflow is estimated to be significant in the area, causing very dynamic conditions and flow of oxygen-rich water through the upper deposits (shown at MB5); the water flow may also explain a low salt content in the upper soil layers along the sheet piling, and possibly also a low content at FB1. The vertical waterflow at the sheet piling is estimated to be significantly higher than in the middle of Bryggen, and the groundwater chemistry in dipwells near the sheet piling is characterised by an increased dilution by rainwater compared to the more stagnant areas. A preliminary geochemical model has been made according to which the decay rate for organic material near the sheet piling is faster than in the more stagnant areas, but better estimates of the waterflow are necessary to confirm it.
Some suggestions are given with regard to future monitoring in the area, which will document the effect on the preservation conditions by the planned construction work around the sheet piling.

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|---|---|
| Henning Matthiesen | David Gregory |
| Author | Control |

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## *Introduction*

Both drainage and oxygen-rich groundwater flowing through the cultural layers cause local preservation problems in the area around the sheet piling that surrounds the SAS-hotel site at Bryggen. Plans are currently being made to modify the sheet piling and drainage system, in order to stop the drainage from the cultural layers and at the same time decrease the waterflow along the sheet piling. In this context it is important to acquire more detailed knowledge of the conditions in the area, both before, during and after the work. In order to elucidate this, five new dipwells were installed along the sheet piling and at Schøtstuene north of it in September and October 2009. The National Museum of Denmark has been contracted by Riksantikvaren to evaluate the conditions of and threats to the cultural layers around the sheet piling based on results from analysis of groundwater, soil and wood samples from these dipwells. Some of the earlier reports from Bryggen are reviewed in order to include all available information in the conclusions.

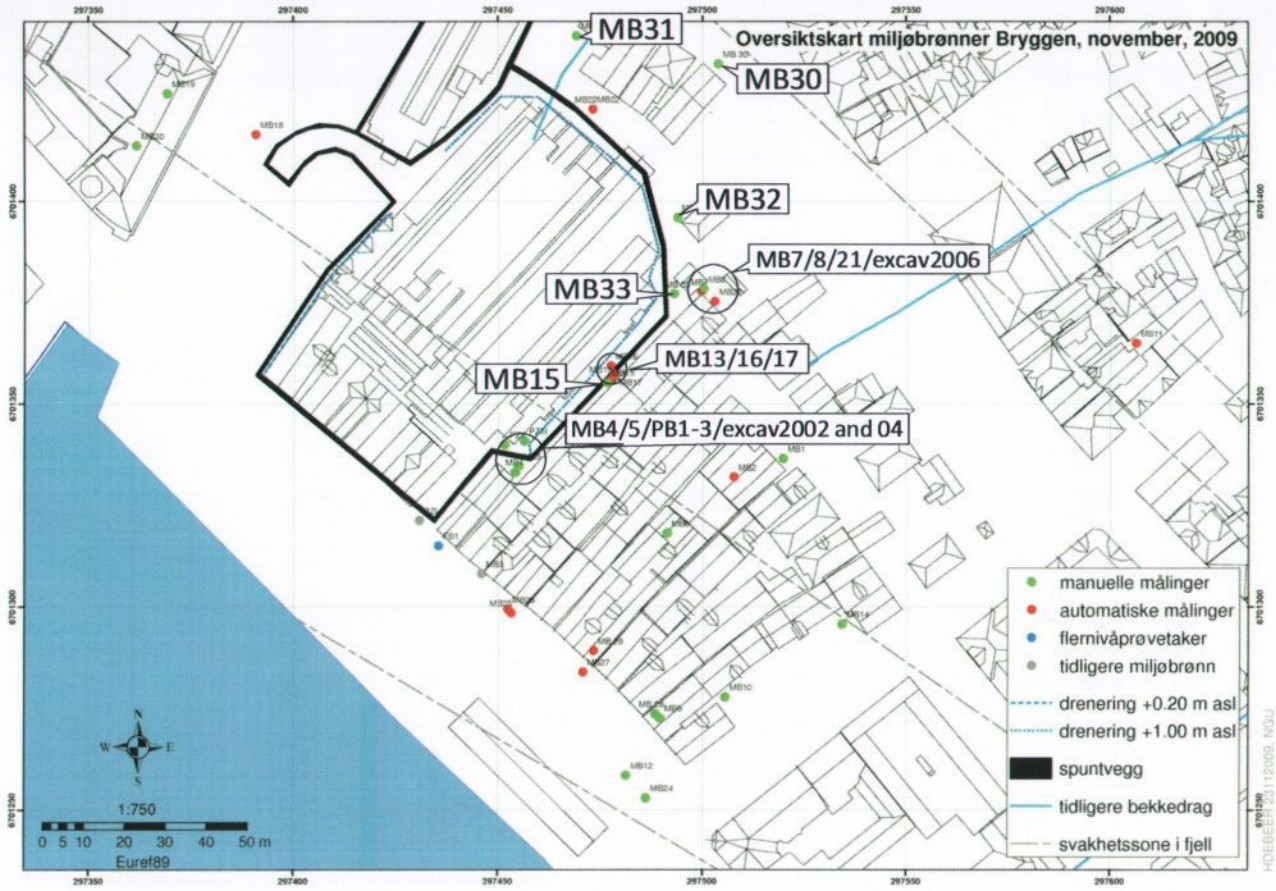



Figure 1: Map of Bryggen, showing the position of the new dipwells MB15 and MB30-33. Other dipwells and excavations discussed in the text are marked as well. The sheet piling ("spuntvegg") is marked by a thick black line. Map from Hans de Beer, NGU

## *Earlier studies at Bryggen*

A total of 36 dipwells and 1 multilevel sampler have been installed in the Bryggen area from 2001 to 2009, in order to get an overview of the preservation conditions for the cultural layers and their current state of preservation. Furthermore small excavations were made in 2002, 2004 and 2006. The state of preservation of the deposits has been described in detail by archaeologist Rory Dunlop from NIKU in a range of reports (Dunlop 2001-2010). Wood is a key material in the cultural deposits, and the state of preservation of archaeological as well as modern wood samples has been investigated on several occasions (Björdal, 2008;Gregory & Matthiesen, 2006;Klaassen et al, 2005). Continuous logging of the groundwater level in (some of) the dipwells has allowed the construction of a dynamic hydrological model for the area (de Beer et al, 2008;de Beer, 2008). Groundwater sampling has been made from the dipwells on several occasions, including sampling in all dipwells in 2005 (Matthiesen, 2006), and in 2008 (Matthiesen, 2008c). The hydrology and the groundwater chemistry are decisive for the preservation conditions in the cultural layers. A conceptual model of the groundwater and preservation conditions has been developed (de Beer & Matthiesen, 2008;Matthiesen, 2008b) and is continuously being refined – the latest version is shown in Figure 2.

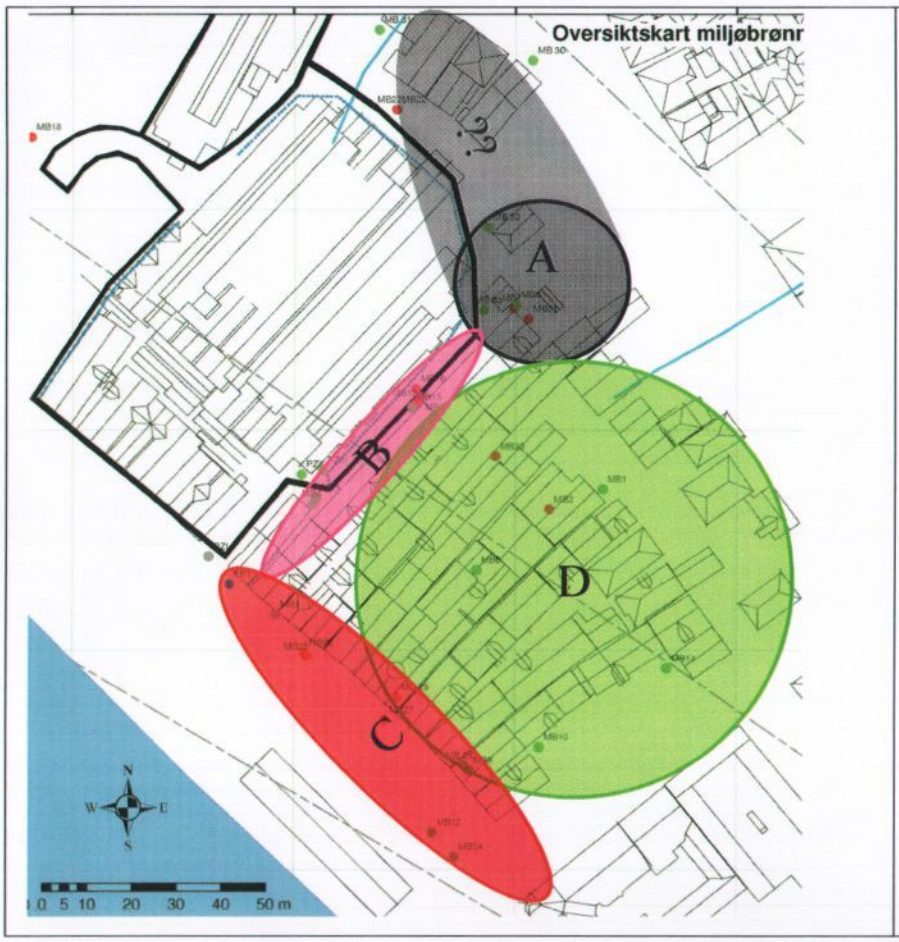
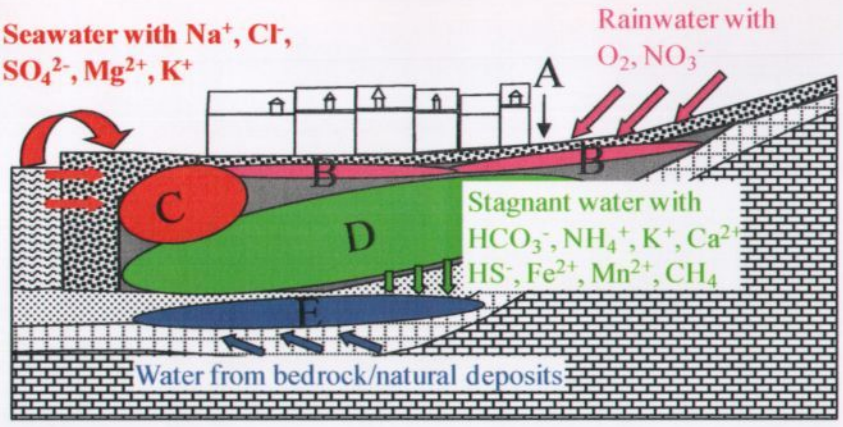



Figure 2: Conceptual model of the preservation conditions in different areas of Bryggen, based on the groundwater level, -flow, and –composition. Area A is influenced by drainage and has bad preservation conditions. Area B is influenced by flushing with oxygen-rich rainwater, possibly governed by the sheet piling, and has intermediate preservation conditions. Area C is influenced by seawater, and has intermediate preservation conditions. Area D has relatively stagnant conditions and very good preservation conditions.




Same areas shown in profile, seen from south-east towards north-west. Area E is in the natural deposits underneath the cultural layers: here the groundwater is a mixture of water from the cultural and natural deposits.

The preservation conditions vary considerably at Bryggen, and threats to the cultural layers are continuously evaluated. It is attempted to quantify the actual decay rates in the different areas, in order to compare the threats and prioritize the remedial actions:

As for area C (influenced by seawater), the extent and effects of seawater intrusion in the cultural layers at the quay front have recently been evaluated – this showed that seawater intrusion may cause a substantial decay of organic material in the cultural layers, but renovation of the sewage system has decreased the frequency of flooding events substantially and the seawater seems to penetrate into the upper soil layers only (Matthiesen, 2008a;Matthiesen, 2010).

As for area D (stagnant conditions) the preservation conditions seem to be very good, and probably as good as it gets at any urban site. A first attempt has recently been made to quantify the actual decay rate of these deposits, in order to have a reference level or a goal for the rest of Bryggen. The decay rates were estimated from the groundwater analyses, by setting up a numerical model in the geochemical program PHREEQC (Matthiesen, 2009). The approach was very promising, but also showed that the hydrology and geochemistry models need to be more closely linked in order to achieve better estimates of the actual rates.

As for area E it consists of natural deposits with no or only very few archaeological artefacts, so the preservation conditions are less important. The hydrological model indicates that the groundwater flow mainly goes from the cultural deposits down into the natural deposits, which implies that the cultural deposits are not influenced by the groundwater composition in area E. On the other hand Dunlop has shown that for some of the dipwells (next to the sheet piling) the state of preservation of the cultural deposits worsens down towards the natural deposits, which is difficult to explain at this stage (Dunlop, 2003 and 2010).

As for area A (drained area) it is characterized by a low groundwater level and high settling rate of the soil surface (Jensen, 2007). A small excavation was carried out in 2006 in order to study the conditions in the drained zone and install monitoring equipment (Matthiesen, 2007). This showed that the soil above the groundwater level still has a high settling potential and the settling will

probably not stop before the groundwater level is raised. It also indicated that the decay and settling mainly takes place in the uppermost soil layers (1-1½ m) in the excavated area, and it was hypothesised that the decay rate is controlled by the flux of oxygen into the soil layers (Matthiesen et al, 2008). The exact extent of the drained area is not known yet, and it is also unknown whether the area excavated in 2006 is representative for the rest of the drained area.

As for area B (flushed by rainwater) it has been shown that the conditions in the upper soil layers can be very dynamic – this was clearly demonstrated by a combined water level and oxygen logger placed in MB5, showing how the groundwater level and the oxygen concentration in the groundwater fluctuated on a daily basis depending on the rainfall (Matthiesen, 2005b). Modern wood samples installed in the fluctuating zone showed the occurrence of wood-decaying soft-rot, which requires oxygen for growth (Gregory et al, 2009;Gregory & Matthiesen, 2006). Further studies in the area include a small excavation and several drillings to evaluate if the sheet piling had a direct effect on the cultural layers next to it (Christensson et al, 2008;Dunlop, 2006): The state of preservation was found to be poor in the upper deposits (down to 1-3 m below sea level), with medium to good preservation deeper down, and with a tendency of showing a slightly worsened preservation in the deepest deposits just above the natural deposits. Chloride measurements showed that the upper soil layers (down to 2 m below sea level) were "washed out" with a very low salt content, possibly because the sheet piling forms a barrier that may guide the rainwater flow towards the quay front (Matthiesen, 2004;Matthiesen, 2005a). There is also an increased vertical water flow at the sheet piling (de Beer, 2008, p 35) as water flowing beneath and through the piling gives a reduced hydraulic head in the natural deposits beneath the cultural layers. Finally, temperature loggers in the groundwater have shown that the highest temperatures are found in dipwells near the hotel (de Beer, 2008). Overall, this indicates non-ideal preservation conditions in the deposits in area B, but it is still unclear if decay takes place at all depths in the deposits and if the decay rate is critical.

