The Interreg IVB North Sea Region Programme

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SKINT WATER SERIES

SUSTAINABLE URBAN WATER PLANNING ACROSS BOUNDARIES

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PREFACE

North Sea Skills Integration and New Technologies – SKINT – raises awareness amongst decision-makers about sustainability in general and the environment in particular. This will help ensure that better decisions are made about measures to improve water quality and reduce flooding in urban areas. However, it is important to realise that the successful integration of land and water management and real sustainable water management yield much more than just the direct benefits of improving surface water quality or reducing floods. The benefits are manifold.

One of the most controversial, yet crucial aspects for the integration of land and water management is how sustainability is considered and assessed. The question of sustainability of options is one with many facets. There is no clear agreed definition of sustainability; rather, there are many definitions, principles, objectives and ideas. Sustainability has become a devalued term due to overuse, misuse and abuse by politicians and others, where everything is now presented as being sustainable or part of sustainable development. The term "sustainable", embodied in the Lisbon and Gothenburg Agendas, has been used and misused by decision-makers. SKINT has been given unique opportunities, not least thanks to the inclusion of Cultural Heritage, to challenge the "traditional" perception of sustainability that relate to multiple benefits, definition of scale and conceptual boundaries. A second SKINT publication will present and evaluate a new operational tool that will allow teams of users to produce integrated sustainability assessments for flood risk and water management applications.

This publication addresses past, current and upcoming approaches to sustainability and sustainability assessments based on a selection of real life exemplary transnational cases. The aim is to provide professionals and decision-makers with good examples, better procedures and tools to demonstrate the need for and benefits of adopting more sustainable solutions to a wider public, which, although it has heard of the need for sustainability, is not quite sure of what it is.

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SUMMARY

This publication illustrates how different aspects of integrating land and water management processes are dealt with in urban planning. Innovative solutions are presented through real world exemplary case studies; organisational structures, legislation, stakeholder roles and communication tools, difficulties as well as key success factors are discussed and analysed. Based on the case studies, the following lessons can be learned:

- Integration of land and water management is hindered by a lack of long-term economic agreements and stable funding mechanisms for construction and maintenance of sustainable solutions.
- Integration of land and water management requires open communication and long-term contracts between stakeholders.
- Communication and education on water management, sustainable drainage solutions and their wider, multiple benefits to environmental and cultural assets is crucial for their acceptance and integration in urban planning.
- Modern technology can significantly improve communication and cost-efficient decision-making, thereby facilitating a better integration of urban land and water management.
- Local champions, coupled with consistent political support, long-term working relationships and mutual trust are key success factors for the integration of land and water management.
- Unmanaged media attention may lead to false perceptions of solutions. A timely, active and open dialogue with the media will contribute to awareness and support for sustainable water management solutions.
- Multiple benefits are lost or become drawbacks when there is a lack of knowledge and awareness among professionals, and procedures and regulations are unclear or too narrowly formulated.
- Successful integration of land and water management and real sustainable water management yields multiple benefits, rather than just the direct benefits of improving surface water quality or reducing floods.

North Sea Skills Integration and New Technologies

SKINT and the EU Interreg programme NSR

The EU Interreg programmes aim at stimulating transnational cooperation in the EU. One of the programmes is the North Sea Region (NSR) Programme. The NSR focuses on encouraging and supporting transnational cooperation in the North Sea Region. SKINT stands for North Sea Skills Integration and New Technologies. In short, SKINT is about speaking a multidisciplinary language to integrate the worlds of spatial planning and water management, and about encouraging the implementation of innovative and sustainable technical solutions which have already proved to be successful.

Rationale for the SKINT project

The Water Framework Directive (WFD) and the Floods Directive (FD) have clear goals to improve water quality and to regulate water quantity. When coupled with the effects of climate change and increased urbanisation these create increasing pressures on water management, especially in urban areas.

Objectives of SKINT

The use of appropriate spatial planning processes can address many urban water management problems. SKINT facilitates the implementation of sustainable urban land and water management by improving the integration of water management in spatial planning processes. SKINT gathers knowledge and experience from successful initiatives and provides (communication) tools for water managers and spatial planners. These will provide an improved skills base to enable effective integrated management of ground and surface water quality and quantity.

SKINT will:

- Facilitate the involvement of water managers and spatial planners in multidisciplinary processes by improving communication;
- Create and apply an international knowledge base of best processes and practices of water management integrated with urban land use;
- Integrate water management in urban land use processes to facilitate the implementation of technical water solutions;
- Provide information to professionals to help decision-makers to select more sustainable solutions;
- Share the findings from SKINT with water and urban land use professionals in ways specified by those professionals;
- Conduct a specially developed training programme for water and urban land use professionals.

Results of SKINT

SKINT raises awareness amongst decision-makers about sustainability in general and the environment in particular to help ensure that better decisions are made about measures to improve water quality and reduce flood risk in urban areas.

The results from the project will be used for a permanent water web portal and a web-based and face-to-face training programme for water and urban land use professionals. The permanent portal for urban water and land use in Europe will be complementary to, and will interact with, portals developed by other projects. After the completion of the SKINT project, the water portal will continue to be a dynamic user-driven website for multidisciplinary stakeholders and a source of communication about truly sustainable urban water management.

The training programme will increase the ability of professional staff in key public bodies to manage the built environment of existing urban areas so that the needs of integrated land and water planning are better met. The target group for the training will be practitioners from a range of disciplines involved in water management and spatial planning/development control who, as end users, will be the champions of sustainability.

Ultimately, SKINT will improve the implementation of the WFD and FD to contribute to the improvement of water quality in urban areas and, inter alia, the reduction of flood risk. The project runs from 01.10.2008 to 31.10.2012 and aims to provide an enduring legacy.

SKINT work packages

The project will be carried out in a series of transnational SKINT work packages (WP) meeting the requirements of transnational objectives. The work packages are:

WP 1: Communication, participation and dissemination

A transnational analysis of communication between stakeholders in multidisciplinary urban land and water management processes, supported by the transnational exchange of professionals. In the course of the SKINT project the partner consortiums and their regional and national networks will be trained with the help of a communications consultant. Results will be used for the SKINT water portal and the training programme.

WP 2: SKINT water portal

The creation of a web portal dedicated to water that will be used during the project as a medium for communication between the partners and their networks and as a permanent web portal for urban water and land use in Europe. The portal will be complementary to and will interact with portals being developed by other projects. After SKINT the water portal will continue to be a dynamic user-driven website for future multidisciplinary stakeholders and a source of communication about truly sustainable urban water management.

WP 3: Placing water earlier in the planning process

A transnational analysis about integrating water in urban land use projects from the start in order to improve the integration of the land and water management processes. The aim is to identify, to enhance and to test the current and emerging water management procedures and solutions available for the integration of land and water management within urban areas.

WP 4: Selling sustainability

Equipping professionals with procedures and tools to understand and demonstrate the need for more sustainable solutions for urban water management. Drawing on previous work such as NORIS and Urban Water, multidisciplinary discussion is facilitated by a framework for sustainability assessment developed within SKINT and tailored for integrated and inclusive urban land and water management.

WP 5: Training the champions of change

The creation of a web-based and face-to-face training programme for future water and urban land use professionals. The training will provide detailed and up-to-the-minute knowledge for professionals involved with the built environment, ensuring the needs of integrated land and water planning are better met. The training programme will pay special attention to our findings with respect to multidisciplinary cooperation. The target group for the training will be practitioners from a range of disciplines involved in water management and spatial planning/development control who, as end users, will be the champions of sustainability. This training will link to other training programmes on multidisciplinary work.

Regional SKINT projects

Besides the transnational work packages, there are also regional SKINT projects. Each partner will undertake at least one regional or national, but transnationally oriented project that will contribute to the above-mentioned transnational activities. The activities of the partners are directly linked to the work packages and will involve the final users of the project results. During the project the regional and national networks will serve as demonstration and implemenation sites for the more theoretical approaches of the work packages. Their involvement in the running of the SKINT project will also guarantee follow-up of the SKINT results after the project has ended. The results of all activities will be used in the water portal and in the training programme.

The SKINT partners

The SKINT partners are:

- Hoogheemraadschap Hollands Noorderkwartier (HHNK, lead partner)
- Hamburg University of Applied Sciences (HAW Hamburg)
- Urban Water Technology Centre, University of Abertay Dundee (UWTC)
- Bradford City Council
- Pennine Water Group, University of Sheffield (PWG)
- Technical University Delft (TU Delft)
- Norwegian Institute for Water Research (NIVA)
    - Directorate for Cultural Heritage in Norway (Riksantikvaren, sub-partner under NIVA)
    - Geological Survey of Norway (NGU, sub-partner under NIVA)
    - Norwegian Institute for Urban and Regional Research (NIBR, sub-partner under NIVA)

Detailed descriptions of the roles, activities, motivation and contact information of all SKINT partners can be found in Appendix A.

Project contact information

All information on the SKINT project can be found at the SKINT website at www.skintwater.eu. The lead beneficiary of the SKINT project is the Hoogheemraadschap Hollands Noorderkwartier, a water authority in the north-western part of the Netherlands.

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CASE STUDIES: THE JOURNEY TO SUSTAINABLE DEVELOPMENT

SUSTAINABLE OR NOT SUSTAINABLE, THAT'S THE QUESTION!

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INTRODUCTION

The question of sustainability of options has many facets. There is no clear agreed definition of sustainability; rather, there are many definitions, principles, objectives and ideas. Sustainability has become a devalued term due to overuse, misuse and abuse by politicians and others, where everything is now presented as being sustainable or part of sustainable development. The term "sustainable", embodied in the Lisbon and Gothenburg Agendas, has been used and misused by decision-makers. The SKINT project, particularly with the inclusion of cultural heritage, provides unique opportunities to challenge the "traditional" perception of sustainability that relates to multiple benefits, definition of scale and conceptual boundaries. This paper addresses past, current and upcoming approaches to sustainability and sustainability assessments based on a selection of transnational cases, and proposes an initial description and definition of a common strategy for sustainability and sustainability assessment in land and water management processes in future projects. The aim is to provide professionals and decision-makers with better procedures and tools to demonstrate the need for and the benefits of adopting more sustainable options to a wider public, which, although it has heard of the need for sustainability, is not quite sure of what it is.

DRIVERS FOR SUSTAINABLE MEASURES

There is a growing recognition that we cannot sustain our current way of life based on current technologies. Climate change and increasing urban pressures for example increase urban storm runoff, with the result that conventional piped solutions for urban drainage are becoming increasingly overloaded. The effects of flooding have been well documented for over 40 years.[1] It has been stated that the percentage of impervious cover that follows from urbanisation has become "the most pervasive, relevant characteristic leading to hydrological impacts"[2] and therefore an important driver for sustainable urban design. However, there are also very significant alterations to the urban subsurface, affecting groundwater levels and chemistry.[3] Although the common assumption is that groundwater recharge decreases because of the increased amount of impervious cover and loss of direct recharge, it has been shown that city-wide recharge in large developing cities is mostly increasing.[4] However, recharge is decreasing in established cities with efficient infrastructure and high natural

[1] Leopold L.B. (1968), "Hydrology for Urban Land Planning: A Guidebook on the Hydrological Effects of Urban Land Use", USGS Circular 554, p. 18.

[2] Arnold C.L. jr. and Gibbons, C.J. (1996), "Impervious surface coverage: The emergency of a key environmental indicator", Journal of the American Planning Association, Vol. 62, No 2, pp. 243–258.

[3] Hibbs, B.J. and Sharp, J.M. jr. (2012), "Hydrogeological Impacts of Urbanization", Environmental & Engineering Geoscience, Vol. XVIII, No. 1, Feb. 2012, pp. 3–24.

[4] Garcia-Fresca, B. and Sharp, J.M. jr. (2005), "Hydrogeologic considerations of urban development – urban-induced recharge", In: Humans as Geologic Agents: GSA, Reviews in Engineering Geology, Boulder, CO, Vol. 16, pp. 123–136.

recharge, such as those in the North Sea area.[5,6] The tipping point beyond which the expected levels of service are no longer provided[7] is difficult to quantify, and varies both geographically within the urban area and in time. The consequences of subsurface alterations on groundwater are, however, important for human activities and the environment and should be considered in urban land and water management. In SKINT, this is illustrated by the inclusion of cultural heritage preservation, which is highly dependent on soil water content and groundwater chemistry. Because groundwater is "out of sight", it is sometimes "out of mind"[3].

In order to cope with the dynamic changes in developing urban areas, it will be necessary for water to play a more prominent role in the urban development and planning process. Changing conditions demand innovative water management solutions, particularly in dense urban areas, and these can only be implemented when water issues are taken into consideration in the early stages of urban planning and holistic development design. The need here is not simply to call in the traditional urban drainage professionals at an early stage; it is to integrate the land and water management processes (e.g. Potter et al., 2011).[8]

However, the responses to the change drivers will come through urban design, and this will require the early engagement of professionals such as highway engineers, landscape architects, planners and regeneration experts (e.g. Digman et al., 2012).[9] It is therefore necessary to build capacity in, and engage with, a much wider group of professionals, many of whom will have little or no formal training in hydrology, hydrogeology, hydrochemistry, hydraulics and water purification processes, or have little awareness of new threats or opportunities that may arise as a consequence of changes in how water and land are managed. A better integration of the land and water management processes requires active communication of the opportunities, multiple benefits and impacts of our decisions to a wide group of professionals and beyond.

Climate change and hard economic realities mean that we have to reduce waste in all aspects of life as we manage the transition from current to new energy sources. Land use and water management planning are no exception. There are requirements to

- Improve economic competitiveness by reducing cost;
- Increase inward investment by improving the local environment;
- Maintain and improve the quality of life.

These three requirements are synonymous with the three pillars (economy, environment and society) of sustainability, which are embodied in the Lisbon and Gothenburg Agendas and are relevant to a wide range of cross-cutting applications such as:

- Reducing energy use, and especially the use of energy from carbon sources in order to face up to depleting energy reserves and climate change;
- Assessing the benefits to urban communities of increasing knowledge and awareness of historical values;
- Flood risk and water management.

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[5] Jeppesen, J., Christensen, S., and Ladekari, U.L. (2011), "Modelling the historical water cycle of the Copenhagen area 1850–2003", Journal of Hydrology, Vol. 404, pp. 117–129.

[6] Knipe, C.V., Lloyd, J.W., Lerner, D.N. and Greswell, R. (1993), Rising Groundwater Levels in Birmingham and the Engineering Implications, CIRIA Special Publication 92, p. 114.

[7] Gersonius B. (2012), The Resilience Approach to Climate Adaptation, PhD thesis, TU Delft, ISBN 978-0-415-62485-5.

[8] Potter, K., War, S., Shaw, D. MacDonald, N., White, I., Fisher, T., Butler, D. & Kellagher, R. (2011), Engineers and Planners: Sustainable Water Management Alliances, ICE Engineering Sustainability, 164, ES4, pp. 239–247.

[9] Digman, C., Ashley, R., Balmforth, D., Balmforth, D., Stovin, B., and Glerum, J. (2012), Retrofitting to manage surface water, CIRIA C713, London, United Kingdom.

SUPPORTING THE IMPLEMENTATION OF SUSTAINABLE MEASURES

Currently it is often the case that innovative water options are available, but their implementation is hindered by barriers to multidisciplinary working and institutional regimes.[10] Lack of multidisciplinary working hinders identification, appreciation and delivery of multiple benefits and therefore hinders delivery of measures that are as sustainable as possible. There is thus a need to foster awareness of the changing and evolving roles of different disciplines and of how these can work better together, and to build capacity within individual disciplines to make the required contributions. Water and land management practices need to become more integrated so that water management becomes an everyday part of the spatial planning and development processes, even in their early stages. This will enable more sustainable responses to problems. Recently, formal "alliances" of professionals, working with decision-makers in "learning alliances", have been shown to be very effective in bringing about innovation and co-formulation of outcome measures that are as sustainable as possible.[11,12]

The perceived high costs of sustainable options play an important role in decision-making and often hinder implementation. There is a need to show the importance of the multiple benefits that can be obtained in different disciplines compared with these costs. Multiple benefits can only be fully appreciated if professionals succeed in looking beyond their own disciplines and consider wide conceptual boundaries in space, time and content. In order to assess and consequently "sell" the benefits and impacts of our decisions we need to consider all aspects of sustainability and to apply weightings to take account of the specific circumstances relevant to each decision.

In this publication, selected transnational cases are presented that illustrate how they have dealt with different aspects of integrating the land and water management processes. Innovative solutions are presented; organisational structures, communication tools and difficulties, as well as key success factors are discussed. One of the most important aspects for integration of land and water management is how sustainability is considered and assessed. A new method and tool for sustainability assessment and consequent improved promotion of solutions that really are more sustainable in terms of the accrued multi-benefits is presented in the SKINT publication "Selling Sustainability in SKINT (SSIS)" (Ashley R.M., Christensson A., De Beer J., Walker L., Moore S. and Saul A. (2012), Selling Sustainability in SKINT (SSIS) – Evaluating the benefits of sustainability [WP4]).

CURRENT APPROACHES TO SUSTAINABILITY

There is a considerable body of research and development work in the field of sustainability, and it is not our intention to reproduce it here. Certainly, there are well-documented, long-established national procedures for economic assessment and cost benefit analysis and there is a growing body of research into the integration of the economic, environmental and social aspects of sustainability. However, because sustainability covers many topics, many of which are not easily quantified, it is difficult to carry out assessments, and also difficult to convey appropriate messages to decision-makers and the public.

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[10] Brown R.R., Ashley R.M., and Farrelly M. (2011), "Political and Professional Agency Entrapment: An Agenda for Urban Water Research", Water Resources Management, Vol. 23, No.4, European Water Resources Association (EWRA) ISSN 0920-4741. DOI 10.1007/s11269-011-9886-y.

[11] Butterworth J. et al (Eds.) (2011), SWITCH in the city, IRC International water and sanitation centre, The Netherlands, ISBN 9798066870789.

[12] S. van Herk., Zevenbergen C., Rijke J., Ashley. R. (2011), "Collaborative research to support transition towards integrating flood risk management in urban development", Journal of Flood Risk Management, Vol. 4, Issue 4, pp. 306–317, December 2011. Article first published online: 11 OCT 2011. DOI: 10.1111/j.1753-318X.2011.01113.

The cases presented in this publication show that there are considerable differences in the definition of sustainability in the first place, dependent on the viewpoint and scope of the professionals and decision-makers. In most cases, and certainly the earlier ones such as Devonshire Park case (UK) and DEX regeneration case (UK), the sustainability of an option is considered in direct comparison with traditional options, and mostly towards environmental aspects. Notably, much consideration of "sustainability" is included in the conversations, narratives and discourses surrounding the finalisation of measures in response to a problem or opportunities (Cettner et al, subm.).[13]

"...the problems caused (…) were not compliant with the emerging legislation (Water Framework Directive). It was clearly not socially or economically acceptable to continue to pollute a major estuary (…) through badly operating combined sewer overflows or diffuse pollution. (…) [This] led to a policy drive to address the problems of diffuse pollution in a more sustainable way" (DEX case).

"The main aim (…) was to alleviate known flooding problems, reducing economic damage (…) and improving the well-being of community members. (…) at no detriment to the local environment, (…) enhancing its value to the community. (…) comparing the impacts of the chosen option with those of the alternatives (…) the chosen option was both socially and economically more sustainable" (Devonshire Park case).

The sustainability of options in these cases is not quantified or monetised, but assessed qualitatively in comparison with traditional options through dialogue and discourse. The success of these projects is very much dependent upon local champions, the clear need to solve an urgent and clearly "non-sustainable" problem, and good stakeholder communication processes.

In the Egmond case (NL), the sustainability of the proposed solutions was visualised in a more systematic and semi-quantified manner, using the triangle People - Planet - Profit. The visualisation was used to show decision-makers that the chosen options are sustainable because they score high on 16 selected aspects or criteria within the People-Planet-Profit triangle.

"The solutions (…) should be sustainable, which is an easy word to use but raises a lot of questions in work-groups. Discussions about the sustainability of the different solutions have their origin in the different interest and ambitions of different stakeholders. To rate the sustainability (…) different categories are rated by 'expert judgement' and visualised in the spider web" (Egmond case).

The fact that the sustainability assessment was performed by "expert judgement" may have biased the results, as not all stakeholders may have been heard or even identified nor do they share the same frames of reference as to what "'sustainability" comprises (e.g. Fraser et al, 2006; Cettner et al, subm.).[14,13] The expert judgement may have overlooked, amongst other things, wider scale benefits or drawbacks. To overcome this, it is essential to define the scale and conceptual boundaries of the assessment beforehand, based on the opinions of a wide group of professionals.

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[13] Cettner A., Ashley R M., Hedströma A., Viklander M. (subm.), "Sustainable development and urban stormwater practice", Urban Water Journal.

[14] Fraser, E.D.G., Dougill, A.J., Mabee, W.E., Reed, M., and McAlpine, P., (2006), "Bottom up and top down: analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management", Journal of environmental management, 78, pp. 114–127.

The Bryggen case (NO) and Heuckenlock cases (GER) illustrate the challenge to traditional ways of assessing sustainability (e.g. Malmqvist et al., 2006)[15] that relate to the required scale and conceptual boundaries to be applied. Cultural heritage and natural resources can be regarded as vulnerable, non-renewable resources. For natural resources, such as nature reserves, European legislation protects these resources and doing so is therefore a commonly accepted consideration in selecting the 'sustainable option". This is illustrated by the Heuckenlock case (GER).

"The designation as a nature reserve and the determinations of the EU Habitats Directive requires sustainable measures with three main goals: to preserve the natural function of the area, to carry out interventions if necessary and to remove and prevent disturbing influences. Sustainability in nature preservation means that measures have to be continuously implemented. (…) The legal status (…) the 'Heuckenlock' is sustainably protected from interference. (…) This is a key factor in achieving the main goal of the nature reserve: keeping the natural dynamics of the area. (…) A key point to ensuring sustainability of measures is the cooperation of stakeholders. The more consensus a measure receives, the more reliable are the implementation and the long-term effect" (Heuckenlock case).

For cultural heritage, different interpretations of the European Convention for Cultural Heritage (Valetta Convention) have led to differentiations in land and water management development. Norway wholeheartedly endorses the principle of cultural heritage protection, and has based its national policy on the Valetta and Faro Conventions. Since 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 one of the foremost tasks, with sustainability as one of the keywords.

"Archaeological deposits were classified (…) as a non-renewable resource, and thereby eligible for sustainable management. (…) The purpose of the Cultural Heritage Act is 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. It is a national responsibility to safeguard these resources and their value (…) as a lasting basis for living and future generations' appreciation, understanding, well-being and development" (Bryggen case).

