



The Interreg IVB
North Sea Region
Programme



*Investing in the future by working together
for a sustainable and competitive region*

European Union



The European Regional Development Fund

SKINT WATER SERIES

SUSTAINABLE URBAN WATER PLANNING ACROSS BOUNDARIES

J. de Beer, A. Christensson, F. Boogaard (eds.)

THE WATER THAT BUOYS UP BRYGGEN IN BERGEN, NORWAY

A. Christensson^{*,a}, J. de Beer^{**}, R. Dunlop^{***}, Henning Matthiesen^{****}

* Directorate for Cultural Heritage Norway (Riksantikvaren)

** Geological Survey of Norway (NGU)

*** Norwegian Institute for Cultural Heritage Research (NIKU)

**** National Museum Denmark

^a corresponding author

INTRODUCTION

Beneath the suite of picturesque historic buildings of the Bryggen World Heritage Site in Bergen (Figure 1) lies a unique archaeological environment. When excavations started after the fire of 1955, which consumed the northern half of the remaining settlement built after the fire of 1702, the archaeologists were unprepared for the enormity of the task awaiting them, and they were generally unaware that the archaeological remains below their feet were among the best preserved in Europe. The excavations brought to light a formidable array of mainly wooden constructions, including houses, thoroughfares, wells and quays, along with myriad artefacts of both perishable and inorganic material. So why is it that preservation conditions at Bryggen are so good?

Vågen, Bergen's harbour, has been the key to Bryggen's existence for a thousand years. Dating from around 1030, the first town-like settlement grew up along Vågen's north-eastern shore. The 11th century shoreline actually runs up to 160 metres inland from today's harbour front, and it didn't take long before the settlement started expanding into the harbour in order to create more building land. This process of infilling – which involved the construction of massive boxes of interlocking timbers weighted down with enormous volumes of occupation refuse – continued in a series of steps down through medieval and post-medieval times. The majority of these expansion steps took place more or less immediately following the numerous catastrophic fires that periodically burnt parts or even the whole of the town to ashes.



FIGURE 1. BUILDINGS AND LOCATION OF BRYGGEN IN BERGEN, NORWAY (SOURCE: E. ROTEVATN, RIKSANTIKVAREN)

On this reclaimed land were built the characteristic wooden tenements running perpendicular to the waterfront, just like the building pattern we see today. But all through the successive steps of expansion, the position of the property boundaries – which were mainly marked by the eavesdrops, the narrow open areas that

lay between the tenements (and which also served to lead away surface water in the direction of the harbour) – has remained relatively unaltered.

Since 2001, an intensive monitoring scheme at the World Heritage site of Bryggen in Bergen has shown damaging settling rates caused by deterioration of underlying, man-made deposits. Low phreatic groundwater levels caused by redevelopment of the area next to the heritage site in the late 1970s have led to an increased flux of oxygen in the subsurface. This currently threatens the heritage site due to decomposition of organic material and consequent settling. A large restoration project is running from 2001 to 2031, covering all the buildings and their foundations. The strategic project aims to bring Bryggen to a state of repair that is in accordance with its status as a World Heritage Site, and where only regular maintenance is necessary. Bryggen has since 2001 received considerable funding from the government for restoration of buildings and monitoring of the cultural deposits. In 2011, the government granted an extraordinary endowment of 45 million NOK for re-establishing the groundwater balance.



FIGURE 2. BURIED QUAY FRONT, OVER 800 YEARS OLD (© BERGEN MUSEUM, MIDDELALDERSAMLINGEN. FOTO: ASBJØRN HERTEIG).

archaeological values, but also taking away the bearing structure of the cultural heritage buildings above. One of the main goals at Bryggen is therefore to establish a stable hydrological environment, so that the heritage site can be safeguarded for future generations.

MAIN STAKEHOLDERS AND THEIR INVOLVEMENT

The protection of the archaeological heritage is based upon effective collaboration between professionals drawn from many disciplines. It also requires the cooperation of government authorities, academics, private and public sector enterprises and, not least, the general public.