In order to elucidate the conditions in area A and B further, five new dipwells were installed in the drained area and along the sheet piling in September and October 2009. This report focuses on the results from the new dipwells, but also includes earlier material from areas A and B. Some suggestions are given on how monitoring should proceed in the area when the drainage system and sheet piling are modified.

## *Site and methods*

The new dipwells are shown in Figure 1, along with other dipwells and excavations referred to in the text. The drilling work was carried out in September and October 2009 by Multiconsult and archaeologist Rory Dunlop from the Norwegian Institute for Cultural Heritage Research (NIKU). The soil stratigraphy and state of preservation is described in two reports by Dunlop (Dunlop 2009;

Dunlop 2010). Twenty seven soil samples were analysed for pH, water content, loss on ignition (LOI), and water-soluble chloride; eighteen of these were also analysed for water-soluble sulphate, total sulphur, total nitrogen and total phosphorus; and two samples were also analysed for pyrite. The results are shown in Appendix 1.

Some of the samples from the drillings contained wood. A total of 15 pieces of wood were retrieved and their density (dry weight vs. wet volume) was measured.

The position of the dipwells and the level of their water intakes (filter) are shown in Table 1.

| Dipwell | Y-COORD. | X-COORD. | Top of dipwell (m asl) | Water intake – bottom (m asl) | Water intake – top (m asl) |
|---|---|---|---|---|---|
| MB15 | 297476.61 | 6701355.22 | 1.91 | -6.09 | -5.09 |
| MB30 | 297503.90 | 6701433.79 | 7.89 | 3.52 | 4.52 |
| MB31 | 297469.21 | 6701440.71 | 6.65 | 1.65 | 2.65 |
| MB32 | 297493.80 | 6701395.98 | 4.54 | 1.04 | 2.04 |
| MB33 | 297492.89 | 6701377.10 | 3.33 | -2.49 | -1.49 |

Table 1: Position of dipwells (data from Multiconsult/NGU).

On 29th October 2009 water was sampled from the dipwells by Multiconsult. The dipwells were emptied before the actual sampling, to ensure that fresh water from the cultural layers was sampled. The water samples were filtered in the field (0.45 µm Gelman high capacity in-line filter). Samples for methane were (as far as possible) taken inline before the filter, to avoid de-gassing of methane. Two of the dipwells were empty (MB30, MB31), and only MB15 had sufficient water flow to ensure a good sampling for methane – de-gassing may have taken place for the samples from MB32 and MB33. The samples were sent to the laboratory (Eurofins) and analysed for alkalinity, salt (sodium, chloride), nutrients (ammonium, nitrate, phosphate), redox-active species (sulphate, nitrate, dissolved iron, dissolved manganese, sulphide, methane), and other major ions (calcium, magnesium, potassium), which gives a good description of the chemical conditions in the ground-water. The reports from the laboratory are shown in Appendix 2.

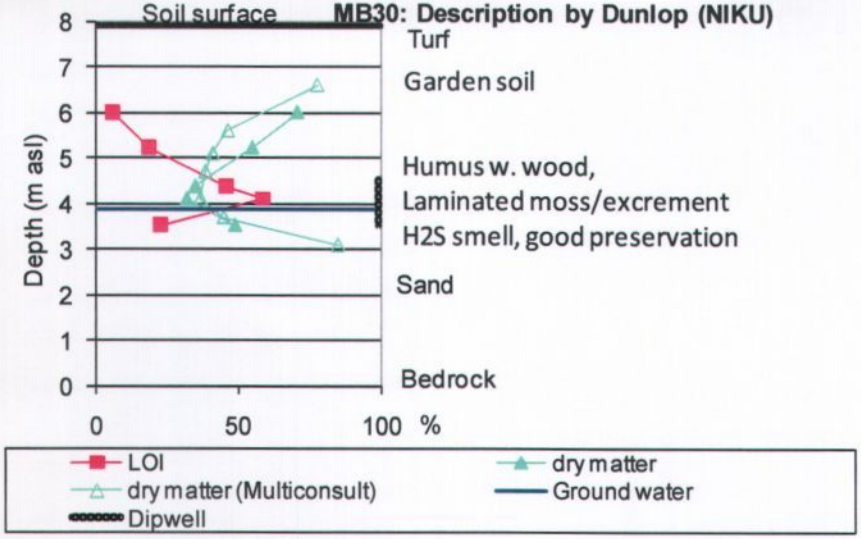
At the site of the 2006 excavation the water content of four different soil strata in the unsaturated zone is measured continuously by SM200 probes connected to a datalogger – the setup and soil strata are described in Matthiesen (2007). Data are downloaded at intervals, latest on 8th June 2010. Furthermore, sensors measuring temperature and oxygen content were installed in three soil strata. These sensors are not connected to a logger, but are measured manually at intervals when the necessary measuring equipment is available in Bergen.

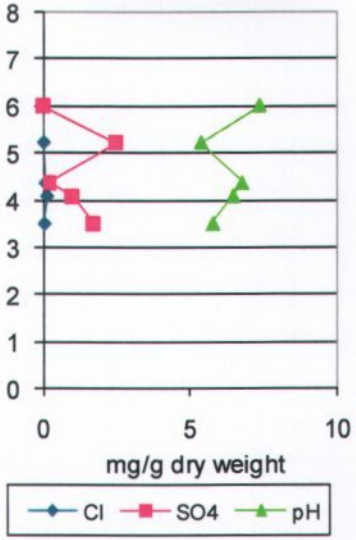
## *Results*

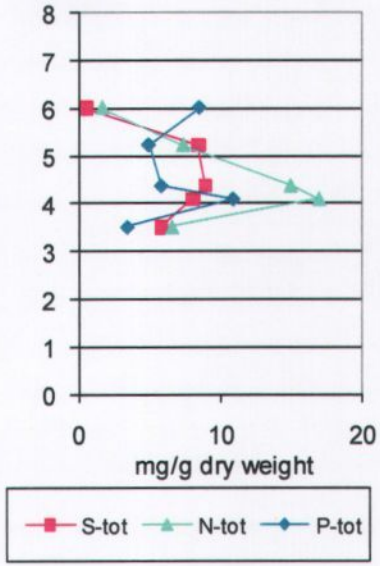
The results from analysis of soil and wood samples from MB30, 31, 32, 33 and 15 are presented in Figure 3, along with the preservation category of the different soil strata given by Dunlop. Results

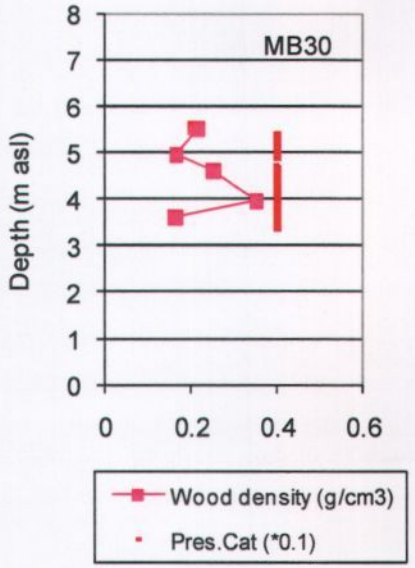
from groundwater analysis of samples taken in MB32, 33 and 15 in October 2009 are presented in Figure 4, along with results from May 2008 from other dipwells at Bryggen; the figure also includes results from a geochemical modelling of the groundwater composition in the cultural layers, based on a slow vertical water flow of 0.1 m/year. Results from water content measurements in the unsaturated zone are given in Figure 5, and results from oxygen and temperature measurements in the same zone are given in Table 2.

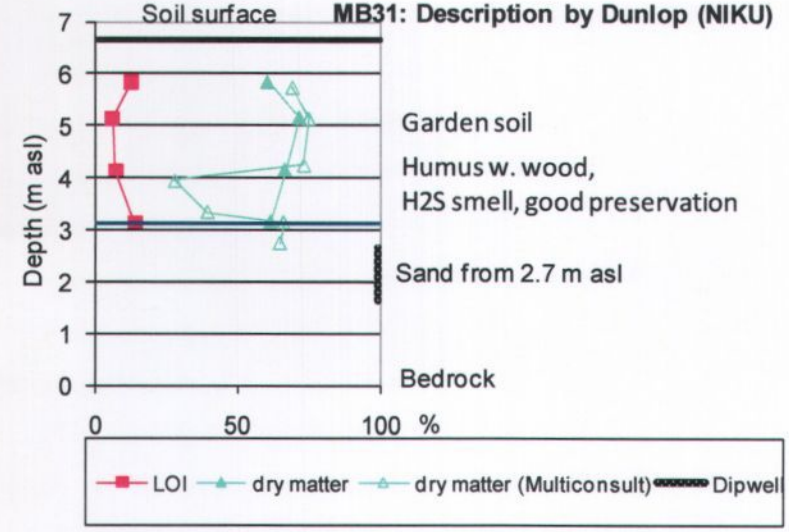
A note about the units used: Dissolved species are given as "mol/L" to allow an easy evaluation of the ion balance in the water and a good overview of their quantitative importance. Results from soil analysis are, on the other hand, normally presented as mg/g dry soil. Modelled decay of organic material (in Figure 4) is given as mol/L/year, which is the annual decay of organic matter in a soil volume containing 1 L pore water. Where it is necessary to make a direct comparison, the recalculation is made in the text.

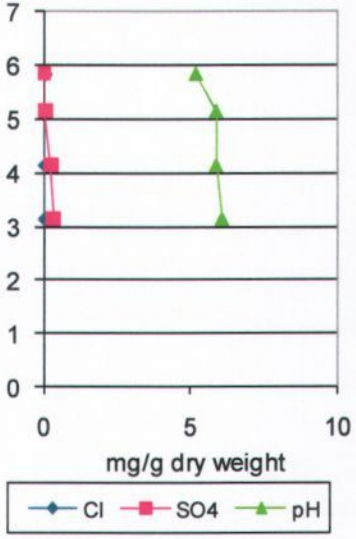

Soil surface
MB30: Description by Dunlop (NIKU)
Turf
Garden soil
Humus w. wood,
Laminated moss/excrement
H2S smell, good preservation
Sand
Bedrock
Depth (m asl)
0
50
100 %
LOI
dry matter
dry matter (Multiconsult)
Ground water
Dipwell

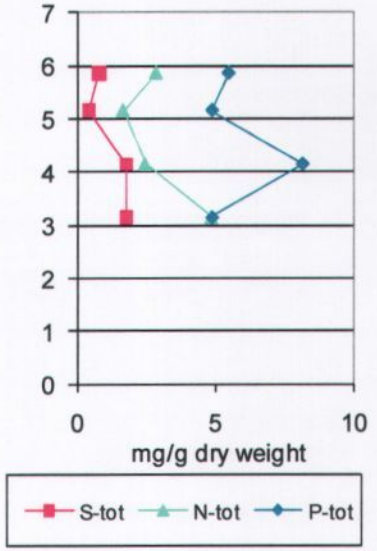

mg/g dry weight
Cl
SO4
pH

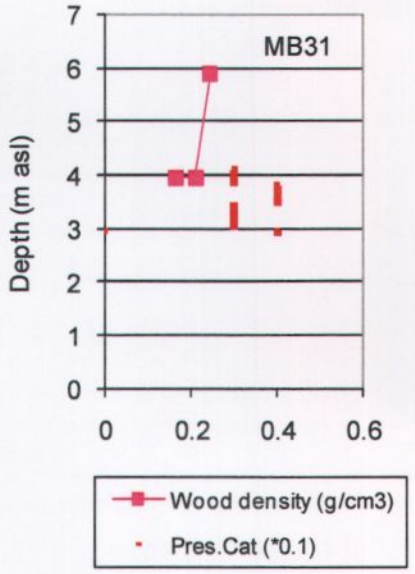

mg/g dry weight
S-tot
N-tot
P-tot


MB30
Depth (m asl)
Wood density (g/cm3)
Pres.Cat (*0.1)

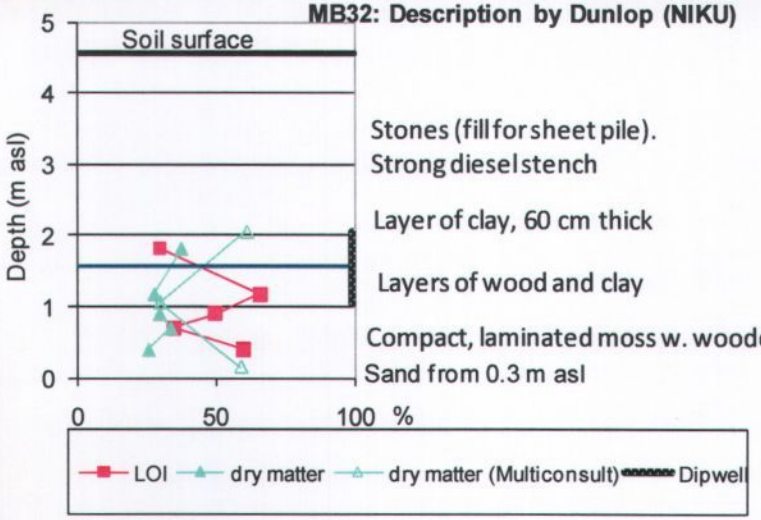

Soil surface
MB31: Description by Dunlop (NIKU)
Garden soil
Humus w. wood,
H2S smell, good preservation
Sand from 2.7 m asl
Bedrock
Depth (m asl)
0
50
100 %
LOI
dry matter
dry matter (Multiconsult)
Dipwell


mg/g dry weight
Cl
SO4
pH


mg/g dry weight
S-tot
N-tot
P-tot


MB31
Depth (m asl)
Wood density (g/cm3)
Pres.Cat (*0.1)