Finally, the Solar City case (NL) shows a unique example of sustainable energy development, "zero-emission development". The focus here has very much been on energy efficiency and CO_2 neutrality. But this focus has led to many other innovative sustainable developments related to economic, social and even cultural heritage benefits. It is interesting to note that the scale and focus on energy efficiency and the drive to build an economically sound "green" development has produced a creative atmosphere that has led to a much wider range of benefits than simply environmental. The fact that Solar City became a showcase for sustainable urban development has led to other small-scale initiatives, creating multiple benefits. Water has been put at the forefront of the development – not by a particular initiative, but based on the physical necessity to handle water in a proper way when developing a polder below sea level. The development area lies in the lowest part of the polder, giving rise to immediate consequences that have to be dealt with up front, such as ground and surface water quality and pumping.

TOWARDS A COMMON STRATEGY FOR SUSTAINABILITY AND SUSTAINABILITY ASSESSMENT

In the above section, past, current and upcoming approaches to sustainability and sustainability assessments from the selection of transnational cases in this publication have been highlighted. The cases illustrate the fact that the definition of "sustainability" is interpreted slightly differently in all cases, based on alternative frames,[16] and that there is no clear consensus on how it can be attained; rather, it is a journey on which we will learn more about the destination as we go along.[17] There is no clear agreed definition of sustainability; rather there are many definitions, principles, objectives and ideas. Sustainability is a devalued term due to overuse, misuse

and abuse by politicians and others, where everything is now presented as being sustainable or part of sustainable development.

Practitioners in the water and other sectors usually have a vision of sustainability that is both personal and held within their institutional culture and is based on established principles, such as:
(1) Substances from the lithosphere must not systematically increase in the ecosphere;
(2) Substances produced by society must not systematically increase in the ecosphere;
(3) The physical basis for the productivity and diversity of Nature must not be systematically deteriorated;
(4) Fair and efficient use of resources with respect to meeting human needs.

There is also the acceptance that the ”sustainable city” is in fact not an entity that can be defined once and for all, but is considered as “an issue in continuous transformation and evolution”; hence sustainable development is a process or a journey rather than a destination or a defined goal.[17]

Despite the above, it is still a common approach to utilise indicators, criteria and/or attributes to determine whether or not an intervention, option or response to changing infrastructure systems is likely to create more or less sustainability. This is because no better alternative has yet emerged. This approach can be defined as the POCIA method: Principles-Objectives-Criteria-Indicators-Attributes.[18]

In order to compare different options and cases with regards to sustainability, there is a need for a clearer definition of the conceptual boundaries of the visions of sustainability. These boundaries will depend on the context of the application and could include additional groups or additional objectives and criteria. For example, considerations of sustainability issues related to water systems in New Zealand require specific cultural grounding in Maori (e.g. Morgan, 2006).[19] This can also be illustrated by the need to consider western cultural heritage in greater detail in certain applications (see textbox). The inclusion of cultural heritage in sustainability assessment raises challenges to traditional ways of sustainability assessment, particularly considering the required scale and conceptual boundaries to be applied, as illustrated in the Bryggen case and in New Zealand.[19]

To identify and recognise the value of multiple benefits, and use them to subsequently disseminate sustainability thinking and outcomes, a starting point for the appraisal of an option should be to challenge the drivers: are they sufficiently broad and with conceptual boundaries defined as widely as possible? For instance, what are the drivers in relation to society as a whole – better quality environment, dual functional land etc.? Widely set boundaries are needed to fully exploit the multi-value potential, for instance of ecosystem services.[20]

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[15] Malmqvist, P-A., Kärrman, E., and Heinicke, G., eds. (2006), Strategic planning of sustainable urban water management, IWA Publishing, London.
[16] Brugnach, M., Dewulf, A., Pahl-Wostl, C. and Taillieu, T., (2008), Toward a relational concept of uncertainty: about knowing too little, knowing too differently, and accepting not to know [online]. Available from: www.ecologyandsociety.org/vol13/iss2/art30 [Accessed 30 June 2012].
[17] Beck, M B (2011), Cities as Forces for Good in the Environment: Sustainability in the Water Sector, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, Georgia (ISBN: 978-1-61584-248-4).
[18] Ashley R M., Blackwood D., Butler D., Jowitt P., Davies J., Smith H., Gilmour D., Oltean-Dumbrava C. (2008), “Making Asset Investment Decisions For Wastewater Systems That Include Sustainability”, ASCE J Env. Engineering, Vol. 161, no. 3, March 1. DOI: 10.1061/ ASCE 0733-9372 2008 134:3 200.
[19] Morgan T.K.K.P. (2006), “Decision-support tools and the indigenous paradigm. Proceedings of the Institution of Civil Engineers”, Engineering Sustainability 159, December 2006 Issue ES4, pp. 169–177
[20] Everard M. (2011), “Why does good ecological status matter?”, Water and Environment journal. ISSN 1747-6585, pp. 1–10.

A careful definition of the following boundary types is required:

(1) Space boundary: local, neighbourhood, city, catchment, national, Europe, world.

(2) Time boundary: one needs to consider the lifetime of the measures proposed as well as how external factors might change, such as climate change.

(3) Benefits boundary: at the outset of the study the presumed boundaries (usually set by policy makers) need to be reviewed and challenged as necessary to ensure that all potential benefits are included – benefits to society as a whole rather than to a specific "client"

(4) Criteria boundary: in evaluation it is almost impossible to avoid overlaps and double counting of benefits; for example, reductions in flows by using source control Green Infrastructure (GI) benefits flooding, water quality and many other criteria, some of which overlap – less flooding leads to less associated water pollution when the floods drain down. It is not clear yet whether or not such double-counting problems are significant or if they balance out when comparing one option with another.

Boundary definitions: an example

The significance of the definition the conceptual boundary conditions is illustrated by the Bryggen case. On a global and national (spatial) scale, Bryggen has a high cultural heritage value, being a World Heritage Site, but what does it mean for Bryggen to be "sustainable"? When seen within the scale of recent history (< 1000 years), Bryggen also has significant cultural value. However, changing the spatial and time scales changes the significance: at an individual property level (the smallest boundary) the cultural heritage value is probably small, as is the value of Bryggen over millennia. This illustrates that where boundaries are set is crucial; e.g. should the paving be blocks or (older) planks? It is likely that Bryggen really needs to be resilient (continues to function) not "sustainable", but what this means needs to be defined in context and scale.

How best to create and elicit the multifunctional value of the cultural heritage that is embodied in a case like Bryggen? What if Bryggen were a replica? The value may possibly be expressed as an equivalent to a non-renewable resource (cultural deposits). The Bryggen buildings have already survived in the present form for some 300 years. The subsurface archaeological remains survived about 1000 years. It is a very unstable environment, near the sea, but the underground remains are a defined part of the World Heritage Site, and thus valued highly worldwide. The competencies to maintain it were largely lost and in the 1950s and 1960s it was not valued (it was known as the German wharf).

Green infrastructural solutions at Bryggen (SUDS) to restore and maintain the water balance are by themselves regarded as environmentally sustainable, but in this case they also support a greater good, the preservation of an extremely highly valued heritage site. There are alternative technical solutions to green infrastructure to preserve Bryggen, which in the traditional approach would fall into the "less sustainable" category. However, seen from a wide value perspective, the safeguarding of Bryggen still is the most sustainable option for land and water management. If SUDS and other green infrastructure had not been the most cost-effective and best solution for safeguarding Bryggen, other water management solutions could just as well achieve the greater sustainable good: preservation of Bryggen. In other words: if after a multi-criteria analysis it was concluded that the best solution to safeguard Bryggen would be permanent pumping, this would still result in the most sustainable result from a holistic urban planning and heritage management perspective, namely the preservation of Bryggen and its world-wide recognised cultural heritage value.

CONCLUSION

Sustainability has become a devalued term, with everything now being presented as being sustainable or part of sustainable development. Today, a common approach to sustainability assessment is to utilise indicators, criteria and/or attributes to determine whether or not an intervention, option or response to changing infrastructure systems is likely to create more or less sustainability. Improvement in the form of a clearer definition of the conceptual boundaries of the visions of sustainability is needed. Nevertheless, it is still possible to use the concept in discourse in framing options, despite the lack of a commonly shared definition.

To identify and recognise the value of multiple benefits, and use them to subsequently move towards measures that are more sustainable, a starting point for the appraisal of an option should be to challenge the drivers: are they sufficiently broad and with conceptual boundaries defined as widely as possible? Boundaries that are as wide as possible are needed to fully exploit the multi-value potential of ecosystem services. A careful definition of space, time, benefits and criteria boundary types is required.

In order to cope with the dynamic changes in developing urban areas, water needs to take a more prominent role in the urban development and planning process. Changing conditions demand innovative water management solutions, particularly in dense urban areas, and these can only be implemented when water issues are taken into consideration in the early stages of urban planning and holistic development design. Responses to the change drivers will come through urban design, which will require the early engagement of diverse professionals. A wide group of professionals needs to be engaged, many of whom will have little or no formal training in hydrology, hydrogeology, hydrochemistry, hydraulics and water purification processes, or have little awareness of new threats that may occur as a consequence of changing water and land management. A better integration of the land and water management processes requires active dissemination of the multiple benefits and impacts of our decisions to a wide group of professionals.

The perceived high costs of options that are more sustainable play an important role in decision-making and often hinder implementation. Individual so-called “sustainable water management solutions” within a wider spatial or time scale do not per se result in the most sustainable option when the widest possible boundaries and different disciplines are considered, as is illustrated when including cultural heritage within sustainability assessments. The importance of the multiple benefits that will be obtained in different disciplines compared with these “high” costs needs to be shown and better acknowledged.

Multiple benefits can only be fully appreciated if professionals succeed in looking beyond their own disciplines and consider as wide conceptual boundaries in space, time and content as possible. In order to assess and consequently “sell” the benefits and impacts of our decisions we need to take all aspects of sustainability and the specific circumstances relevant to each decision into account.

Drainage Improvements to Facilitate Expansion of Eastern Dunfermline

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INTRODUCTION

This case study investigates the drainage strategy within the development of the eastern area of Dunfermline, a historic town located in eastern Scotland. The development, known as Dunfermline Eastern Expansion (DEX), is located within an area of what was formerly predominantly Greenfield land, comprising some 350 hectares, within which 3500 houses, schools, commercial and industrial areas were to be developed over a ten-year period.

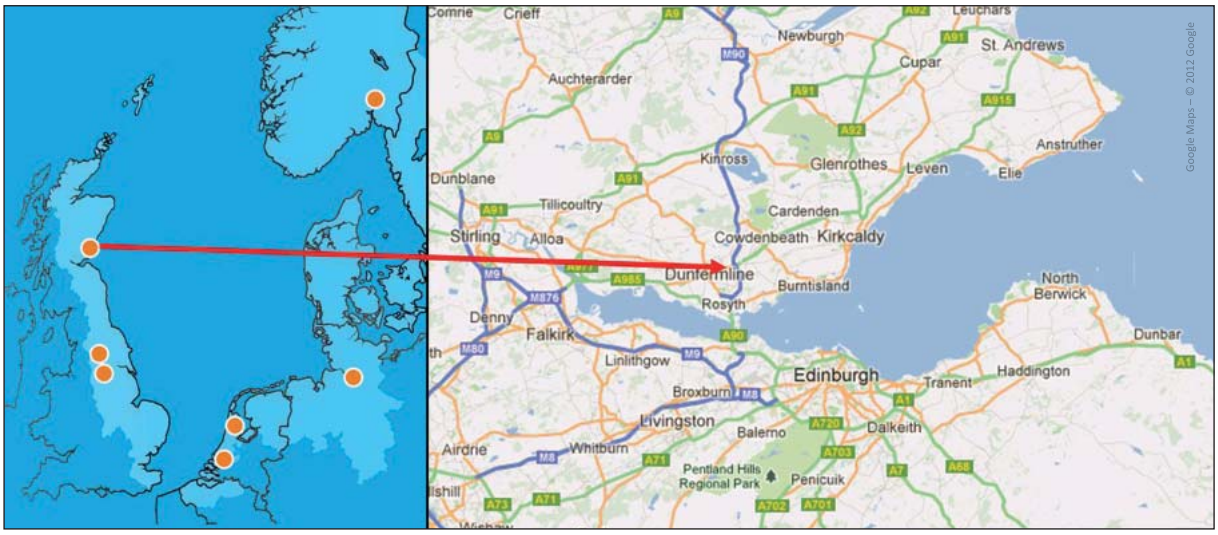

FIGURE 1. NORTH SEA REGION, AND THE DEX DEVELOPMENT, FIFE, SCOTLAND

The development, highlighted within the Local Authority's 1994 development plan for the region, was intended to regenerate the area's economy following the demise of the coalmining and shipbuilding industries as well as catering for an increase in demand for housing as a result of rising house prices in the nearby capital city, Edinburgh.

Concern was raised regarding the drainage of the development area and its impact on the receiving watercourses both in terms of flood risk and water quality.

The site master-planning coincided with the emergence of new "green" technologies for managing surface water drainage in the UK. These were being actively promoted by the Environmental Regulator; the principal driver of this was the imminent Water Framework Directive (2000/60/EC). This new surface water management process would eventually be known as sustainable urban drainage systems (SUDS) within the UK.

MAIN STAKEHOLDERS AND THEIR INVOLVEMENT

Planning consent was granted in 1995 to Wilcon Homes and Alfred Stewart Properties for a development area. A planned total of 3,500 new homes, a leisure park, industrial units, schools, library, and a shopping centre were to be built over 15 years.

FIGURE 2. AERIAL IMAGE OF PART OF THE DEX DEVELOPMENT.

The main decision-making consortium comprised Fife Council (parks and environment, transportation and planning), Fife Enterprise Board (the local development agency) and two statutory bodies: East of Scotland Water (now Scottish Water) and the Scottish Environment Protection Agency (SEPA). These statutory bodies would play a key part in drawing up the drainage master plan for the site.

Technical design was carried out by two local consultants (W.A. Fairhurst & Partners and Ironside Farrar Ltd.) under the expert guidance of Larry Roesner from Camp Dresser McKee, an American consultancy. Meedhurst Project Management (now CEIMA Ltd) was the project manager for the design and construction process for site infrastructure.

Two Scottish academic institutions, the University of Abertay Dundee and the University of Edinburgh, were contracted to carry out condition and performance monitoring of the development. This was required as a condition of the planning consent. Other stakeholders included the local community and wildlife organisations including the World Wildlife Fund (WWF) and the Royal Society for the Protection of Birds (RSPB). All stakeholders and their roles are summarised in Table 1.

Stakeholder	Role				Interest										
					Regulators and interest groups						*Planning bodies*				*Others*
	Decision-maker	Advisor	Developers	Long term ownership	Wild life	Heritage	Environment	Water quality	Water quantity	Local communities	Strategy planners	Development control	Building control	Road/Transport	
Taylor Wimpey Homes	x		x	x						x				x	
Alfred Stewart Properties	x		x							x				x	
Fife Council	x			x		x			x	x	x	x	x	x	
Scottish Enterprise		x									x				
Scottish Water															
Scottish Environment Protection Agency (SEPA)		x					x	x	x						
Fairhurst and partners		x					x	x	x		x			x	
Ironside Farrar		x					x	x	x						
Camp Dresser McKee		x					x	x	x						
CEIMA Ltd		x		x											
University of Abertay Dundee		x					x	x	x	x					
University of Edinburgh		x			x		x	x	x	x					
Local community		x			x	x	x	x	x	x				x	
World Wildlife Fund (WWF)		x			x		x	x							

TABLE 1. STAKEHOLDERS AND THEIR ROLES

WATER MANAGEMENT PROCEDURES

In the mid-1990s the Forth River Purification Board (FRPB, now SEPA) actively promoted surface water BMPs as an alternative to traditional drainage methods. This change in approach was predominantly driven by a realisation that a change in drainage paradigm was needed to address chronic long-term downgrading of receiving water bodies.

In 1994 a review of river water qualities within the Forth catchment was published by the FRPB. This report identified that diffuse pollution from storm water runoff was responsible for 22% of degradation to classified watercourses. Amongst the recommendations of this report, which coincided with the master planning of DEX, was that "Best management practice must be adopted, comprising source control and treatment".[21]

[21] Forth River Purification Board (1994), A Clear Future for Our Waters, FRPB, Edinburgh.

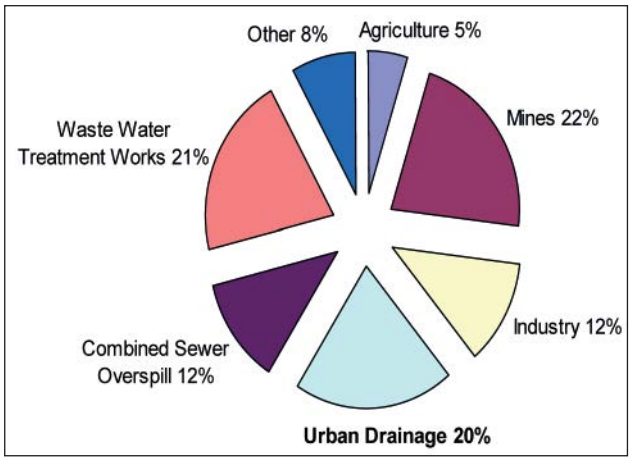

FIGURE 3. CAUSES OF LOW WATER QUALITY IN SCOTLAND (FRPB 1994)

This heralded a change in thinking for drainage design in Scotland. DEX became the first major development where BMPs (SUDS) were stipulated within planning consents.

MAIN PROBLEMS RELATED TO THE INTEGRATION OF LAND AND WATER MANAGEMENT

The DEX catchment included a number of small rivers that already received runoff from built-up areas, industry, motorways and arterial roads. Downstream watercourses were already heavily modified with existing flooding problems which would be exacerbated by further large scale development. The rivers were also nutrient-rich due to intense upstream agricultural farming practices, as was the Forth Estuary to which the watercourses all drained.

In addition to the issue of water quality and flood risk, other problems that would have to be overcome to gain approval for the development included:

- There were no statutory design criteria for retention and treatment structures;
- There were no agreements as to who would pay construction and maintenance costs;
- There were also unexpected problems, such as political issues and the media regarding safety of the ponds and basins which fill with water during higher return storms;
- One pond was close to existing housing and was not welcomed by the local residents;
- Some of the developers did not want to allocate enough land area for the SUDS features.

WATER MANAGEMENT SOLUTIONS

SELECTED SOLUTIONS

Master planning of the drainage design at DEX challenged the norm. In previous developments, areas were drained by piping runoff via a surface water sewer to the nearest watercourse. However, due to the existing poor water quality of the local rivers and subsequent risk of flooding this was not acceptable. Another option was to pipe surface water directly to the Firth of Forth, a large estuary with a high dilution factor. However, the cost of such an option was prohibitive due the distance involved. This solution was also not acceptable because it removed water from local streams.

Alternative surface water management techniques were being used in other countries, particularly the USA, using above ground, predominantly soft engineered drainage structures. These techniques were referred to as best management practices (BMPs) but would later become commonly known as sustainable urban drainage systems (SUDS) within the UK.

INTEGRATION OF WATER MANAGEMENT SOLUTIONS IN THE PLANNING PROCESS

Stakeholder consultation was a critical part of the implementation process, with more than 40 different people and organisations involved including: statutory bodies, consultants, private developers, landscape architects, NGOs and the public. SUDS were an almost unheard-of concept within the UK and education would play an important part in breaking down barriers within the various stakeholder groups.

A series of workshops was organised over a period of six months to promote the SUDS approach, how they function and how they can integrate and benefit communities. Since SUDS were an imported technology and the process driven by an American consultant, one of the first tasks of these workshops was to agree on the definitions and technical terminology to be used, translating terms used in US English to UK English. For example, in the US the area contributing surface water runoff to a drainage system or watercourse is referred to as the watershed, whereas in the UK it is known as the catchment.

Other decisions made in these workshops included items such as determination of catchment areas, derivation of (local) pre-development runoff rates, acceptable forward flow rates and volume from the new (developed) catchments, impervious areas, return storms, practicality of porous surfaces, treatment volume calculations, design criteria for each SUDS technique, etc. An interim output from the consortium workshops was the development of a "rule book" for the drainage design.

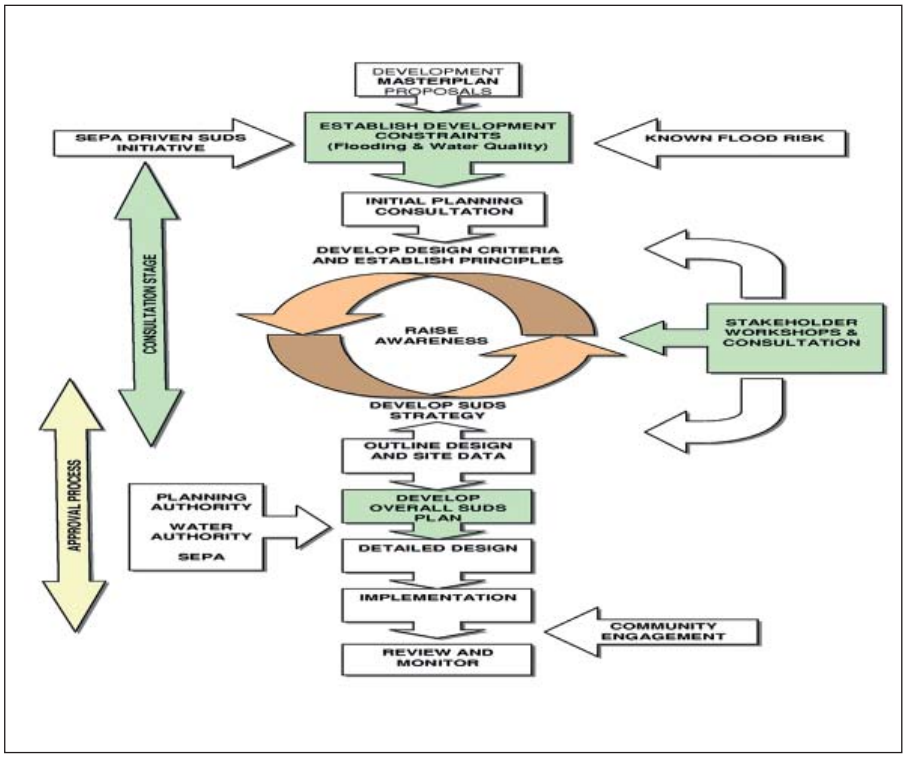

FIGURE 4. IMPLEMENTATION OF THE DEX PROCESS (SOURCE: W.A. FAIRHURST & PARTNERS).

The location of the SUDS within each catchment was carefully considered so that they would provide attractive features, integrating within public open space (both parkland and residential areas). SUDS were designed so that they could be accessed and enjoyed by local residents. Where SUDS, particularly ponds, were located in close proximity to housing they were designed so that they were overlooked by houses or public roadways, so that anyone in difficulty could be easily seen (Figure 4).

Local media and politicians were initially concerned over the risk of children drowning within the proposed ponds and criticised the drainage design. The perceived level of risk was raised by negative publicity, ignoring common sense, in contrast to examples of similar schemes or water features used in other parts of the UK and the world at the time.