The project is led by the Norwegian Directorate for Cultural Heritage (Riksantikvaren), in cooperation with regional and local heritage authorities of Hordaland County Council and the City of Bergen. The heritage authorities need to comply with the UNESCO requirements of reporting and preserving the site. Riksantikvaren has a coordinating and guiding role for subordinate authorities in order to preserve Bryggen, both the buildings and the underlying archaeological remains, as a national and international heritage site. The Bryggen Foundation (Stiftelsen Bryggen), established in 1962 by private owners, is responsible for implementing

Cultural heritage buildings often reside on extensive archaeological remains, also known as cultural deposits. Depending on the natural environment, the cultural deposits at many sites consist of highly organic material such as wooden or other natural degradable foundations (Figure 2). Preservation conditions of natural degradable archaeological remains are strongly dependent on water quality and particularly the presence or absence of groundwater. Deterioration of archaeological materials often occurs as a consequence of change in the groundwater level. Both mechanical settling of the terrain and oxidation of organic material occur, thereby not only removing



conservation measures and restoration work on the historic buildings. The objective of the Foundation is to preserve Bryggen in close cooperation with the authorities. The foundation owns 35 of 61 buildings and supervises the buildings on behalf of the authorities and has its own staff of craftsmen, care-takers and architect. In addition to the above mentioned stakeholders who are directly involved in research and restoration processes, other important stakeholders are private owners of 26 buildings, often used for commercial purposes (shops, offices) as well as neighbours, of which the hotel on the redeveloped area next to Bryggen is the most relevant due to its effect on the groundwater situation.

Bergen Municipality has a special stakeholder role, as it is responsible for development plans at Bryggen and surrounding areas. Different sections within the municipality need to take into account the restrictions that are being placed upon the water and land use in and around the heritage site. An open and constructive communication with regular meetings has been established with the water and sewage section, in which changes to the storm and sewage water system were discussed in an early phase in order to avoid conflicts of interests later on in the development process.

A range of research disciplines is involved in the project in order to find optimal solutions for the preservation of both the buildings and the archaeological remains. At Bryggen, this involved the participation of, at one time or another, archaeologists, architects, carpenters, chemists, conservators, engineering and geotechnical consultants, microbiologists, mycologists, tree scientists, wood anatomists and hydrogeologists. The researchers themselves are not direct stakeholders in the heritage site, but form a crucial advisory group for the authorities and other stakeholders to make the right decisions to preserve Bryggen for future generations. The multidisciplinary research groups are able to identify problems, risks and opportunities and explain those to the general public. One of these issues is how to manage the water system at Bryggen in a sustainable way, as well as to explain a complex system of surface- and groundwater related interactions to stakeholders with no professional background in this field of expertise. Besides the role of “technical” experts, this research group is used to create support for new water management solutions that benefit not only the (re)distribution of surface and ground water, but also the preservation of archaeological remains and heritage buildings.

The most important stakeholders and their roles are summarised in Table 1.

Stakeholder	Role				Interest											
	Decision-maker	Advisor	Developers	Long term ownership	Regulators and interest groups					Planning bodies				Others		
					Wild life	Heritage	Environment	Water quality	Water quantity	Local communities	Strategy planners	Development control	Building control		Road/Transport	
Riksantikvaren	x			x		x						x				
Hordaland County Council	x			x		x	x	x	x	x						
City of Bergen	x			x		x	x	x	x		x	x	x	x		
UNESCO	x			x		x										
State building society (Statsbygg)			x									x	x			
Bryggen Foundation				x		x				x						
Private building owners' ass.				x						x						
Vital				x			x									x
Norwegian Inst. for Cult. Heritage Research (NIKU)		x				x										
Geological Survey of Norway (NGU)		x					x	x	x							
National Museum of Denmark		x					x	x	x							
Multiconsult AS		x	x				x		x							
Norconsult AS		x	x				x	x	x							
Instanes		x	x													
PAST		x				x	x									x
University of Abertay Dundee		x					x	x	x							x
TU Delft		x					x	x	x							
VU University Amsterdam		x				x	x	x	x							