**MB32: Description by Dunlop (NIKU)**

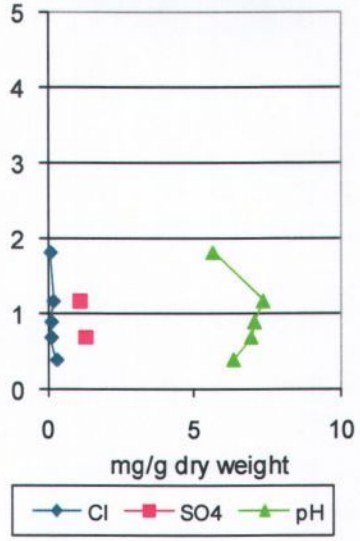


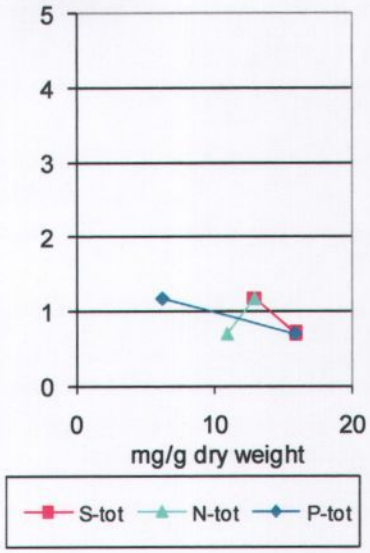

Stones (fill for sheet pile).
Strong diesel stench

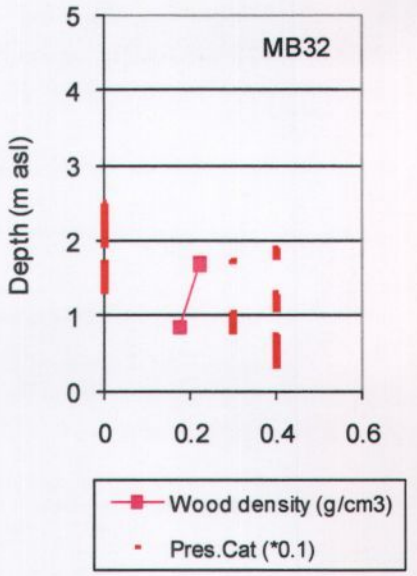
Layer of clay, 60 cm thick

Layers of wood and clay

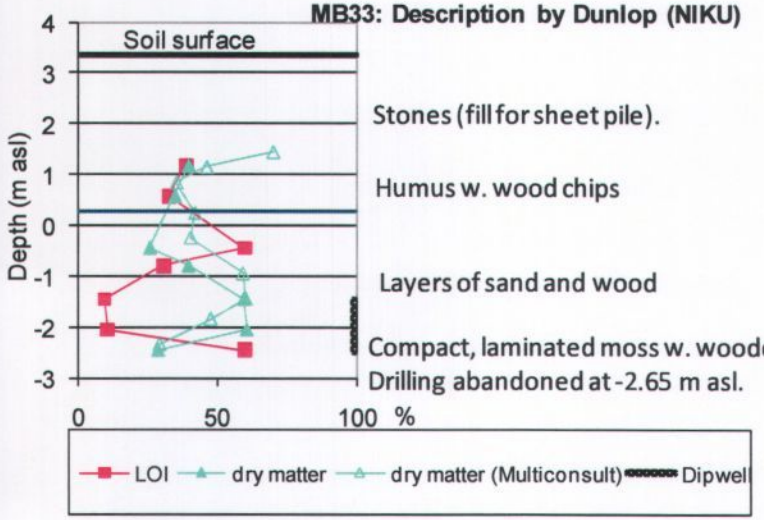
Compact, laminated moss w. woodchips.
Sand from 0.3 m asl




**MB33: Description by Dunlop (NIKU)**

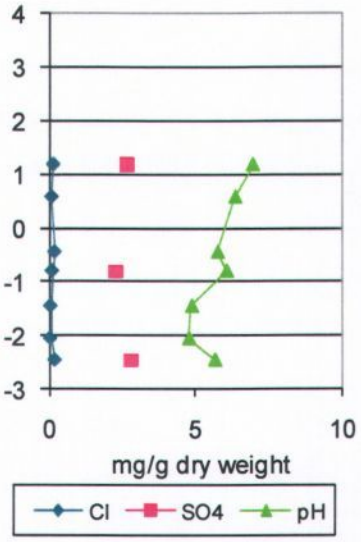


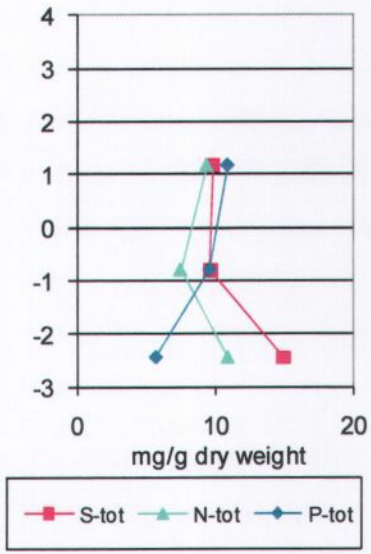

Stones (fill for sheet pile).

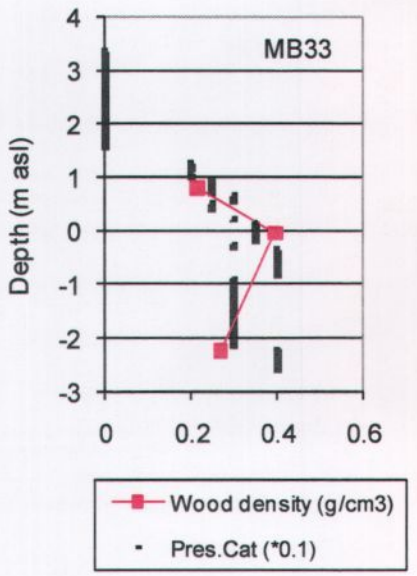
Humus w. wood chips

Layers of sand and wood

Compact, laminated moss w. woodchips.
Drilling abandoned at -2.65 m asl.



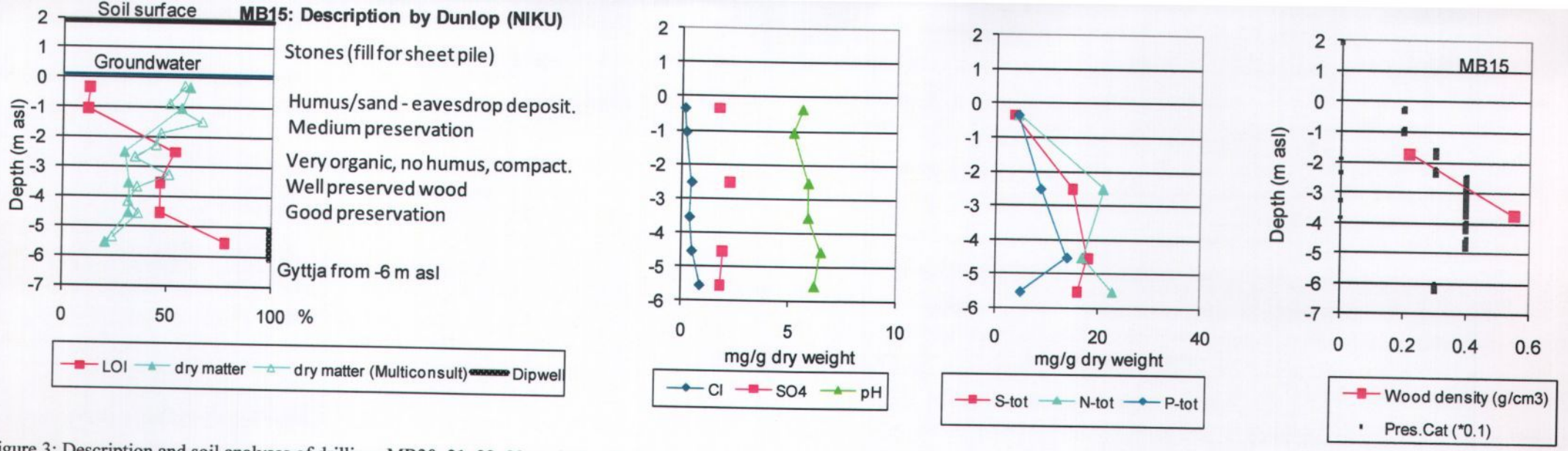



Figure 3: Description and soil analyses of drillings MB30, 31, 32, 33, and 15. LOI is loss-on-ignition, Cl is water extractable chloride, $SO_4$ is water extractable sulphate, S-tot N-tot and P-tot are the total amount of sulphur, nitrogen and phosphorus, and density of wood is the dry weight to wet volume density. The preservation category of the different soil strata is evaluated by Dunlop on a scale from 1 (very poor) to 5 (very good) – here the numbers have been downscaled by factor 10 to include them in the graph. 0 is used for inorganic or modern fill. Black lines are for soil beneath the groundwater level (C1-C5) and red lines are for soil above the water level (A1-A5).

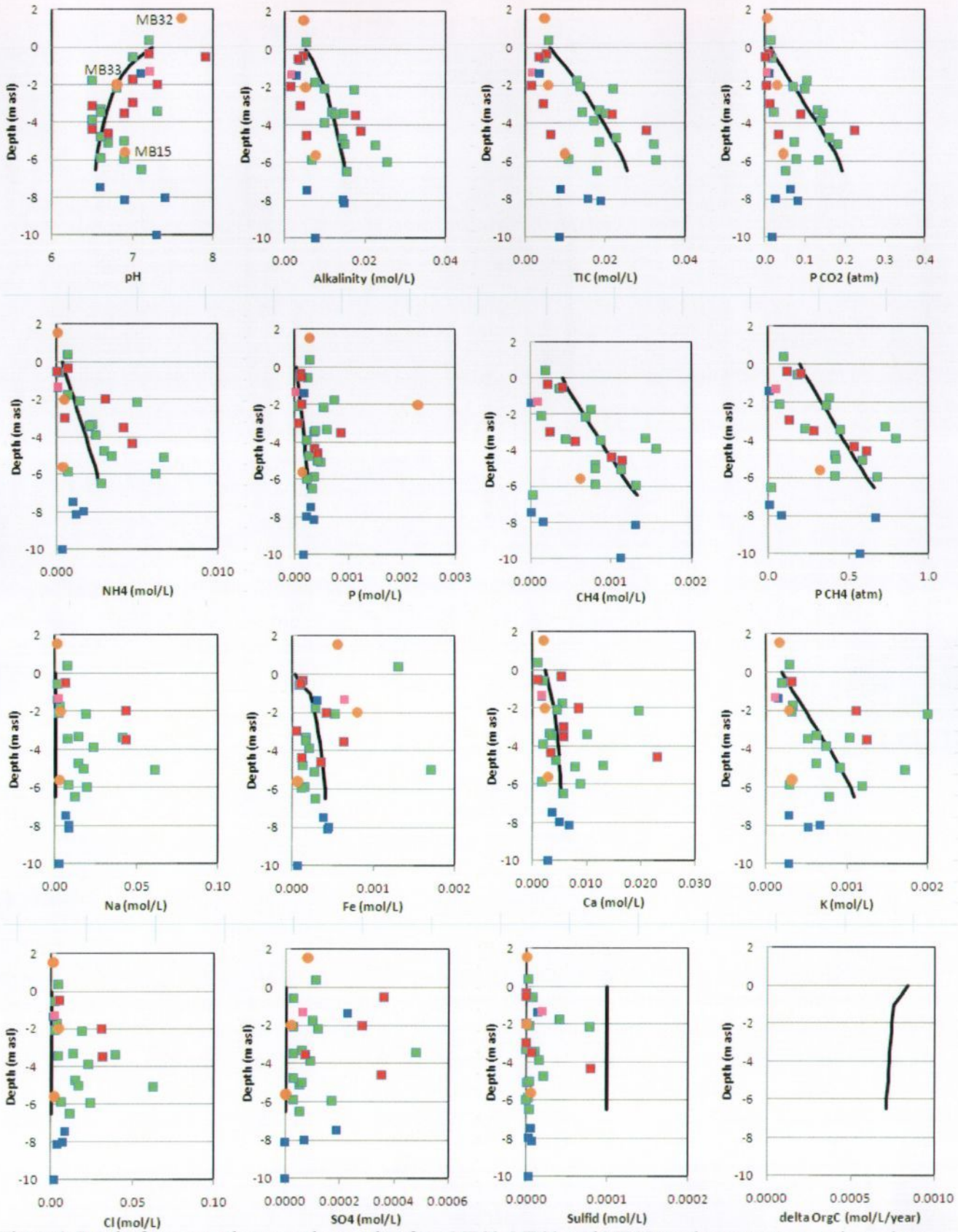



Figure 4: Results from groundwater analyses – data from MB32, MB33, and MB15 are shown as orange points, where the uppermost is MB32 (1.54 m asl), MB33 is in the middle (-1.99 m asl), and the lowest is MB15 (-5.59 m asl). For comparison, data from sampling of other dipwells on Bryggen in May 2008 are shown (some results are missing as they are higher than the maximum value on the x-axis). The different colours indicate different types of water identified hitherto: Green – water from relatively stagnant conditions; red – influenced by seawater; pink – "young" samples very diluted by rainwater; and blue – samples from natural deposits underneath the cultural layers. The black lines are the output from a numerical groundwater geochemistry model made in PHREEQC attempting to model the stagnant condition using a moderate vertical flow of 0.1 m/year through organic deposits. It must be emphasized that the model still needs validation and the numbers should not be over-interpreted. Updated from Matthiesen (2009).

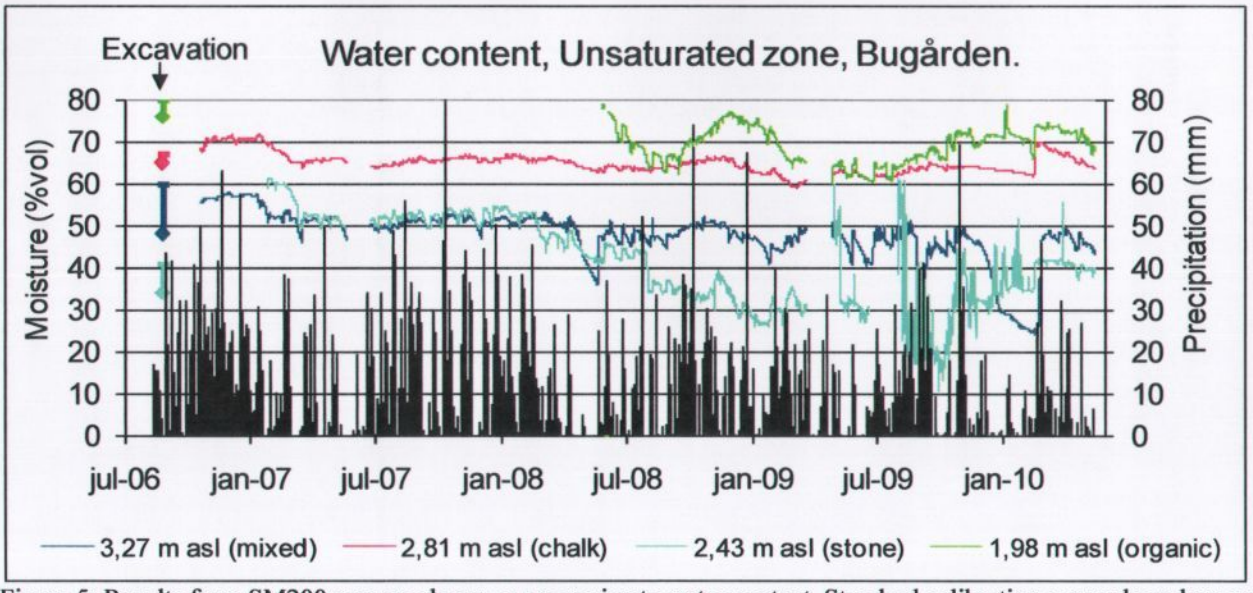



Figure 5: Results from SM200 sensors shown as approximate water content. Standard calibration curves have been used for the different soil layers, as described in Matthiesen (2007). The results from soil samples taken during the excavation in September 2006 are shown as well (soil porosity shown as horizontal lines, water content during the excavation shown as diamonds). The daily precipitation values are taken from www.met.no for the Florida weather station in Bergen. Data are missing for two periods (summer 2007 and spring 2009) due to logger problems. The output from the sensor at 1.98 m asl (organic) was "over range" for the first two years, indicating a water content higher than 80% vol. The soil surface (cobble-stone) is at 4.15 m asl.