Subsequently, a safety audit of the design was agreed with local planning officials. Recommendations included encouraging local schools to use the SUDS areas for practical "show and tell" classes and specifying dense low lying vegetation to deter access to permanent water SUDS. However, despite these measures, there was still much concern over safety voiced by local Councillors. As a result, Fife Council insisted that 1m high metal fences be erected around the SUDS to prevent access by young children but be low enough in height to allow an adult to gain access in the case of an emergency.

The most contentious item of the process was not in fact safety, but cost, in particular where the balance would lie between involved parties. The question of who should pay for the design, construction and aftercare of the scheme presented a significant challenge and one that to date is not fully resolved.

An initial agreement was reached whereby East of Scotland Water would adopt all underground drainage and Fife Council would adopt all above ground drainage, with the developer contributing to the overall cost. Under the Roads (Scotland) Act 1984, Fife Council as the Roads Authority was responsible for maintenance of road drainage (pipes or above ground structures). Similarly, under the Sewerage (Scotland) Act 1968, there was an obligation for East of Scotland Water (now Scottish Water) to finance in part or total the surface water and foul drainage from the site within reasonable costs.

FIGURE 5. CASCADE BASIN AND HALBEATH POND – BOTH OVERLOOKED BY RESIDENTIAL HOUSING.

The consultation process for did not fully address the question of cost, ownership and ongoing responsibilities. The lead developer had agreed to provide land for the SUDS and to finance the initial implementation costs and did not think that any further contribution (commuted sum) was necessary. The developer was also of the opinion that as the SUDS drained different areas of responsibility (i.e. road, residential and commercial areas) it was reasonable to expect that the public bodies should be responsible for future maintenance. Legal arguments ensued, the outcome of which has not been fully resolved to date.

Fife Council has adopted road drainage for the site, and two SUDS: a wetland and the landscaping area of one pond. Both adopted structures have public obligations in that the wetland is the central attraction of a district park and the pond was implemented at a location where council owned homes already existed. Developers either continue to maintain the SUDS within their ownership or contract the work to factoring agents. There

are also a small number of SUDS (and surrounding public open space) which have been legally transferred to private owner-maintainers within the site.

FIGURE 6. HALBEATH POND; LOCATED WITHIN A LOCAL AUTHORITY HOUSING AREA AND CONSEQUENTLY MAINTAINED BY FIFE COUNCIL

Knowledge gained from DEX has since informed changes in ownership and maintenance responsibilities within Scotland. This, together with legislative changes and the amendment to the legal definition of sewer to include SUDS now means that there is an obligation for Scottish Water to adopt SUDS. As of November 2007 Scottish Water will adopt SUDS which are designed in accordance to the new technical standard Sewers for Scotland 2nd Edition.

DIFFICULTIES AND HOW THEY WERE OVERCOME

In a number of locations, local residents have taken "ownership" of the SUDS, and one detention basin is maintained like a garden by people living in the adjacent houses. This shows that barriers to social acceptance can be overcome with careful consideration of design and planting specifications.

It is still an ongoing question who should be responsible for owning and maintaining SUDS in Scotland. Scottish Water will now adopt a range of SUDS if designed in accordance to the revised technical standard, but is only responsible for in-curtilage drainage, i.e. water from within the property boundary, and not road drainage which is the responsibility of the Local Authority.

To overcome the potential problem of separate drainage systems (to drain different areas) within new developments there has been an amendment to the Sewerage Scotland Act (1968), referred to as a Section 7 Agreement. This agreement "makes provision for Scottish Water to enter into agreement with the Roads Authority to allow the use of their sewers for the conveyance of water from the surface of a road or to allow the use of road drains for the conveyance of surface water from premises".[22]

KEY SUCCESS FACTORS

The drainage master planning at DEX was achieved through a flexible and pragmatic approach. Cooperation between, and education of, the statutory bodies, authorities and the developers was key to the success of the holistic approach to sustainable urban drainage. Early consideration of SUDS in the master plan was also crucial to the success of the strategy.

SUSTAINABILITY ASSESSMENT

At the time the drainage issues of DEX were first considered (about 1992), the extent to which SUDS were sustainable was not known. However, what was certain was that the problems caused by inadequate urban drainage systems were not compliant with the emerging legislation (Water Framework Directive). It was clearly not socially or economically acceptable to continue to pollute a major estuary (Firth of Forth) which supports a salmonid fishery and contact-based water sports through badly operating combined sewer overflows or diffuse pollution. The FRPB report (1994) led to a policy drive to address the problems of diffuse pollution in a more sustainable way.

Rather than focusing merely on drainage issues, DEX was seen as being a showcase to encourage greater sustainability in a wide range of construction and development activities. There was much debate about whether SUDS were actually sustainable or just how much "more sustainable" they would be, but there was little evidence at the time to answer the question. It was decided to use DEX as a large scale test site which would be intensively monitored by a range of universities to try to establish the extent to which the new drainage systems were sustainable. In this way, the full range of sustainability issues – environment, economy, responsibility, social value – could be evaluated in the long term. Knowledge gained from the design and implementation, and importantly from the post-project monitoring, has informed legislation and current best practice for SUDS within the UK.

DISCUSSION AND CONCLUSIONS

Although DEX is by no means perfect, it is accepted as a success dating back to a time when there were no precedents. This showcase development set a standard for drainage master planning on a large scale in Scotland and the rest of the UK. Design philosophy has progressed since the implementation of DEX, and some of the structures implemented are now not considered best practice. However, the SUDS designed and implemented at DEX, and subsequent monitoring of their operation and performance, have informed what we now consider best practice.

An example of this is the concept of treatment volume and method of volume calculations for ponds, which were derived during the workshop process. The treatment volume (the permanent pond volume) is a function of local hydrological characteristics, soil type and the level of impermeability of the catchment.[23] Ponds were initially designed to a treatment volume of 4Vt to ensure adequate treatment of runoff. However, subsequent studies have shown that residential catchments are generally considered low risk (for nutrient and contaminants) and a treatment volume multiple of one (1Vt) is acceptable. This change in hydraulic design is replicated in the new Scottish Water technical standard which stipulates 1Vt ponds.

Other large-scale developments in the UK have built upon the success of the DEX example. These include:

- Edinburgh South East Wedge development, Scotland.
- Ravenscraig re-development in Lanarkshire, Scotland.
- Waterlooville development in Hampshire, England.

All of these developments would have been seriously constrained without the use of SUDS drainage to achieve both water quality and flood attenuation criteria.

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[22] SUDS Scottish Working Party (2010), SUDS for Roads [online]. Available from: http://scots.sharepoint.apptix.net/suds/General%20Publications/Forms/AllItems.aspx

[23] Woods-Ballard, B. et al. (2007), The SUDS Manual, C697, CIRIA, London.

The Water That Buoys Up Bryggen in Bergen, Norway

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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.

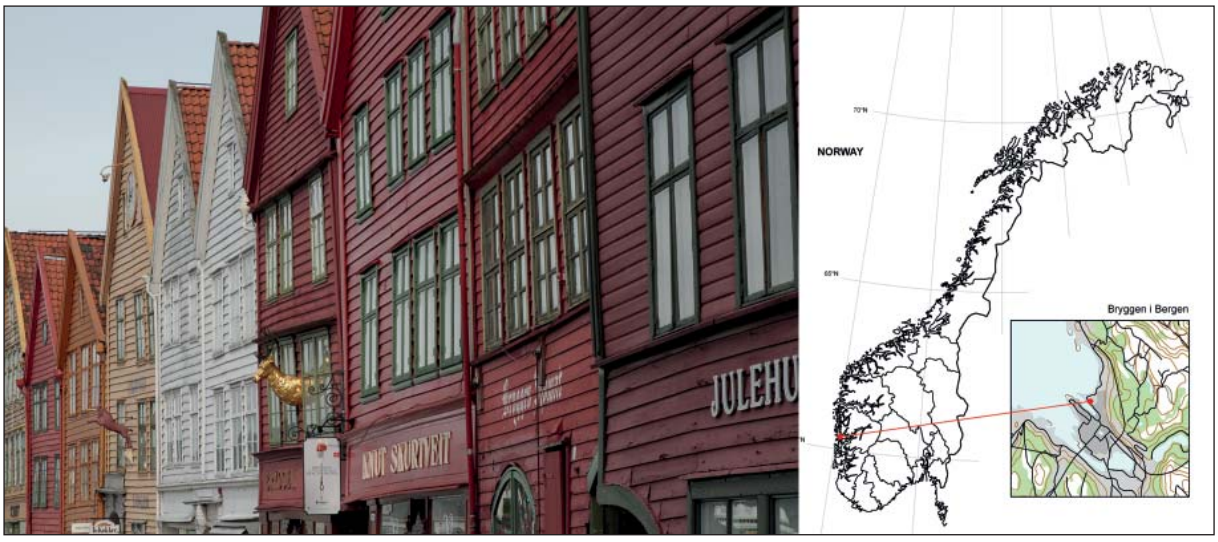

FIGURE 1. BUILDINGS AND LOCATION OF BRYGGEN IN BERGEN, NORWAY (SOURCE: E. ROTEVATN, RIKSANTIKVAREN)

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).

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 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

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										
					Regulators and interest groups						Planning bodies				Others
	Decision-maker	Advisor	Developers	Long term ownership	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

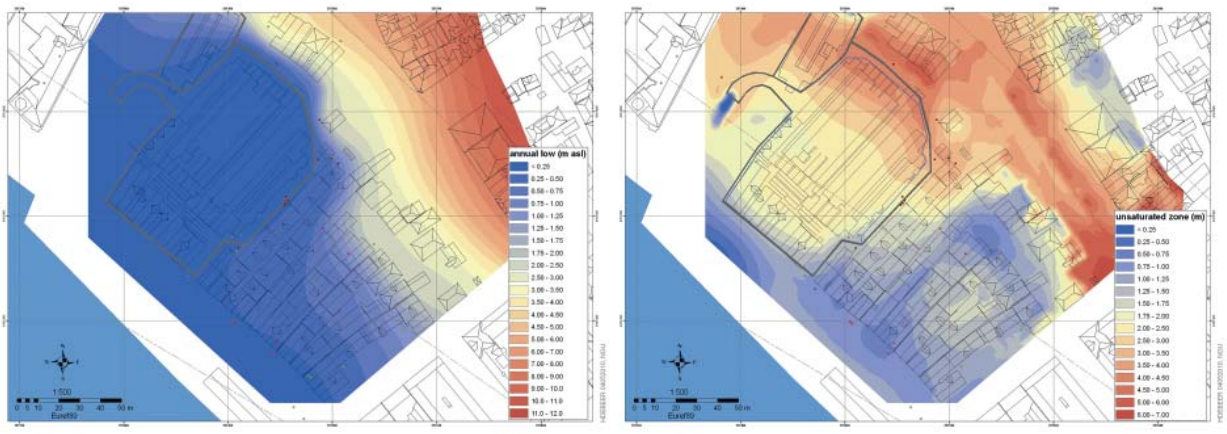

FIGURE 3. GROUNDWATER LEVELS AND THICKNESS OF THE UNSATURATED ZONE (SOURCE: NGU)

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 m^3 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.

Heuckenlock Nature Reserve – a Hamburg Case Study

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INTRODUCTION

The Heuckenlock nature reserve, situated within the city state of Hamburg in northern Germany, is an exemplary case-study area due to its specific location in the floodplain of the Elbe, which offers various points of reference for nature and water protection and exposure to the most diverse interest groups. The case study will focus on the ecological features of the nature reserve, its role as a recreational area, the statutory conditions governing its status and conflicts of interest and use.

With a length of more than 1,094 km, the River Elbe is the fourteenth longest river in Europe. It rises in the Czech Republic, flows in a north-westerly direction through Germany and finally into the North Sea. The Heuckenlock area in northern Germany, which is the subject of this case study, has an area of 120 ha and is located close to the end of the river. It lies in a particular section of the Elbe valley known as the "Stromspaltungsgebiet" (area where the river splits). With the post-glacial rise of the sea level and the resulting tidal backwater, a large tidal floodplain landscape emerged, of which the Heuckenlock is now the main remaining section. The name "Heuckenlock" means "tideway of the Heucke", Heucke being the name of a family which is still one of the landowners in the nature reserve.

FIGURE 1: THE NATURE RESERVE HEUCKENLOCK FROM A BIRD'S EYE VIEW (© GÖP E.V.).

The nature reserve is situated on the Elbe undercut slope and is an area with a high level of natural vitality and constantly changing vegetation. Since the river gorge on the undercut bank is close to the bank of the river, there is a lack of shallow water areas upstream. The area is nowadays flooded up to a height of 3.5 m as many as a hundred times a year (the highest storm surge occurred in 1976). The mean tidal range (difference between the mean high and low tides) of the Elbe is today approximately 3.3 m. The nature reserve is located in the lee of the Harburg hills to the south, which rise to an altitude of 155 m. It extends for three kilometres along the bank of the Southern Elbe and has a width of up to 400 m (Figure 1).

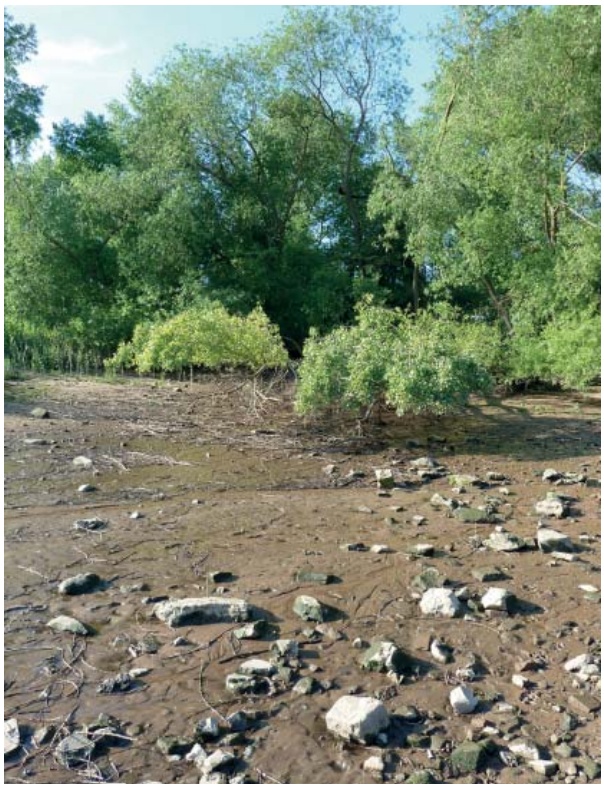
The driver for developing the nature reserve is to maintain its natural vitality and to restore disturbed sections.

BACKGROUND

FLOODING POTENTIAL

The Heuckenlock is a freshwater tidal area with remnants of an alluvial forest and exhibits a characteristic variety of terrain (Figures 2 and 3): areas of water (tideway), freshwater mud flats which dry out at low tide, reed beds, shrub land, the softwood floodplain comprising above all willows and poplars, and the remains of the hardwood floodplain with ash, oak and elm trees, including an old white elm with a trunk circumference of almost 4.5 m. Apart from the young roots of hybrid poplar trees, there are very few young trees, and hardly any hardwood varieties.

The frequency of flooding and the soil structure are the decisive locational factors for vegetation. The area is rich in mud, while the preponderance of sand deposits increases towards the river, partly in the form of an extensive sand embankment on which primarily the alluvial forest grows. The value of nature protection is particularly high in the middle section, while the eastern section and areas around the former castle offer less variety of relief.



FIGURES 2 AND 3: FRESHWATER TIDAL AREA WITH REMNANTS OF AN ALLUVIAL FOREST (© HAW HAMBURG).

VEGETATION

The shrubbery (containing willow species, hawthorn, guelder rose and spindle trees, including one example estimated to be 300 years old) and weed beds exhibit a high diversity. The richness of nutrients due to flooding gives rise to almost impenetrable primeval-forest-like vegetation and a unique landscape. The shrub land and reed beds are partly characterised by overgrowth, with reed heights of four to five metres. The marsh marigolds are also extremely overgrown. The lush vegetation creates a clearly measurable filtering effect on the water of the Elbe as it flows in and, six hours later, out of the area. Such pre-embankment areas are an important pillar of the river's self-cleaning power.

BIODIVERSITY

The area exhibits considerable biodiversity. 700 plant species have been identified in the past, but changes in the area mean that the number is probably much lower nowadays. The difficulty of surveying the area, the frequent natural reshaping of the terrain and the introduction of seeds by the Elbe and shipping make it virtually impossible to obtain a precise listing.

FIGURE 4: THE WATER DROPWORT ONLY GROWS IN THE FRESHWATER TIDAL AREA OF THE ELBE AND IS A HIGHLY ENDANGERED SPECIES (© GÖP E.V.).

Flora

The plant species include the following: Elbe hair grass and Elbe water dropwort (Figure 4), which only occur in the freshwater tidal area of the Elbe, wheat sedge, which only grows at this location in Germany, and species at the edge of their natural range of distribution. Plant species of eastern origin have also settled here, such as the long-leaf speedwell and black poplar. Rare or eye-catching species include broad-leaved ragwort, danewort, butterbur, common fleabane, various allium species, calamus, purple loosestrife, bistort, other sedge and scipus species, flowering rushes and snake's head fritillary, whose decline can only be warded off by their being cut back to prevent overgrowth and disappearance. The Elbe water dropwort is found in its greatest numbers in the Heuckenlock. A project by the Botanical Association, which has received financing from the Federal Ministry of the Environment for a period of five years, is concerned with the chances of survival and propagation of these plants along the Elbe in Hamburg. A new embankment has been constructed in Overhaken (Vierlande).

FIGURE 5: THE PENDULINE TIT AND ITS HANGING NEST (© GÖP E.V.).

Fauna

Due to the frequent flooding, there are only a few ground-nesting birds in the nature reserve. Tree/reed-nesting birds predominate. Breeding birds include the penduline tit (Figure 5) with its distinctive hanging nest, the nightingale, the long-eared owl, the lesser spotted woodpecker, the great reed warbler and the reed bunting. Large bird colonies of grey heron and cormorant can no longer be found in the alluvial forest; these birds only come to the nature reserve to feed and rest. The area does serve as a roost during bird migration: as many as 20,000 barn swallows and 42,000 starlings have been counted. If north-westerly winds are strong, up to 20 other seabird species appear along the Elbe in Hamburg.

The tideways in the nature reserve offer a good calm-water refuge for Elbe fish, but can also be a death trap if water levels are extremely low.

NATURAL VITALITY OF THE RIVER ELBE

The development of vegetation is essentially dependent on the area's natural vitality. There is no forest use, and only at two places has an attempt been made to push back cultivated poplar. Deadwood is removed from the nature reserve only if it threatens embankments. To maintain stocks of snake's head fritillary in particular, three areas are cut back at least once a year. Willow trees are regularly cut in the area of the footpath by the River and Port Development Office (known since 2005 as the Hamburg Port Authority) and, in the western section of the nature reserve, by the Society for Ecological Planning (GÖP), an association concerned with nature conservation. There has been little planting in recent decades: willow cuttings have been planted, mainly close to the embankment, by the River and Port Development Office, a few hawthorn bushes by the hunting leaseholder and a group of oaks and white elm trees at the former castle by the association which looks after it.

Surrounding the nature reserve are a number of smaller dike forelands with freshwater tidal habitats, giving rise to the possibility of cross-linking with other areas along the river, although these are potentially open to development. The Society for Ecological Planning has produced a catalogue of measures for biotope improvement in these areas.

Inside the embankment, the Society for Ecological Planning, Friends of the Earth Germany (BUND) and the Foundation for Nature Protection have attempted to establish better linkage by restoring and rehabilitating small biotopes. However, intensive market gardening and the lowering of trench water levels have had a negative impact on the natural diversity of species there.

MAIN STAKEHOLDERS AND THEIR INVOLVEMENT

AUTHORITIES

Hamburg City, Authority of Urban Development and Environment (BSU)

In Hamburg the governmental nature preservation is executed by the Authority of Urban Development and Environment (BSU). Hamburg is divided into seven districts, each with its own district authority that is responsible for local nature preservation. The BSU is responsible for defining areas as legal nature reserves. Specific measures for each reserve are defined within various individual plans, the so-called PEP plans ("Pflege- und Entwicklungsmaßnahmen", care and development measures). The district authorities carry out the PEP in cooperation with local partners. Currently the BSU is finalising a special management planning for the Tideelbe region called IBP ("Integrierter Bewirtschaftungsplan Elbe-Ästuar", Integrated Management Plan Elbe-Estuary).

It includes very specific measures to save different sorts of habitats in the entire Tideelbe region, according to Article 6 of the EU Habitat Directive. All plans are focused on communication and cooperation between different stakeholders: the neighbouring states of Niedersachsen and Schleswig-Holstein, various associations for nature protection, other authorities such as HPA and residents and companies that operate in shore areas. The IBP is accompanied by a funding programme from the Federal Ministry of the Environment (BMU) to ensure that the measures can be financed.

Harburg District Authority ("Bezirksamt")

Harburg is a district in the south of Hamburg. Until 2008, the Hamburg-Harburg District Authority was responsible for the Heuckenlock nature reserve. In that year responsibility was transferred to the Hamburg Central District Authority, due to a reform of the administrative organisation. Nevertheless, Hamburg-Harburg

still co-operates in the administration of Heuckenlock as the district authority is responsible for the neighbouring Schweensand nature reserve. Both nature reserves are managed by the Society for Ecological Planning (GÖP e.V.).

Hamburg Central District Authority
Hamburg Central District Authority is responsible for the Heuckenlock nature reserve. The district authority executes measures defined in the local PEP in cooperation with its main local partner for the Heuckenlock nature reserve, the Society for Ecological Planning (GÖP e.V.). The PEP includes general instructions. Most of the smaller measures do not change from year to year. To ensure that measures also match the changing situations, regular meetings take place in order to devise an up-to-date plan. In case extended measures are necessary, other stakeholders are also invited to join the meetings, for example the Authority of Urban Development and Environment of the City of Hamburg (BSU) and Hamburg Port Authority (HPA).

River and Port Development Office (known since 2005 as the Hamburg Port Authority)
The Hamburg Port Authority (HPA) was established in October 2005 during the merging of the port-related activities of various Hamburg authorities. The HPA is the central contact partner for all inquiries related to infrastructure, navigational and operational safety and port security, property management and economic conditions in the port.

The essential aim of the HPA is to develop the port of Hamburg for economical purposes. However, there is also awareness that this development can only be sustainable if it takes the natural dynamics of the Tideelbe into consideration. Further planning, therefore, takes a more integrated and sustainable approach which also considers the interests of the various stakeholders.

In 2006, HPA published the Tideelbe Concept. The main goal is to harmonise ecological and economic demands within this area. The measures planned to secure the Elbe for economical use are aligned as far as possible with current guidelines for nature conservation. Measures for a better flood protection are also detailed. HPA is a cooperation partner for the Heukenlock, as described above. HPA also assists the work of GÖP e.V. by executing small measures such as regularly cutting willow trees within the area of the footpaths.

