Nordic Hydrological Conference 2018

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Guide to walk:

"How blue-green solutions saved the world heritage site bryggen"

NHC2018 13.-15. August in Bergen, Norway.
www.nhc2018.org

Bryggen World heritage site

The Bryggen Project was led by the Directorate for Cultural Heritage, which allocates about 20 million NOK to the restoration of Bryggen each year. In 2011, the government granted an extraordinary endowment of 45 million NOK for stabilizing the cultural deposits underneath the buildings by raising the groundwater levels.

During the last decade, unique multidisciplinary investigations have been carried out to understand and counteract the deterioration of archaeological deposits and historical buildings at Bryggen in Bergen, Norway.

The listed buildings at Bryggen were constructed after the city fire of 1702 in which almost 90 percent of the city was lost. The buildings represent a unique type of settlement structure that stretches all the way back to the early medieval period.
The number of wooden buildings was originally far higher than it is today, and the row of wooden gables stretched all the way from Finnegården at the South end of the harbour to the North end, where the Radisson Blu Royal Hotel is found today. The Southern parts were torn down in 1899 following a City Council decision. Five more tenements were destroyed in a fire in 1955, and a further 14 buildings belonging to the tenements Hjortegården and Holmedalsgården were lost in a fire in 1958. Today, seven tenements with 11 gable walls remain, comprising
a total of 63 individual buildings.

The content in this brochure is from: J. de Beer a, A. Seither a, H. Matthiesen b, F.C. Boogaard c,d, e, R. Dunlop f, J.A. Jensen g, M. Vorenhout h and A. Christensson i (2016), and the website www.prosjektbryggen.com

a Geological Survey of Norway; b National Museum of Denmark; c Technical University Delft; d Hanze University of Applied Sciences Groningen, the Netherlands; e TAUW Consultancy, the Netherlands; f Norwegian Institute for Cultural Heritage Research; g Multiconsult AS Bergen, Norway; h MVH Consult, the Netherlands; i Directorate for Cultural Heritage in Norway