The results from oxygen and temperature measurements in the unsaturated zone are shown in Table 2:

| Date | 01-03-2007 | | 10-06-2007 | | 22-10-2008 | | 19-10-2009 | | 08-06-2010 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth | Oxygen (% sat) | Temp. (°C) | Oxygen (% sat) | Temp. (°C) | Oxygen (% sat) | Temp. (°C) | Oxygen (% sat) | Temp. (°C) | Oxygen (% sat) | Temp. (°C) |
| 2.81 m asl | 0.2 | 4.2° | 0.1 | 10.1° | 0.0 | 10.2° | 0.0 | 10.1° | 0.0 | 8.4 |
| 2.43 m asl | --- | 5.4° | --- | 8.7° | --- | 11.7° | --- | 11.1° | --- | 7.5 |
| 1.98 m asl | 0.0 | 6.0° | 0.0 | 8.2° | 0.0 | 11.6° | 0.0 | 11.6° | 0.0 | 6.8 |

Table 2: Oxygen concentration and soil temperature at different depths in the excavation pit from 2006, measured with sensors left in situ. The oxygen sensor at 2.43 m asl was not working.

## *Discussion*

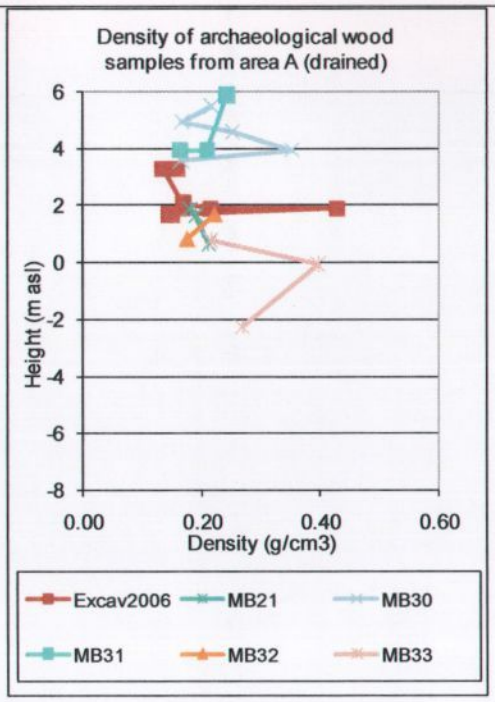
The discussion is organised to discuss the following: first, the results from the drained area A (MB30, 31, 32, 33 as well as old dipwells MB7, 8, 21 and 22), and secondly area B (MB 15 as well as old dipwells 4, 5, 13, 16, 17, and drillings PB1-3). There is some overlap, as the group MB13, 15, 16 and 17 also belong to the drained area. For both areas firstly the actual state of preservation is discussed, then the preservation conditions above and beneath the groundwater level, and finally some suggestions are given concerning monitoring before, during and after the construction work at the sheet piling, to document its effect on the preservation conditions.

## *Area A - drained*

### State of preservation:

In the area around Schøtstuene (MB30 and MB31) the upper 2½ meters consist of postmedieval "garden soil" with an indefinable state of preservation – Figure 3. Beneath this up to 2 m of relatively organic medieval layers with medium to good state of preservation (A3-A4) are found (Dunlop, 2009). A similar picture was observed for MB22 nearby. MB32 is unusual as the sequence contains some thick layers of pure clay. As for MB33 the upper 2 m consists of modern fill from the installation of the sheet piling. Beneath this 4 m of medieval layers with poor to good state of preservation (C2-C4) are found (Dunlop, 2010). MB7 is placed nearby, but further from the sheet piling. Here there is only ½ m of modern fill, but the upper 1½ m of the medieval deposits are in a very poor to poor state of preservation (A1-A2). Beneath this 4½ m of medieval layers of medium to very good state of preservation (C3-C5) are found (Dunlop, 2007) – significantly better than at MB33. MB21 was only drilled to a depth of 4 m, here there is 1 m of modern fill, and beneath this 3 m of medieval deposits of very poor to medium state of preservation (A1-A3) are found.

A few archaeological wood samples have been retrieved from the drillings and characterized in terms of their density (Figure 3). In area A samples have been retrieved from MB30, 31, 32, 33, 21, and the excavation in Bugården in 2006, and their densities are compiled in Figure 6. Most of the samples are from above the groundwater level and most of them show a low density around 0.2 g/cm$^3$. The tree species have not been formally identified for these samples, but it is assumed that most are pine. For comparison, fresh pine has a density of approximately 0.35-0.50 g/cm$^3$, dependent on the proportion of early and late wood in the sample. A decrease in density indicates that different components in the wood have decayed. Depending on the environmental conditions this decay may be caused by either bacteria or fungi, which have different consequences for the wood as described in Gregory & Matthiesen (2006). A density of only 0.2 g/cm$^3$ indicates that the wood will collapse if it is excavated and allowed to dry without conservation. It is difficult to decide if the decay is ongoing, or if it took place a long time ago. A decay experiment in an active compost heap (trying to simulate pre-burial conditions for archaeological material) showed that the density of fresh pine could decrease to 0.33 g/cm$^3$ in 20 months (Gregory et al, 2009) and further to 0.24 g/cm$^3$ in 30 months (unpublished) under humid, oxic conditions.



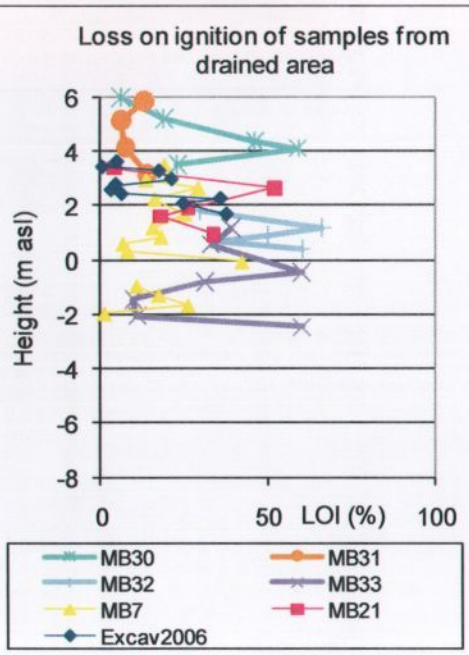




Figure 6: Density of wood samples (left), and loss on ignition of soil samples (right) from area A.

Loss on ignition (LOI) is used to characterize soil samples and their vulnerability to oxidation; it is closely linked to the amount of organic matter in the soil. LOI is very variable in the drained area, as seen in Figure 6, where results from the different drillings are compiled. There is a vague tendency towards increasing LOI with depth, but not as clear as one might expect – thus there is no distinct difference between LOI values measured above and below the groundwater level, which is found at approximately 1 m asl in this area. This indicates that the LOI values found today are mainly determined by the origin of the deposits, rather than a possible decay and decrease in LOI over time. The high LOI values found for some of the soil samples from above the groundwater level means that there is still a large settling potential for the soil. For MB7 it was estimated that if all the organic material above the groundwater level disappeared over time, the theoretical worst case settling potential would be up to 2 m (Matthiesen, 2004). Figure 6 shows that the other drillings from the area have LOI values similar to MB7 and thus similarly large settling potentials.

## Preservation conditions:

*Groundwater level*: In the area around Schøtstuene the water level is several meters below the soil surface. At MB30 the cultural deposits are all above 3.3 m asl; the dipwell was dry during the groundwater sampling on 29th October 2009 (meaning that the water level was below 3.5 m asl) and on 11th November it was measured at 3.86 m asl. At MB31 the cultural deposits are all above 2.7 m asl; the dipwell was dry during the sampling (meaning that the water level was below 1.65 m asl) and on 11th November it was measured to 3.13 m asl. At MB22 the groundwater level fluctuates

between 0.4 and 1.6 m asl, and the cultural deposits are all above 0.55 m asl. This means that for these 3 dipwells all the cultural deposits are often or at least occasionally above the groundwater level.

At MB32 the cultural deposits extend down to 0.3 m asl and the groundwater level on 11th November was 1.57 m asl. At MB33 the cultural deposits extend down to at least -2.65 m asl (not drilled to the bottom) and the water level was 0.27 m asl. At MB7 the cultural deposits extend down to -1.8 m asl and the groundwater level fluctuates between 0.4 and 1.6 m asl. At MB21 the cultural deposits extend down to at least 0.3 m asl (not drilled to the bottom) and the water level fluctuates between <1.25 and 2.5 m asl. This means that for these four dipwells the cultural deposits are found both above and below the groundwater level.

*Preservation conditions above the groundwater level*: The conditions above the groundwater level are critical for the cultural layers as there may be a significant supply of oxygen through unsaturated soil – the transport rate of oxygen through air is >1000 times faster than through water. Oxygen is used by microorganisms to decompose organic material, which can result in the settling of buildings and ground surface that is observed in the area (Jensen, 2007). However, the organic material doesn't all disappear overnight, and there may be a lag phase where the soil layers gradually dry out and where the oxygen is consumed in the upper soil strata before it reaches the deeper deposits. Results from the water content logger (Figure 5) placed in the excavation pit from 2006 show a decreasing tendency over time: the water content at the uppermost sensor at 3.27 m asl decreases from approximately 58% vol in autumn 2006 to 40-50% vol in autumn 2009 (the absolute values should not be over-interpreted, as no soil-specific calibration could be made). A very low water content (down to 25% vol) is seen during the winter 2009/10 with a sudden increase to 45-50% in March 2010 – this is because the precipitation is stored as snow during the winter, which then melts in March. The next sensor at 2.81 m asl is placed in lime – this shows a decrease from 70 to 60% vol. The fluctuations in water content over the seasons are much lower for lime, as it is a fine-grained material with a good ability to retain water. The third sensor at 2.43 m asl is placed in coarse stone material, which has a low water-retaining ability. Here the water content decreases from 60% to 40% and the fluctuations are much larger. During the autumn/winter 2009/10 the fluctuations are very rapid and difficult to correlate to the precipitation – it cannot be excluded that this is due to the water content being below the reliable measuring range, or the sensor may be at the end of its use-life. The deepest sensor at 1.98 m asl is of prime interest, as it is placed in a very organic soil layer. For the first two years the water content was above the measuring range of the sensor (above 80% vol), but since the summer of 2008 it has decreased from 80% vol to 60-70% vol, with an apparent seasonal variation. It thus seems that the layers even 2 meters below the soil surface are slowly drying out. The results from the small excavation in 2006 indicated that most

decomposition of organic material was taking place in the uppermost 1½ m of the soil (Matthiesen, 2007), but the slow drying out could mean that the decomposition will also take place in deeper soil layers in the future.

As for the oxygen concentrations measured in situ it was observed during the excavation that the layer of fine-grained lime formed an efficient oxygen barrier. The high water content of the lime slowed down the oxygen transport so no oxygen reached the deeper deposits (Matthiesen, 2007). The oxygen measurements carried out after the excavation (Table 2) confirms this picture and no oxygen has been present during the four visits made until now. However, only two out of the three installed sensors are working, and it would be more informative to have continuous logging of the oxygen at several depths.

The lime layer doesn't cover all of Bryggen, and there is no guarantee that the excavation pit from 2006 is representative for the whole of the drained area. At MB30 and MB31 there is a 2 m thick layer of post-medieval "garden soil" instead. This covers some surprisingly well-preserved organic-rich medieval layers (C3-C4), and it seems likely that the garden soil functions as an oxygen barrier stopping the oxygen penetration from above, just like the lime layer. However, oxygen measurements down through the different soil strata would be necessary to confirm this.

*Conditions below the groundwater level:* In the area around Schøtstuene (including MB30, 31 and 22) all the cultural layers are (at least occasionally) above the groundwater level, and it is not relevant to discuss the preservation conditions for the natural deposits underneath. For MB32 and 33 some of the cultural layers are permanently beneath the groundwater level. The groundwater composition is shown in Figure 4 (orange points) and in Appendix 2. Oxygen measurements could not be made in the water samples, but there is no nitrate and the concentration of dissolved iron is high, both of which indicate anoxic conditions in the water at the time of sampling. The concentration of sulphate is low so there is little to oxidize organic material in the soil. It is, however, too early to say if this is a stable condition – this will require repeated sampling or even better the use of an automated oxygen logger. Furthermore it is necessary to know the water flow through the deposits to evaluate the decay rate and preservation conditions.

## Further monitoring:

The preservation conditions around the sheet piling have to be improved in order to stop the ongoing settling of the buildings and soil surface. It is planned to raise the groundwater level by making the sheet piling watertight. In order to verify the effect it is necessary to continue the monitoring before, during and after the construction work:

Obviously, logging of the groundwater level and measurements of the settling in the area must continue. In the soil strata above the groundwater level, logging of water content in the excavation

pit from 2006 must continue, in order to see if the "drying out" tendency is stopped (Figure 5). It is recommended to supplement this with measurements of oxygen in the different soil strata, ideally with automated equipment. Also it is recommended to make similar measurements in other parts of the drained area, for instance near Schøtstuene, as the conditions at the excavation pit are not necessarily representative for the whole area.

For the conditions beneath the groundwater table it is recommended to use one or more oxygen loggers that are moved between the dipwells in the drained area. If an oxygen logger is not available, a conductivity logger may also reveal if the conditions are stable or dynamic. The logging should be supplemented by frequent sampling of water and analysis for redox-active species.