ASSOCIATIONS FOR NATURE PRESERVATION/NGOS

The Society for Ecological Planning (GÖP e.V.)
The Society for Ecological Planning (GÖP e.V.) handles various nature reserves in Hamburg, in the context of care contracts with the Authority of Urban Development and Environment (BSU) and the district authorities. Therefore GÖP executes a wide range of measures which are defined in official plans, so-called PEP plans (“Pflege- und Entwicklungsmaßnahmen”, care and development measures). GÖP also provides detailed reports on the situation of habitats and offers recommendations for measures to the local authorities. GÖP is a member of the Community for Nature Protection (Arbeitsgemeinschaft Naturschutz), a union of several established associations. This community reviews and comments on current federal plans which may have a significant effect on nature in Hamburg.

Currently, the development and conservation of the Hamburger Elbauen is one of their largest projects. GÖP therefore runs a public information centre at Bunthäuser Spitze in Hamburg-Wilhelmsburg including information and education services. It also supports cooperation and dialogue between the stakeholders.

As described above, GÖP executes measures in Heuckenlock according to the PEP and in close cooperation with the Hamburg-Harburg District Authority. There is also a close cooperation and exchange of practical experience with other associations for nature protection on an informal level. Inside the Heuckenlock embankment, the

Society for Ecological Planning, Friends of the Earth Germany (BUND) and the Foundation for Nature Protection (NABU) have attempted to establish better links by restoring and rehabilitating small biotopes. These biotopes are not officially part of the nature reserve but nevertheless worth saving.

Friends of the Earth Germany (BUND)
Friends of the Earth Germany (BUND) is a non-profit non-governmental organisation (NGO) that handles its own project on nature preservation for the river Elbe. The goal is to restore flood areas and habitats for flora and fauna and improve the water quality of the Elbe. BUND is not formally handling the Heuckenlock; however, it takes part in cooperation and exchange with the different associations to support the parent goal of nature preservation.

Foundation for Nature Protection (NABU)
The Foundation for Nature Protection (NABU) is a non-profit NGO which handles several nature reserves along the Tideelbe, for example Mühlenberger Loch/Neßsand and Elbinsel Pagensand. The goal is to conserve rare habitats for flora and fauna. NABU is also committed to preventing further deepening of the Elbe shipping channel. NABU is not formally handling the Heuckenlock; however, it also co-operates with the different associations to support the parent goal of nature preservation.

Botanical Association Hamburg (Botanischer Verein zu Hamburg e.V.)
The Botanical Association is a non-profit NGO that handles various natural monuments and nature reserves in Hamburg. Members of the Botanical Association Hamburg also support the work of GÖP in an informal way, as partners and counsellors, especially in matters of the endangered Elbe water dropwort species. The Botanical Association has received financing from the Federal Ministry of the Environment.

The greatest numbers of Elbe water dropworts are found in the Heuckenlock and are classified as a priority species in the EU Habitats Directive. Therefore, a testing and development project (E+E-Vorhaben/Erprobungs- und Entwicklungsvorhaben) was run from 2000 to 2004. The aim of the project was to develop appropriate measures for the settlement of the Elbe water dropwort. The results support the aim to sustainably establish and maintain the Elbe water dropwort in this area as set in the EU Habitats Directive.

OTHER NATURE RESERVES

Schweenssand nature reserve
Schweensand is a nature reserve neighbouring Heuckenlock. It is protected by a separate municipal decree. It is under the responsibility of Hamburg-Harburg District Authority and is also handled by the Society for Ecological Planning (GÖP e.V.).

PARENT ORGANISATIONS

UNESCO
UNESCO biosphere reserves are model regions for sustainable development. They strike a balance between the interests of environmental protection and of social and economic development. Biosphere reserves are proposed by member states, and are designated and regulated on the basis of national legislation.

Territories must be characteristic of important ecosystems and specific landscapes. Biosphere reserves must combine nature conservation with the promotion of sustainable social and economic modes of utilisation of natural resources. As model regions they are outdoor laboratories for testing innovative methods which harmonise preservation and utilisation. Biosphere reserves are the only category of “protected areas” set up according to globally consistent criteria by an intergovernmental organisation.

In 1979 the Elbe River Landscape was designated a biosphere reserve (extended in 1997). The designation broadly strengthens the existing legal guidelines (EU Habitats Directive and nature reserve) and validates the importance of nature protection in this region.

CITIZENS

Citizens/residents

All described plans and concepts are always open to dialogue between stakeholders and the public. Information about current measures is provided on the web (for example the special HPA website www.tideelbe.de) and particularly at the public information centre at Bunthäuser Spitze in Hamburg-Wilhelmsburg, run by GÖP. Where comprehensive measures are planned, the public is regularly informed by the media. This approach has already led to a much better appreciation amongst the public for environmental measures, for example amongst neighbouring farmers, who might naturally be sceptical of these issues. The Heuckenlock is located in a reasonably remote area, so that measures generally do not directly affect citizens. The main stakeholders and their roles are summarised in Table 1.

Stakeholder	Role				Interest										
					Regulators and interest groups						Planning bodies				Others
	Decision-maker	Advisor	Developers	Long term ownership	Wild life	Heritage	Environment	Water quality	Water quantity	Local communities	Strategy planners	Development control	Building control	Road/Transport	
Main Stakeholders:															
Authority of Urban Development and Environment (Hamburg City, BSU)	x			x	x	x	x	x	x	x	x	x			
Hamburg-Central District Authority	x									x	x	x			
Hamburg Port Authority (HPA)	x		x					x	x	x	x	x			
Society for Ecological Planning (GÖP e.V.)	x	x			x		x	x	x		x	x			
Other Stakeholders:															
Hamburg-Harburg District Authority		x								x					
Friends of the Earth Germany (BUND)		x			x		x	x	x						
Foundation for Nature Protection (NABU)		x			x		x	x	x						
Botanical Association		x			x		x	x	x						
Schweenssand Nature Reserve		x			x		x	x	x						
UNESCO		x			x	x	x	x	x						
Citizens															x

TABLE 1. MOST IMPORTANT STAKEHOLDERS LINKED TO HEUCKENLOCK

MAIN PROBLEMS RELATED TO THE INTEGRATION OF LAND AND WATER MANAGEMENT

Conflicts of interest and use arise wherever nature protection, economic use and citizens, as both residents and users, come into contact with each other. Some of the main aspects relating to the use of the site are described below:

Economic use

The alluvial areas were extensively exploited in the Middle Ages, and there was agricultural activity in what is now the nature reserve, such as cutting and grazing, timber harvesting, fruit growing, reed cutting, tree cutting to obtain willow rods and, after 1945, market gardening. All such use was suspended at the beginning of the 1970s because of the difficult terrain and frequent flooding.

Bank stabilisation

The river bank has been largely stabilised with a stone edge. If this were to disintegrate as a result of the present-day flow velocity and water level, this would lead to rapid floodplain loss.

Extension of navigation channels and embankment construction

The extension of navigation channels and embankment construction have permanently changed the frequency and height of flooding and thus impacted on the microclimate and vegetation.

Transport infrastructure

The present-day nature reserve was split in two by the construction of the motorway back in 1939.The area east of the motorway suffered the most damage, with a tideway being filled in. After 1945, the hardwood trees were felled to be supplied as reparations to Great Britain, and they were later replaced with fast-growing balsam poplar trees.

Changes to the water level

However, the greatest problems for the nature reserve result from water-level changes caused by the deepening of the Elbe shipping channel, the closing of barriers on Elbe tributaries due to storm surges and the construction of embankments closing off former tidal areas. While the tidal range at the Bunthäuser Spitze was indicated as being 2.21 m in 1959, it had risen to 3.22 m by 1989. Further deepening of the shipping channel from 13.50 m to 14–15 m will again affect water levels and would inevitably impact the vegetation.

WATER MANAGEMENT SOLUTIONS

SELECTED SOLUTIONS

The main aim in developing the nature reserve is to maintain its natural vitality and to restore disturbed sections. A number of water management solutions have been applied, such as lowering the bank revetment at a number of additional points in order to encourage the formation of further inlets and natural and diverse river banks. There had previously been four 8–15 metre-wide openings behind which troughs formed. However, the erosive force at the undercut bank of the river is so high that, over long stretches away from inlets, the bank reinforcement can be lowered but not completely dismantled.

In order to restore the flow diversion, the Heuckenlock tideway has been extended and is again connected to the Elbe on both sides, which might reduce silting in the tideway.

In order to maintain a minimum water level for fish in the main tideway, remains of old bank reinforcements have been removed and deep-water drums have been dredged at a depth of 1.5–2 m.

Higher flooding has made it necessary in recent decades to raise the level of embankments and strengthen them. Considerable encroachment occurred in 1965 as a result of the embankment being moved inland, and the most recent raising and widening of the embankment in the 1990s took up further land in the nature reserve. It was initially agreed between the environmental and building authorities to leave out the section of the embankment situated in the nature reserve in order to examine further the possibility of shifting it towards the river so as to reduce floodplain encroachment to a minimum. However, shortly after, the turf was removed over the full length of the embankment on the nature reserve, and it was only after the environmental authorities intervened that the works in question were suspended. In view of the fait accompli and the fact that the embankment had to be finished by the autumn in order for it to perform its protective function, it was agreed to continue the works. Nevertheless, a steeper embankment with a paved exterior was built in the Heuckenlock in order to protect the floodplain. Although embankment construction was not subject to compensation measures under the (legally contested) Hamburg Nature Protection Act, the authorities agreed to act in accordance with the impact rules for the purposes of the €180 million programme to raise the Elbe embankment. The replacement of embankments planned as a substitute measure at other locations was only partially implemented, primarily because of legal problems, which meant that there was a deficit of compensation measures.

Other problems for the nature reserve are the water quality of the Elbe, which is still not optimal, and the large-scale washing-up of refuse with the tide, which gets caught in the lush vegetation and accumulates. Recreational activities are limited in the nature reserve because the area is not accessible beyond a footpath that has been built. At the end of 2003 a new bridge was inaugurated over the tideway, which means that the circular route can again be walked. The lush flora in the freshwater tidal area offers the possibility of nature watching.

The water bodies in the nature reserve are closed to boat traffic.

SUSTAINABILITY OF THE SOLUTIONS

The designation as a nature reserve (national legislation) and the determinations of the EU Habitats Directive (international legislation) requires sustainable measures with three main goals: to preserve the natural function of the area, to carry out interventions if necessary (such as the promotion of settlements of endangered species) and to remove and prevent disturbing influences.

Sustainability in nature preservation means that measures have to be continuously implemented. The cooperation between partners such as the BSU, the district authorities and GÖP are, therefore, based on long-term contracts. Agreements are legally set in the PEP. Short-term issues can be quickly resolved as a result of continuous cooperation between the partners.

The legal status of the nature reserve does not allow building and forest use, and the water bodies in the area are closed to boat traffic, so the Heuckenlock is sustainably protected from interference of this kind. This is a key factor in achieving the main goal of the nature reserve: keeping the natural dynamics of the area. Small interventions such as cutting and planting and larger interventions such as lowering embankments also support this aim.

A key point to ensuring sustainability of measures is the cooperation of stakeholders. The greater the consensus that a measure receives, the more reliable are the implementation and the long-term effect. In the past, there already has been a good cooperation between stakeholders, often on an informal basis. Newer concepts and plans such as the IBP and the Tideelbe Concept bring all partners together with a single aim, which in turn means that short-term, unilateral solutions are avoided. The focus lies on measures which are supported by all. Thus conflicts of interest and harmful actions can be avoided.

INTEGRATION OF WATER MANAGEMENT SOLUTIONS IN THE PLANNING PROCESS

An important factor to the success of the preservation of the Heuckenlock was, above all, the competition between Hamburg and Harburg. The channel flow for the North and South Elbe rivers could be partially regulated at the Bunthäuser Spitze, which meant that the relative importance of both ports could be shifted. Hamburg succeeded in concentrating port development on the North Elbe. The conflict was not resolved until 1937, with the passing of the Greater Hamburg Act, which ended Harburg's autonomy. Up to that point, the boundary between the two cities was disputed at the Heuckenlock, so that parts of the territory were not even used for agriculture and the alluvial forest could be preserved. Protection of the area was already envisaged by Harburg, then part of Prussia, as early as 1935. In 1948, Hamburg issued a decree establishing a nature reserve. This was revised in 1977 to extend the nature reserve, primarily to areas to the west of the motorway. Up to 2008, the Hamburg-Harburg District Authority was responsible for the nature reserve, but responsibility was transferred in that year to Hamburg Central District Authority.

As a unique area in Europe, the nature reserve has been incorporated into the network of biogenetic reserves, a worldwide programme of UNESCO. The Heuckenlock is also a European protected area under the EU Habitats Directive.

The decree setting up the nature reserve does not restrict hunting, and the District Authority is therefore able to issue a normal hunting lease. The nature reserve also includes many small, narrow privately owned plots of land, largely on the meadowland behind the embankment. On the opposite bank of the Elbe is the Schweenssand nature reserve, which is also protected by its own decree.

All of the upstream dike forelands have also been notified to the European Commission under the Habitats Directive, but have not yet been designated as a nature reserve by the Hamburg Senate. The new Auenlandschaft Norderelbe nature reserve borders directly on the Heuckenlock to the east.

Of the plant species to be found in the Heuckenlock, the Elbe water dropwort is one of the priority species covered by the EU Habitats Directive.

DIFFICULTIES AND HOW THEY WERE OVERCOME

The main issues were the economic use of the Elbe, the need for protection against floods and the need for nature protection. Changing water levels due to constant extension of navigation channels and embankment construction have had a deep impact on the habitat. On the other hand, higher flooding has made it necessary in recent decades to raise the level of embankments and strengthen them. For example, in order to restore the natural tidal vitality of the area, a lowering of the bank revetment has taken place wherever possible.

The issue does not only have a physical aspect. In previous years, it was legal practise to comprehensively seal the river banks of the Elbe. Nowadays, there is a better understanding of environmental needs and the aim of planning is to achieve agreements with a broad consensus. The HPA, responsible for economic river management, has become more sensitive to nature issues and has integrated them into the Tideelbe Concept. As neighbours at the Tideauen-Zentrum (information centre, run by GÖP), cooperation and exchange between HPA and GÖP has greatly improved over the years.

New measures such as the IBP (developed by the BSU) aim to carry out projects that take environmental and economic needs into consideration and find a balance between these contrary interests. Issues may also arise due to unforeseen costs. For example, the lowering of revetments exposes contaminated material such as rubble and stones. The disposal of this is problematic and expensive. Problems of this kind should be solved more easily in the future when more financial funding is provided, as announced in the IBP.

KEY SUCCESS FACTORS

The conflict between Hamburg and Harburg can definitely be seen as the key factor. The Heuckenlock was not affected by any economic factors. Neither planners nor environmentalists have been particularly interested in the area. As a consequence, it has been left to itself, and habitats could flourish undisturbed.

DISCUSSION AND CONCLUSIONS

As it is so multi-faceted, the Heuckenlock nature reserve is well suited as a case-study area. The flora and fauna at this site are exceptional and worthy of protection. This is legally achieved by the site's designation as a nature reserve.

The nature reserve touches on the specific interests of a wide variety of groups: economic, political, ecological and residents. The Society for Ecological Planning, through its on-site information centres and activities, promotes dialogue enabling these often conflicting interests to be voiced and reconciled.

In this context, this case promotes awareness among experts and the public of the value of the Heuckenlock nature reserve and the need for sustainable water management. An integrated approach to spatial planning and water management and the interaction between the various stakeholder groups involved in planning offer important opportunities for guaranteeing the preservation of this area so worthy of protection.

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Flood Alleviation at Devonshire Park and Mayfield Road, Bradford, West Yorkshire, England

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INTRODUCTION

Several flooding incidents in recent years have caused considerable concern over flooding in the vicinity of Devonshire Park. Apart from the physical damage, local citizens suffer from the mental stress each time it rains, especially when thunderstorms are forecast in summer, even though a storm forecast does not necessarily mean that flooding will occur. There is a long standing history of flooding in the area; however, the perception amongst residents is that both the frequency and intensity is increasing.

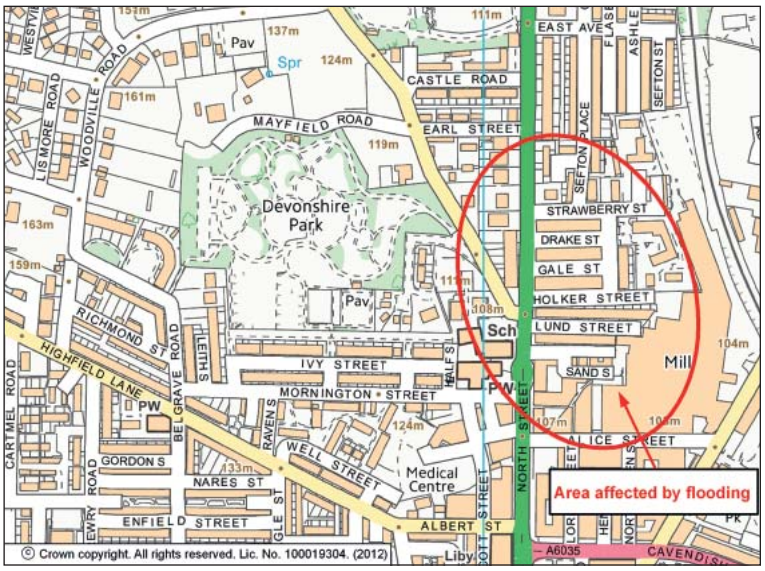

FIGURE 1. LOCATION PLAN

Devonshire Park is located immediately to the north-west of Keighley town centre. The ground slopes from west to east. The area is served predominantly by a combined drainage system, but there is also a complex, though poorly defined natural drainage system, much of which has been culverted and some of which has been destroyed. During extreme rainfall, water from the park and adjacent housing flows down the hill and into the area around Spring Gardens Lane and North Street. This causes flooding to properties along Spring Gardens Lane and North Street, and also to properties in lower-lying areas to the east of North Street. There is also flooding in the urban area to the south of Devonshire Park, but this problem is not described here. The area around Devonshire Park is identified in Figure 1.

Water flows from the hillside to the west of North Street. This is shown in Figure 2, in which the principal flow paths are shown in blue, public sewers in red and known locations of property flooding with red stars. In recent years, prolonged wet weather and/or extreme rainfall has caused water to flow from Devonshire Park and Mayfield Road (Locations 1 and 2 in Figure 2) and areas to the north and west of these. The main flooding problems occur at the junction of Spring Gardens Lane and North Street (Location 3 in Figure 2), where property owners have constructed upstands at the entrance to their properties to minimise ingress of water, and to the east of North Street culminating in the flooding of Tonson Court, which is a sheltered housing scheme operated by a housing association (Location 4 in Figure 2).

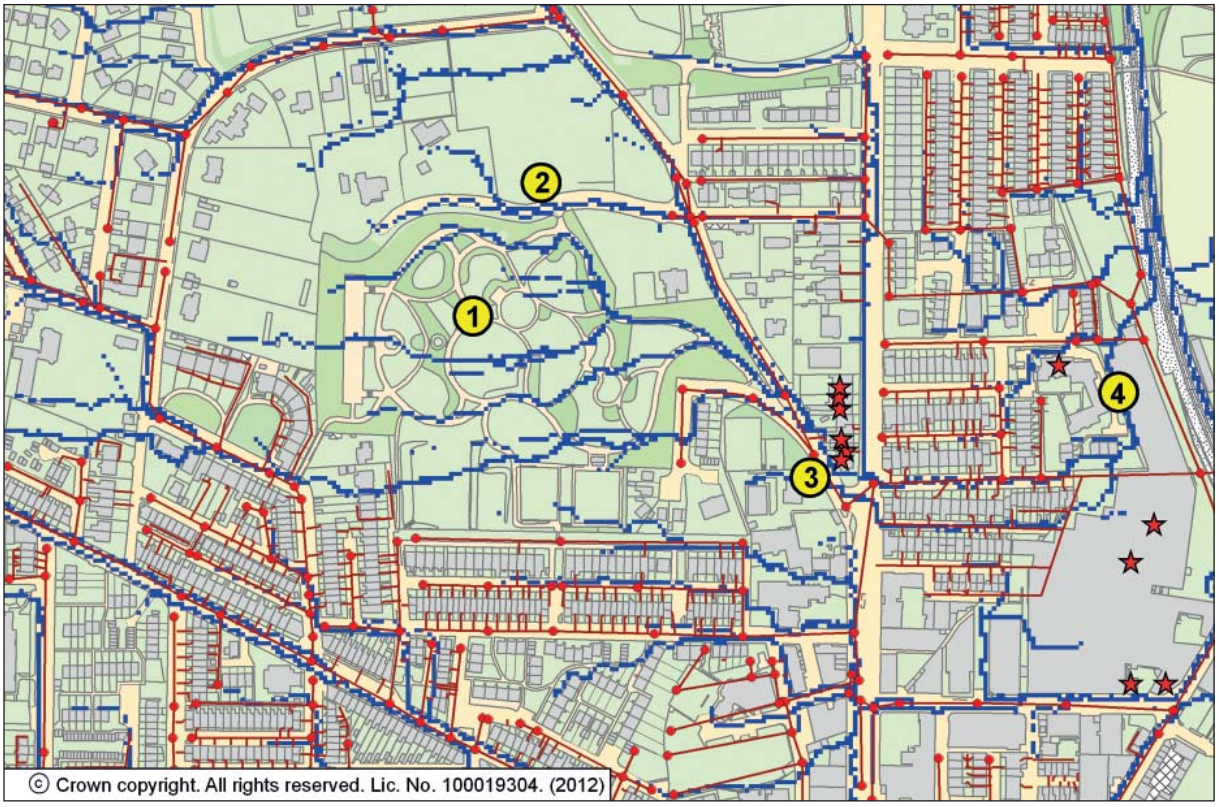

FIGURE 2. SOURCES, PATHWAYS AND RECEPTORS

MAIN STAKEHOLDERS AND THEIR INVOLVEMENT

It was immediately recognised that CBMDC had a major role to play in the flood risk management within the area. Notwithstanding the many other priorities relating to statutory responsibilities, and the lack of funding, there was a clear need for leadership and for the council to set an example as a key stakeholder. The role was to work with other key stakeholders to define the problems, facilitate the apportionment of responsibilities and identify appropriate adaptive responses to which it could contribute. It was evident that there was a need for more than a cursory investigation, and so steps were taken to reveal the location, size and condition of key watercourses and surface water drainage systems and to carry out GPS surveys in key locations to supplement the Lidar data which had been acquired in 2004.