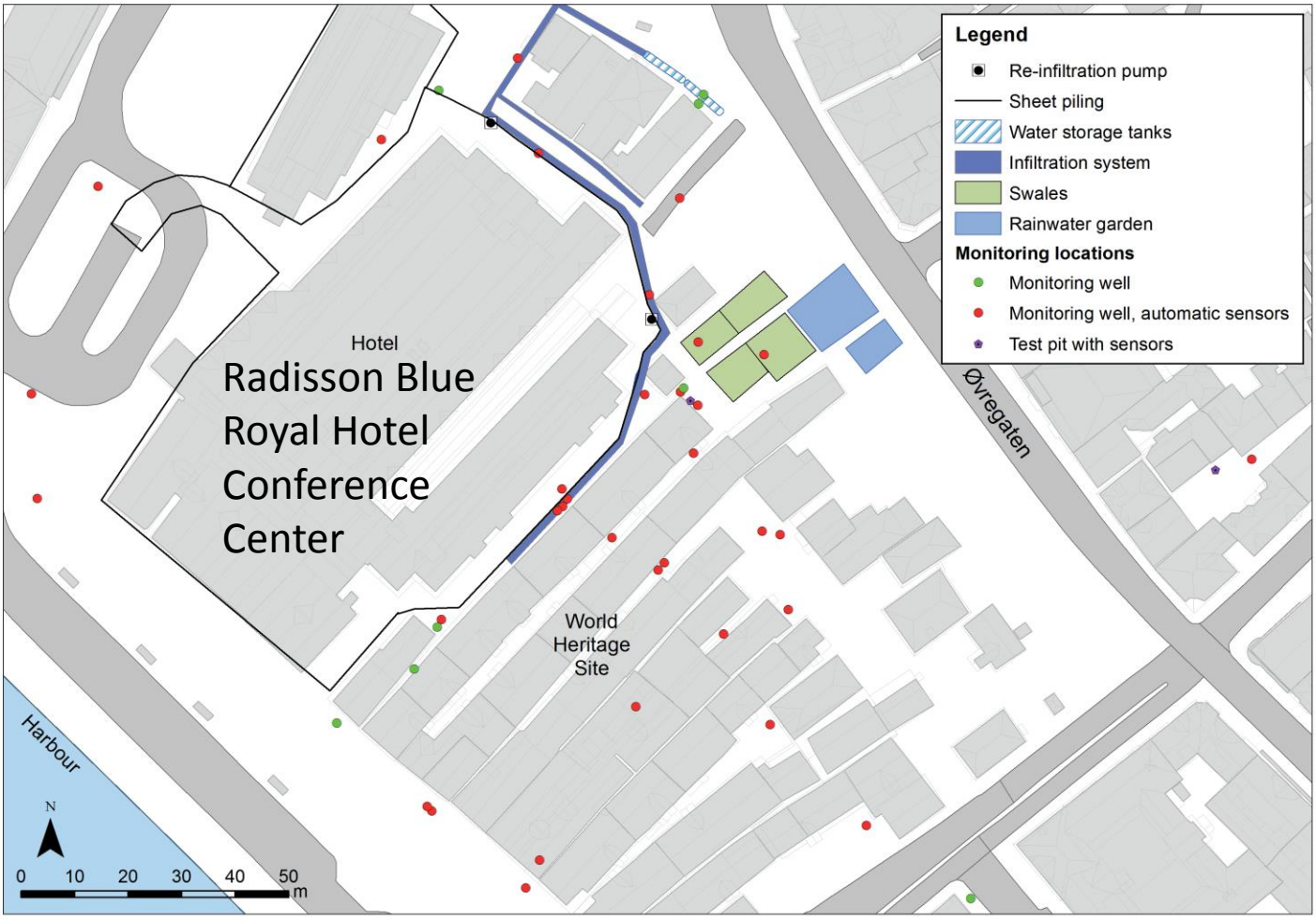
Cultural deposits

Documentation of archaeological deposits and constructions in a section at Bryggen. Photo: Universitety Museum in Bergen, UiB

Subsidence damage and decay

Bryggen is not built on solid ground, but rather on cultural deposits which are slowly subsiding. This means that the buildings themselves are also settling and slowly moving into new and unintended positions. The subsidence damages have resulted in the buildings becoming slanted, and to extra strain on the load bearing constructions, which can, at worst, lead to breakage of the wooden constructions. The wooden foundations are especially vulnerable to decomposition. These kinds of foundations are traditionally made of crossbanded pine, laid directly on the ground. The conditions are at their worst in areas where the cultural deposits meet the foundation of the buildings. Conditions are also critical in the eavesdrops – the narrow area between the buildings intended to catch the rainwater and lead it into the passageways that transport it away. Today, drainage is not satisfactory and this has led to problems with decay in the narrow eavesdrops. The restoration of the buildings is therefore a highly complex challenge.

Cultural deposits



Overview map of mitigation measures carried out by the Groundwater Project, including locations of monitoring wells for measurement of groundwater level, temperature and sampling. Map: Anna Seither, Geological Survey of Norway.