## *Area B – increased water flow*

An overview of the different dipwells, drillings and soil strata along the sheet piling are shown in Figure 7:

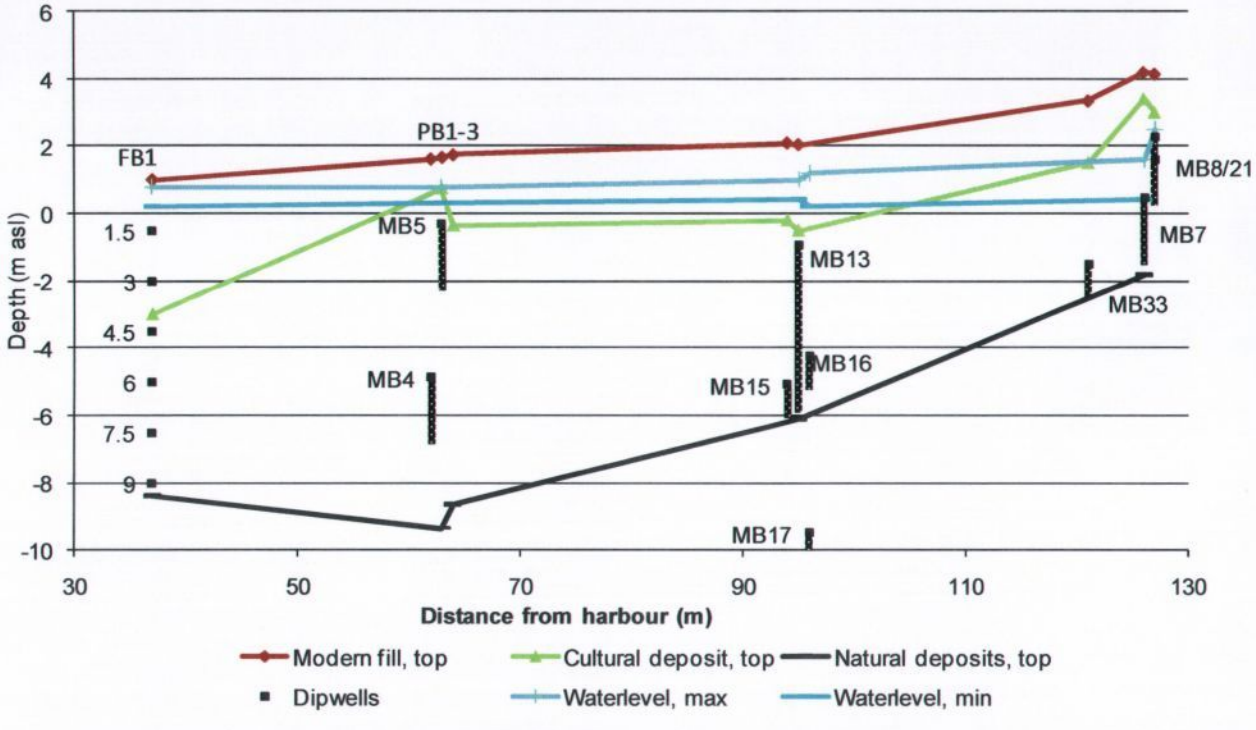



Figure 7: Transect along the sheet piling, showing the different drillings and dipwells in area B, along with the soil surface, groundwater level and top/bottom of the cultural layers found in these drillings. The top of the cultural layers (green curve) looks very variable as the layer of modern fill is a couple of meters thick right next to the sheet piling (e.g. at PB1-3) whereas it is less than 1 m thick just a few meters from the sheet piling (e.g. MB5).

## State of preservation:

The upper 2 m of the drilling for the new dipwell MB15 consisted of modern fill from the installation of the sheet piling (stone/large pebbles) and the next 1 m consisted of post-medieval fill of poor or indefinable state of preservation (Dunlop, 2010). The medieval deposits beneath were in

medium to good state of preservation (C3-C4). For comparison the drilling for MB13 (1 m from MB15, drilled in 2005) showed a significantly better state of preservation (C4-C5) in the medieval layers. MB16 is placed on the hotel site of the sheet piling, here the upper 5½ m consisted of modern fill from building of the hotel, the next ½ m was medieval deposits in poor to medium state of preservation (C2-C3), beneath which the deposits were good to excellent (C4-C5) (Dunlop 2008b). The soil from MB17 has not been described or analysed in any detail. Closer to the harbour, three drillings (PB1-3) were made in 2005 at different distances to the sheet piling (0.2, 0.5 and 1.0 m) to evaluate its effect on the state of preservation (Dunlop, 2008). A 2 m thick layer of modern fill was found in the top, followed by a 3 m thick layer of post-medieval fill in poor or very poor state of preservation (C1-C2). The preservation of the medieval deposits underneath was found to be medium to good (C3-C4). There was no clear correlation between the distance to the sheet piling and the quality of the deposits in PB1-3, but some physical disturbance caused by the sheet piling was noted (mixing of different soil strata and drawdown of the natural deposits). Drillings MB4 and MB5 from 2002 are placed a few meters further away from the sheet piling: here the layer of modern fill is less than 1 meter, and the quality of the deposits was noted to be better (C4-C5) than at PB1-3 (Dunlop, 2008). It was noted by Dunlop (2003) that the state of preservation in "rotary drilling 1" (placed right next to MB5) worsened from very good (C5) to medium (C3) in the deepest layers just above the natural deposits. FB1 is closer to the harbour and influenced by the construction of the modern quay front. Here the upper 4 m consisted of modern fill, followed by 1½ m of post-medieval and 4 m of medieval deposits in medium to good state of preservation (C3-C4). A few archaeological wood samples from the drillings and from an excavation in Bredsgaarden in 2004 have been analysed (Figure 8). There is a tendency that the density increases at greater depths, corresponding to a better state of preservation of the wood. Most samples down to -2 m asl have a density around 0.2 g/cm$^3$, as was also seen in area A (Figure 6). The deeper samples have densities up to 0.45 g/cm$^3$, which corresponds to the density of fresh, non-degraded pine (a single sample at -4 m asl has a density of 0.55 g/cm$^3$, but this is a thin twig that cannot be compared to samples from larger pieces of wood). Wood samples from the excavation in 2004 have been analysed in more detail by microscopy (Gregory & Matthiesen, 2006). This showed that the wood was attacked by softrot and bacteria. Similar results were found within the BacPoles project, where 4 samples from the same excavation were analysed (Klaassen et al, 2005, p 85 + p 201-204 in their appendix 2).

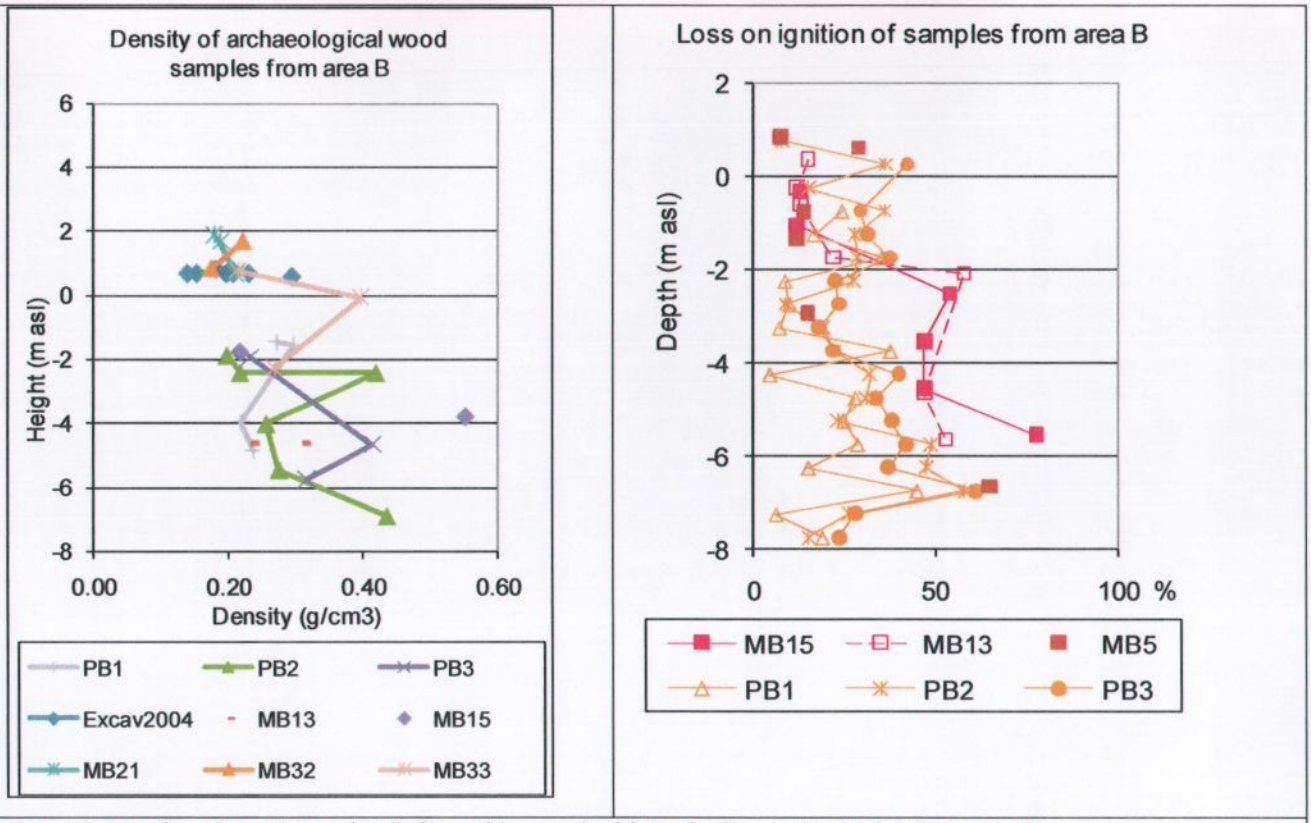



Figure 8: Density of wood samples (left), and loss on ignition of soil samples (right) from area B.

The loss-on-ignition of soil samples from area B varies, but most samples have relatively high LOI values, corresponding to high organic contents. The contents in MB15 and in MB13 (pink curves) are similar, reflecting that they were drilled very close to each other. The difference observed in their state of preservation (as described by Dunlop) is not reflected by a corresponding difference in the loss-on-ignition. The curves show two distinct areas, with low loss-on-ignition above -2 m asl (corresponding to the modern and post-medieval fill in the top) and high values below (in the organic medieval layers). The drillings PB1-3 and MB5 are similar to each other; they also show a slight increase in LOI with depth, but not as distinct as for MB13 and MB15.

## Preservation conditions:

*Groundwater level:* In the area along the sheet piling the groundwater level is mainly governed by a drain around the hotel placed at approximately -0.09 m asl. The water level measured by a logger in MB7 varies between 0.4 and 1.6 m asl, at MB13 it varies between 0.4 and 1.0 m asl (de Beer, 2008) and in MB5 it varies between 0.3 and 0.8 m asl (Matthiesen, 2005b), as shown in Figure 7. For comparison, the soil surface at MB7 is at 4.21 m asl, at MB13 it is 2.02 m asl, and at MB5 it is 1.67 m asl. The uppermost soil layers next to the sheet piling consists of modern fill, and the cultural deposits are all beneath 2.8 m asl at MB7, -0.5 m asl at MB13 (-0.2 at MB15), and 0.75 m asl at MB5. Figure 7 indicates that the unsaturated zone mainly contains modern fill, but this is only the

case just next to the sheet piling – a few meters away (and for instance beneath the buildings) the unsaturated zone will probably also contain organic-rich medieval deposits.

*Preservation conditions above the groundwater level:*

The preservation conditions above the groundwater level in area B will be just as critical as described for area A. Small excavations were carried out in Bredsgaarden in 2002 (Matthiesen, 2002;Matthiesen, 2004) and 2004 (Matthiesen, 2005a) to study the conditions and to place and retrieve modern wood samples for decay studies (Gregory & Matthiesen, 2006). The results showed that the soil layers down to at least -1.0 m asl are "washed out" and have a low conductivity comparable to that of rainwater. Oxygen measurements by Ev Kretschmar from the BacPoles project showed full oxygen saturation down to 0.8 m asl, then a decreasing oxygen content down to -0.5 m asl, and then (quite surprisingly) increasing contents down to -1.4 m asl (Matthiesen, 2004). Modern wood and iron samples were placed in the soil at MB5 for two years, after which they were retrieved and analysed. The samples were placed at 0.0 to 0.6 m asl, where the groundwater level varies from 0.4 to 0.8 m asl. The results showed that the samples were attacked by bacteria in the outer 1 mm, and a few samples were attacked by whiterot. Softrot, which was abundant on the archaeological samples, was not present on the modern samples after two years. The density of the samples varied between 0.35 and 0.50 g/cm$^3$, which is similar to the range observed for fresh pine wood. It thus takes more than two years to have a significant decrease in density in this environment, i.e. it is less aggressive than described for the compost experiment (Gregory et al, 2009). As for the iron samples they showed a corrosion rate of 0.02-0.03 mm/year, which is relatively high and not acceptable if it concerned archaeological iron artefacts.

*Preservation conditions below the groundwater level:*

The groundwater flow is key for the preservation conditions. Flow may take place both vertically down through the cultural deposits, and horizontally alongside the sheet piling towards the quay front. As for the vertical flow it is due to drainage of water through and beneath the sheet piling, which gives a lower groundwater pressure in the deeper deposits compared to the upper deposits. The flow rate is probably a few meters per year, but the exact value is very uncertain and there is a strong need for better estimates or direct measurements. For comparison, the vertical groundwater flow in the central part of Bryggen has been estimated to 0.1 m/year (Matthiesen, 2009).

As for the horizontal flow along the sheet piling it is even more difficult to estimate as the deposits are very heterogeneous with lenses of modern fill material, which are very porous. In dry periods the water level in dipwells along the sheet piling is almost horizontal (0.3-0.4 m asl) as seen in Figure 7, but when it rains the water level increases abruptly, and there is a height difference of 0.8

m between MB7 (1.6 m asl) and MB5 (0.8 m asl). This can cause a significant water flow through the porous deposits.

A significant water flow is also indicated by the composition of the groundwater: An oxygen logger placed in MB5 in 2004 showed very dynamic conditions, where the oxygen concentration in the water increased abruptly whenever it rained (Figure 9). This confirmed the in situ measurements by Kretschmar, who found significant oxygen concentrations at -1.4 m asl (2 m beneath the groundwater level).