Analysis of the rainfall data showed that the situation throughout the area was tolerable for rainfall return periods of up to 10 years. Above this there was a real risk of flooding somewhere in the area. It was also recognised that without an expensive and disruptive renewal programme, there was little benefit in increasing the capacity of the sewerage system. Even if that was done, it would still be necessary to manage the runoff from permeable areas and to compensate for the loss of capacity in the major drainage system. Finally, it was evident that infiltration was not the solution as the permeable surfaces were saturated when flooding occurred.

Community engagement has taken place throughout the duration of the investigation process. This has involved visits during and after the flood events, for the compilation of the questionnaires and whilst further investigations were being undertaken. Once an appreciation of the problems had been gained, a meeting was held with the local community to confirm that this appreciation was correct and to test the initial ideas for solutions. At this meeting further flood locations were identified and additional information on flood pathways and the drainage system was obtained.

Engagement with individual householders and landowners has continued where appropriate and, given that a stream of funding may emerge, it is now time to go back to the community to present the more detailed proposals worked up since the first meeting for assistance with prioritisation and to identify the focus of further investigations within the area.

The main stakeholders and their roles are summarised in Table 1.

Stakeholder	Role				Interest										
					Regulators and interest groups						Planning bodies				Others
	Decision-maker	Advisor	Developers	Long term ownership	Wild life	Heritage	Environment	Water quality	Water quantity	Local communities	Strategy planners	Development control	Building control	Road/Transport	
City of Bradford Metropolitan District Council	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
University of Sheffield		x													
Householders and landowners	x		x	x						x					

TABLE 1. MAIN STAKEHOLDERS AND THEIR ROLES

THE INVESTIGATION PROCESS

DOCUMENT INCIDENTS

In addition to the archive of photographs of the flooding, the incidents were documented in the CBMDC drainage incident database and many householders responded to the flood incident questionnaires that were sent out. The response was further improved following public meetings held to consult about the problems.

DATA COLLECTION

The data immediately available for the investigation was as follows:

- OS master map
- Sewer data
- Combined sewers
- Surface water sewers
- Terrain data (1 m horizontal and ± 150 mm vertical resolution).
- LIDAR elevation model
- LIDAR terrain model
- LIDAR terrain model with buildings
- Rainfall data
- 15 minute data from EA gauge sites within 10 km of Keighley
- 2 minute data from CBMDC rain gauge network commissioned August 2005
- 2 minute data from Yorkshire Water short term sewer flow survey rain gauge network installed May–July 2002
- Flood archives
- CBMDC drainage incident database
- CBMDC flood questionnaires
- Yorkshire Water incident database and Keighley High Level model build report

INITIAL REVIEW – CURRENT PRESSURES

The City of Bradford MDC took on the responsibility to lead the investigations. Not only does it have responsibilities of Civil Contingencies, it is also the highway authority and has responsibilities for drainage and as a major landowner in the area.

RAINFALL

Reports of flooding have been received on several occasions, but the major event affecting all of the area occurred on 11 August 2003. This was caused by extreme short duration rainfall superimposed upon relatively low return period longer duration rainfall. Nevertheless, the 2-day rainfall was significant enough to saturate the ground and with up to 40 mm of rainfall falling within 3 hours, a return period of 25 years, the resultant runoff caused widespread flooding in the area.

DRAINAGE SYSTEM

This area of Keighley is predominantly drained by a combined sewer system operated by Yorkshire Water. The natural drainage system is poorly defined, but investigations have revealed a piped surface water drainage system flowing from Devonshire Park, down Spring Gardens Lane, through the area affected by flooding and then eastwards to join the River Aire (Figure 3). When Tonson Court was constructed, the piped system was severed and the upstream section was diverted into the public sewer in Holker Street. Downstream, the culvert became blocked. Investigations have been carried out and the route of the watercourse has now been traced for some distance downstream, and work will continue until the entire route down to the river Aire is proven. As a result of the investigation, riparian owners are being contacted and work is now ongoing to clean the culvert and to check its structural condition.

The current challenge is to maximise the effective capacity of the minor drainage system and to compensate for the loss of the major drainage system, allowing members of the local community to take appropriate measures to minimise the residual risk to their own properties without causing problems to others. Given that there are significant flooding problems within the entire area, and that thoughtless actions in one location can cause problems further down the hillside, it was evident that the solutions developed should avoid the rapid conveyance of flows through the affected areas.

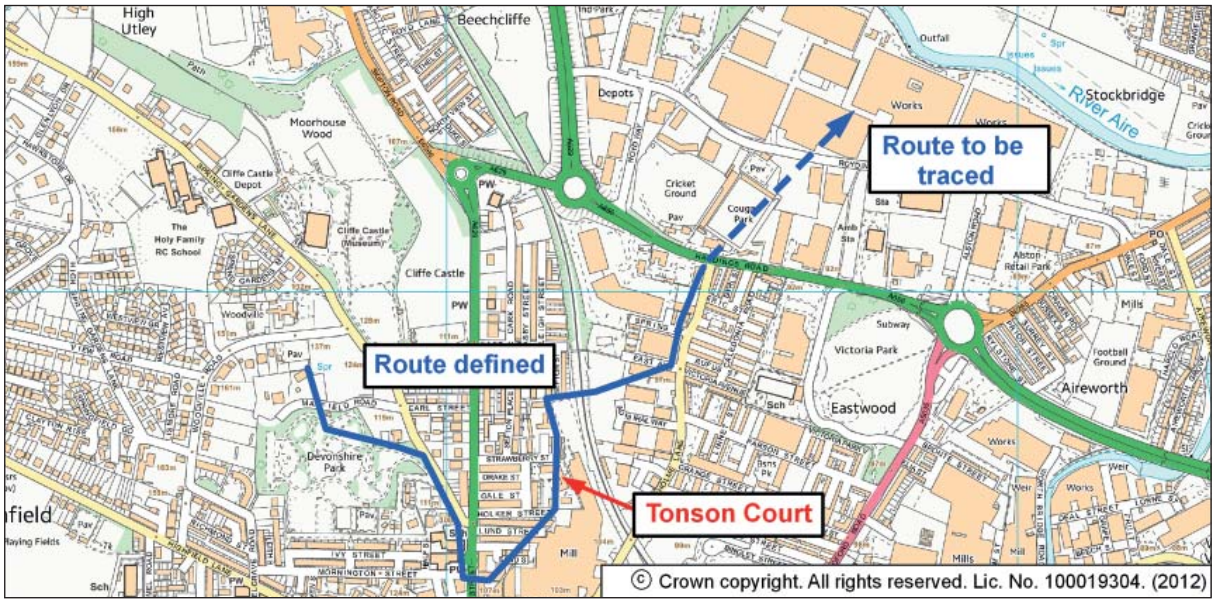

FIGURE 3. ROUTE OF THE DRAINAGE SYSTEM

TONSON COURT

Tonson Court was constructed on a former school playing field and provides sheltered accommodation for more vulnerable members of the community.

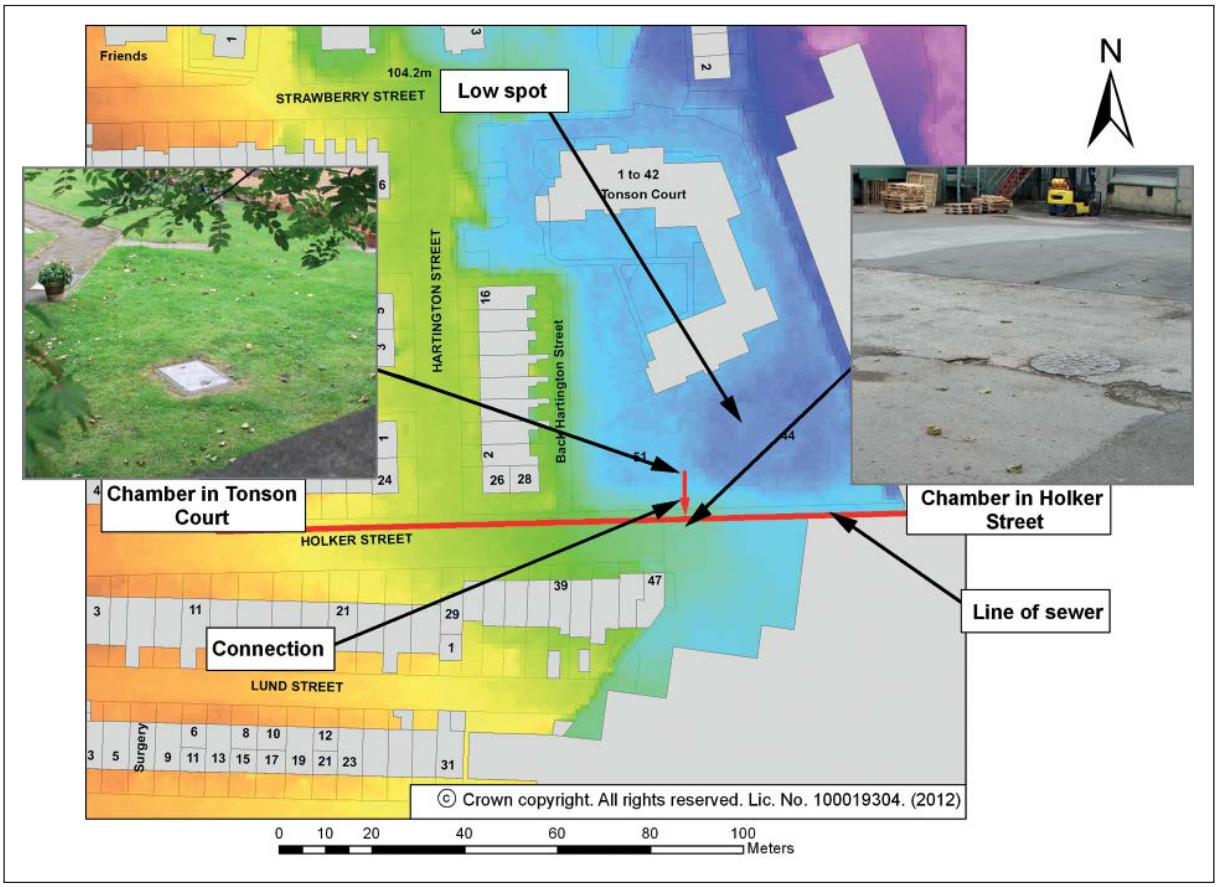

FIGURE 4. FLOODING AT TONSON COURT

The development has been constructed in a hollow and flooding frequently occurs. When the development was constructed, the surface water drain was severed and was connected to the combined sewer in Holker Street together with the drainage from the site. The ground level in Holker Street is significantly higher than that in Tonson Court, and so, as the sewer surcharges in normal operation, Tonson Court floods prematurely. The problem is exacerbated by the overland flow from the area to the west of North Street which migrates to the low point. There is evidence of flooding to a depth of approximately 300mm (Figure 4). The flooding has normally occurred in the summer months as a result of intense rainfall, and the physical damage is compounded by the distress caused to occupants.

INITIAL REVIEW – FUTURE PRESSURES

URBANISATION

There has been a significant amount of development within the catchment since the 1960s. This is illustrated in Figure 5.

FIGURE 5. STUDY AREA AROUND 1960 AND IN 2000

Figure 5 shows that in the 1960s the area to the north and west of Devonshire Park was largely farmland with some areas of predominantly low-density housing. During the intervening period, much of the farmland has been developed, mainly with medium-density housing, and a school has also been constructed

In addition to planned development, there has been a considerable amount of development within the curtilages of properties, and it is anticipated that this will increase into the future. This is known as urban creep or intensification. A study was commissioned in order to quantify the amount of creep over the past 20 years and to estimate the potential for creep into the future. Typical increases in impermeability are presented in Table 2, which shows the proportion of permeable area, paved area, pitched roofs and total impermeable area as a percentage of the total area within the curtilages of properties. The study only considered properties that were constructed prior to 1971.

	Low Density				Medium Density			
Year	Permeable Area	Paved Areas	Pitched Roofs	Impermeable Area	Permeable Area	Paved Areas	Pitched Roofs	Impermeable Areas
1971	72.9	11.8	15.3	27.1	65.5	15	19.5	34.5
1989	60.8	22.8	16.4	39.2	46.1	26.4	27.5	53.9
2002	55.5	27	17.5	44.5	44.2	27.3	28.5	55.8

TABLE 2. GROWTH OF IMPERMEABILITY 1971–2001

The main inferences that can be drawn from this information are that there was a significant increase in paved areas in both low and medium density dwellings during the period from 1971 to 1989 and that significant increases in the roof area of medium density properties also took place during the same period. The increase in both paved and roof areas slowed during the period 1989–2002, but did not stop. It is anticipated that a steady but slow increase in overall roof and paved areas within curtilages will continue as additional parking spaces are provided and those houses currently without extensions are further developed, and that low density development will tend to a peak of 55% impermeability, while medium density development will peak at 70%.

CLIMATE CHANGE

The impact of climate change is difficult to predict. As the amount of CO_2 emissions is dependent on global socio-economic responses, they are not within the control of local communities. The effect on precipitation is likely to be seasonal. During winter, the intensity and volume of rainfall is predicted to increase, whereas in summer, intensity is predicted to increase but overall volume to decrease. Because the change in precipitation are dependent on the CO_2 emissions this is difficult to predict, but a pragmatic approach of hoping for the best but preparing for the worst is being adopted and provision is being made for increasing the volume of storage should this prove necessary. In the meantime, a 10% increase in rainfall intensity and volume is being factored into the design. This equals the guideline allowance in PPS 25 up to 2055.

DRAINAGE ASSETS

Drainage assets have a long life, and it is not possible to “tinker” with them as small changes occur. From the perspective of the asset, major changes should only occur as the serviceable life of the asset ends.

WATER MANAGEMENT SOLUTIONS

SELECTED SOLUTIONS

RATIONALE BEHIND SOLUTION

Future urbanisation and climate change will continue to increase the annual probability of flooding, unless something is done to increase the capacity of the drainage assets. A strategic flood risk assessment of the Keighley area has shown that disconnection and source control are the most cost-effective way of reducing the impact, which means that solutions are required at source rather than at end of pipe. In addition, all available assets should be utilised. The blocked and severed culverts should be restored, and where capacity is exceeded, storage should be distributed throughout the upstream catchment.

The rationale behind the design for Devonshire Park and Mayfield Road is to utilise the full capacity of the surface water drainage system which runs through the area and to store excess flows from Devonshire Park and Mayfield Road when the capacity is exceeded. The reality of this is that the greater the flow that can be passed down the culvert, the less the storage requirement. However, the culvert serves an area larger than Devonshire Park and Mayfield Road and in the long term, its capacity should be apportioned across the whole area that it serves.

ELEMENTS OF SOLUTION

The elements of the solution are shown in Table 3.

Element	Action
Trace route of downstream culvert to river Aire, clean and reinstate to provide drainage outlet at Tonson Court.	Investigation by Bradford MDC. Cleaning and reinstatement by culvert owners.
Reconstruct severed culvert at Tonson Court.	Design by Bradford MDC. Reconstruction by Housing Association.
Connect Tonson Court surface water drainage and upstream culvert to new section.	Design by Bradford MDC. Connections by Housing Association.
Provide high level pumped connection to sewer for Tonson Court foul drainage.	Specification by Yorkshire Water. Connection by Housing Association.
Storage pilot project to reduce runoff from council owned land.	Specification and design by Bradford MDC.

TABLE 3. ELEMENTS OF SOLUTION

As a temporary measure, Yorkshire Water is diverting the surface water drainage system into the sewer upstream of the point where it enters Tonson Court.

DIMENSIONS OF THE SOLUTION

Extreme rainfall events

The Flood Estimation Handbook was used to obtain rainfall parameters for the Keighley area. These parameters were then used to produce synthetic summer rainfall profiles for events of different durations and probabilities.

Storage depth

Because flooding only occurs during extreme rainfall, it can be assumed that a combination of infiltration, surface ponding and the local drainage systems provide adequate capacity for low level flooding. Historical evidence suggests that the capacity is sufficient to contain flows from an event of 10% annual probability. Therefore the storage capacity required to contain an event with annual probability of 1% will be found by subtracting the volume of water generated by the 10% annual probability event from the water generated by the 1% annual probability event. This was determined for events with durations ranging between 15 minutes and 12 hours, and the peak volume occurred for an event of 2 hours duration. Making an allowance of 10% additional rainfall as a result of climate change, the storage volume was determined to be 220 cubic metres per hectare.

Storage volume

The area of Devonshire Park is 6 ha. Multiplying this by 220, the storage volume is 1,320 cubic metres and that in Mayfield Road is 220 cubic metres.

Storage in the form of SUDS was provided in Devonshire Park using a series of “trench-trough” structures (known as Mulde Rigole in Germany and wadis in the Netherlands, where they are widely used); see Figure 6. These take the form of troughs or depressions (swales), with gently sloping sides, set over trenches containing underground infiltration tanks or infiltration trenches with high void space.

FIGURE 6. TRENCH-TROUGH SYSTEM OR "WADI" IN DEVONSHIRE PARK

FIGURE 7. COMPLETED STEPPED TRENCH SYSTEM ON MAYFIELD ROAD

The water from the troughs percolates into the infiltration tanks which are protected from sediment by a geotextile layer. The infiltration tanks provide subsurface land drainage to the troughs, thus improving their performance and reducing the general water logging of the ground that used to occur. Ground profiles were managed to direct the majority of flows into the trench troughs, and residual flows are collected in swales which are also connected to the drainage system. Controlled discharge from the infiltration tank units is directed to the drainage system in the park.

A stepped trench system was constructed on land owned by the City of Bradford MDC on the south verge of Mayfield Road with a capacity for 110 m3 storage. There is an option for another trench on the northern verge should this be required. Although benign with respect to the local environment, the trench-trough system on Mayfield Road is striking and brings attention to the drainage works that were undertaken in the area. The wadis in Devonshire Park look much like depressions in the landscape, and they neither add to nor detract from the previous aesthetics of the grassed parkland which existed previously.

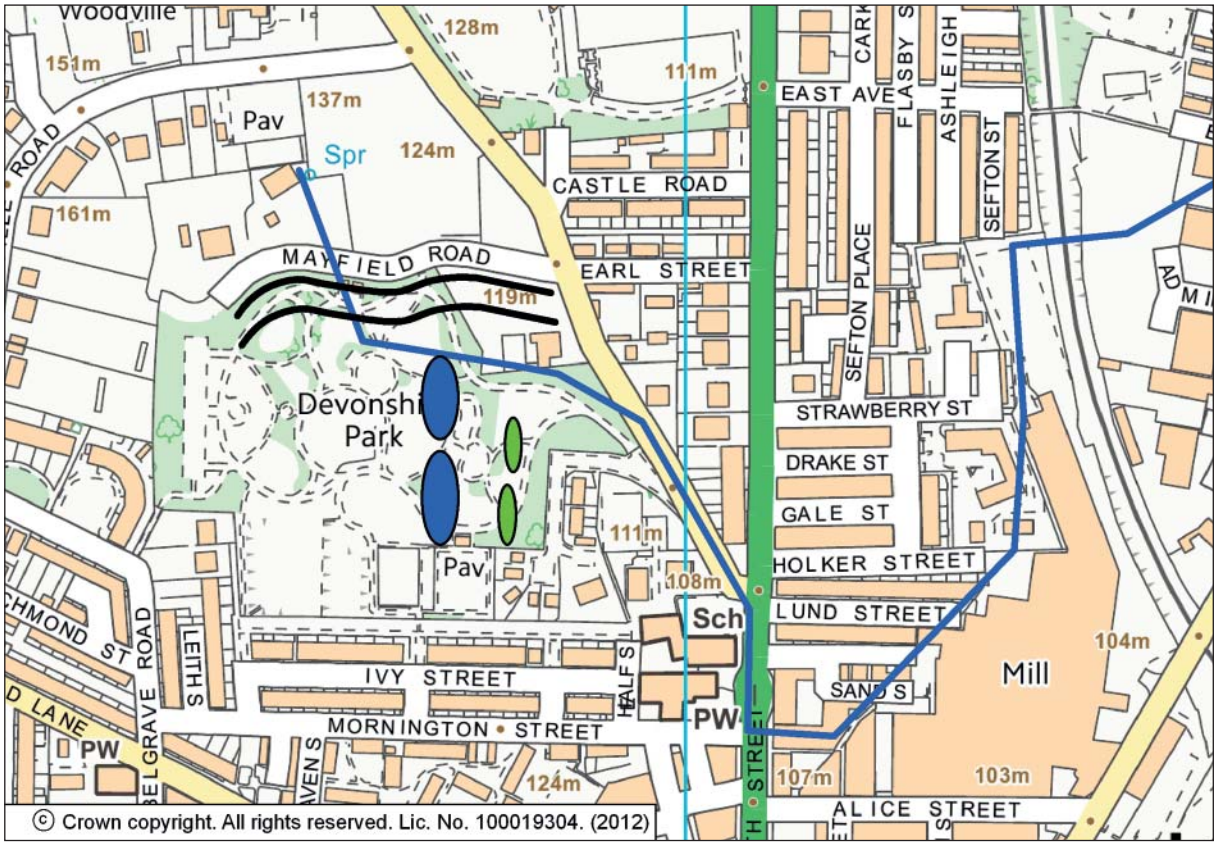

FIGURE 8. NOTATIONAL LOCATION OF TRENCH-TROUGH STRUCTURE

INTEGRATION OF WATER MANAGEMENT SOLUTIONS IN THE PLANNING PROCESS

As well as the flood abatement aspects of the storage pilots, their purpose is also to demonstrate how source control and disconnection measures can be built into the urban environment without detriment to the local community.

KEY SUCCESS FACTORS

The critical success factors enabling this scheme to go ahead were the presence of a strong driver, an overloaded drainage network causing flooding, and the presence of a local champion at the council who was able to provide the impetus behind the investigations and secure funding. A key part of the success of the project was the engagement of the community, which provided information on historical flooding and on drainage features no longer in use or filled in and helped to identify the required focus of investigations. The champion also worked in an enabling environment, with consistent political support (from Cllr Anne Hawksworth, who remained in office over a period of more than a decade) that allowed him to exercise interventions based on permissive powers, rather than through any regulatory duty.

SUSTAINABILITY ASSESSMENT

The main aim of the chosen options was to alleviate known flooding problems, reducing economic damage to local communities and improving the well-being of community members. This was achieved at no detriment to the local environment and minor improvements were made to the amenity value of Devonshire Park by reducing the water logging of the ground and hence enhancing its value to the community. Other benefits in terms of sustainability were found when comparing the impacts of the chosen option with those of the alternatives, all of which required considerable disruption within the local communities, either through work to

be undertaken to provide storage or disconnect surface water drainage within properties or wide scale sewer capacity enhancements. In addition to the disruption, the alternative solutions would have required a much greater administrative and community engagement input because of the number of people and organisations that would be affected by the solutions and involved in the works. Also, the alternatives would involve significantly greater costs in terms of materials and reinstatement. Hence the chosen option was both socially and economically more sustainable.