Historic layers

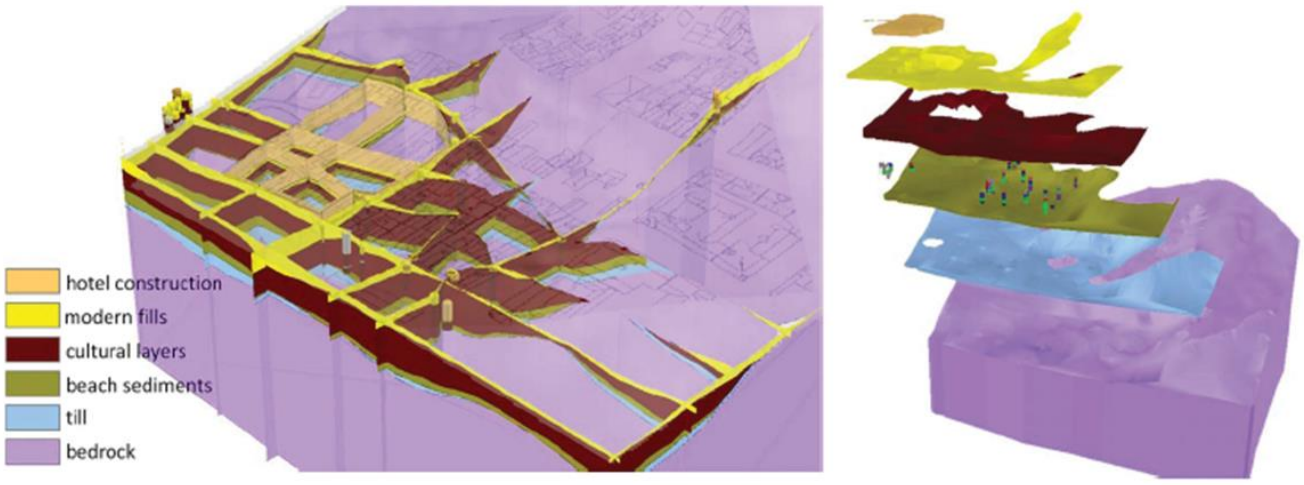
Cultural deposits are the remnants of human activity over time. They are formed near human settlements, by the accumulation of waste materials and the remains of old building structures. Bryggen is built on top of such deposits – on refuse and the remnants of medieval buildings. In several places, the deposits beneath Bryggen are over 10 meters thick, and represent an invaluable, non-replenishable and endangered historical archive. Until the mid-20th century, the preservation conditions at Bryggen were very good, but until recently, the conditions were growing considerably worse for every passing year. As much as 30 cubic metres of deposits were lost every year.

Cultural deposits

Historic layers

What has caused these changes in the preservation conditions? What consequences will the changes have for the cultural heritage site that is Bryggen? And what can be done to reverse the process, stop further deterioration, and re-create good preservation conditions?

The cultural deposits beneath Bryggen can be compared to an unread archive. We know that they contain large amounts of hitherto unknown information about medieval Bergen – both about people who lived there and practical details from everyday life. At the same time, the cultural deposits constitute the foundation for the listed wooden buildings at Bryggen. All in all, there are plenty of well-founded reasons to take good care of the cultural deposits!



Modell of layers in the subsurface below Bryggen. The cultural layers, consisting mostly of organic material from human waste, can be more than 10 meter thick. Underneath are natural sediments beposited by the fjord and glacier, on top of bedrock. The walls of the modern hotel, sheet pile wall, is marked with orange in the modell (Source: De Beer, 2015).

