Water and Heritage management; Experiences gained at Bryggen in Bergen, Norway

Sustainable urban water planning through multi-benefits

Ann Christensson, Hans de Beer and Tone Muthanna

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Prosjekt Bryggen

NGU
Norges geologiske undersøkelse
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1912 – 2012

HORDALAND COUNTY COUNCIL

The protection of the archaeological heritage must be based on effective collaboration between professionals from many disciplines

STATSBYGG

The Interreg IVB North Sea Region Programme
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BERGEN KOMMUNE

OLAV THON GRUPPEN

Prosjekt Bryggen

«During the last 25 years, groundwater levels in parts of the Bryggen area have been lowered by more than 1.5 metres. This has led to a considerable amount of settlement, which has severely damaged several of the area's preservation-worthy buildings. This dewatering is to be stopped without delay. The government has provided 45 million *kroner* for works aimed at improving the groundwater situation. This will be a major contribution to the safeguarding of the world heritage site's two main components: the standing buildings, and the underlying cultural deposits with all their invaluable historical data.»

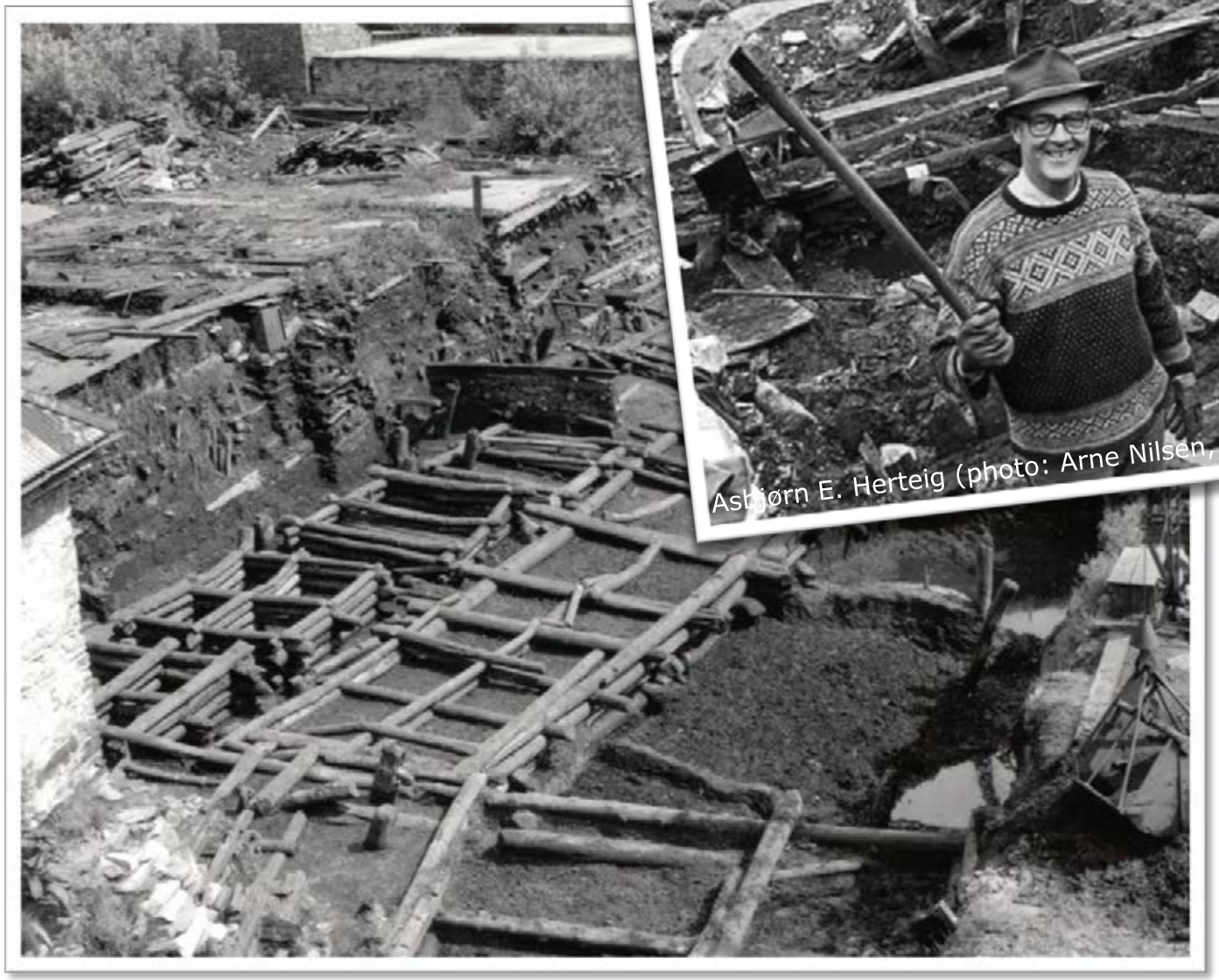
(Report to the Norwegian Parliament 1, 2011-12)