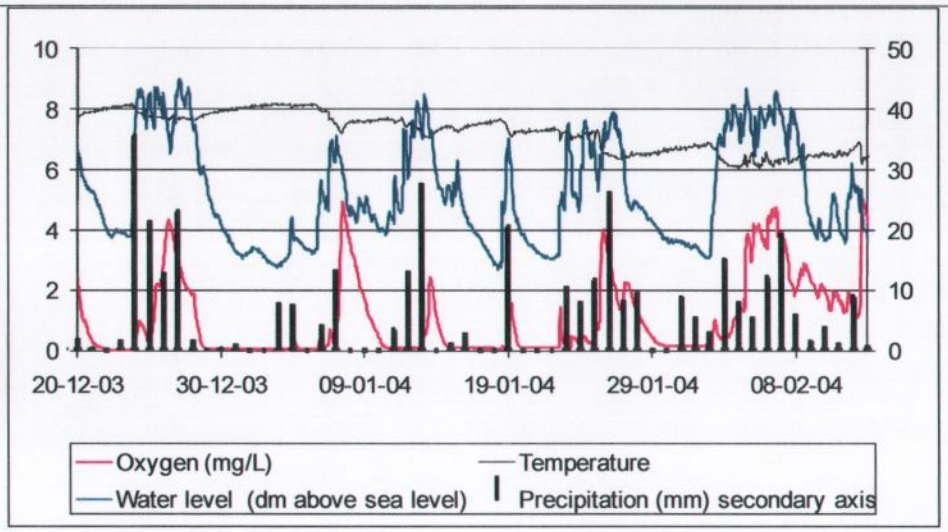



Figure 9: Dynamic conditions in MB5, measured by an OTD logger (oxygen, temperature, depth). Dipwell MB5 has its water intake between -0.3 and -2.3 m asl. From Matthiesen (2005b)

This is interpreted as oxygen-rich rain water streaming through the modern fill and cultural deposits whenever it rains. It gives un-satisfactory preservation conditions, as the oxygen may be used by microorganisms to oxidize organic material in the soil. The effect on wood was documented by Gregory & Matthiesen (2006) and also in a recent study by Charlotte Bjørdal and Thomas Nilsson: They placed samples of modern wood and kapok in some of the dipwells at Bryggen (MB1, 5, 6, 7, 12, 13, 14, 18), and when the samples were retrieved after 14 months, the samples from MB5 were the most degraded, showing attack by softrot and bacteria in the outer 1 mm (Björdal, 2008). The second most aggressive dipwell was MB13, followed by MB7 and MB18, all placed around the SAS hotel.

The oxygen logger showed similar dynamic conditions, with the occasional presence of oxygen-rich water in MB3, which was placed at the quay front buildings just next to FB1. MB3 had a water intake between -0.08 and -4.58 m asl; it has since been removed, as it was drilled right through a sewage pipe, and it is difficult to say if the dynamic conditions were representative for the soil layers or due to the sewage pipe. As for the multilevel dipwell FB1 no oxygen measurements have been made yet. However, frequent groundwater sampling during 2009 (for analysis of chloride and sulphate) showed variable conditions in the modern fill at -0.5 and -2.0 m asl, and also showed that the chloride concentrations found in FB1 were 5-10 times lower than the concentrations found in

other dipwells close to the harbour (MB24, 25, 26, 27, 28 and 29) (Matthiesen, 2010). The chloride comes from seawater, and the lower chloride concentrations indicate a lower seawater:rainwater ratio at FB1. This could possibly be due to large amounts of rainwater directed towards FB1 by the sheet piling, which might be confirmed by logging the oxygen concentration in FB1. Chloride content of soil samples taken near the sheet piling are compiled in Figure 10 (only drillings from the lower end of the sheet piling near the harbour are included). These data show low chloride contents in the upper soil layers, which indicates a large flow of rainwater washing out the soluble chloride. As for the upper end of the sheet piling, the chloride content is low at all depths (not shown) but this is probably due to the distance to the harbour and not necessarily to dilution by rainwater. The oxygen logger showed relatively stable conditions and no oxygen in the groundwater in MB7 (Matthiesen, 2005b).

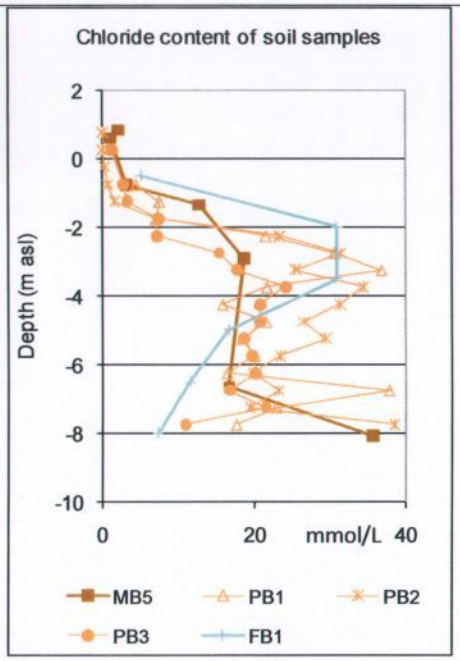



Figure 10: Compilation of chloride measurements in soil samples taken near the sheet piling, at the lower end near the harbour. Results have been recalculated to corresponding concentration dissolved Cl in the soil pore water.

Also the deeper deposits along the sheet piling may be influenced by an increased water flow: Figure 11 is a modified version of Figure 4, where all the dipwells near the sheet piling have been marked orange. It is seen that for most species the orange points have lower concentrations compared to the green points (stagnant conditions) at a given depth. The orange points seem to form a group with the blue points, which are dipwells from natural deposits where the groundwater is a mixture of water from cultural and natural deposits (Figure 2).

Figure 11 also shows results from a preliminary model of the groundwater chemistry at the sheet piling (orange lines). It is based on the PHREEQC model described in Matthiesen (2009), but with a vertical groundwater flow of a few meters per year instead of 0.1 m/year. The decay rate for the organic material (deltaOrgC) is estimated from the best fit of the measured groundwater data. As an example is shown the best fit for a vertical flow of 2.8 m/year – this gives a decay rate of 6 mM

organic carbon/year, which is approximately 10 times faster than the rate estimated for stagnant conditions (black lines in Figure 4). For comparison, the total amount of organic material in the cultural deposits is on average 6500 mM (calculated from a loss-on-ignition of 28% and a dry matter content of 42%, average values for all soil samples from Bryggen), i.e. the annual loss of organic material is approximately 1‰ of the total content.

It must be emphasized that the model is only preliminary: The estimated decay rate is very dependent on the flow rate used, and it is necessary to obtain a better measurement of the flow along the sheet piling in order to make more precise estimates of the decay rate. Two of the orange points (MB13 and MB16) don't fit the model very well: they have higher alkalinity, ammonium and potassium concentrations, which are key elements for modelling decomposition of organic material. This might for instance be due to a lower water flow locally: As for MB16, it lies on the hotel side of the sheet piling (where the water drains rapidly in the horizontal direction and probably less in the vertical direction), and as for MB13, Dunlop (2010) describes it as significantly better preserved than for instance MB15 (which could indicate that the deposits at MB13 are less porous on a very local scale, giving a reduced water flow). Furthermore MB13 has a very long filter (5 m) and it is difficult to say exactly from which depth the water samples come.

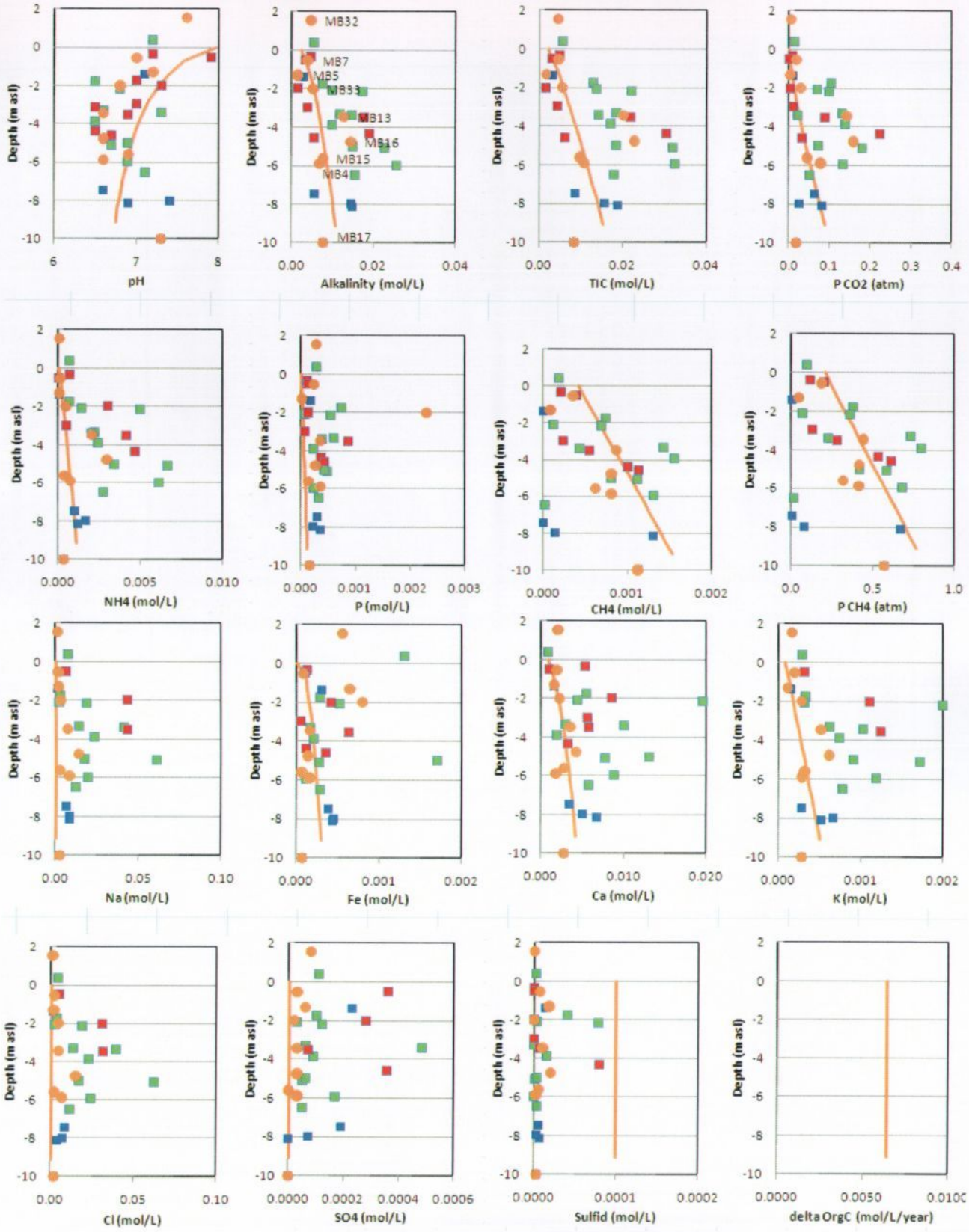



Figure 11: Results from groundwater analysis in all dipwells on Bryggen, as in Figure 4 (some dipwells have been re-classified and given new colours based on the results in this report). Dipwells along the sheet piling have here been marked as orange, and their names are indicated next to the symbols for alkalinity. Orange lines are results from a preliminary groundwater chemistry model for the conditions at the sheet piling. A vertical groundwater flow of 2.8 m/year has been used as example, but it must be emphasized that this number is very uncertain so the results should not be over-interpreted.

All in all this indicates that the sheet piling diverts the groundwater flow, and that an increased flushing of the cultural layers takes place both in the upper and deeper deposits (Figure 12). In the upper deposits the conditions are very dynamic: the groundwater occasionally contains oxygen (Figure 9), and there is a significant decay of modern wood samples. However, it is still not known if this only takes place near MB5 or all along the sheet piling from MB7 to FB1. As for the deeper deposits there is an increased vertical water flow, which may increase the decomposition of organic material. However, the exact flow rate is still not known, and neither is it known if oxygen in the water can reach the deeper deposits.

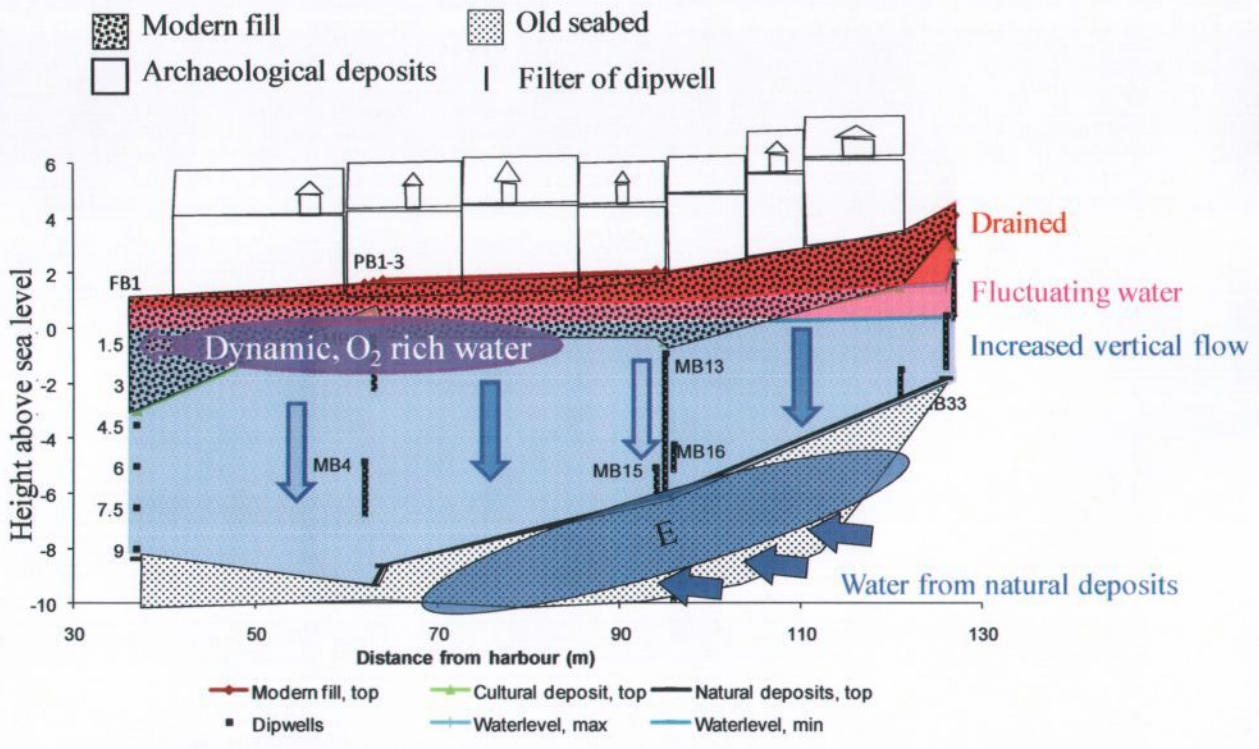



Figure 12: Conditions along the sheet piling, overview.

## Further monitoring

The aim of the coming construction work at the sheet piling is twofold: to raise the groundwater level in the drained area, and to reduce the through-flow of water in the deposits along the sheet piling. It is planned to achieve these aims by making the sheet piling watertight (to reduce drainage and vertical flow) and by placing lenses of clay in the porous deposits on the Bryggen side of the sheet piling (to reduce horizontal flow). In order to verify the effect it is necessary to continue the monitoring before, during and after the work.

Direct measurement of the water flow is difficult, but could possibly be done by tracer experiments or by dating water samples from the different dipwells. Another possibility is to perform recovery tests in the monitoring wells, using automated dataloggers. This would give an indication of the permeability directly around the monitoring wells. The response of gradually raising the drainage level below the hotel area on the groundwater levels at Bryggen can be seen as a large-scale recovery test, and will give an indication of the average permeability of the cultural deposits. The uncertainty concerning the horizontal and vertical water flows must be reduced in order to make more reliable estimates of the decay rates, and the hydrological and geochemical models should be more closely linked.