Challenges

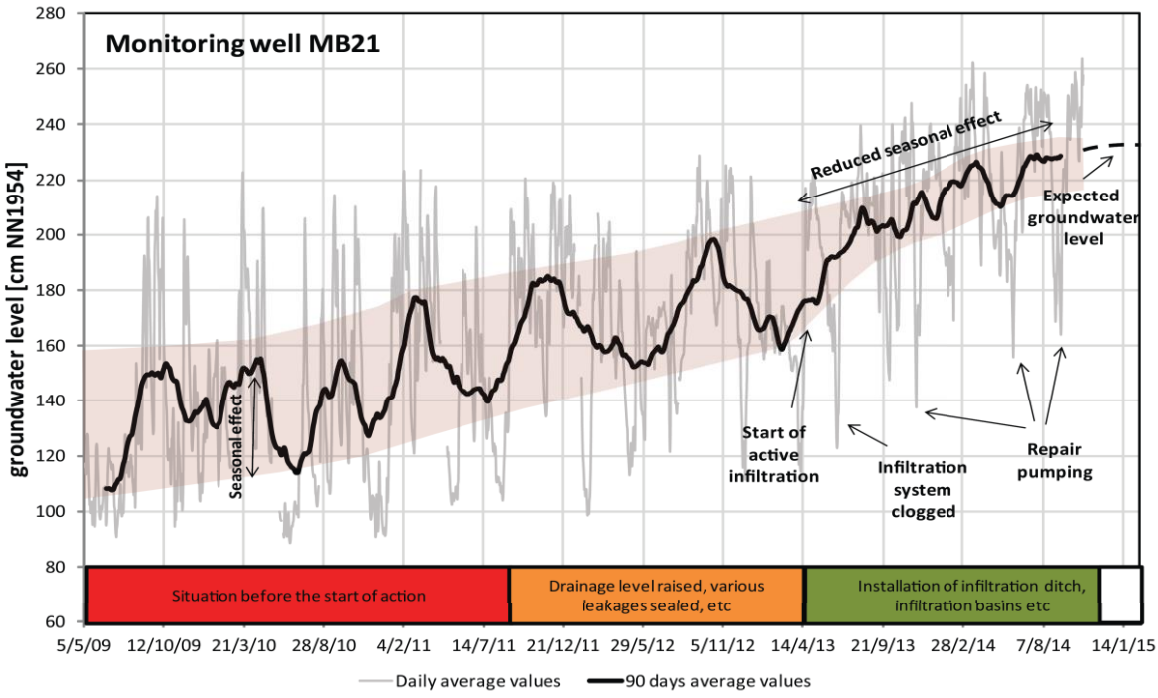
Subsidence

Lowered groundwater levels have caused compaction of the ground and decay of archaeological deposits underneath Bryggen. The damage to the World Heritage Site and neighbouring areas is substantial.