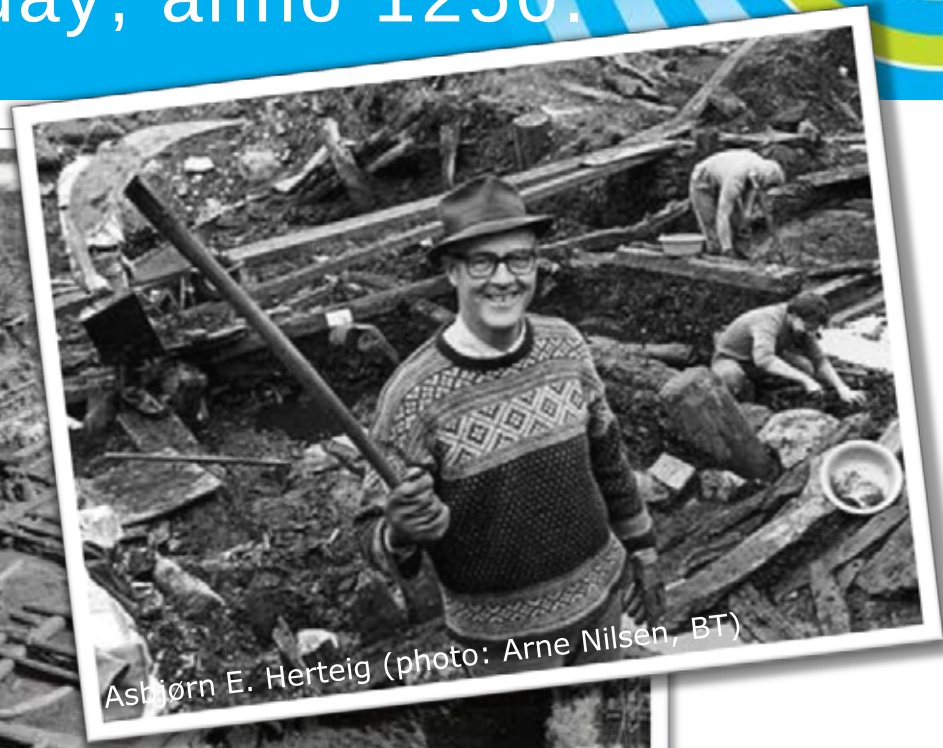
Sustainability

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 by law is extended to all standing monuments older than 1649 and archaeological remains older than 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).
- There was no similar provision in earlier legislation, which can be considered one of the main causes that urban redevelopment including groundwater drainage at Bryggen in the late '70s 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 by increased rainfall and sea water level.

King Sverre's quay, anno 1250.



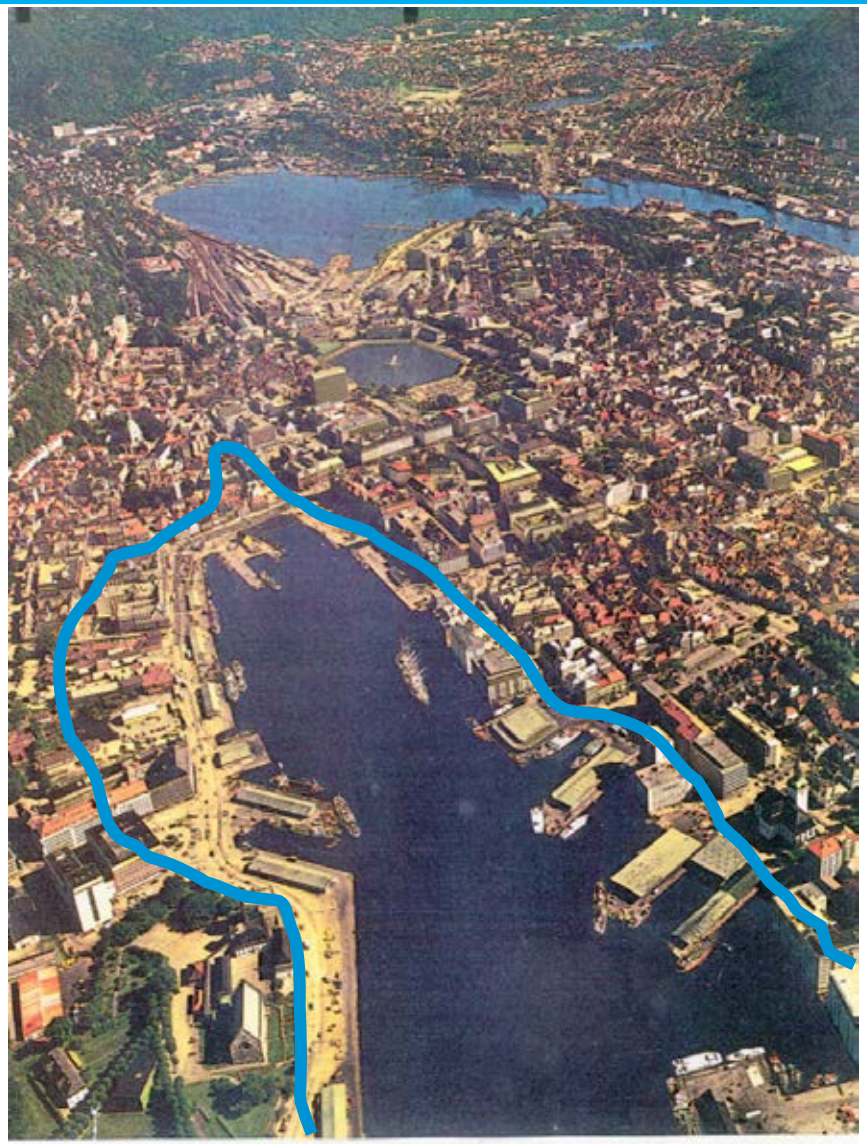


Asbjørn E. Herteig (photo: Arne Nilsen, BT)