The conditions in MB5 have been shown to be very dynamic, but less is known about the dynamics in the rest of the area. Continuous logging should be made in selected dipwells (for instance FB1, MB4, MB5, MB13, and MB15) or directly in the soil, to find out how dynamic the conditions are today and verify if they become less dynamic after the construction work. Logging of oxygen would be the first priority, or else conductivity loggers may be an alternative, as the conductivity of the water will also reflect its dilution by fresh rainwater. The logging should be supplemented by frequent sampling of water and analysis for redox-active species.

Wood samples placed in the excavation from 2004 could be retrieved and new ones installed, if they are exposed or made accessible during the construction work at the sheet pile. These samples have now been in the soil for 6 years, which should be sufficient to measure the decay.

The effect of increased temperature measured in dipwells close to the sheet piling is still unknown and should be evaluated.

## *Conclusions and future work*

The conditions around the sheet piling have been evaluated based on the results from 5 new dipwells and a review of previous studies in the area. It has been shown that

- The area with drained or unsaturated medieval deposits is larger than hitherto documented and includes the area around Schøtstuene
- Archaeological wood samples from the unsaturated soil are decayed to a density of around 0.2 g/cm$^3$ and will probably collapse if they are allowed to dry uncontrolled. Wood samples from deeper deposits are less decayed.
- The water content has been monitored in four soil layers in the unsaturated zone since 2006, showing a decreasing water content
- The oxygen concentration has been measured at intervals in two of these soil layers, showing anoxic conditions.

- There is a significant horizontal water flow along the sheet piling, which causes dynamic conditions at MB5 and which can explain a low salt content in the upper soil layers and (possibly) at FB1.
- There is an increased vertical water flow next to the sheet piling, which has a significant impact on the groundwater quality in dipwells in the area.
- The decay rate for organic material in the saturated zone along the sheet piling may be estimated from a numerical model of the groundwater chemistry as soon as the water flow is quantified. For instance a water flow of 3 m/year would give an estimated annual decay of 1‰ of the total amount of organic material in the soil.

Further studies may include

- Continued logging of the water content in the excavation from 2006
- Installation of oxygen sensors at different depths in the excavation from 2006 for continuous logging
- Installation of monitoring equipment elsewhere in the drained area, for instance at Schøtstuene, to evaluate if the upper "garden soil" protects the deeper cultural deposits.
- Continuous logging of oxygen (or conductivity) in dipwells
- Cunducting tracer experiments, groundwater dating or pumping tests in dipwells to quantify the horizontal and vertical water flows along the sheet piling
- Frequent sampling of groundwater for limited chemical analysis of redox-active species
- Combined modelling of the geochemical and hydrological data to verify the decay rates

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## *Appendix 1*

Results from soil analysis of 27 soil samples from MB15, 30, 31, 32, and MB33

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Prøvetager.....: Rekvirenten
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| Prøvenr.: | **A4167901** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB15 C1** | grænse | Metoder | (%) |
| pH | **5.6 pH** | | *DS 287 mod. | |
| Tørstof | **61 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **13 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **2700 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **4400 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **4200 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **2500 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **120 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **1700 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **3500 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

*) Ikke omfattet af akkrediteringen.

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Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: A4167902<br>Prøve ID:<br>Prøvemærke: MB15 C2 | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **5.2 pH** | | *DS 287 mod. | |
| Tørstof | **57 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **12 % i ts.** | 0.10 | DS 204 | 5 |
| Chlorid, vandopløselig | **190 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |

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| Prøvenr.: | **A4167903** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB15 C3** | grænse | Metoder | (%) |
| pH | **5.9 pH** | | *DS 287 mod. | |
| Tørstof | **30 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **54 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **6300 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **21000 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **8700 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **2600 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **460 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **2200 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **15000 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |
| Pyrit, FeS2 | **0.29 % i ts.** | 0.01 | *SM3120 mod. | |

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Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: **A4167904** Prøve ID: Prøvemærke: **MB15 C4** | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **5.9 pH** | | *DS 287 mod. | |
| Tørstof | **32 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **47 % i ts.** | 0.10 | DS 204 | 5 |
| Chlorid, vandopløselig | **380 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |

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| Prøvenr.: | **A4167905** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB15 C5** | grænse | Metoder | (%) |
| pH | **6.5 pH** | | *DS 287 mod. | |
| Tørstof | **32 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **47 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **5500 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **17000 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **14000 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **4400 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **490 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **1900 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **18000 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

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Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: A4167906<br>Prøve ID:<br>Prøvemærke: MB15 C6 | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **6.2 pH** | | *DS 287 mod. | |
| Tørstof | **21 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **78 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **4700 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **23000 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **4900 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **1000 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **860 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **1800 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **16000 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

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Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: **A4167907** Prøve ID: Prøvemærke: **MB32 C1** | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **5.7 pH** | | *DS 287 mod. | |
| Tørstof | **38 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **30 % i ts.** | 0.10 | DS 204 | 5 |
| Chlorid, vandopløselig | **99 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |

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| | Prøvenr.: A4167908<br>Prøve ID:<br>Prøvemærke: MB32 C2 | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **7.4 pH** | | *DS 287 mod. | |
| Tørstof | **28 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **66 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **3700 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **13000 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **6300 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **1700 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **200 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **1100 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **13000 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

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| Sidenr.: | 9 af 18 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: | Detekt. | | RSD |
|---|---|---|---|---|
| | Prøve ID: | | | |
| | Prøvemærke: | grænse | Metoder | (%) |
| pH | **7.1 pH** | | *DS 287 mod. | |
| Tørstof | **30 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **50 % i ts.** | 0.10 | DS 204 | 5 |
| Chlorid, vandopløselig | **130 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |

*) Ikke omfattet af akkrediteringen.

Tegnforklaring:
RSD : Relativ Analyseusikkerhed.
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Nationalmuseet
Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej
2800 Kgs. Lyngby

Att.: Henning Matthiesen

| | |
|---|---|
| Registernr.: | A41679 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4167910 |
| Sagsnr.: | 08/00262 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 10 af 18 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| Prøvenr.: | **A4167910** | | | |
|---|---|---|---|---|
| Prøve ID: | | | | |
| Prøvemærke: | **MB32 C4** | Detekt. grænse | Metoder | RSD (%) |
| pH | **7.0 pH** | | *DS 287 mod. | |
| Tørstof | **34 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **35 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **3800 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **11000 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **16000 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **5500 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **130 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **1300 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **16000 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

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2800 Kgs. Lyngby

Att.: Henning Matthiesen

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|---|---|
| Registernr.: | A41679 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4167911 |
| Sagsnr.: | 08/00262 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 11 af 18 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: **A4167911** | | | |
|---|---|---|---|---|
| | Prøve ID: | | | |
| | Prøvemærke: **MB32 C5** | Detekt. grænse | Metoder | RSD (%) |
| pH | **6.4 pH** | | *DS 287 mod. | |
| Tørstof | **26 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **60 % i ts.** | 0.10 | DS 204 | 5 |
| Chlorid, vandopløselig | **320 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |

*) Ikke omfattet af akkrediteringen.

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Att.: Henning Matthiesen

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| Registernr.: | A41679 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4167912 |
| Sagsnr.: | 08/00262 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 12 af 18 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| Prøvenr.: | **A4167912** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB33 C1** | grænse | Metoder | (%) |
| pH | **7.0 pH** | | *DS 287 mod. | |
| Tørstof | **40 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **39 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **3800 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **9500 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **11000 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **4300 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **190 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **2700 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **9900 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

*) Ikke omfattet af akkrediteringen.

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2800 Kgs. Lyngby

Att.: Henning Matthiesen

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| Registernr.: | A41679 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4167913 |
| Sagsnr.: | 08/00262 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 13 af 18 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: A4167913<br>Prøve ID:<br>Prøvemærke: MB33 C2 | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **6.4 pH** | | *DS 287 mod. | |
| Tørstof | **35 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **33 % i ts.** | 0.10 | DS 204 | 5 |
| Chlorid, vandopløselig | **130 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |

*) Ikke omfattet af akkrediteringen.

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| Registernr.: | A41679 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4167914 |
| Sagsnr.: | 08/00262 |
| Modt. dato: | 2009.11.18 |
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# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: **A4167914** Prøve ID: Prøvemærke: **MB33 C3** | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **5.8 pH** | | *DS 287 mod. | |
| Tørstof | **26 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **60 % i ts.** | 0.10 | DS 204 | 5 |
| Chlorid, vandopløselig | **230 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |

*) Ikke omfattet af akkrediteringen.

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Att.: Henning Matthiesen

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| Registernr.: | A41679 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4167915 |
| Sagsnr.: | 08/00262 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 15 af 18 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| Prøvenr.: | **A4167915** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB33 C4** | grænse | Metoder | (%) |
| pH | **6.1 pH** | | *DS 287 mod. | |
| Tørstof | **40 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **31 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **3100 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **7600 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **9700 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **3900 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **140 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **2300 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **9700 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

*) Ikke omfattet af akkrediteringen.

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2800 Kgs. Lyngby

Att.: Henning Matthiesen

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|---|---|
| Registernr.: | A41679 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4167916 |
| Sagsnr.: | 08/00262 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 16 af 18 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: **A4167916** Prøve ID: Prøvemærke: **MB33 C5** | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **4.9 pH** | | *DS 287 mod. | |
| Tørstof | **60 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **9.8 % i ts.** | 0.10 | DS 204 | 5 |
| Chlorid, vandopløselig | **87 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |

*) Ikke omfattet af akkrediteringen.

Tegnforklaring:
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Att.: Henning Matthiesen

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| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4167917 |
| Sagsnr.: | 08/00262 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 17 af 18 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| | Prøvenr.: **A4167917** | | | |
|---|---|---|---|---|
| | Prøve ID: | | | |
| | Prøvemærke: **MB33 C6** | Detekt. grænse | Metoder | RSD (%) |
| pH | **4.8 pH** | | *DS 287 mod. | |
| Tørstof | **61 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **11 % i ts.** | 0.10 | DS 204 | 5 |
| Chlorid, vandopløselig | **81 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |

*) Ikke omfattet af akkrediteringen.

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2800 Kgs. Lyngby

Att.: Henning Matthiesen

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| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4167918 |
| Sagsnr.: | 08/00262 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 18 af 18 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 27290001 Indsatsomr: 050263, Bugården**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 2009.11.20 kl. 15:7 - 2009.12.02

| Prøvenr.: | **A4167918** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB33 C7** | grænse | Metoder | (%) |
| pH | **5.7 pH** | | *DS 287 mod. | |
| Tørstof | **29 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **60 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **3200 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **11000 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **5800 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **1700 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **230 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **2800 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **15000 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |
| Pyrit, FeS2 | **0.42 % i ts.** | 0.01 | *SM3120 mod. | |

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02. december 2009

Kundecenter: tlf.70224267 Hanne Jensen
Kontaktperson Kvalitetssikring

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I.C.Modewegs vej
2800 Kgs. Lyngby

Att.: Henning Matthiesen

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|---|---|
| Registernr.: | A41680 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4168001 |
| Sagsnr.: | 06/02802 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 1 af 9 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 82510001 Indsatsomr: 050005, Schøttstue**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 0912.01. kl. 09:02 - 2009.12.01

| Prøvenr.: | **A4168001** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB30 C1** | grænse | Metoder | (%) |
| pH | **7.4 pH** | | *DS 287 mod. | |
| Tørstof | **71 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **6.1 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **1200 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **1700 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **8600 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **6100 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **36 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **11 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **620 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

*) Ikke omfattet af akkrediteringen.

Tegnforklaring:
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Att.: Henning Matthiesen

Registernr.: A41680
Kundenr.: 82983
Ordrenr.: 407823
Prøvenr.: A4168002
Sagsnr.: 06/02802
Modt. dato: 2009.11.18

# ANALYSERAPPORT



Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 82510001 Indsatsomr: 050005, Schøttstue**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 0912.01. kl. 09:02 - 2009.12.01

| | Prøvenr.: **A4168002** Prøve ID: Prøvemærke: **MB30 C2** | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **5.4 pH** | | *DS 287 mod. | |
| Tørstof | **55 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **19 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **4100 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **7400 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **5000 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **2800 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **31 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **2500 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **8500 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

*) Ikke omfattet af akkrediteringen.

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Eurofins Miljø A/S
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6600 Vejen
Telefon: 7022 4266
CVR/VAT: DK-2884 8196

TEST Reg.nr. 168

Nationalmuseet
Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej
2800 Kgs. Lyngby

Att.: Henning Matthiesen

| | |
|---|---|
| Registernr.: | A41680 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4168003 |
| Sagsnr.: | 06/02802 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 3 af 9 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 82510001 Indsatsomr: 050005, Schøttstue**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 0912.01. kl. 09:02 - 2009.12.01

| Prøvenr.: | **A4168003** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB30 C3** | grænse | Metoder | (%) |
| pH | **6.8 pH** | | *DS 287 mod. | |
| Tørstof | **35 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **46 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **5400 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **15000 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **5900 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **2100 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **87 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **220 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **9000 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

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I.C.Modewegs vej
2800 Kgs. Lyngby

Att.: Henning Matthiesen

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|---|---|
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| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4168004 |
| Sagsnr.: | 06/02802 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 4 af 9 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 82510001 Indsatsomr: 050005, Schøttstue**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 0912.01. kl. 09:02 - 2009.12.01

| Prøvenr.: | **A4168004** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB30 C4** | grænse | Metoder | (%) |
| pH | **6.5 pH** | | *DS 287 mod. | |
| Tørstof | **32 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **59 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **5500 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **17000 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **11000 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **3300 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **150 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **1000 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **8100 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

*) Ikke omfattet af akkrediteringen.

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I.C.Modewegs vej
2800 Kgs. Lyngby

Att.: Henning Matthiesen

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|---|---|
| Registernr.: | A41680 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4168005 |
| Sagsnr.: | 06/02802 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 5 af 9 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 82510001 Indsatsomr: 050005, Schøttstue**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 0912.01. kl. 09:02 - 2009.12.01

| | Prøvenr.: **A4168005** Prøve ID: Prøvemærke: **MB30 C5** | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **5.8 pH** | | *DS 287 mod. | |
| Tørstof | **49 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **23 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **3300 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **6600 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **3500 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **1700 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **59 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **1700 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **5900 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

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Att.: Henning Matthiesen

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|---|---|
| Registernr.: | A41680 |
| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4168006 |
| Sagsnr.: | 06/02802 |
| Modt. dato: | 2009.11.18 |

# ANALYSERAPPORT



Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 82510001 Indsatsomr: 050005, Schøttstue**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 0912.01. kl. 09:02 - 2009.12.01

| | Prøvenr.: **A4168006** Prøve ID: Prøvemærke: **MB31 C1** | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **5.2 pH** | | *DS 287 mod. | |
| Tørstof | **61 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **13 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **1800 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **2900 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **5500 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **3400 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **44 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **32 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **800 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

*) Ikke omfattet af akkrediteringen.