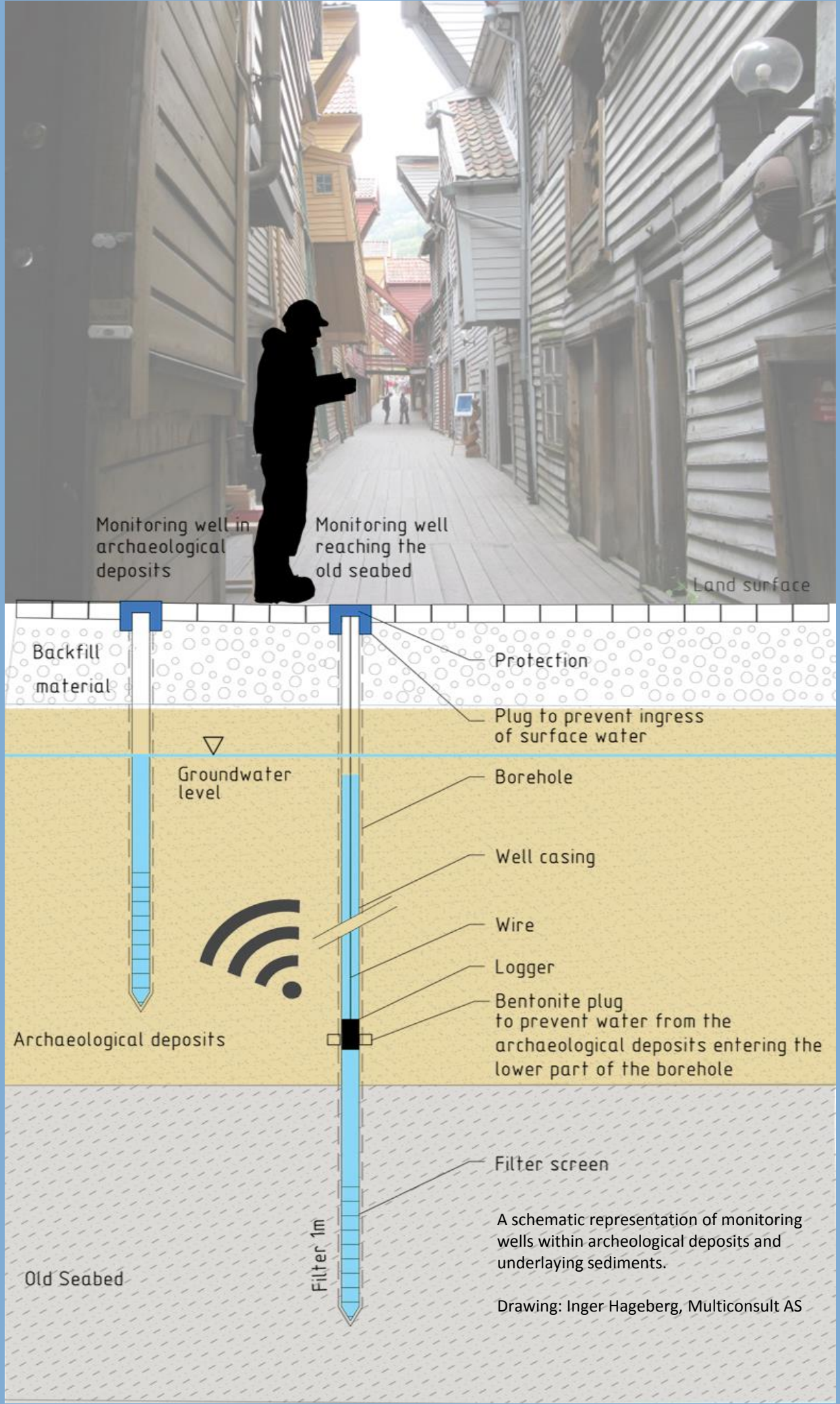
Mitigation

In September 2011, a large-scale mitigation project was started to improve conditions for the preservation of the organic archaeological deposits. The measures are focused on increasing and stabilizing groundwater levels and soil moisture content in affected areas. The main mitigation target is to create a hydrological divide between the area where urban development has disturbed the local water balance and the affected areas at Bryggen that are characterized by poor preservation conditions.

Mitigation measures consist of a “treatment train” made up by rainwater gardens, green swales, permeable pavement and a subsurface infiltration/transport system with storage facility and re-infiltration of groundwater.



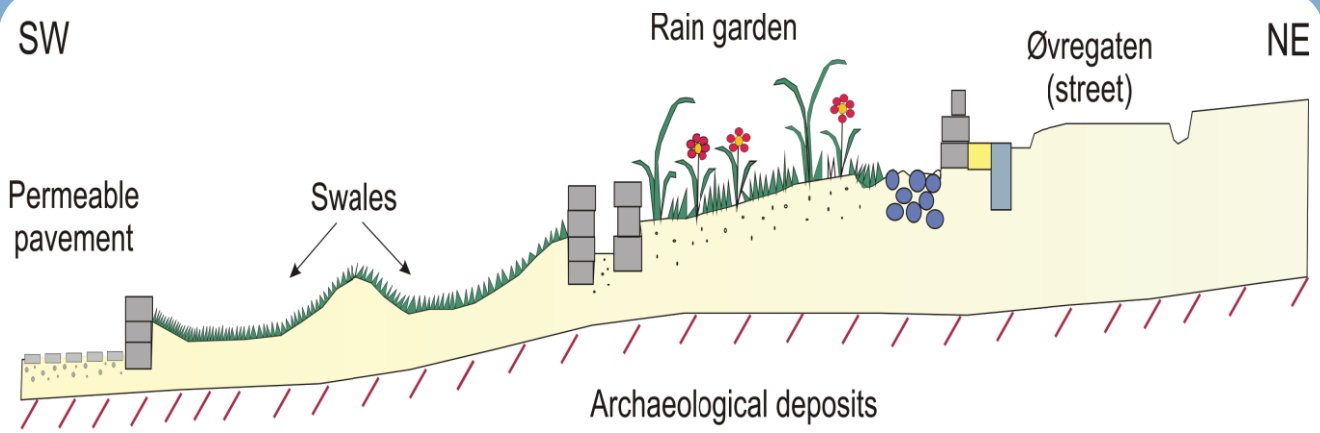
Groundwater level in monitoring well MB 21. The grey line shows daily variations of the groundwater level. The black curve gives a simplified impression of the groundwater level, by showing average values over three-month intervals. Graph: Anna Seither, Geological Survey of Norway



A schematic representation of monitoring wells within archeological deposits and underlaying sediments.

Drawing: Inger Hageberg, Multiconsult AS

Measures



Section of the sustainable water management “treatment train”, with rainwater garden, swales and permeable pavement. Drawing: Johannes de Beer, Geological Survey of Norway.