Medieval artefacts from Bryggen

Photos Svein Skare © Bergen Museum

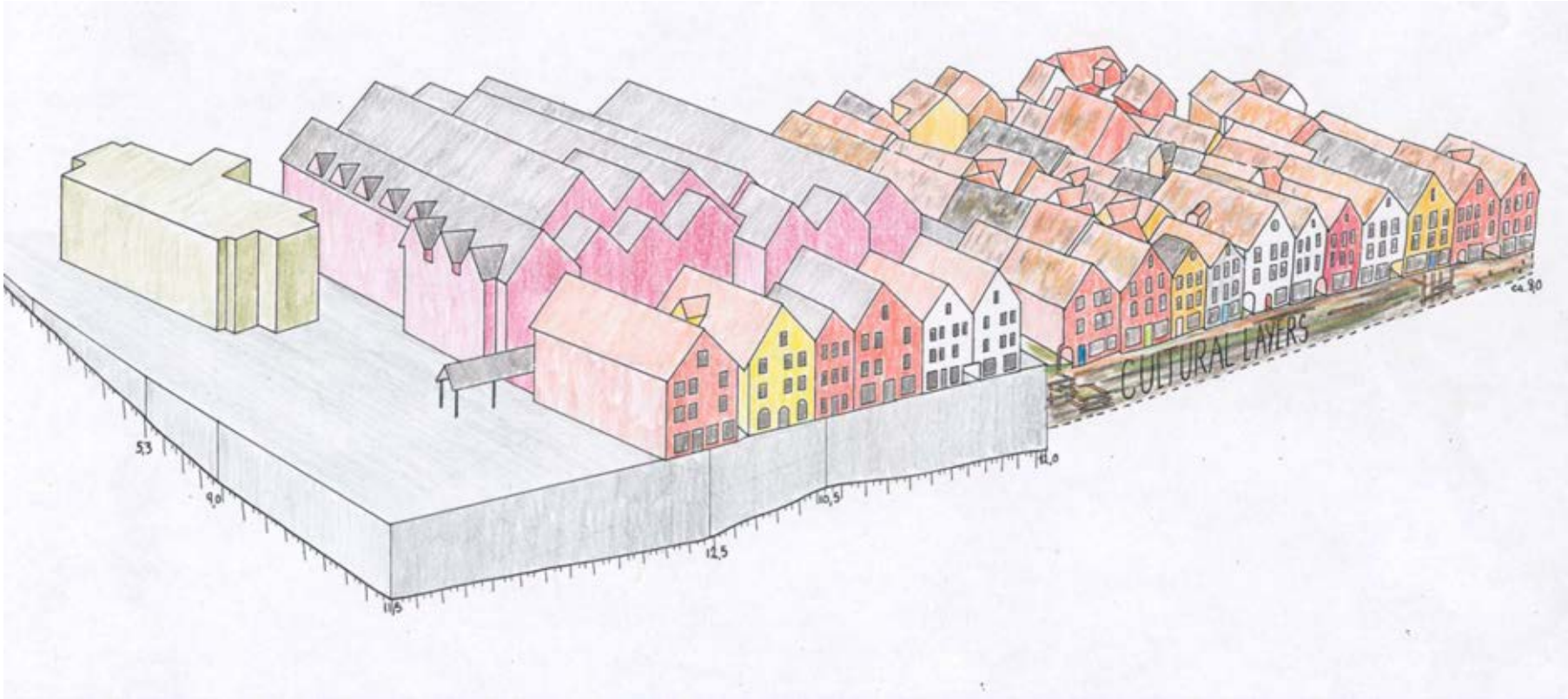
Shoreline anno 1000



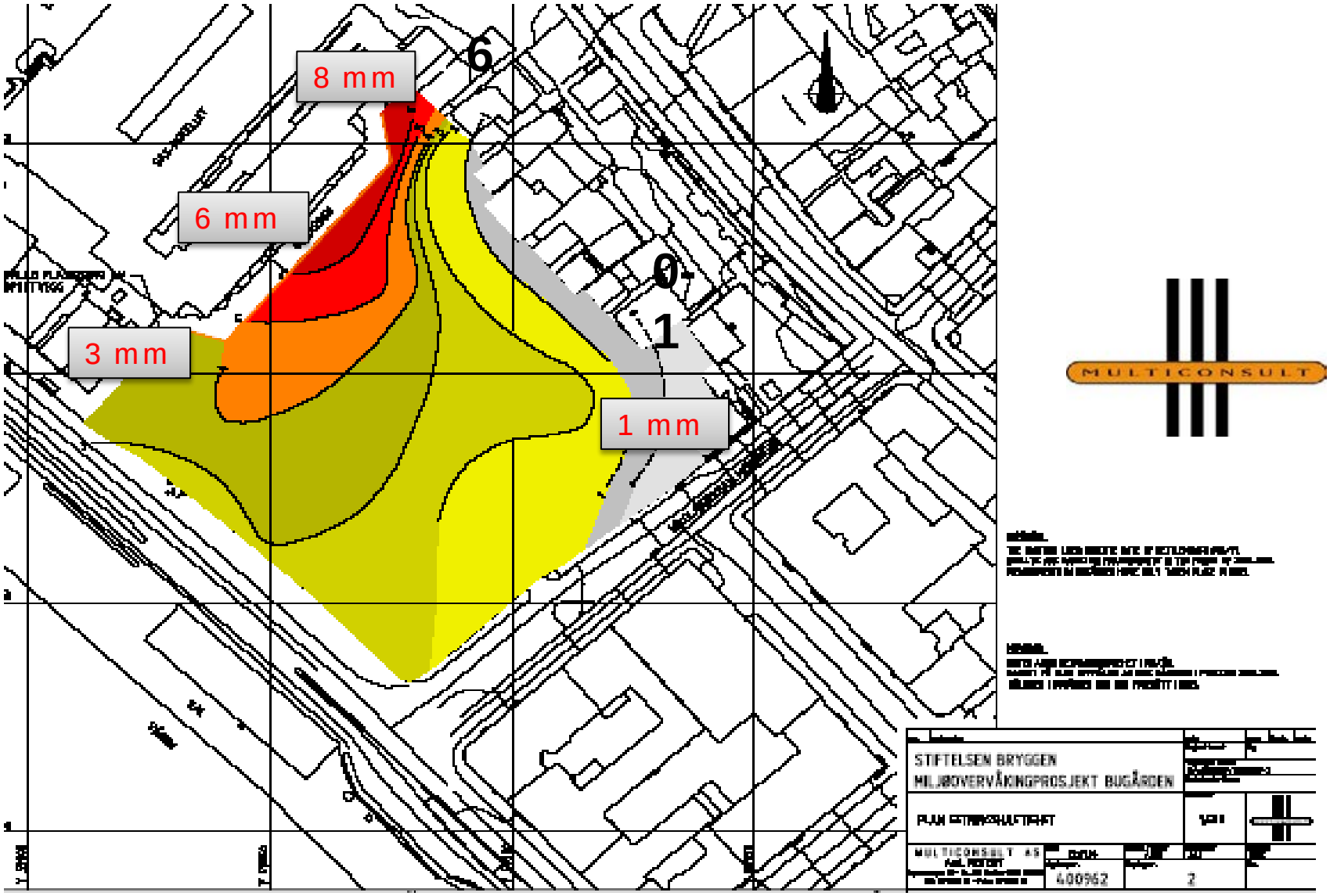
Prosjekt Bryggen

Bryggen anno 1980

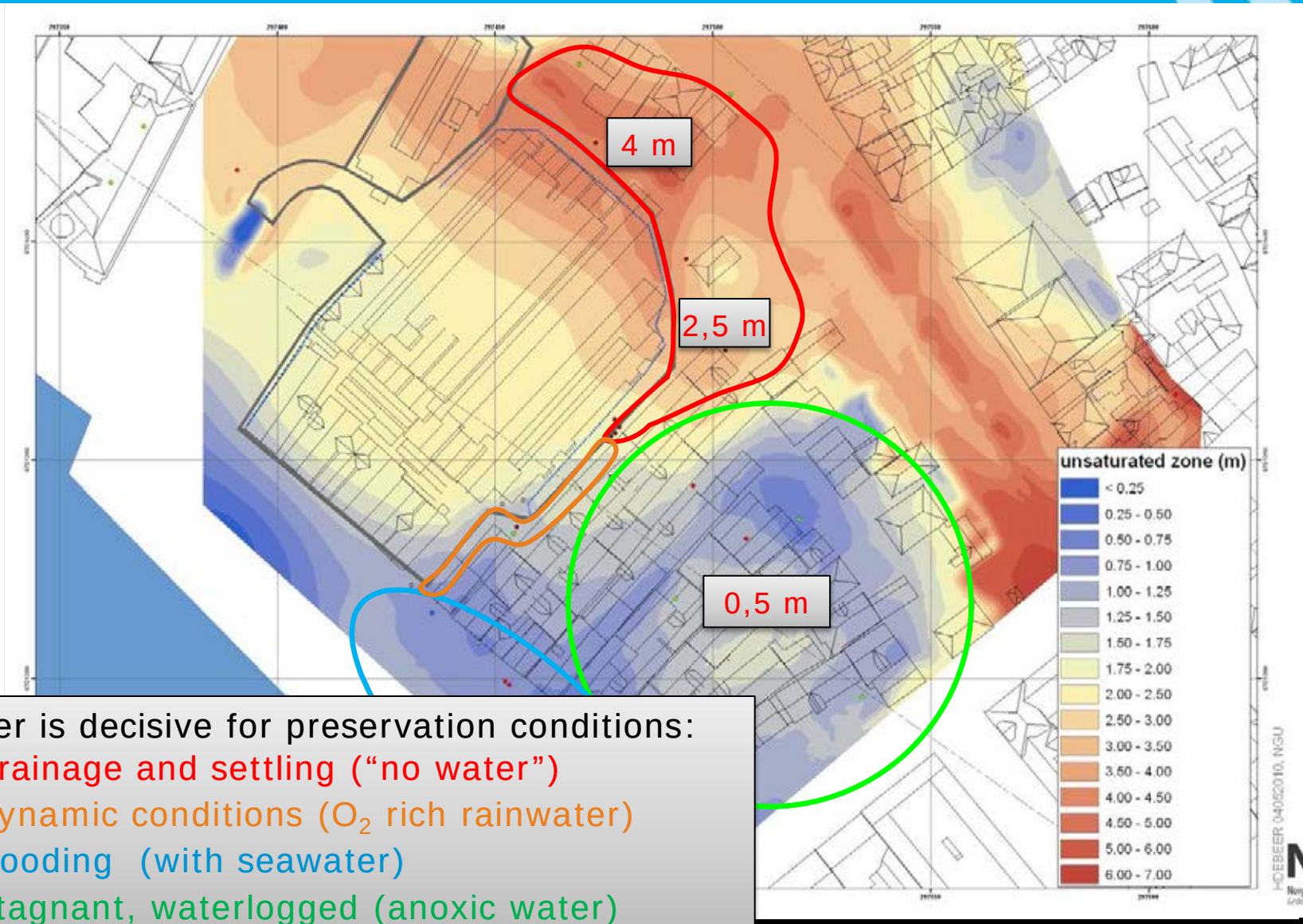
Bryggen after 1982



Annual settling rate



Unbalanced, unsustainable



Water is decisive for preservation conditions:

- Drainage and settling ("no water")
- Dynamic conditions (O_2 rich rainwater)
- Flooding (with seawater)
- Stagnant, waterlogged (anoxic water)

Installation of sensors in test-pit

Monitoring in the unsaturated zone

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Drilling of dipwells

Monitoring the saturated zone

Drilling observation wells
- archaeological documentation

Norsk institutt for kulturminneforskning

What have we done about it?

- Establishment of a comprehensive monitoring programme for investigation of archaeological state of preservation and geochemical preservation conditions
- Annual reporting of all works; reports accessible via the Internet
- 10 years of sampling and testing. Annual water sampling
- Compilation of Norwegian Standard NS 9451: ‘Requirements for environmental monitoring and investigation of cultural deposits’
- Logging of water-level, temperature, salinity etc.
- Logging of oxygen and redox values
- Surveying of fixed points for measurement of settling rate
- Handling of huge data quantities