DISCUSSION AND CONCLUSIONS

The scheme utilises the full capacity of the surface water drainage system which runs through the area and stores excess flows from Devonshire Park and Mayfield Road when the capacity is exceeded. As well as the flood abatement aspects of the storage pilots, the purpose of the design was also to demonstrate how source control and disconnection measures can be retrofitted into the urban environment with minimal disruption and without detriment to the local community. Since the works were undertaken the new drainage system appears to be working well, and there have been no reported flooding incidents despite significant rainfall in June 2007 and January 2008, when problems could have been expected to arise.

A strategic flood risk assessment of the Keighley area showed that disconnection and source control would be the most cost-effective way of reducing the impact, meaning that responses were required at source rather than at end of pipe. However, a large proportion of the surface water runs off the steep fields to the west of Keighley, and here the lack of capacity to infiltrate at source is a problem. The scheme considered the most efficient ways to use funding to provide the greatest flood mitigation benefits, and by utilising a portion of the open space available was able to achieve this.

SUDS AND FLOOD MAPPING URBAN FLOODS IN BERGEN, THE NETHERLANDS

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INTRODUCTION

The increase of the paved area and the effect of climate change can have a considerable impact on urban areas. One of the effects is the increase of storm water peak intensities and an increase in the frequency of these showers. These extreme events cause the sewer system to be overloaded and flood the streets and pose a possible health risk.

The popular beach resort Egmond aan Zee in the north-west of the Netherlands experienced two extreme storm water events in August 2006. The storm water events had an intensity of 60 mm/hour, which statistically should occur once in 50–100 years, and led to flooding of the area. The storm water flowed from the higher parts to the lower-lying centre and flooded shops (see photo), with damage to property and much (political) unhappiness. This flooding and the possible health risks could occur more often due to climate change and needed to be resolved immediately.

FIGURE 1. INTENSIVE STORM WATER EVENTS IN AUGUST 2006 LED TO FLOODING IN THE MAIN SHOPPING STREET IN EGMOND AAN ZEE

It is becoming commonly accepted that these problems need to be resolved by providing more space for water at ground level. The European Flood Risk Directive (EU, 2007) promotes flood risk management plans with non-structural measures aiming at resilience of urban infrastructures and preparedness of the social system. SUDS can be used as an effective way to reduce flooding. There is a growing consensus that sewer capacity is limited and that there is a need to consider all aspects of water drainage during extreme rainfall events.

MAIN STAKEHOLDERS AND THEIR INVOLVEMENT

The flooding problems had to be solved, and solutions using sustainable urban drainage systems would have a large impact in this area. Therefore a lot of stakeholders had to be involved:

- The municipality of Bergen; several departments were involved: urban planning, civil engineering, green, infrastructure;
- Consultancy agency TAUW; planning and implementation of sustainable urban drainage systems in several stages: long -and short-term measures;
- The water authority Hoogheemraadschap Hollands Noorderkwartier; guides municipalities regarding water quantity and water quality problems;
- The water authority Rijkswaterstaat; guides after-flood protection and the quality of water in the beach area;
- Residents; people participation is needed for the large-scale implementation of SUDS. Basins of 3000 m³ were implemented, which have a large impact in a dense urban area;
- Province Noord Holland; guides the municipality in Bergen on deeper groundwater level impact.

All stakeholders and their roles are summarised in Table 1.

Stakeholder	Role				Interest										
					Regulators and interest groups						Planning bodies				Others
	Decision-maker	Advisor	Developers	Long term ownership	Wild life	Heritage	Environment	Water quality	Water quantity	Local communities	Strategy planners	Development control	Building control	Road/Transport	
Municipality of Bergen	x		x	x			x	x	x		x	x	x	x	
Consultancy agency Tauw		x	x												
Water authority HHNK	x	x						x	x						
Water authority Rijkswaterstaat	x	x													
Province Noord Holland		x							x						
Local community							x			x					

TABLE 1. STAKEHOLDERS AND THEIR ROLES

WATER MANAGEMENT PROCEDURES

The European Water Framework Directive (WFD) aims at reduction of flooding and an enhanced protection of the aquatic environment. As a consequence, the WFD requires municipalities to address the emission from wastewater systems properly and to take action when these emissions affect the quality of receiving waters. Sustainable Urban Drainage Systems (SUDS) can play an important role in achieving this goal.

WATER MANAGEMENT SOLUTIONS

The implementation of SUDS in the densely populated polders (low-lying tracts of land with generally high groundwater tables and low permeable soil enclosed by embankments) of the Netherlands requires specific guidelines for design, construction and maintenance to prolong the lifespan of SUDS. However, the techniques used in the Netherlands can also be used in more undulating landscapes, adding flood risk management opportunities to the list of water quality applications that is already well established.

In order to make areas flood resilient and achieve Dutch quality ambitions there is a large variety of SUDS to choose from, such as: infiltration trenches and basins, (slow) sand filters, soakaways, ponds, swales, wetlands, bio-retention, filter strips, sedimentation basins, filters and pervious pavements.

SELECTED SOLUTIONS

For Egmond a wide variety of SUDS was available, choosing which systems were implemented was based on the following criteria:

- (removal) efficiency and reducing floods
- cost (building and maintenance)
- required space
- experience maintenance
- sustainability
- aesthetics
- robustness
- life cycle analyses

Experiences in designing, building and maintaining SUDS were gathered through an international literature review, interviews and fieldtrips.

In Egmond aan Zee several SUDS were implemented:

- swales
- improving the sewer capacity
- infiltration trenches
- infiltration basins
- pervious pavements
- water barriers to guide water

FIGURE 2. WATER BARRIERS TO PREVENT WATER FROM FLOWING TO THE LOWER CENTRE WERE INSTALLED. THE WATER IS STORED AND INFILTRATES TO REDUCE FLOODS

To implement SUDS in the right locations, flood mapping was used to establish the water flows in the Egmond area during storm water events. This method was used to search for above-ground measures against flooding.

In order to maximise the possibilities of interaction between professionals of different spatial fields (water, green, road) the maps were presented in a workshop using a touch table. Showing pictures and a visualisation of storm water flooding provides a relatively easily interpretable insight into the problem and the cause, making this tool ideal for multidisciplinary decision-making and the implementation of solutions like SUDS. Because the measures are implemented at street level, it is necessary for sewer specialists to discuss possible areas for ground level measures with professionals responsible for roads and green areas. These professionals from fields unrelated to water joined the discussion on how to solve the problem.

FIGURE 3. LEFT: RESULT OF FLOOD MAPPING; RIGHT: USING VISUAL TOOLS TO UNDERSTAND AND INTERACT WITH DIFFERENT STAKEHOLDERS

In order for the managers of the urban area in Bergen to take full advantage of the visual power of the maps a multi-disciplinary workshop was organized. In this workshop the results of flood mapping, showing the problems and possible solutions, were presented on the touch table. The touch table is used to:

- identify areas of interest;
- analyse the model output at those areas;
- decide whether to solve the identified problem;
- decide to find and discuss solutions;
- allow non-water professionals and specialists to understand easily interpretable visual maps;
- direct input from multiple disciplines to use in the decision-making.

This leads to fast decisions that are commonly accepted by the municipality and the parties involved.

DIFFICULTIES AND HOW THEY WERE OVERCOME

Implementing solutions in a dense urban area like Egmond aan Zee is a challenge. The area was developed over years, leaving little space for water to be stored or to infiltrate in the ground. To restore the natural water balance and make this area flood-resilient, numerous measures had to be implemented in a short time.

Plan of approach

First, a short list of quick and cost-effective measures was drawn up and discussed with all stakeholders. To prevent water from flowing from the higher parts to the lower centre, speed bumps were built and SUDS implemented to store the storm water and let it infiltrate where it lands. During the construction of these “simple” solutions, long-term plans were made which are highly effective but have a large impact on special planning and the community. Two large infiltration basins were designed for storing more than 6500 m^3 of storm water in the lower areas and prevent flooding. The basins’ volume was optimised by using innovative technical building solutions, constructing the walls above ground and lowering them during construction. This leads to lower space requirements, optimises the storage volume and minimises the obstruction for local residence in their daily lives.

To reduce the health risks, storm water sewers were inspected for foul water connections using temperature loggers. Wastewater from houses (e.g. water from showers, with a higher temperature) connected to storm water sewers were located and the systems were separated, reducing the risk of contact with wastewater and reducing emissions to the surface and groundwater.

KEY SUCCESS FACTORS

There are many factors that contributed to making the quick implementation of solutions to make Egmond aan Zee flood-resilient a success. Having so called “champions of change” in the municipality, consultants and a good cooperation from the water authorities was one determining factor. Using international technical and communication innovations and solutions was another.

The project Skills Integration and New Technologies (SKINT) encourages transnational knowledge exchange and the implementation of innovative technical and sustainable solutions which have already proved to be successful around the North Sea region. The problems and solutions in Egmond contributed to this transnational knowledge exchange. The municipality of Bergen in the Netherlands visited the municipality of Bergen in Norway and spoke at an international congress about the key success factors and lessons learned from this case study. Egmond aan Zee is also one of the districts in the transnational serious game WaterTown designed by the University of Abertay. The game is used to share knowledge about the problems and solutions whether they arise in the Netherlands, in Norway, in UK or in Scotland.

FIGURE 4. FLOODING IN EGMOND IN THE SERIOUS GAME WATERTOWN; RIGHT: APPLYING THE GAME AT DIFFERENT INTERACTIVE SEMINARS USING EGMOND AS A SUSTAINABLE EXAMPLE

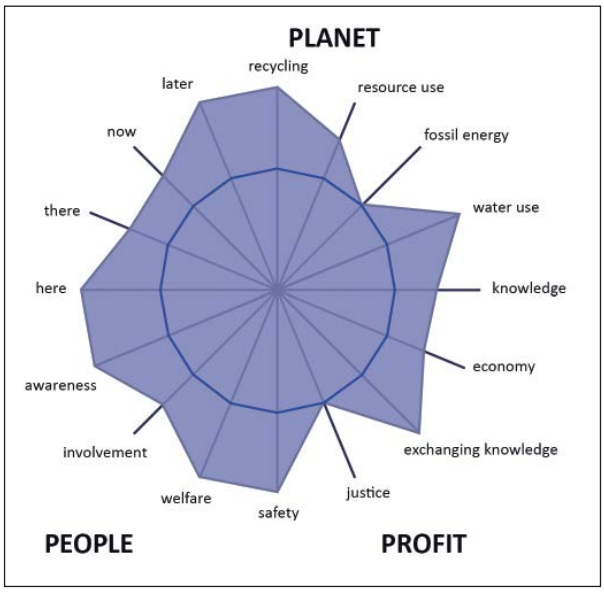

FIGURE 5. SPIDER DIAGRAM TO VISUALISE SUSTAINABILITY SCORE

SUSTAINABILITY ASSESSMENT

The solutions in Egmond aan Zee should be sustainable. This is an easy word to use but it raises a lot of questions in workgroups. Discussions about the sustainability of the different solutions have their origin in the different interests and ambitions of the various stakeholders. To rate the sustainability of this project, different categories are rated (“expert judgement”) and visualised in the spider web in Figure 5.

DISCUSSION AND CONCLUSIONS

Following the floods in Egmond aan Zee several solutions were implemented. With tools like flood mapping and international knowledge about sustainable urban drainage systems, in a short period of time this area was transformed into one of the most flood-resilient places on the globe.

The GIS-based method of modelling and mapping urban storm water flooding is an effective tool for deciding how to prevent urban storm water flooding in a cost-effective way. The output of the model is generated in a manner that allows specialists of various disciplines involved in determining measures at ground level to comprehend the process. The urban storm water flood maps visualised on the touch table improve the communication between various disciplines, generating an environment for fast, successful and cost-effective decision-making in the prevention of urban storm water flooding. Together with the serious game WaterTown from the University of Abertay, these communication tools will be used in several projects, like SKINT, which emphasise the need for speaking a multidisciplinary language to integrate the worlds of spatial planning and water management.

Transnational knowledge exchange is needed to raise awareness of the functioning of SUDS in different circumstances or countries. The monitoring and evaluation of SUDS in different European countries has yielded a wealth of experience which allows us to review and expand our guidelines of SUDS to guarantee their performance over time.

Solar City, Heerhugowaard, The Netherlands

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INTRODUCTION

Solar City is a 118 ha new urban area with about 1,400 houses southwest of the municipality of Heerhugowaard. Solar City is the world's largest carbon neutral community. The energy-efficient houses use solar and wind power.

In the early 1990s the Fourth White Paper on Spatial Planning identified the area of the municipalities of Heerhugowaard, Alkmaar and Langedijk in the province Noord-Holland as a future urban development area. Besides the large housing task there were tasks for recreation, water storage and aquatic biodiversity as well. On top of that, the province and the three municipalities had high ambitions for CO_2 reduction.

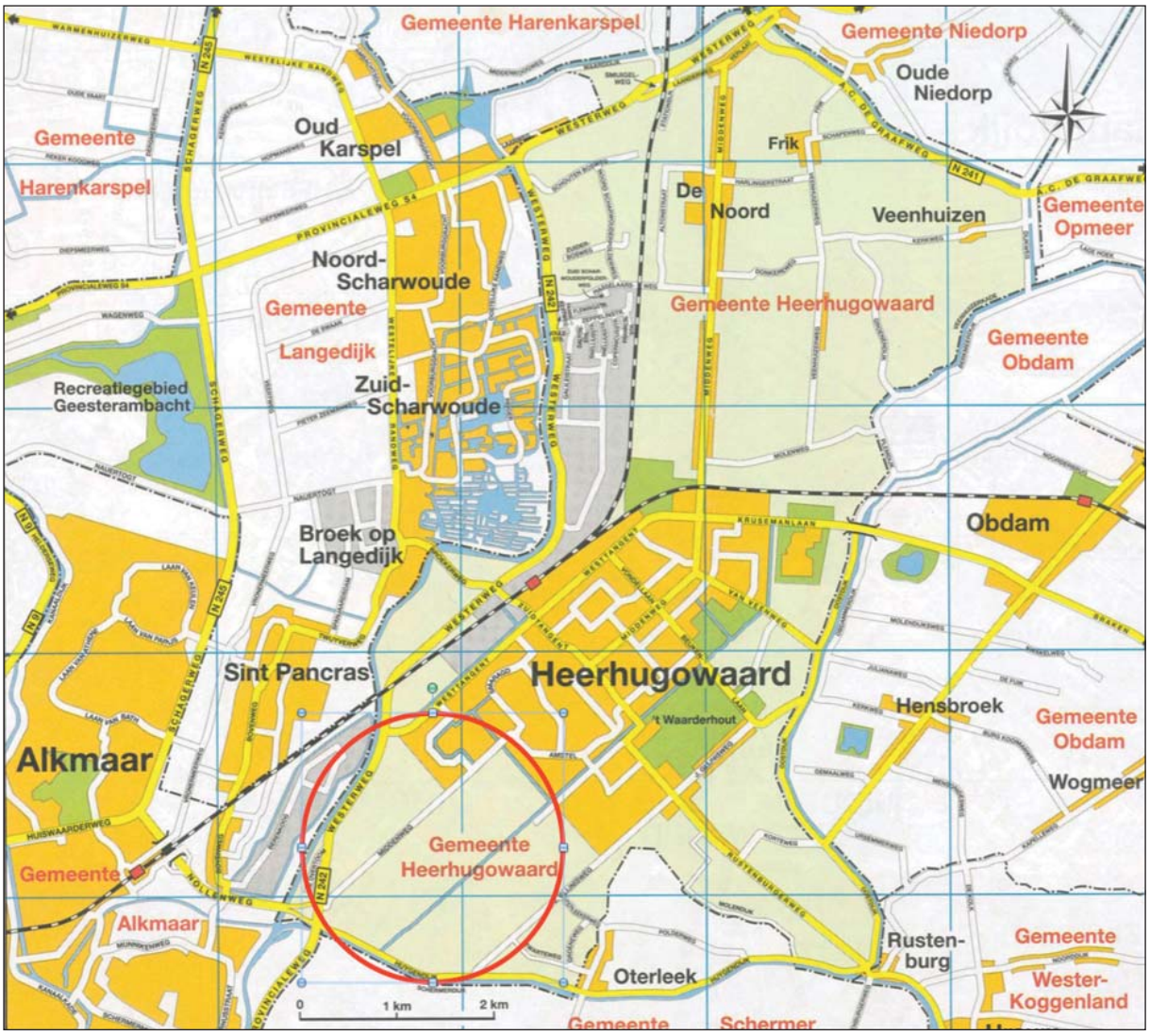


FIGURE 1. LOCATION OF SOLAR CITY

In a shared spatial planning vision the three municipalities combined housing, energy neutrality, water storage, aquatic biodiversity, nature and recreation in the ambitious plans for Solar City in Heerhugowaard – all at the lowest part of the polder of Heerhugowaard, which dates from 1630. The planning of the project lasted from 1992 to 2006. Ever since, residents have been moving into their new homes.

FIGURE 2. ARTIST'S IMPRESSION OF SOLAR CITY

MAIN STAKEHOLDERS AND THEIR INVOLVEMENT

A development like Solar City requires many different fields of knowledge as well as the skills to integrate and to harmonise all these fields. The municipality of Heerhugowaard is the project manager of the development plan for Solar City. Throughout the planning period Heerhugowaard cooperated closely with the Water Board of Hoogheemraadschap Hollands Noorderkwartier. Heerhugowaard invited Hollands Noorderkwartier as the municipality wanted to use the expertise of the water managers to make a so-called waterproof spatial plan.

This initiative of Heerhugowaard to cooperate with the water board was taken long before the water board's involvement could be enforced by legislation, the so-called Water Assessment as we know it nowadays in the Netherlands.

As a water manager, Hoogheemraadschap Hollands Noorderkwartier was responsible for the flood risk management, the water quality and the aquatic ecology of the area. This led to a water system with hardly any water supply or discharge of excess rainwater, and a naturally purified water system in the Luna Park. After completion of the project Hollands Noorderkwartier will continue to manage the water in Solar City and Luna Park.

FIGURE 3. ARTIST'S IMPRESSION OF LUNA PARK

The province Noord-Holland helped in dividing and combining the large national housing task with the other national and regional tasks, especially in the field of renewable energy. This led to cooperation between public bodies.

Ashok Bhalotra, the world-renowned urban developer from Kuiper Compagnons, was the first to introduce the sketches for a city largely based on photovoltaic energy. The energy utility company NUON is the owner of most of the photovoltaic systems. Urban planning consultancies, energy consultancies, architects, landscapers, etc. created new plans, new views and new solutions. The recreation authority manages the Luna Park. The main stakeholders, their roles and interests, are summarised in Table 1.

Stakeholder	Role				Interest										
					Regulators and interest groups						*Planning bodies*				*Others*
	Decision-maker	Advisor	Developers	Long term ownership	Wild life	Heritage	Environment	Water quality	Water quantity	Local communities	Strategy planners	Development control	Building control	Road/Transport	Subsidies
Heerhugowaard	x		x	x		x	x	x		x	x	x	x	x	x
Hollands Noorderkwartier		x						x	x						
Province of Noord-Holland	x					x	x	x						x	x
Dutch Government	x														x
European Union															x
Kuiper Compagnons		x					x		x		x				
PWN water company		x					x	x	x						
Nuon Energy		x	x				x								
Recreation authority Noord-Holland					x		x	x							
Housing association Woonwaard				x									x		
Private project developers			x										x		
Real estate developers				x									x		
Property owners				x						x					

TABLE 1. MOST IMPORTANT STAKEHOLDERS LINKED TO SOLAR CITY DEVELOPMENT

MAIN PROBLEMS RELATED TO THE INTEGRATION OF LAND AND WATER MANAGEMENT

Until 1630 the current polder of Heerhugowaard used to be a lake. This lake was part of the water storage in Noord-Holland. Since the reclamation started in 1600 the percentage of surface water in Noord-Holland decreased from 50% to only 8% nowadays. Urbanisation caused further surface run off to the remaining water system.

More specifically, the area to be built for Solar City was in the lowest part of the polder. Solving water management problems at the lowest part of a polder will cause severe water management problems elsewhere in the polder.

Besides the flooding problems there are also serious water quality problems. Birds discovered the lakes around Solar City from the start. The bacteria in their excrements sometimes cause problems for swimmers. Unfortunately, the better the weather conditions are for swimming, the more likely it is that poor water conditions occur.

Another water quality problem is caused by sport fishermen when evicting fish. Sport fishermen evict fish, which is hardly ever ecologically sound as they usually want to catch the heavyweights. These heavyweights like carp dig the sediment, causing turbid water and free nutrients resulting in algae. A downward spiral is created as the declining water quality decreases the numbers of ecologically sound fish like pike, since hunting is more difficult in turbid water.

FIGURE 4. RECREATIONAL ACTIVITIES IN WINTERTIME

The communication on the principles of Solar City generally went well. However, communication on an important issue, the use of the water system, was not as smooth. It was agreed with the municipality of Heerhugowaard that the water quality would be sufficient for recreation purposes but not for swimming. However, the municipality created a small beach and talked about swimming water in the newspapers. The water quality does not always meet the requirements for swimming, especially during warmer periods. This sometimes leads to resentment as citizens counted on swimming possibilities.

More than once, the above-mentioned water management solutions were threatened by financial limitations.

FIGURE 5. LAND RECLAMATION MAP „HEER-HUYGHEN-WAERT“

WATER MANAGEMENT SOLUTIONS

To preserve Solar City from flooding a lot of surface water was dug: over 30% of the project's area consists of surface water. Furthermore, a lot of flexibility in the water level is allowed. During summer the water level can drop to 0.40 metres below the average level. In winter the water level might rise up to 0.30 metres above average. This permitted level fluctuation of 0.70 metres enables the water system to be more or less self-sufficient. Only in very dry periods is a small water supply needed, and in very wet periods water is discharged by an automated weir. These results are really exceptional for a polder more than 3 metres below sea level, given the Dutch climate.

FIGURE 6. RECREATIONAL ACTIVITIES IN SUMMER TIME

FIGURE 7. LIVING CLOSE TO THE WATERFRONT

Initially a flexible water level seemed to be impossible because of the existing buildings. Eventually, it was decided to raise small dikes around the historical farms in the surrounding area to protect them from high water levels. The newly built houses have no crawl space underneath to enable the water level to fluctuate.

A reasonable water quality is achieved by using the natural purifying water system in Luna Park. Here the water is circulated through a wetland area. This rids the water of most of its nutrients. However, the required water quality for swimming can hardly be met, especially not when the weather conditions for swimming persist.

From design to blueprint, there was always a tension between functionality, safety, experience, construction costs and maintenance costs of the water system. In the end, an acceptable balance between the water management requirements and the financial means was found.