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I.C.Modewegs vej
2800 Kgs. Lyngby

Att.: Henning Matthiesen

| | |
|---|---|
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| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4168007 |
| Sagsnr.: | 06/02802 |
| Modt. dato: | 2009.11.18 |
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# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
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Prøvested.....: **Projektnr.: 82510001 Indsatsomr: 050005, Schøttstue**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 0912.01. kl. 09:02 - 2009.12.01

| Prøvenr.: | **A4168007** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB31 C2** | grænse | Metoder | (%) |
| pH | **5.9 pH** | | *DS 287 mod. | |
| Tørstof | **72 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **6.1 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **1200 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **1700 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **4900 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **3500 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **26 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **52 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **440 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

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2800 Kgs. Lyngby

Att.: Henning Matthiesen

| | |
|---|---|
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| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4168008 |
| Sagsnr.: | 06/02802 |
| Modt. dato: | 2009.11.18 |
| Sidenr.: | 8 af 9 |

# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 82510001 Indsatsomr: 050005, Schøttstue**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 0912.01. kl. 09:02 - 2009.12.01

| | Prøvenr.: A4168008<br>Prøve ID:<br>Prøvemærke: MB31 C3 | Detekt. grænse | Metoder | RSD (%) |
|---|---|---|---|---|
| pH | **5.9 pH** | | *DS 287 mod. | |
| Tørstof | **67 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **7.4 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **1700 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **2500 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **8200 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **5400 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **29 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **260 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **1800 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

*) Ikke omfattet af akkrediteringen.

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I.C.Modewegs vej
2800 Kgs. Lyngby

Att.: Henning Matthiesen

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|---|---|
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| Kundenr.: | 82983 |
| Ordrenr.: | 407823 |
| Prøvenr.: | A4168009 |
| Sagsnr.: | 06/02802 |
| Modt. dato: | 2009.11.18 |
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# ANALYSERAPPORT

Rekvirent.....: Nationalmuseet, Bevaringsafdelingen, Arkæologi
I.C.Modewegs vej, 2800 Kgs. Lyngby
Prøvested.....: **Projektnr.: 82510001 Indsatsomr: 050005, Schøttstue**
Prøvetype.....: Jord ,
Prøveudtagning...:
Prøvetager.....: Rekvirenten
Kundeoplysninger.:
Analyseperiode...: 0912.01. kl. 09:02 - 2009.12.01

| Prøvenr.: | **A4168009** | | | |
|---|---|---|---|---|
| Prøve ID: | | Detekt. | | RSD |
| Prøvemærke: | **MB31 C4** | grænse | Metoder | (%) |
| pH | **6.1 pH** | | *DS 287 mod. | |
| Tørstof | **62 %** | 0.05 | DS 204 mod. | 10 |
| Glødetab på tørstof | **14 % i ts.** | 0.10 | DS 204 | 5 |
| Kvælstof, total | **3000 mg/kg** | 5 | NF1975:6/59/VKI | 10 |
| Kvælstof, total | **4900 mg/kg ts.** | 300 | Beregning | 10 |
| Phosphor, total | **4900 mg/kg ts.** | 100 | DS259/SM3120ICP | 15 |
| Phosphor, total | **3000 mg/kg** | 100 | Beregning | |
| Chlorid, vandopløselig | **33 mg/kg ts.** | 5 | *SM 17 udg. 4500 | 10 |
| Sulfat,vandopløselig | **330 mg/kg ts.** | 1 | *SM 17 udg. 4500 | 10 |
| Svovl, total | **1800 mg/kg ts.** | 50.0 | DS259/SM3120ICP | 15 |

*) Ikke omfattet af akkrediteringen.

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01. december 2009

Kundecenter: tlf.70224267 Hanne Jensen
Kontaktperson Kvalitetssikring

## *Appendix 2*

Results from analysis of groundwater sampled from MB15, MB32 and MB33 on the 29th of October 2009.

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Postbox 265

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Norge
Att.: Jann Atle Jensen

Registernr.: A30674
Kundenr.: 623294
Ordrenr.: 810153
Prøvenr.: A3067401

Modt. dato: 2009.11.03

# ANALYSERAPPORT



Rekvirent.....: Multiconsult A/S, Postbox 265
N-0213 Oslo, Norge
Prøvested.....: **Bryggen Prosjekt Bryggen nr. 27290001 - /4173101000**
Prøvetype.....: Råvand
Prøveudtagning...: 2009.10.29 kl. 11:00
Prøvetager.....: Rekvirenten (MUL)
Kundeoplysninger.:
Analyseperiode...: 2009.11.03 - 2009.11.14

| | Prøvenr.: | A3067401 | | | |
|---|---|---|---|---|---|
| | Prøve ID: | | **Grænseværdier | | RSD |
| | Prøvemærke: | MB15 | Vejl. | Max. Metoder | (%) |
| pH | 6.9 | pH | | DS 287:1978 | |
| Ledningsevne | 89 | mS/m | | DS/EN 27888 | 5 |
| Hårdhed, total | 17.5 | H grader | | SM3120-ICP | 4.3 |
| Calcium (Ca) | 110 | mg/l | | SM3120-ICP | 15 |
| Magnesium (Mg) | 8.4 | mg/l | | SM3120-ICP | 15 |
| Kalium (K) | 12 | mg/l | | SM3120-ICP | 15 |
| Natrium (Na) | 62 | mg/l | | SM3120-ICP | 15 |
| Jern (Fe) | 3.4 | mg/l | | SM3120-ICP | 15 |
| Mangan (Mn) | 0.36 | mg/l | | SM3120-ICP | 15 |
| Ammonium | 6.5 | mg/l | | SM 17 udg. 4500 | 5 |
| Nitrit | <0.005 | mg/l | | SM 17 udg. 4500 | 5 |
| Nitrat | <0.50 | mg/l | | SM 17 udg. 4500 | 5 |
| Total-P | 4.4 | mg/l | | DS/EN I 6878aut | 10 |
| Chlorid | 67 | mg/l | | SM 17 udg. 4500 | 5 |
| Fluorid | 0.16 | mg/l | | SM 17 udg. 4500 | 5 |
| Sulfat | <0.20 | mg/l | | DS/EN 10304-1 | 5 |
| Aggressiv kuldioxid | 9 | mg/l | | DS 236:1977 | 10 |
| Hydrogencarbonat | 463 | mg/l | | DS/EN I 9963 | 5 |
| Turbiditet | 39 | FTU | | DS/EN I 7027 | 10 |
| Farvetal, Pt | 17 | mgPt/l | | DS/EN I 6271-2 | 5 |
| Inddampningsrest | 530 | mg/l | | DS 204:1980 | 6 |
| NVOC, ikke-flygt.org.kulstof | 4.9 | mg/l | | DS/EN 1484 | 5.0 |
| Sulfid-S | 0.16 | mg/l | | DS 278:1/1976 | 14 |
| Methan | 10 | mg/l | | GC/FID | 19 |

**) Miljøministeriets bekendtgørelse nr. 1449 af 11. december 2007

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Att.: Jann Atle Jensen

Registernr.: A30674
Kundenr.: 623294
Ordrenr.: 810153
Prøvenr.: A3067402

Modt. dato: 2009.11.03

# ANALYSERAPPORT



Rekvirent.....: Multiconsult A/S, Postbox 265
N-0213 Oslo, Norge
Prøvested.....: **Bryggen Prosjekt Bryggen nr. 27290001 - /4173101000**
Prøvetype.....: Råvand
Prøveudtagning...: 2009.10.29 kl. 11:00
Prøvetager.....: Rekvirenten (MUL)
Kundeoplysninger.:
Analyseperiode...: 2009.11.03 - 2009.11.14

| | Prøvenr.: A3067402<br>Prøve ID:<br>Prøvemærke: MB33 | | **Grænseværdier Vejl. | Max. | Metoder | RSD (%) |
|---|---|---|---|---|---|---|
| pH | 6.8 | pH | | | DS 287:1978 | |
| Ledningsevne | 100 | mS/m | | | DS/EN 27888 | 5 |
| Hårdhed, total | 15.4 | H grader | | | SM3120-ICP | 4.3 |
| Calcium (Ca) | 89 | mg/l | | | SM3120-ICP | 15 |
| Magnesium (Mg) | 13 | mg/l | | | SM3120-ICP | 15 |
| Kalium (K) | 11 | mg/l | | | SM3120-ICP | 15 |
| Natrium (Na) | 76 | mg/l | | | SM3120-ICP | 15 |
| Jern (Fe) | 44 | mg/l | | | SM3120-ICP | 15 |
| Mangan (Mn) | 1.9 | mg/l | | | SM3120-ICP | 15 |
| Ammonium | 8.5 | mg/l | | | SM 17 udg. 4500 | 5 |
| Nitrit | <0.005 | mg/l | | | SM 17 udg. 4500 | 5 |
| Nitrat | <0.50 | mg/l | | | SM 17 udg. 4500 | 5 |
| Total-P | 71 | mg/l | | | DS/EN I 6878aut | 10 |
| Chlorid | 160 | mg/l | | | SM 17 udg. 4500 | 5 |
| Fluorid | 0.19 | mg/l | | | SM 17 udg. 4500 | 5 |
| Sulfat | 1.7 | mg/l | | | SM 17 udg. 4500 | 5 |
| Hydrogencarbonat | 313 | mg/l | | | DS/EN I 9963 | 5 |
| Turbiditet | 450 | FTU | | | DS/EN I 7027 | 10 |
| Farvetal, Pt | 27 | mgPt/l | | | DS/EN I 6271-2 | 5 |
| Inddampningsrest | 630 | mg/l | | | DS 204:1980 | 6 |
| NVOC, ikke-flygt.org.kulstof | 5.5 | mg/l | | | DS/EN 1484 | 5.0 |
| Sulfid-S | <0.02 | mg/l | | | DS 278:1/1976 | 14 |
| Methan | <0.005 | mg/l | | | GC/FID | 19 |

**) Miljøministeriets bekendtgørelse nr. 1449 af 11. december 2007

Tegnforklaring:
RSD : Relativ Analyseusikkerhed.
< : mindre end. i.p.: ikke påvist.
> : større end. i.m.: ikke målelig.
# : ingen af parametrene er påvist.

Eurofins Miljø A/S
Ladelundvej 85
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Telefon: 7022 4266
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DANAK TEST Reg.nr. 166

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Multiconsult A/S
Postbox 265

N-0213 Oslo
Norge
Att.: Jann Atle Jensen

Registernr.: A30674
Kundenr.: 623294
Ordrenr.: 810153
Prøvenr.: A3067403

Modt. dato: 2009.11.03

# ANALYSERAPPORT

Sidenr.: 3 af 4

Rekvirent.....: Multiconsult A/S, Postbox 265
N-0213 Oslo, Norge
Prøvested.....: **Bryggen Prosjekt Bryggen nr. 27290001 - /4173101000**
Prøvetype.....: Råvand
Prøveudtagning...: 2009.10.29 kl. 11:00
Prøvetager.....: Rekvirenten (MUL)
Kundeoplysninger.:
Analyseperiode...: 2009.11.03 - 2009.11.14

| | Prøvenr.: A3067403<br>Prøve ID:<br>Prøvemærke: MB32 | | **Grænseværdier Vejl. | Max. | Metoder | RSD (%) |
|---|---|---|---|---|---|---|
| pH | 7.6 | pH | | | DS 287:1978 | |
| Ledningsevne | 56 | mS/m | | | DS/EN 27888 | 5 |
| Hårdhed, total | 12.9 | H grader | | | SM3120-ICP | 4.3 |
| Calcium (Ca) | 82 | mg/l | | | SM3120-ICP | 15 |
| Magnesium (Mg) | 6.0 | mg/l | | | SM3120-ICP | 15 |
| Kalium (K) | 6.3 | mg/l | | | SM3120-ICP | 15 |
| Natrium (Na) | 27 | mg/l | | | SM3120-ICP | 15 |
| Jern (Fe) | 31 | mg/l | | | SM3120-ICP | 15 |
| Mangan (Mn) | 1.7 | mg/l | | | SM3120-ICP | 15 |
| Ammonium | 1.3 | mg/l | | | SM 17 udg. 4500 | 5 |
| Nitrit | 1.3 | mg/l | | | SM 17 udg. 4500 | 5 |
| Nitrat | <0.50 | mg/l | | | SM 17 udg. 4500 | 5 |
| Total-P | 8.7 | mg/l | | | DS/EN I 6878aut | 10 |
| Chlorid | 39 | mg/l | | | SM 17 udg. 4500 | 5 |
| Fluorid | 0.12 | mg/l | | | SM 17 udg. 4500 | 5 |
| Sulfat | 7.4 | mg/l | | | SM 17 udg. 4500 | 5 |
| Hydrogencarbonat | 283 | mg/l | | | DS/EN I 9963 | 5 |
| Turbiditet | 53 | FTU | | | DS/EN I 7027 | 10 |
| Farvetal, Pt | 24 | mgPt/l | | | DS/EN I 6271-2 | 5 |
| Inddampningsrest | 340 | mg/l | | | DS 204:1980 | 6 |
| NVOC, ikke-flygt.org.kulstof | 5.9 | mg/l | | | DS/EN 1484 | 5.0 |
| Sulfid-S | <0.02 | mg/l | | | DS 278:1/1976 | 14 |
| Methan | 0.018 | mg/l | | | GC/FID | 19 |

Analysekommentarer:
Resultater for Ilt kan ikke opgives pga. Iltflasker ikke var fyldt op.
Resultater for aggressiv kuldioxid kan ikke opgives pga flasken ikke var fyldt op.

**) Miljøministeriets bekendtgørelse nr. 1449 af 11. december 2007

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ilac-MRA DANAK TEST Reg.nr. 168

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| | |
|---|---|
| Registernr.: | A30674 |
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| Modt. dato: | 2009.11.03 |
| Sidenr.: | 4 af 4 |

# ANALYSERAPPORT

| | |
|---|---|
| Rekvirent.....: | Multiconsult A/S, Postbox 265<br>N-0213 Oslo, Norge |
| Prøvested.....: | **Bryggen Prosjekt Bryggen nr. 27290001 - /4173101000** |
| Prøvetype.....: | Råvand |
| Prøveudtagning...: | 2009.10.29 kl. 11:00 |
| Prøvetager.....: | Rekvirenten (MUL) |
| Kundeoplysninger.: | |
| Analyseperiode...: | 2009.11.03 - 2009.11.14 |

Kopi af rapporten er sendt til:

- Nationalmuseet, Bevaringsafdelingen, Arkæologi, I.C.Modewegs vej, 2800 Kgs. Lyngby

Tegnforklaring:
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16. november 2009

Kundecenter: tlf.72187295 Sys Bisgaard Hansen
Kontaktperson Kvalitetssikring