Mitigation measures

Mitigation measures implemented at Bryggen

Mitigation measures:
completed/underway

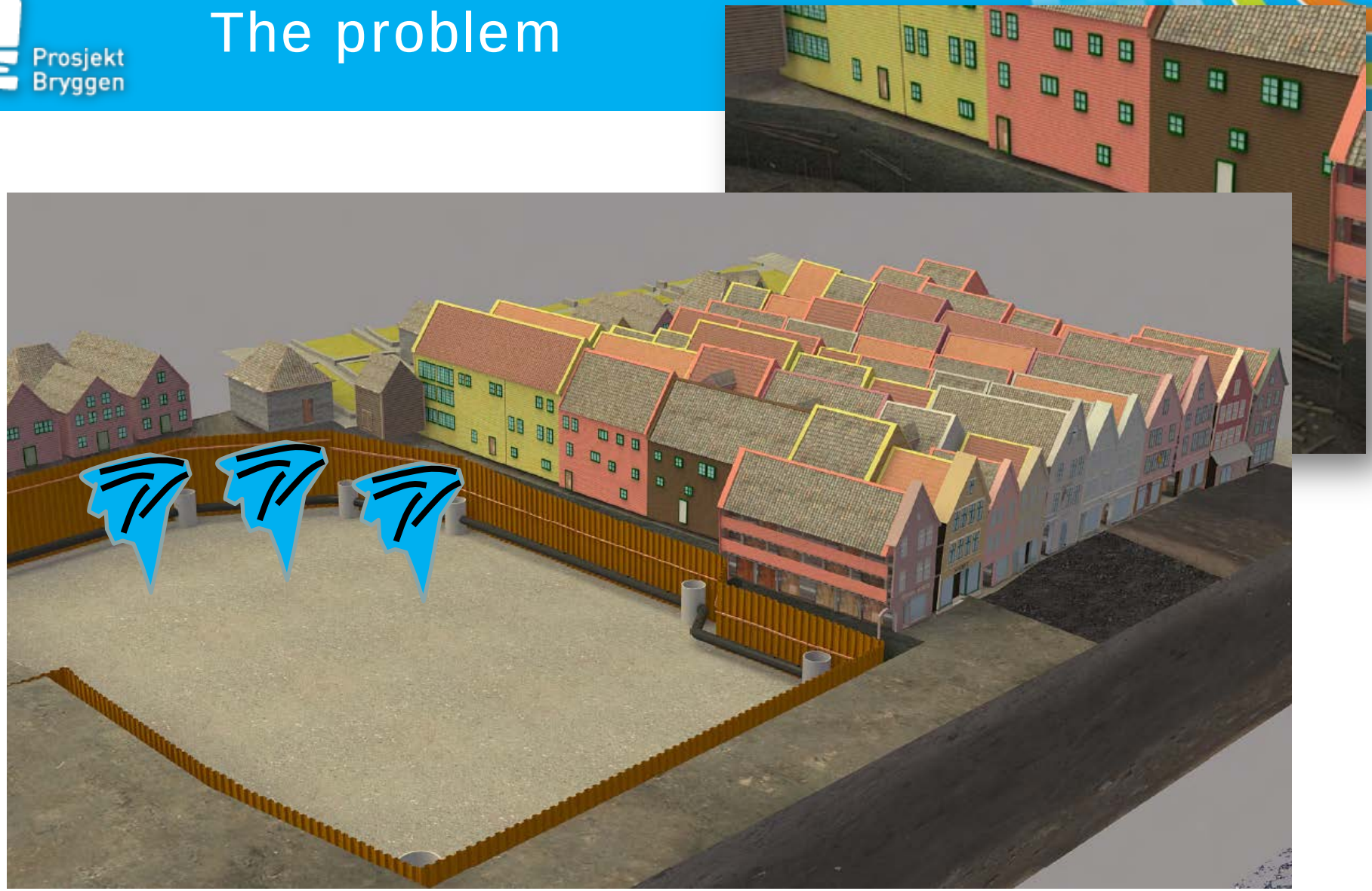
- Raising of drainage outflow level under the Radisson Blu Royal Hotel.
- Construction of 5 bentonite dams at points along the sheet piling running along the Bredsgården tenement in order to hold back rainwater as a contribution to the replenishment of the water-table.
- Construction of swales and installation of storage facilities for collection and infiltration of water into the cultural deposits.
- Plugging of anchor stay holes and other leakage points in the sheet piling.
- Replacement of permeable soil with materials such as woodchips or clay.
- The effect of the measures is monitored continuously by means of sensors and other devices (some telemetry is now online to provide real-time data).
- If, contrary to expectations, the desired results are not achieved, implementation of large-scale works, primarily to stop all leakage through/under the sheet piling, will be considered.
- These works have been carried out in cooperation with TAUW, TU Delft.

New challenges

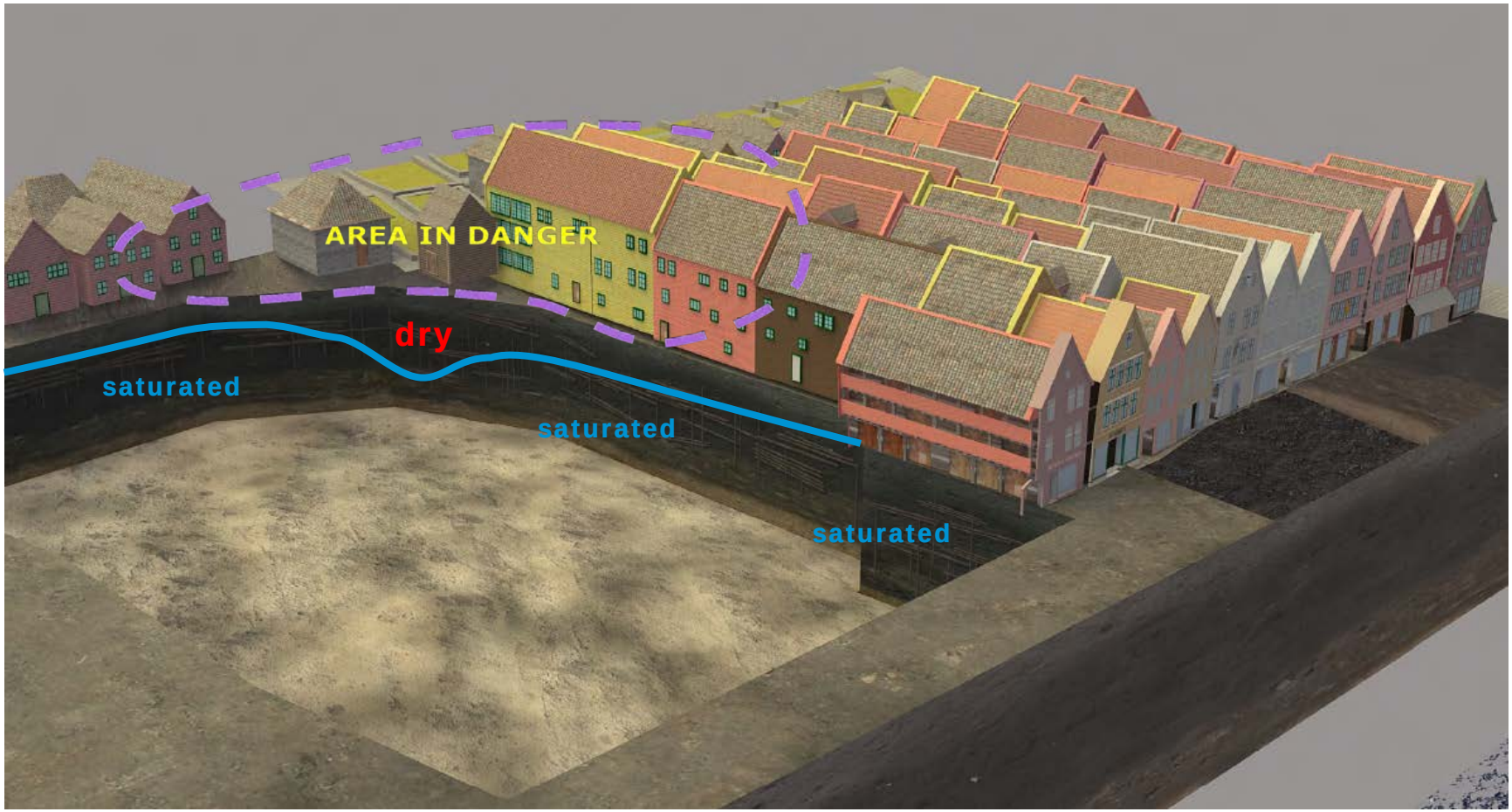
Social sustainability?