FIGURE 8. OVERVIEW OF LUNA PARK, A COMBINED WATER TREATMENT AND RECREATIONAL AREA

DIFFICULTIES AND HOW THEY WERE OVERCOME

The instability of the Dutch subsidy policy and the bureaucratic procedures caused numerous problems. The realisation of the project was heavily dependent on a Dutch national subsidy programme, as photovoltaic systems could not otherwise compete with conventional or other renewable energy systems. The termination of this subsidy programme required innovative financing schemes.

The rigidity of the European Commission with regards to the time frame and planning of the project also caused major concerns. The time frame was too narrow for a project of this scale. This was solved by holding an official opening of Solar City when only two thirds of the project had been realised.

The project developer was very demanding; he wanted to avoid future claims on uncertain and unproven construction methods. Furthermore, many of the architects had no experience with, and hardly any knowledge about photovoltaic systems. But in the end, all the purely technical problems in the design and in the realisation of the project were solved.

KEY SUCCESS FACTORS

As in most such ambitious projects, success relied on the enthusiasm of individuals working in public bodies. They are the ones that need to convince the decision-makers. Here they were able to do so because they believed in the principles of the project, they trusted their colleagues from the other public bodies and they cooperated whenever possible.

SUSTAINABILITY ASSESSMENT

Many areas of the Netherlands lie below sea level. This means that all the excess rain water needs to be pumped out to sea. This is mainly true during the winter; in summer fresh water from the rivers supplies the regional water systems. The flexible water system in Solar City leads to less fuel consumption at the pumping stations.

A positive side effect of this flexible water system is that more local water is available in the area. This is interesting from an ecological point of view. Thanks to the natural purifying water system in Luna Park, the water quality is also much higher than could be expected with a traditional water system.

The photovoltaic systems, together with the power of the three windmills, supply enough energy for Solar City and its residents to be fully carbon neutral.

FIGURE 9. HOUSING IN SOLAR CITY: ALL THE ROOFS HAVE SOLAR PANELS

DISCUSSION AND CONCLUSIONS

Solar City is a sustainable neighbourhood. It is designed to be climate proof, as solar and wind power generate the needed electricity for almost 1,400 households. The neighbourhood and its surroundings have an excellent water quality and aquatic biodiversity, promoting water-related recreation and nature. To achieve a good aquatic environment, rainwater is retained and circulated through an integrated purification labyrinth. The water banks and aquatic plants purify the water in a natural way.

THE TRANSNATIONAL EXPERIENCE: LEARNING BY SHARING

In this chapter, the presented cases are compared and key factors for the successful integration of land and water management are reviewed to see what can be learnt.

TRANSNATIONAL ANALYSIS: LESSONS LEARNED ON THE INTEGRATION OF LAND AND WATER MANAGEMENT

LEGISLATIVE ISSUES AND FUNDING MECHANISMS

The case studies presented here discussed a range of different problems related to the integration of land and water management. Some of these hindrances are clearly rooted in national institutional arrangements such as funding mechanisms or legislative issues.

In the Netherlands, the subsidy policy for environmentally friendly products such as photovoltaic cells was ended during the construction of the carbon neutral urban development Solar City. This funding was crucial to the economic viability of the project and new financing mechanisms had to be found in order to be able to fulfil the original development plan without compromising the space for water.

In Scotland, the DEX development struggled with similar issues of financing innovative sustainable development as no economic agreements were at hand. This issue of long-term maintenance responsibility is still being debated in Scotland. The local water authority, Scottish Water, will now adopt maintenance of a range of SUDS within property boundaries if they are designed in accordance to a technical standard. Public road drainage is the responsibility of the Local Authority.

Integration of land and water management is hindered by a lack of long-term economic agreements and stable funding mechanisms for construction and maintenance of sustainable solutions.

STAKEHOLDER PARTICIPATION AND COMMUNICATION

All the cases described here show that early stakeholder involvement and clear communication are essential for creating awareness and support. They also enable stakeholders to adapt and acknowledge innovative sustainable water management solutions and actively contribute to their long-term maintenance.

In the DEX development area, stakeholder consultation was a critical part of the implementation process, with more than 40 different people and organisations involved. As SUDS were almost unheard of in the UK, education played an important part in breaking down barriers within various stakeholder groups. Through workshops, the function and design of SUDS were worked out, and their benefits promoted. Unexpected problems occurred when local media and politicians initially raised concerns over safety issues and criticised the design. This perceived level of risk ignored common sense and the examples of similar schemes in other parts of the world at the time. Finally, several additional safety measures had to be taken in order to satisfy the local authority.

The Heukenlock case shows that for sustainable nature preservation, measures have to be continuously implemented. This requires long-term cooperation and formal contracts between stakeholders. The more common consent a measure receives, the more reliable are the implementation and the long-term effects. New

concepts and plans bring all stakeholders together with a single sustainable aim, namely to develop the nature reserve by maintaining its natural vitality and restoring disturbed sections. In order to deal with conflicting interests of different stakeholders, such as the economic, political, ecological and other interests of residents, a Society for Ecological Planning was developed at Heuckenlock to promote dialogue between stakeholders and reconciliation of different interests.

Integration of land and water management requires open communication and long-term contracts between stakeholders.

The Bryggen case shows that awareness of the value of archaeological heritage needs to be communicated, as many stakeholders, including authorities, are not aware or convinced of the intrinsic value and importance of archaeological remains, even when national and European legislation describes them as such. The Norwegian government describes the remains as “non-renewable resources”, similar to natural limited resources such as oil, which underlines the value that is assigned to the remains on a national level. Among professionals in urban planning and other stakeholders, there is even less knowledge and awareness of the vulnerability of these non-renewable resources to land and water management. The fact that the remains are “hidden” below the terrain surface does not make communication easier. The fact that modern technical solutions should not disturb the authenticity of the cultural remains both above and below the ground is also challenging to communicate. Regular information meetings with stakeholders, including residents, are held to promote dialogue and increase awareness and understanding of the special conditions in this heritage area. Open dialogue with all stakeholders and active contact with the local press are seen as important elements in the communication strategy in order to find long-lasting and widely accepted solutions.

Communication and education on water management, sustainable drainage solutions and their wider, multiple benefits to environmental and cultural assets are crucial for their acceptance and integration in urban planning.

In the Egmond case, measures had become dramatically urgent after two floods, and stakeholders were eager to implement solutions. In contrast to the Heuckenlock and Bryggen cases, stakeholders did not have to be convinced of the need to take action, but consensus was nevertheless needed on the type of solution. In the later years, it has become commonly accepted in the Netherlands that the kind of flooding problems described in the Egmond case need to be solved by providing more space for water at ground level and that Sustainable Urban Drainage Systems (SUDS) are an effective way to reduce urban storm water flooding. New innovative tools such as GIS flood-mapping and serious gaming presented on a large touch table improved communication between various stakeholders and provided an environment where decisions on urban drainage solutions could be taken in a fast and cost-effective manner.

Modern technology can significantly improve communication and cost-efficient decision-making, thereby facilitating a better integration of urban land and water management.

The Yorkshire case is generally comparable with the Egmond case. A critical driver, namely an urgent flooding problem, needed to be solved, and suitable sustainable solutions had to be chosen. In Yorkshire, a more traditional stakeholder engagement process was followed than in Egmond, with questionnaires followed by meetings with the local community to test initial ideas for solutions and to detail the extent of the problem. A challenge here was to enable members of the local community to take appropriate individual measures to minimise the residual risk to their own properties without causing problems for others. The critical success factor in the stakeholder communication of the Yorkshire case was the presence of a local champion at the council, who was able to provide the impetus behind investigations and secure funding, and who received consistent political support from a person at the Council office over many years.

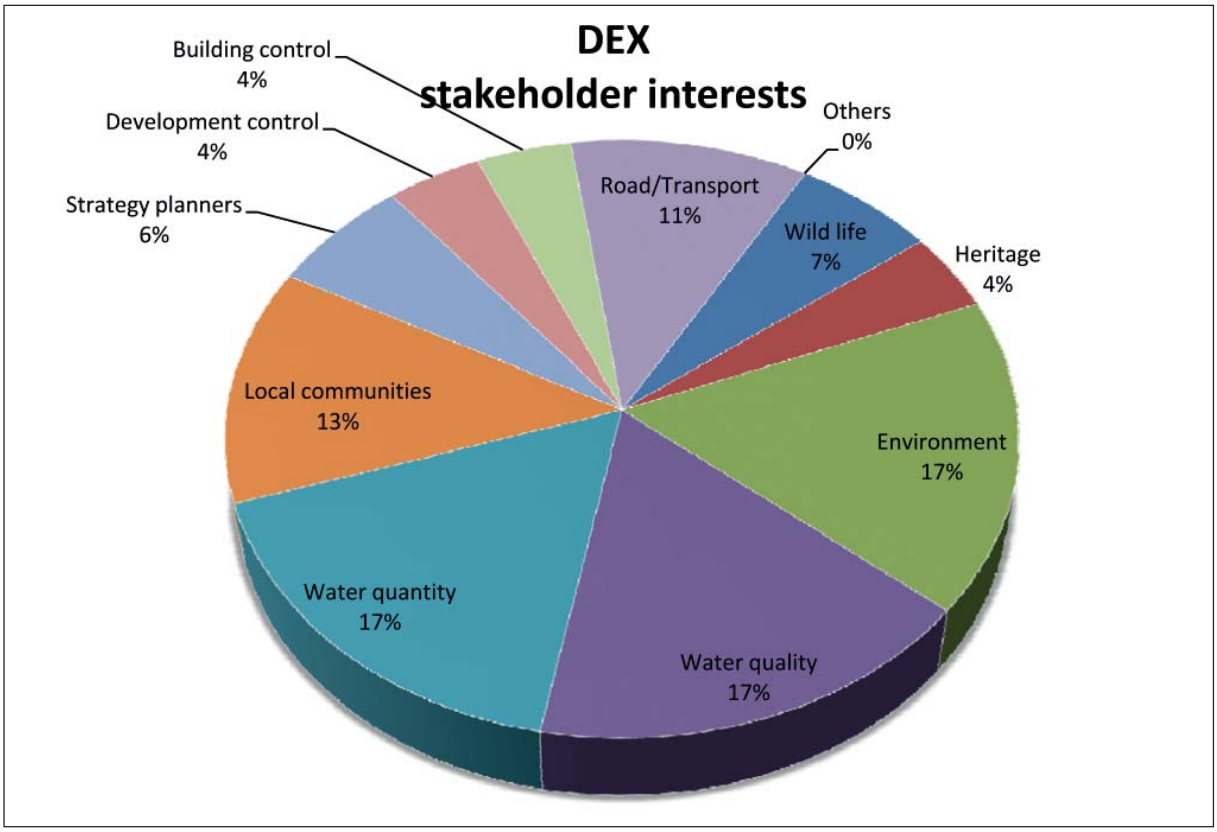
A similar success factor is mentioned in the Solar City development case. Local champions working for different public authorities were seen as the key to success through their ability to convince decision-makers. Mutual trust is mentioned as a key success factor for champions. Mutual trust requires consistent working relations and open communication.

Local champions, supported by consistent political support, long-term working relationships and mutual trust are key success factors for the integration of land and water management.

The Solar City development case shows that the project manager initiated an active cooperation with the regional water authorities to develop a so-called "waterproof" spatial plan. Nowadays, this involvement of the water authorities in development projects is enforced by legislation. Although communication between different stakeholders generally went well, an important exception was the communication about the water quality. Although it was agreed that the surface water quality could be good enough for recreational purposes, but not for swimming, the local municipality created a small beach and communicated (unrealistically) high expectations for swimming to the local press. This has led to resentment by citizens.

Unmanaged media attention may lead to false perceptions of solutions. A timely, active and open dialogue with the media will contribute to awareness and support for sustainable water management solutions.

Looking at the different roles and interests of stakeholders, we often see a dominant position for the municipality, which fills multiple roles at the same time, such as a decision-maker, developer and in many cases land owner. Certainly in large cities, the city council does have many different interests as well as different roles to fulfil. A good example is the CBMDC illustrated by the Devonshire park case study. Depending on the project and the options, this may facilitate the integration of urban land and water planning processes, but there is a danger that the solutions are not widely accepted among the minority of stakeholders with a long-term ownership role, the local community. In those cases, it seems to be of major importance that an independent advisor is taken into the project in order to secure an objective and transparent process. For the CBMDC case, the University of Sheffield played this role. In most other cases, there are many different stakeholders involved, and many of them have an advisory role on different interests


DEX
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Development control
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Strategy planners
6%
Others
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Road/Transport
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Wild life
7%
Heritage
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Local communities
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Environment
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Water quantity
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Water quality
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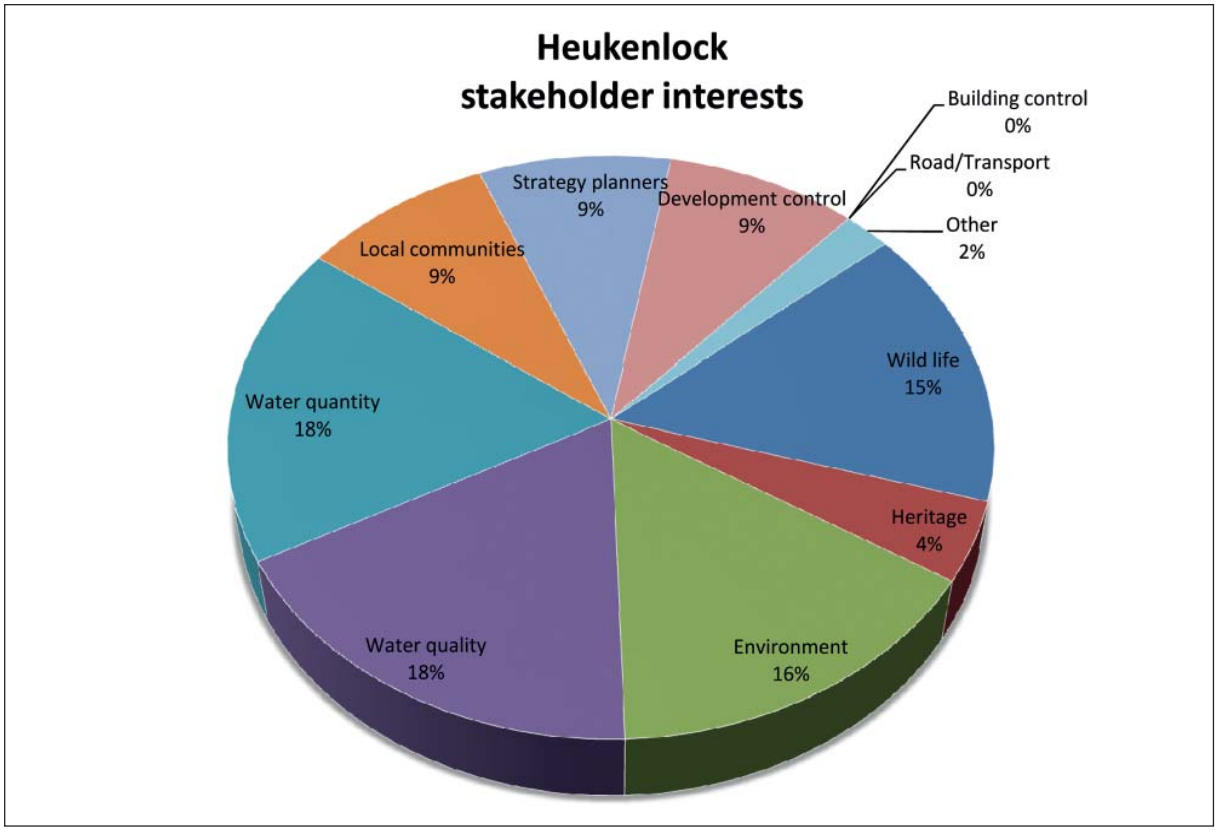
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Environment
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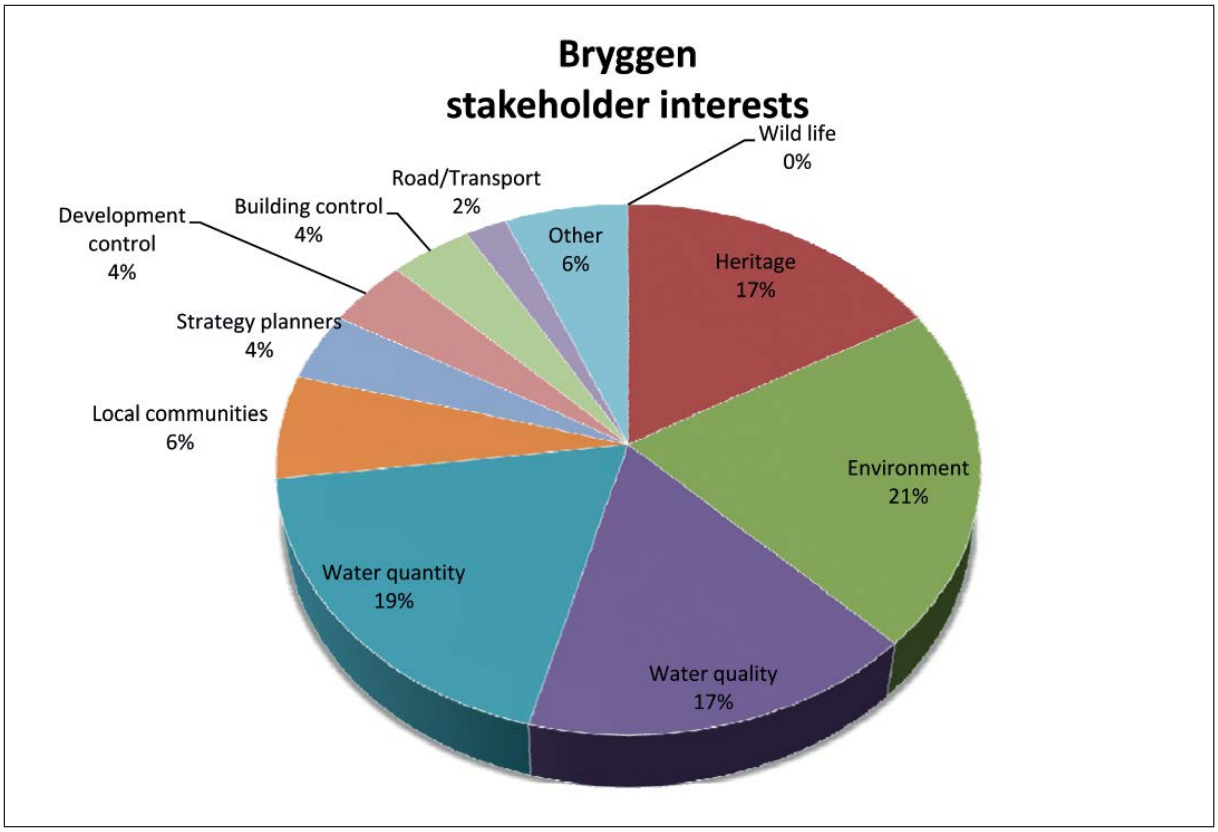
Bryggen
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Building control
4%
Development
control
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Other
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Heritage
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Strategy planners
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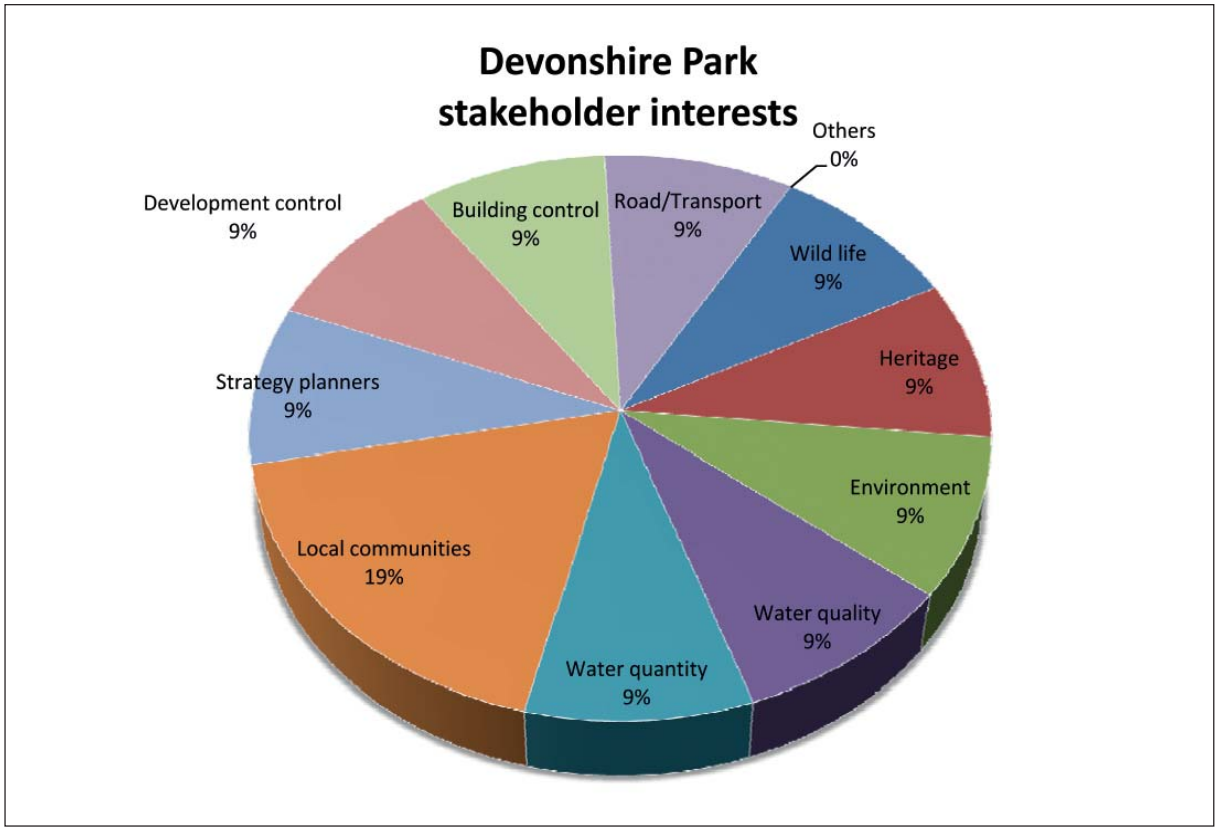
Local communities
6%
Environment
21%
Water quantity
19%
Water quality
17%