Monitoring

The initial baseline study at Bryggen included measurements of oxygen, groundwater levels, subsidence rates, soil and groundwater temperatures, redox-potential as well as soil - and stormwater chemistry. After risk assessment and mitigation, a long-term environmental monitoring programme will now document the solutions’ performance and their effects on the preservation conditions.

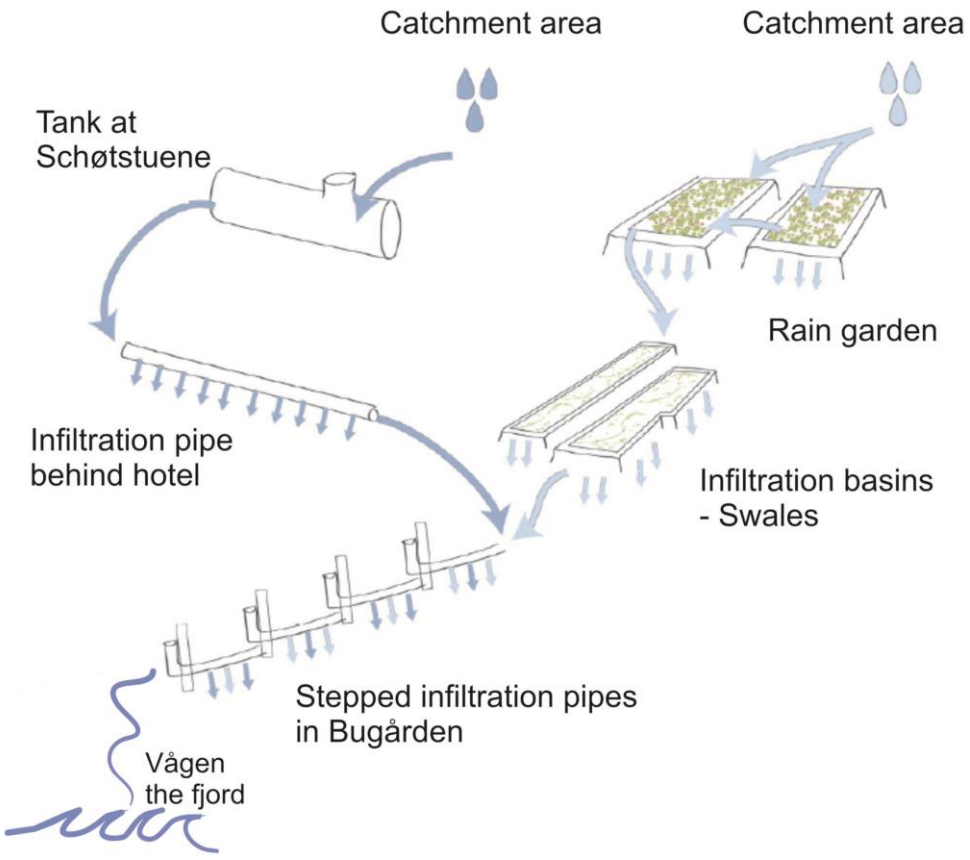
Water as a measure

Why are we experiencing groundwater problems today, when conditions have been stable for almost 1000 years? The explanation is quite complex. Earlier, the rainwater was not drained away from the buildings, but ran from the roofs via eavesdrops and down into narrow passageways or open ditches where the oxygen was “washed” out of the water, which was then led down into the ground. In addition, there was a steady trickle of water coming from the mountains behind Bryggen, and some of this water also permeated down into the ground. At the same time, the Vågen harbour has helped prevent the water from seeping away from the cultural deposits.

Previously, the rainwater and surface water was not led into the ground, but was drained away. In addition, the sheet filling that were supposed to protect the cultural deposits were leaking, and the ground water was drained away to avoid too high a pressure beneath newer buildings. The rainwater therefore needs to be drained away from the buildings, while at the same time, the groundwater levels need to be raised and kept stable. For almost 1000 years, people have managed the water flow at Bryggen. By managing and infiltrating the surface water into the ground the the water imbalance will be regained. Restoring the groundwater level til stop the decay of organic material, prevent subsidence and the following damage on the buildings.