Anti-Bryggen demonstration, 1961

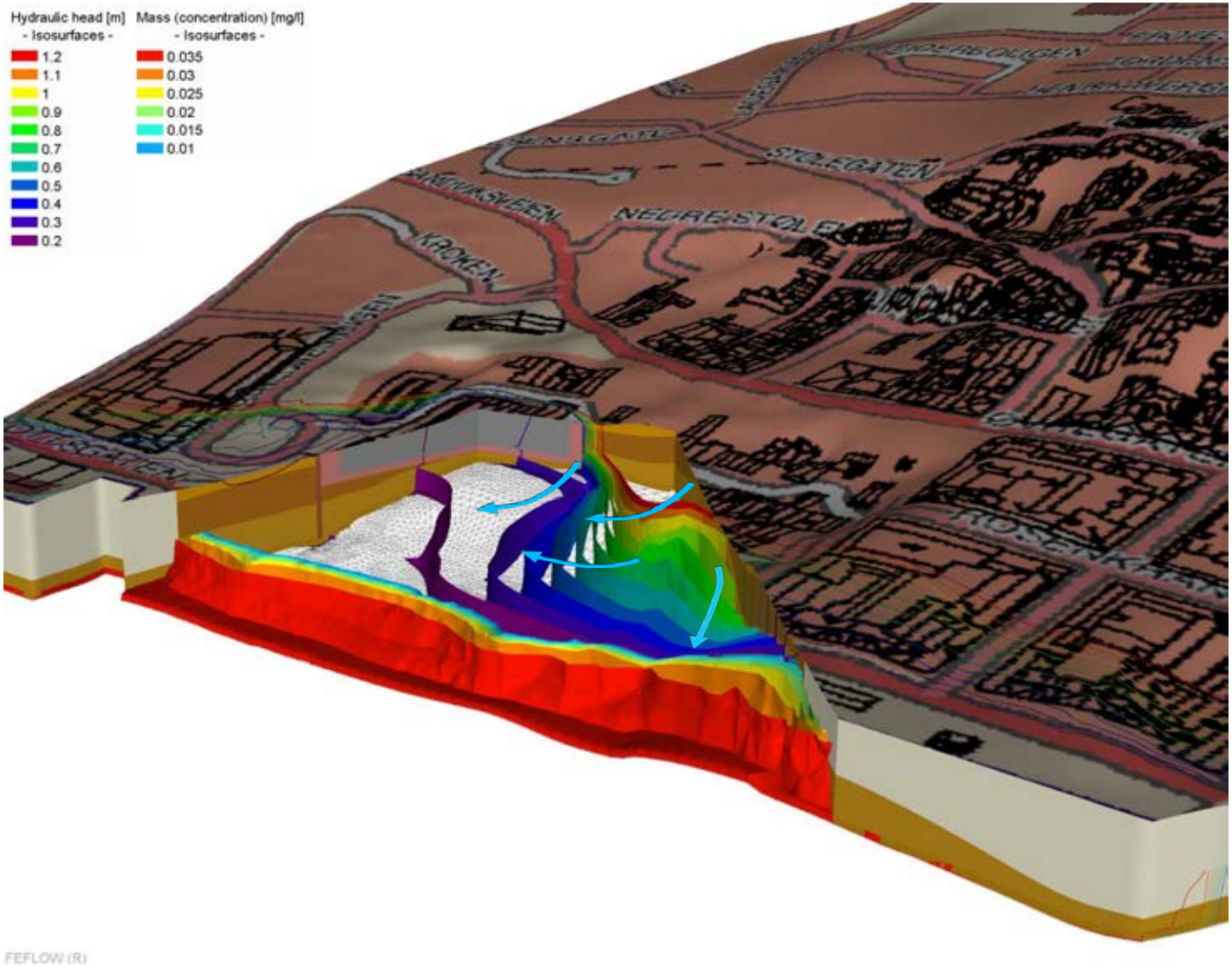
The problem



Large area drying out



Prosjekt Bryggen



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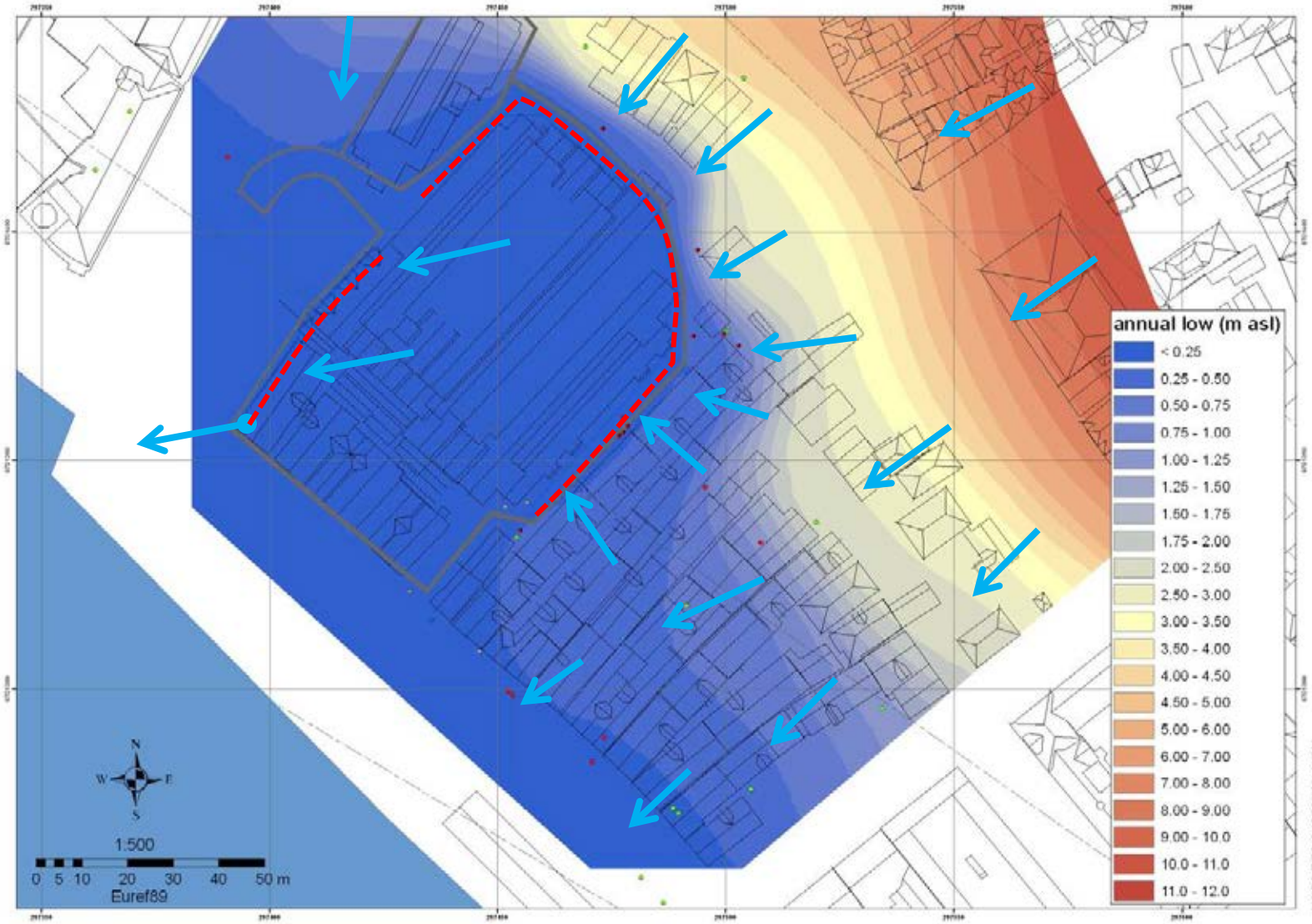
Unbalanced, unsustainable



Mitigation measures

Stepwise infiltration facility

Vannet skal styres under Bryggen

SEGET: Gatedekket i Bugården var ikke sitjevt da det ble lagt i forbindelse med byggingen av SAS-hotellet for vel 30 år siden. I dag ser vi tydelig hvordan dekket heller kraftig ned mot Bryggen. Spuntveggen av stålfjeller som avstiver byggegrunnen under SAS-hotellet forløper gjennom Bugården (se stor illustrasjon).

SPUNTVEGG OG GRØFT: Illustrasjonen viser hvordan spuntveggen av stålplater er satt på plass før byggingen av SAS-hotellet i 1979. Spuntveggen sikrer byggegrunnen under SAS-hotellet fra kulturlagene under Bryggen. Her er også skissert hvordan en grøft med overløp er tenkt på utsiden av spuntveggen, for å samle opp sigevann som skal filtreres i kulturlagene og heve grunnvannet.

HOLDER VANNET TILBAKE: Terskler i grøften vil holde vannet tilbake slik at det siger ned i kulturlagene under Bryggen i stedet for å renne forbi. Vann fra takrennene skal også samles opp.

Spuntvegg

Det meste av regnet som faller over Bryggen renner vekk over brostein og gjennom avløp. Nå skal det ledes dit Bryggen trenger det, i undergrunnen.

JOHN LINDEKOTTEN
TOR SPONGA (foto/illustrasjon)
john.lindekotten@bt.no

Dette skal skje gjennom såkalt styrt infiltrasjon av regnvannet.

I redningsaksjonen for Brys-

vil samle opp mye av regnvannet som faller på gresset. Vannet som samler seg opp, blir holdt tilbake i stedet for at det bare renner bort og tar korteste veien mot avløpene. Litt etter litt vil