TABLE 1. MOST IMPORTANT STAKEHOLDERS LINKED TO THE BRYGGEN PROJECT

LAND AND WATER MANAGEMENT PROCEDURES

Bryggen, as well as the rest of the medieval town of Bergen, is protected under the provisions of Norway's Cultural Heritage Act. Automatic protection is extended by law to all standing monuments dating to before 1649 and archaeological remains dating to before 1537. The foremost aim for the last 20 years has been to protect the archaeological remains, as recommended in the Charter for Protection and Management for Archaeological Heritage (ICOMOS 1990). As protection of the archaeological remains is largely dependent on the groundwater level, the Water Resources Act (2001) is of relevance. The Water Resources Act is intended to ensure that river systems and groundwater are used and managed in accordance with the interests of society. The main objectives of the Water Resources Act are to promote sustainable development and to maintain biological

diversity and natural processes in river systems. Water resources themselves are renewable, but parts of the ecological system along and within watercourses are not.

Archaeological remains can be seen as such a non-renewable resource. Before the Water Resources Act entered into force in 2001, there were no provisions on the abstraction of groundwater. Abstraction of groundwater must not contravene the provision on the minimum permitted rate of flow. A licence has been made mandatory for abstracting groundwater or for activities with an impact on groundwater. There was no similar provision in earlier legislation, which can be considered one of the main reasons that urban redevelopment, including groundwater drainage, at Bryggen in the late 1970s has led to unsustainable hydrological conditions for the preservation of the archaeological remains at Bryggen. Other relevant regulations are the Planning and Building Act and the Pollution Act. The EU Water Framework Directive is of less direct importance for Bryggen, but the Flood Directive is, as Bryggen is prone to flooding due to increased rainfall and sea water level.

MAIN PROBLEMS RELATED TO THE INTEGRATION OF LAND AND WATER MANAGEMENT

FRESH WATER

Despite Bryggen's proximity to the sea, it is not salt water that constitutes the primary preservation-promoting agent. Rather, it is fresh water: the water that percolates down into the ground beneath Bryggen – most of it coming from the hillside above the site – and becomes the area's reservoir of groundwater. Sea-water intrusion in the cultural deposits is only to be found in the zone extending from, roughly speaking, the buildings' seaward gables and out to the quay front.

MONITORING

Monitoring is the systematic gathering of data over time. The specific methods employed depend on and are tailored to the different kinds of heritage – archaeological and architectural – and the various environmental factors. Monitoring of the cultural deposits at Bryggen started in 2001, and in the decade since then numerous investigations have been undertaken to map the problems and identify causal relationships. In 2002 it was found that the buildings and the ground surface in the northern corner of the World Heritage Site were settling at a dramatic rate (it was expected that this problem would affect the front of Bryggen to a greater extent instead, but such was not the case). When the pattern from the settling data was compared with the