Conclusions

The SUDS primary mission is to provide the ground with enough water to rise the groundwater level and to stabilize the waterlevel and stop the subsidence.



Conclusions

The use of sustainable water management solutions specifically targeted on improving in-situ archaeological preservation conditions is an innovative approach with multiple benefits.

The measures at Bryggen has been a success. Implementing blue-green solutions such as sustainable urban drainage systems (SUDS) to regain control of the groundwater level below the buildings and in the cultural layers has given the wanted effect. And thereby saved the world heritages site Bryggen from further decay and distortion.

The uniqueness of the Bryggen project is that it combined expertise within all field of science involved, and delivered the best common solution of remidiation.

The used methods are designed to be resilient in the face of climate change, and can easily be modified for implementation in other Norwegian centres and abroad.

More information

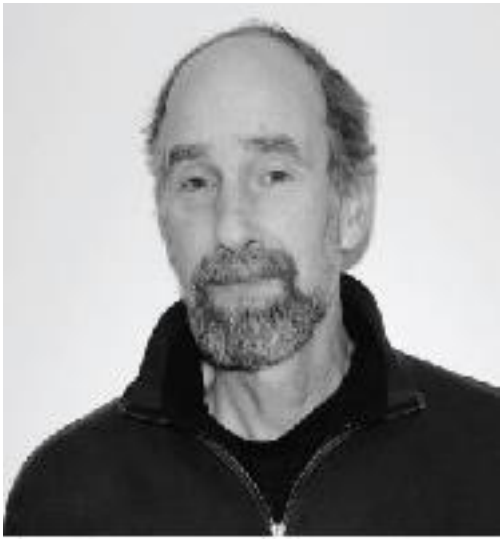
For further info see: www.prosjektbryggen.no or read the book.

Tuesday 14 August 2018

08:00 Registration
09:00 Keynote session
10:20 Coffee break
10:45 Parallel sessions
12:30 Lunch
13:30 Parallel sessions
14:30 Short poster presentations
15:00 Poster session and coffee
16:30 Introduction to Bryggen visit
17:00 Walk: “How blue-green solutions saved the world heritage site Bryggen”
18:30 Break
19:30 Conference dinner

Guides

Rory Dunlop, NIKU



Rory Dunlop is an archaeologist and has been in Norwegian Institute of Cultural Heritage Research (NIKU) since 1994, linked to daily Department's regional office in Bergen. From 1980 to 1994 he worked as a project-led archeologist at the National Heritage Site's excavation office for Bergen.
His main areas of work include medieval archaeological research, primarily in Bergen city. Since 2000, much of the work has been associated with environmental monitoring of the cultural heritage of the world heritage site Bryggen, and in connection with the subject of cultural law monitoring he has participated in the preparation of two significant publications: The Monitoring Manual, and Norsk Standard NS 9451: 2009 Environmental Monitoring and Surveillance Requirements of cultural law.

Floris C. Boogaard, HUAS, Tauw

Graduated in 1998 in water management with an additional graduation on working in third world countries at TU Delft. Working at the consulting agency Tauw BV with urban drainage and water management for amongst others municipalities and water authorities. His specialities are dealing with hydrology, ecology, waste and surface water. Since 2013 he has had a professorship at Hanze University of Applied Sciences in Groningen, specializing in the quality of stormwater and optimising sustainable urban drainage systems in order to integrate the worlds of spatial planning and water management. Further ncouraging the implementation of innovative technical and sustainable solutions in the urban dense areas around the world.

Guri Venvik, NGU

Geologist working at the Geological Survey of Norway (NGU).
Working experience within multiple fields all from large scale rockslides, tunnelling with a focus on water leakage and feasibility studies, mapping of radon hazard, and at present working in projects with a focus on urban geology and management of surface water linked to groundwater. With focus on the ground beneath our cities and especially the processes linked to the interaction of surface water and groundwater with the aim for sustainable solutions for future resilient cities.

www.prosjektbryggen.no

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