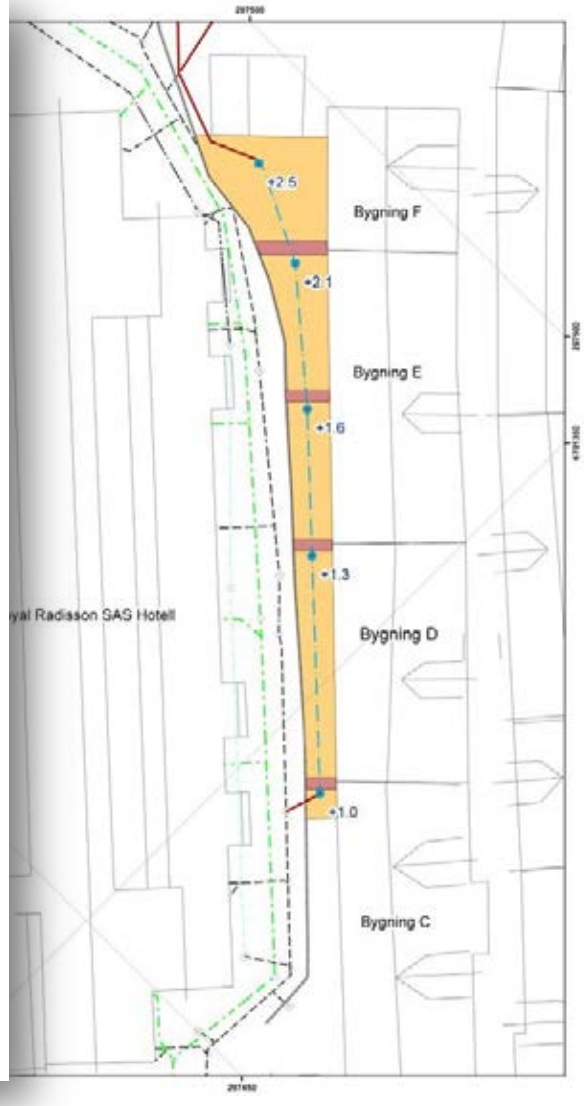
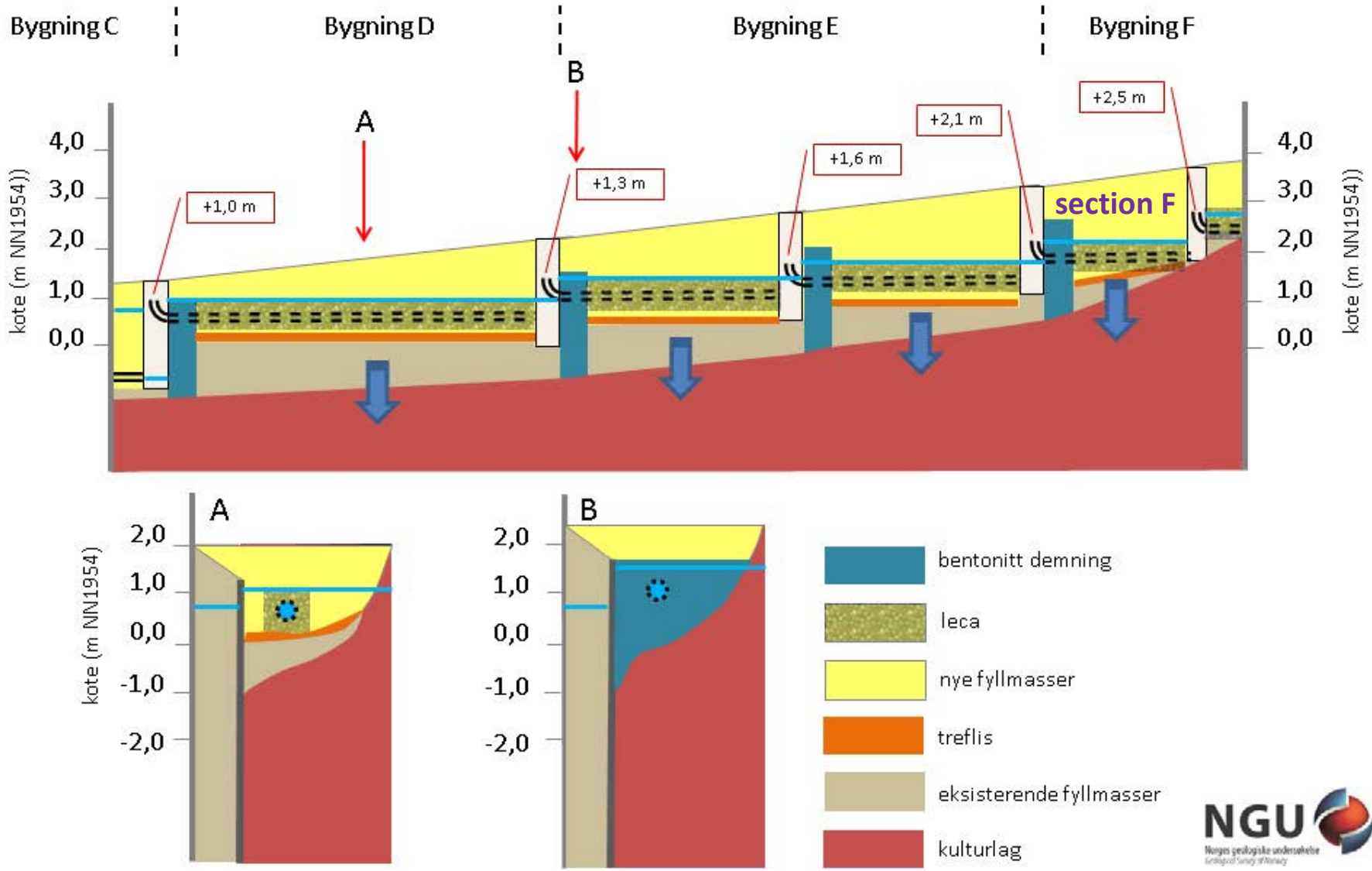


Illustration: Tor Sponga, BT

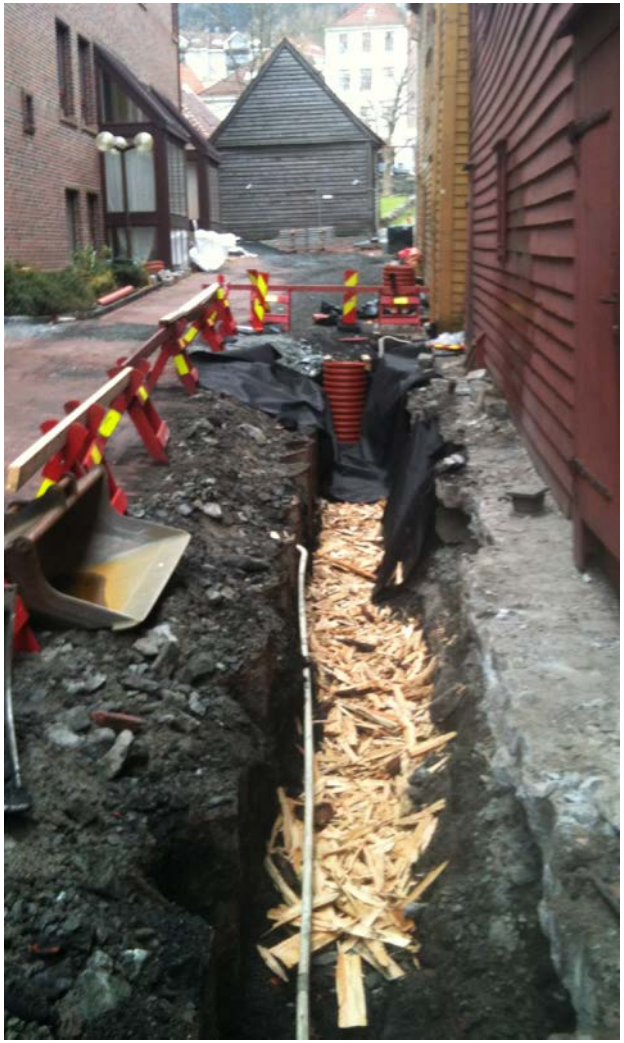
Mitigation measures

Stepwise infiltration facility



Mitigation measures

Stepwise infiltration facility



Mitigation measures

Sustainable Urban Drainage Systems

Spuntvegg_ny

Overvåkingspunkter

- forslag ny miljøbrønn
- automatiske målinger
- automatisk, fjernstyrt
- manuelle målinger
- flernivå prøvetakingsbrønn
- tidligere miljøbrønn

Høydekoter

- CONTOUR_0_05
- CONTOUR_0_25
- FOUNDATIONS
- water_holes
- vegsituasjon

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Photos: Floris Boogaard, Rory Dunlop