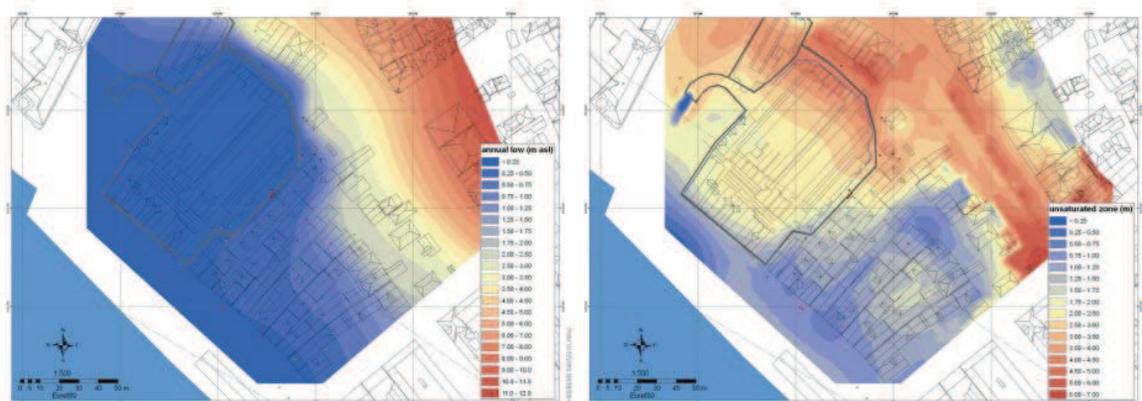


FIGURE 3. GROUNDWATER LEVELS AND THICKNESS OF THE UNSATURATED ZONE (SOURCE: NGU)

map of groundwater levels, the conclusion was very clear – the worst settling resulted from a substantial lowering of the groundwater table. Based on earlier records, it was possible to ascertain that the groundwater



level in the affected area had been stable up until 1980, but the construction of a building with an underground basement and associated drainage system subsequently caused the level to drop by almost three metres.

ATTRITION OF CULTURAL DEPOSITS

Once this had been determined, it was vital to initiate a monitoring project capable of making sense of the complex interplay of the factors and mechanisms that govern preservation conditions underground.

The cultural deposits in the Bryggen area reach thicknesses in excess of 10 metres and contain a very high proportion of organic material. The deposits consist of varying mixtures of refuse such as woodchips, twigs, moss, leather off-cuts and textile strips, along with the remains of buildings, quays, passages, latrines and wells – and all manner of artefacts. As long as these organic materials remain permanently inundated in water, preferably fresh and with as little throughflow as possible, the outlook for their preservation is good. But if the water is removed, oxygen concentrations skyrocket and the microorganisms that break down organic matter can go into a feeding frenzy, accelerating the process of decomposition to an alarming degree. As a result, the cultural deposits are literally eaten away. A variety of methods for monitoring the cultural deposits have been developed, and at the same time the authorities have invested heavily in the formulation of proposals for mitigation strategies aimed at reducing the dewatering of the Bryggen area. Given that with each passing year a considerable volume of irreplaceable archaeological heritage is lost to decomposition – as is the case in certain parts of Bryggen – there is no time to waste in getting these mitigation strategies started.

WATER MANAGEMENT SOLUTIONS

SELECTED SOLUTIONS

Currently, the biggest problem is to stop the loss of groundwater towards the redeveloped hotel area next to Bryggen. The research group has presented a range of different technical solutions to the authorities. The solutions are all based on creating a hydrological division between the hotel area and the heritage site, ranging from improving and extending the existing sheet piling to hydrological controls to actively control ground and surface water flow. Currently, discussions with involved stakeholders are underway to explain the solutions and create support. The existing groundwater quality and quantity monitoring net is being extended and automated to create a direct, on-line monitoring system to follow up effects of solutions and at the same time act as an early warning system.

In close cooperation with Bergen municipality, restoration and improvement of the storm water and sewage system in the upstream area of Bryggen is being done in such a way that it will not damage Bryggen, but instead creates opportunities to increase infiltration rates. SUDS with infiltration facilities are considered as a technical solution that may offer opportunities to stabilise the water balance at Bryggen.

Today, mitigation solutions are being implemented. A stepwise-approach was chosen, in which the effects of each step are monitored before the next measure is implemented. It is expected that this approach will lead to the most sustainable and long-lasting package of solutions that will reduce the loss of cultural deposits to a minimum and reduce the settling to a natural rate.

The first step was to raise the artificial drainage overflow level below the underground parking by about 0.5 metres (September 2011). The groundwater level however rose only about 0.25 m because of this measure, as other unknown leakages in the surface water drainage system were activated and thus discovered during the process. Currently these leakages are being repaired, which will likely be followed by a further increase of the groundwater level.



FIGURE 4. CONSTRUCTION OF SUBSURFACE INFILTRATION SYSTEM (PHOTO: R. DUNLOP, NIKU).

The next steps will be to further increase the drainage level, up to the technical maximum of 1 metre. Parallel to this process, the surface water drainage system will be changed from a piped solution to a sustainable urban drainage system with infiltration facilities (SUDS) in the upstream part of Bryggen. A transnational knowledge exchange programme has been set up with other SKINT partners in order to ensure that the design of SUDS is done according to best international practices. As stated earlier, the implementation of SUDS is expected to increase and stabilise the recharge of groundwater towards

the cultural deposits and recreate the “natural” hydrological balance before construction of the underground parking. SUDS are implemented in two phases. The first phase contains the construction of quick-wins, which are easy to implement measures in the area where they are most needed. Infiltration facilities are implemented (see Figure 4) and knowledge exchange is achieved through workshops and fieldtrips.

In phase two further measures in the greater area around Bryggen will be designed and implemented. All measures will be monitored and evaluated. If continued monitoring shows that the hydrological situation is not effectively restored, further geotechnical measures will be necessary to physically divide Bryggen from the neighbouring underground constructions, such as repair or renewal of the existing sheet piling.

INTEGRATION OF WATER MANAGEMENT SOLUTIONS IN THE PLANNING PROCESS

The preservation of Bryggen requires a stable hydrological environment, hence groundwater conditions that are favourable to the preservation of archaeological remains and a minimal impact of flooding on the above ground heritage buildings. It is thus necessary to consider the whole urban water cycle at different time and spatial scales. Precipitation is high with an average of 2250 mm per year, but most rainwater generates rapid surface runoff towards the harbour. Before 2007, regular flooding at the front of Bryggen occurred due to overflowing mixed sewage systems, causing nuisance and contamination at the front of Bryggen, where most shops are located. In 2007, improvements in the storm water system as well as groundwater level controls have been executed by the municipality. No flooding incidents have occurred since.

For Norway, climate change scenarios indicate an increase in yearly precipitation on the average of about 20% towards the year 2100, with the relatively highest precipitation increase during autumn (up to 30%). Temperature is expected to increase by 2–3 degrees Celsius. As precipitation is highly wind- and mountain-driven in Bergen, the frequency of heavy rainfall intensity is dependent on the frequency increase of south-western winds. This frequency is expected to increase, which will lead to a two- to threefold increase in heavy rainfalls (50–100 mm) during autumn. Due to the temperature increase, a doubling of heavy “tropical” rainfall events during summertime can be expected (source: Storm Weather Center, 2006). Based on the described scenarios, one may expect a regional groundwater level rise and an increased pressure on surface water discharge systems. The rising sea water level complicates this by limiting discharge possibilities and increasing flooding risks.



As previously stated, throughout the project continuous multidisciplinary discussions and regular meetings between researchers, authorities and other stakeholders have been taken place. Yearly seminars are organised in order to communicate the state of knowledge and to receive feedback on proposed solutions. Although this is not formalised, Bergen municipality now takes early initiatives by contacting the heritage authorities if it has development plans that may interfere with the goals of preserving Bryggen, such as changes to the storm-water runoff or sewage system. A guideline “monitoring manual” has been developed based on the knowledge gathered at Bryggen. The guideline is used to ensure that vulnerable sites such as Bryggen are monitored in a standardised way and that hydrology is considered. Parts of the monitoring manual are formalised in a Norwegian standard. Preliminary investigations following the Norwegian standard for environmental monitoring in protected heritage areas is now mandatory for (urban) planners and contractors in order to get permission for (re)development plans.

DIFFICULTIES AND HOW THEY WERE OVERCOME

The main problems hindering implementation of land and water management solutions at Bryggen are that stakeholders do not have knowledge, or are not aware, of the implications of urban land and water development solutions on the preservation conditions at Bryggen. A problem here is also the fact that currently the largest problems are “hidden” below the terrain surface, which makes communication difficult.

A third problem that can be seen as a hindrance is the fact that many stakeholders, including authorities, are not aware or convinced of the intrinsic value and importance of the archaeological remains. At Bryggen this is less of a problem, as the archaeological remains are part of the UNESCO World Heritage Site, and are thus protected. Nonetheless, a lot of effort was required to convince stakeholders and engineers that technical solutions to preserve Bryggen cannot include modern measures within the heritage site that disturb the authenticity of the cultural remains, both below and above the ground. Restoration of the buildings has to be based on traditional methods, craftsmanship and materials. The underlying archaeological strata are defined en masse as a non-renewable resource, and are to be protected in-situ.

Preserving Bryggen is thus by principle a challenge on how to re-establish the water balance using a combination of traditional (read: mediaeval) water management solutions at the site itself, and using new solutions in the surrounding area that has undergone an urbanisation process, in order to create the right boundary conditions.

KEY SUCCESS FACTORS

Open discussions with all stakeholders have been the most important means to overcome the above-mentioned problems. Organisation of and participation at seminars and congresses to present the Bryggen case and explain the challenges Bryggen is facing have been very important to raise awareness and to convince stakeholders to take the right measures. Use of modern visualisation techniques and tools in order to show what lies below the terrain surface has been, and still is, important.

In addition to the above-mentioned dissemination activities, a Norwegian standard (NS 9451:2009 “Cultural property: Requirements on environmental monitoring and investigation of cultural deposits”) has been created to ensure that cultural heritage and proper investigation of the burial environment, including ground and surface water handling, is taken care of early in the planning process. The standard is mostly based on the knowledge and experience gathered at Bryggen and is a binding document for urban developers in areas with cultural heritage, which currently includes the automatically protected mediaeval cities of Trondheim, Oslo, Tønsberg, Skien, Sarpsborg, Hamar, Stavanger and Bergen. In addition to the Norwegian standard, a manual for monitoring urban archaeological deposits has been developed (The Monitoring Manual, Procedures & Guidelines for the Monitoring, Recording and Preservation/Management of Urban Archaeological Deposits, Norwegian Directorate for Cultural Heritage and Norwegian Institute for Cultural Heritage Research).



SUSTAINABILITY ISSUES

As Norway's Directorate for Cultural Heritage, Riksantikvaren comes under and reports to the Ministry of the Environment. Endeavouring to realise the government's national targets for cultural heritage is therefore one of the Directorate's foremost tasks, with sustainability one of the keywords. The sustainability principle was introduced by the Brundtland Commission in 1987: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

"The concept of sustainability conjures up a number of diverse images, from energy conservation and the reduction of air pollution, through preservation of natural resources such as old growth forests and clean waterways, to the preservation of ecosystem biodiversity. This diversity of scope extends in a logically natural way to socio-economic 'environmental' problems such as urban air pollution, industrial accidents and poverty traps. The corresponding appropriate policy responses are to reduce pollution, injury and inequity. These policy problems are commonly presented in the form of a negative impact" (Brinsmead and Hooker (2005), *Sustainabilities: A systematic framework and comparative analysis*, Cooperative Research Centre for Coal in sustainable development, Research Report 53, The University of Newcastle Queensland, Australia).

Archaeological deposits were classified in Report to the Storting No. 16 ((Leve med kulturminner, St.meld. nr. 16, 2004-2005)) as a non-renewable resource, and thereby eligible for sustainable management. Riksantikvaren's Strategic Plan for the Management of Archaeological Heritage and Cultural Environments 2011-2020 (Riksantikvaren 2011) contains a number of important premises. The following statements are taken from this plan:

"The purpose of the Cultural Heritage Act is:

The preservation of archaeological heritage and cultural environments with their individuality and diversity, as part of the nation's cultural heritage and in accordance with a holistic environmental and resource management."

And furthermore:

"It is a national responsibility to safeguard these resources and their value as well-springs of scientific information and as a lasting basis for living and future generations' appreciation, understanding, well-being and development."

It is important to emphasise that the contemporary management of archaeological heritage and cultural environments in Norway functions well, with a high level of expertise and professionalism. All the same, there is room for improvement in a number of areas, such as increased efficiency, and clearer communication of the reasons for the priorities and choices that are taken. We must continue to strive to make the past interesting to the general public, and to raise awareness and create a feeling of shared responsibility for the management and preservation of the remains of the past. Raising the level of general awareness of these remains' historical value is a good place to start in order to reduce the loss of cultural heritage, much of this loss being the result of unwitting actions rather than malicious intent. With greater awareness and knowledge we stand a much better chance of achieving the national target that the annual rate of loss of protected archaeological heritage not exceed 0.5%.

Through its ratification of the Valletta Convention, Norway has undertaken to "implement measures for the physical protection of the archaeological heritage by making provision for the conservation and maintenance of the archaeological heritage, preferably in situ", otherwise through archaeological excavations and documentation.



The Faro Convention – The Council of Europe’s Framework Convention on the Value of Cultural Heritage for Society was ratified by Norway in 2008. Important elements in this convention include the right of every ethnic grouping to have its cultural heritage preserved, the sustainable use of cultural heritage in the development of society, universal right of access to cultural heritage, and the democratic management of cultural heritage.

Strategic central principles are thus in place for the management of all kinds of archaeological heritage, irrespective of age or location. Concerning the country’s world heritage sites, the State Budget 2010-11 contains the following: “The subsidy funding is earmarked for the preservation programme for the seven Norwegian localities on UNESCO’s World Heritage Sites list and is meant as a contribution to their safeguarding and restoration. The Norwegian world heritage sites are to be managed in a satisfactory manner and are to be given formal protection through legislation. Restoration and/or maintenance work is on-going at all seven world heritage sites, none of which is in an optimal state of maintenance”.

DISCUSSION AND CONCLUSIONS

The current condition of World Heritage Site Bryggen in Bergen is not satisfactory. The principal cause of the problems is leakages of groundwater, which contribute to settling damage, among other things. Numerous buildings are subsiding at an annual rate of several millimetres, and about 30 m³ of organic cultural deposits are lost to decomposition each year. Bryggen is protected under the Cultural Heritage Act, and the heritage site together with a buffer zone is designated a preservation area with reference to the Planning and Building Act.

There are many interested parties involved in World Heritage Site Bryggen. Major institutional collaborations are under way. Planning of measures to improve preservation conditions for the cultural deposits at Bryggen started in 2009. A general expertise-building process concerning the current state of preservation of and preservation conditions for the cultural deposits in selected towns is taking place with a view to developing suitable methods for the re-establishment of good preservation conditions and the stabilisation of the state of preservation of these deposits. Restoration and safeguarding of the buildings is a continuous process.

In order to maintain a long-term integration of land (including cultural heritage) and water management at Bryggen, an informal working group has been established with participants from Bergen municipality (Water and Sewage), the Directorate for Cultural Heritage and the Geological Survey of Norway in order to hold early discussions on regional and local water management measures and plans with the heritage authorities. This ensures an early identification of problems and opportunities to better integrate land and water management. A suggestion could be to formalise these working groups in areas that have specific vulnerable aspects, such as cultural heritage, not only at Bryggen, but also at areas outside of the case study area.

It is often noted that sustainable water management solutions come into the planning process too late, not because of unwillingness, but mostly because of communication failures. A regular discussion forum with different disciplines could prevent this. The multidisciplinary approach developed at Bryggen has a very high potential for replication in other areas with cultural deposits. This is facilitated by the strong Cultural Heritage Act, which gives the heritage authorities the possibility to intervene and enforce communication between different disciplines, amongst others urban land and water planners/developers, water managers and cultural heritage managers. The newly developed Norwegian standard clearly states that hydrogeological issues, and particularly groundwater flow, have to be considered and monitored. This has a direct replicating effect for better integration of land and water management in the protected mediaeval cities of Trondheim, Oslo, Tønsberg, Skien, Sarpsborg, Hamar, Stavanger and Bergen.