Devonshire Park
stakeholder interests
Others
0%
Development control
9%
Building control
9%
Road/Transport
9%
Wild life
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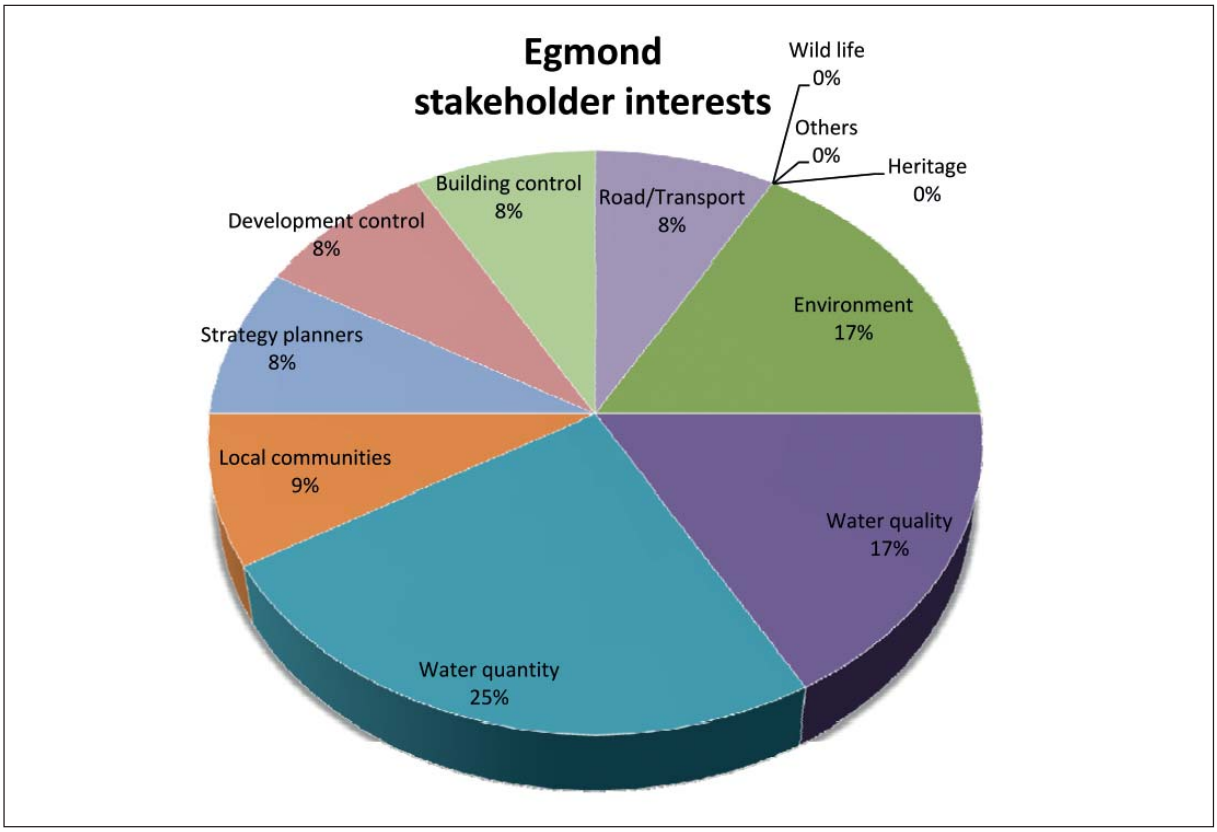
Heritage
9%
Strategy planners
9%
Environment
9%
Local communities
19%
Water quality
9%
Water quantity
9%


Egmond
stakeholder interests
Wild life
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Others
0%
Heritage
0%
Road/Transport
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Building control
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Development control
8%
Strategy planners
8%
Environment
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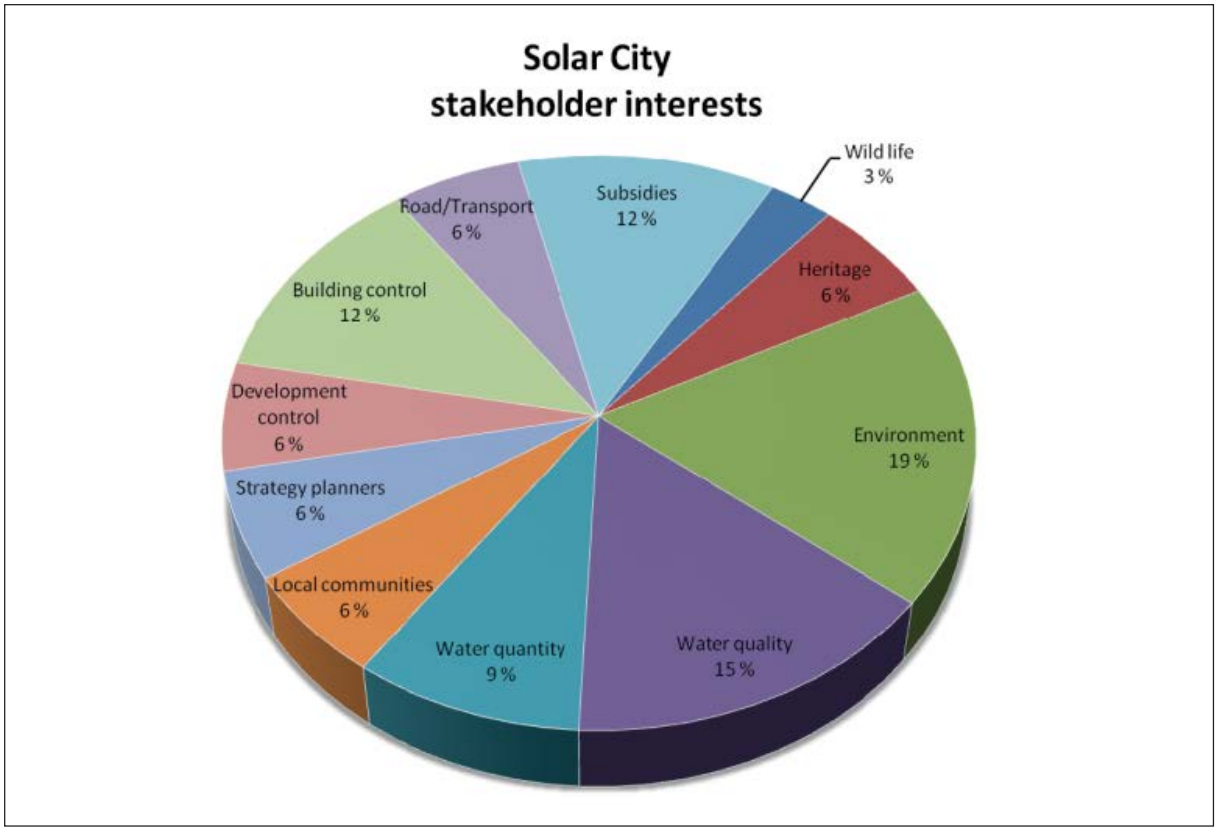
Local communities
9%
Water quality
17%
Water quantity
25%


Solar City
stakeholder interests
Wild life
3 %
Subsidies
12 %
Road/Transport
6 %
Heritage
6 %
Building control
12 %
Development
control
6 %
Environment
19 %
Strategy planners
6 %
Local communities
6 %
Water quantity
9 %
Water quality
15 %

The previous diagrams show the differentiation of the main stakeholder interests for all case studies. In all diagrams, the stakeholders that represent interests in environment, water quality and water quantity are most dominant. In the Bryggen case heritage is clearly important and in the Heukenlock case wildlife interests are significant. The CBMDC Devonshire park case has a very equal distribution because only 3 stakeholders groups are represented, namely the CBMDC, University of Sheffield and the local community. The District Council embodies almost all interests. The number of stakeholders for each case are summarised in Table 1.

Case study	Number of stakeholder groups
Heuckenlock, Germany	10
Bryggen, Norway	18
DEX, Scotland, United Kingdom	14
Devonshire Park, United Kingdom	3
Egmond, the Netherlands	6
Solar City, the Netherlands	13

TABLE 1. NUMBER OF STAKEHOLDER GROUPS

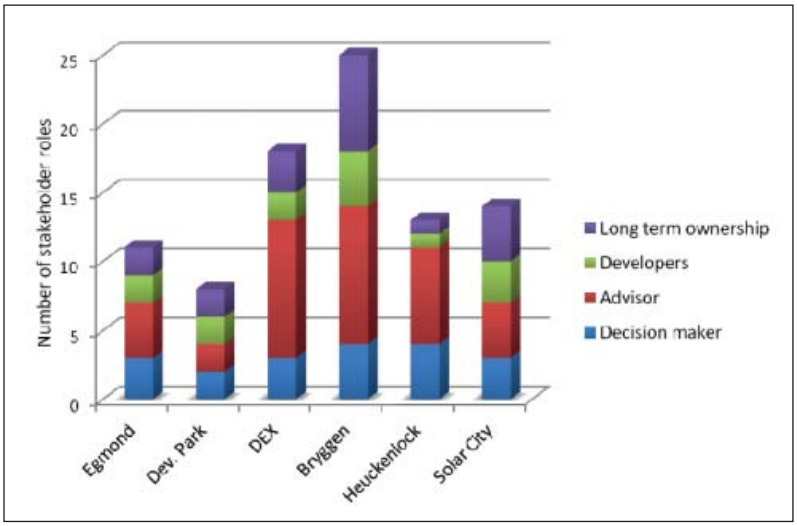


FIGURE 1. DISTRIBUTION OF STAKEHOLDER ROLES

Figure 1 summarises the distribution of stakeholder roles in five cases. The distribution reflects the number of stakeholders, although some stakeholders have multiple roles, such as for example advisor and developer. One may observe that the amount of advisors increases linearly with the amount of stakeholders. Particularly in complex cases with many stakeholders, such as Bryggen, the trend is that each stakeholder is represented by its own advisor.

WATER MANAGEMENT REGULATIONS AND PROCEDURES

The presented cases show a wide range of regulations and procedures that influence the integration of land and water management. These have evolved over time. The DEX case in Scotland, one of the first major developments where SUDS were stipulated within planning permissions, was initiated due to active promotion of surface water BMPs as an alternative to traditional drainage by the Forth River Purification Board (FRPB, now SEPA) in the mid-1990s. This was predominantly driven by a realisation that a change in drainage paradigm was

needed to address chronic long-term qualitative downgrading of receiving water bodies. Over time, the application of SUDS in redevelopment plans has become mandatory in Scotland.

The Bryggen case shows that in existing urban areas, regulations that are not directly related to land and water management, such as the Cultural Heritage Act, may be important drivers and regulators for the integration of land and water management. At Bryggen, the foremost aim for the last 20 years has been to protect the subsurface archaeological remains, as recommended in the Charter for Protection and Management for Archaeological Heritage (ICOMOS 1990). Since protection is largely dependent on the groundwater level, one should expect that the Water Resources Act (WRA, 2001) should be applicable. The WRA should ensure that groundwater is used and managed in accordance with the interests of society. However, the WRA unfortunately is mainly focused on groundwater as a drinking water resource and does not provide clear regulations for avoiding stability (settling) problems or the protection of archaeological remains due to drawdown of groundwater, for instance through drainage or pumping. Instead, the Planning and Building Act and the Neighbouring Act are (sporadically) used to avoid damage to neighbouring plots caused by improper water management. A problem is that local authorities have insufficient (technical) knowledge and awareness of possible consequences caused by water balance changes. Possible conflicts are not detected in ordinary planning consent, and there is therefore a risk that problems will not be detected before damage has occurred.

Multiple benefits are lost or become drawbacks when there is a lack of knowledge and awareness among professionals, and procedures and regulations are unclear or too narrowly formulated.

The Solar City case shows that problems related to the integration of land and water management may be dictated by already existing water management restrictions of the development area. Solar City was planned at the lowest part of a polder, which, as an artificial hydrological entity, per definition already has a strictly regulated water management challenge, namely permanent pumping of water to the sea. Further urbanisation without compensating hard surfaces with surface water area would increase the pressure on the water system dramatically. At the same time, the creation of larger surface water bodies does pose water quality issues, threatening the proposed multiple recreational benefits.

Successful integration of land and water management and real sustainable water management is characterised by multiple benefits, rather than by the direct benefits of improving surface water quality or reducing floods alone.

KEY SUCCESS FACTORS

The key success factors that emerge from the case studies are illustrated in the Wordle® on the right hand side. In all cases, stakeholder communication, education and cooperation are key elements. But the appearance of a local champion, either in the municipal planning department, in the political system or in involved consultancy organisations, is also mentioned as a key success factor for the projects.

Appendix A: SKINT Partners

Hoogheemraadschap Hollands Noorderkwartier (lead beneficiary)

Hoogheemraadschap Hollands Noorderkwartier (HHNK) is the water authority in the north-western part of the Netherlands. Most of its management area is below sea level. To keep the country habitable the water authority maintains dikes, manages a system of canals and ditches and maintains pumping stations. This water system enables the discharging if excess water into the North Sea during the winter and to supply fresh water from Lake IJssel in the summer. It also manages the water quality and the aquatic biodiversity. Furthermore, HHNK purifies the domestic and industrial sewage water at a number of purification plants and manages rural (access) roads. It makes it possible for 1.1 million people to live, work and relax in an area of about 200,000 ha.

To ensure current land use and a habitable environment for future generations it is necessary to keep the fragile balance between land use and water management in the Netherlands intact. This balance is mainly threatened in the existing or future urban areas. To overcome this threat, all spatial plans in the Netherlands require a Water Assessment. In theory, the Water Assessment ensures sustainable water management. In practice misunderstandings sometimes lead to poorer relationships and less constructive cooperation with the municipalities. But the worst misunderstandings lead to less sustainable water systems for future generations.

To overcome the misunderstandings, HHNK is participating in the SKINT project. Being the lead beneficiary indicates the importance of this subject for HHNK.

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Research and Transfer Centre "Applications of Life Sciences" of the Hamburg University of Applied Sciences

The Research and Transfer Centre "Applications of Life Sciences" of the Hamburg University of Applied Sciences is the German partner within the SKINT partner consortium.

The river Elbe, as the river Alster and some smaller streams run through the city of Hamburg. Protection and conservation of surface water is a central topic for the city. Particularly in Wilhelmsburg, one of the poorest districts with a high immigrant rate, the integration of environmental protection and water management into urban planning is of great importance. The population on the island of Wilhelmsburg is growing, while the quality of life is decreasing due to noise and a loss of green spaces. Only 25% of the natural flood plains remain because large areas have been dredged for construction projects. Wilhelmsburg may therefore be at risk of flooding from heavy rainfall events and storms.

The University of Applied Sciences participates in SKINT in order to disseminate successful initiatives and tools gathered from regional projects dealing with the protection and conservation of surface water in the city of Hamburg. Hamburg benefits in several ways from the SKINT project. SKINT offers water managers and university staff access to special training sessions organised by the Hamburg University of Applied Sciences. Furthermore, interdisciplinary teams can use the project platform and SKINT events to get and share information about innovative technologies, approaches and processes. Moreover, the project results will be available to stakeholders from spatial planning and water management beyond the project's life time via the SKINT Internet portal and specially designed training programs to foster sustainable water management and effective urban planning practices.

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Urban Water Technology Centre (UWTC), University of Abertay Dundee

The Urban Water Technology Centre (UWTC) was established in August 1993 within the School of Contemporary Sciences at the University of Abertay Dundee. It developed from the activities of a group of staff carrying out research and consultancy work associated with wastewater and environmental management. This has resulted in valuable links being established between academia and industry, which continue to be expanded and reinforced.

The Centre is also fortunate in that it can obtain support from other specialists in the school and from elsewhere in the university, for example in chemistry, computing, microbiology and electronics, as well as a broad range of civil and environmental engineers. The Centre's stated mission is to provide a service to the water industry (in the UK and overseas) in three main areas: research, academics and consultancy. In the many projects carried out to date the Centre has been highly successful in combining academic skills with commercial expertise. A broad range of clients has approached the Centre for advice and assistance, including water companies and authorities, local authorities, manufacturers and private sector companies involved in the construction and civil engineering industry. Typically the Centre has a turnover of some £0.3 million per annum.

Professor Chris Jefferies is recognised internationally for his experience in the planning, design, operation and maintenance of sustainable urban drainage systems (SUDS). He is actively involved with and maintains a high profile for the Centre within international and national bodies.

The UWTC participation in SKINT provides an opportunity to work with a diverse group of European partner organisations engaged with up-to-the–minute, cutting-edge water management issues. These challenging projects provide opportunities to develop understanding of new and innovative solutions, contribute shared experience, and inform the development of new training and guidance material. The UWTC is a recognised centre of excellence for water management within the UK and provides a range of academic and professional development courses. One of the key outputs of the project is the development of an interactive learning computer game – WaterTown. The game reflects current water management challenges within the North Sea Region and has been developed in close partnership with SKINT partner organisations.

In this volume, the exemplary case study "Drainage Improvements to Facilitate Expansion of Eastern Dunfermline" is presented. This case study marks the emergence of new "green" technologies for managing surface water drainage in the UK, actively promoted by the imminent implementation of the Water Framework Directive. This new surface water management process would eventually be known as sustainable urban drainage systems (SUDS) within the United Kingdom.

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Bradford City Council

The City of Bradford lies at the administrative heart of the fourth largest metropolitan district in England, and is located in the county of West Yorkshire, in northern England. It is situated in the foothills of the Pennines, 14 km west of Leeds and 26 km northwest of Wakefield. Bradford became a municipal borough in 1847, and received its charter as a city in 1897. Following local government reform in 1974, city status was bestowed upon the wider metropolitan borough. Bradford has a population of 293,717, making it the fourteenth-most populous settlement in the UK. Bradford forms part of the West Yorkshire Urban Area conurbation, which in 2001 had a population of 1.5 million and is part of the Leeds-Bradford Larger Urban Zone (LUZ), the third largest in the UK after London and Manchester, with an estimated population in the 2004 Urban Audit of 2.4 million (source: Wikipedia).

The Bradford City Council, Drainage Services Unit is engaged in SKINT and Flood Resilience City (FRC) to help better understand the future flood risk management needs for the wider Bradford Metropolitan District. The participation in both projects will provide the Council with practical and useful information to inform residents at risk of flooding where to seek help in the event of a flood and how to recover afterwards. One of the tasks is to deliver case studies to produce a water resources web portal and web-based training programme for water and land use professionals, which will be of benefit to local politicians, professionals and the public (source: www.bradford.gov.uk).

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Pennine Water Group, University of Sheffield

The Pennine Water Group (PWG) is an Engineering and Physical Sciences Research Council (EPSRC) funded Platform Grant centre at the University of Sheffield, dedicated to research into water and wastewater. PWG aims to advance engineering and scientific knowledge across all aspects of potable water, storm water and wastewater service provision and management of associated assets. The strategic vision of PWG is to maintain and extend the breadth and depth of group activities at home, in Europe and overseas. Crossing boundaries is the group's key strength and it is crucial that PWG facilitate the continuing exchange of its research and perspectives. PWG sees opportunities to better link mathematics to engineering and to improve understanding in bio-, eco- and human-related engineering, asset management and sustainability of water services.

PWG is in the process of widening its activities to include the interactions of other types of service and infrastructure provision, such as energy and waste, with the water cycle. As part of this, PWG sees new opportunities in utilising cyber infrastructure for more effective and robust water system management.

The Pennine Water Group comprises academics from a broad range of disciplines, including ecology, social sciences and economics in addition to engineering. PWG has an active research programme, ranging from theory-driven fundamental research, through numerical modelling to industry-led applied research and consultancy. PWG has strong links with a number of UK industrial and European partners, and its work is steered by an International Advisory Group. New initiatives include a recent strategic partnership with Yorkshire Water, which is funding mutually beneficial research over the next 5 years.

PWG is participating in SKINT to help disseminate the outputs of relevant research to a wide audience of practitioners. It is working in collaboration with Bradford City Council to help in the establishment of a community of practitioners associated with urban design and management to share knowledge and experience in drawing land and water management together.

In this volume, the case study developed by Bradford City Council and the University of Sheffield is about flood alleviation. "Devonshire Park and Mayfield Road" is an exemplary case on flooding caused by excessive overland flow and a steep-sided valley. The chosen solutions have been implemented.

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Technical University Delft (TU)

The main activities of the Water Resources Section of the Technical University Delft are the analysis of water movements on and through the ground and to make these water resources available for human use. The section consists of a Chair of Hydrology and a Chair of Water Resources Management (WRM); the latter is participating in SKINT.

WRM conducts research on irrigation systems, polders, urban areas and complete river basins. Its aim is to support water management practices by increasing understanding of water management processes, providing know-how and expertise, and offering an independent view. To this end, the Chair collaborates closely with water managers and stakeholders.

The Chair of WRM applies a broad, interdisciplinary approach to water management issues. The tools that are used in research range from data assimilation and remote sensing to real-time control and legal and stakeholder analysis. The issues studied include floods and droughts, climate change, water pollution, performance, international conflicts and IWRM.

In this volume, the innovative case study “Flood mapping in Bergen, the Netherlands” is presented. Due to climate change, urban areas will flood more frequently. In order to make cities more resilient to flooding, more space for water at ground level is needed. The main problem is how to convince professionals concerned with planning and maintenance of urban areas of the importance of space for water. To improve this situation, a novel method for mapping urban storm water has been developed in close cooperation with the consulting agency Tauw. It provides easily understandable insight into the above ground flow and storage of water. Due to its straightforward concept the method is understandable for all stakeholders in the urban management process. This, together with the research outcomes from extensive research on Sustainable Urban Drainage Systems, promotes the collaboration of those stakeholders in finding and maintaining solutions.

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Norwegian Institute for Water Research (NIVA) and sub-partners

NIVA is Norway's leading multidisciplinary centre of expertise in water-related issues. NIVA contributes towards water-related competence building and distributes information to academics, politicians and the public. NIVA is to an increasing degree contributing to solutions to water-related issues internationally. NIVA's research and work comprise feasibility studies and evaluations of the state of rivers, lakes, groundwater, fjords and coastal waters. Also, NIVA conducts environmental technical research related to water purification, industrial processes and biotechnology aiming to find practical solutions to environmental problems in water. The institute is also working to improve the methods of complete management and use of water resources (integrated water resource management), and develops action plans to improve the environment. NIVA is a foundation established on 1 July 1958.

NIVA participates in SKINT because it provides a unique opportunity for a national and international collaborative approach to increase knowledge and awareness regarding the relation between urban water management and preservation of cultural heritage. To strengthen the multidisciplinary approach for the SKINT project, and to address the link between water management and cultural heritage protection, a national consortium has been established with the following organisations: the Norwegian Institute for Water Research (NIVA), the Directorate for Cultural Heritage (Riksantikvaren), the Geological Survey of Norway (NGU) and the Norwegian Research Institute for Urban and Regional Research (NIBR). Riksantikvaren, NGU and NIBR are formally participating in SKINT as sub-partners under NIVA. The sub-partner institutions are described in the following pages.

The main goals for the Norwegian team are:

- to link groundwater, surface water and sustainable management of cultural heritage in urban areas, early in the urban planning process;
- to develop guidelines for management of ground and surface water in urban areas with water-sensitive cultural heritage;
- to identify methods for surface water management that are suitable for use in areas with cultural heritage, and take into account groundwater level, water quality and climate change;
- to improve national guidelines and work for a national directive for urban surface water management.

In this volume, the case study "The water that buoys up Bryggen" is presented. This case study clearly illustrates the strong relation between cultural heritage preservation and water management. It highlights the necessity of increasing knowledge and awareness about this relationship among urban land and water planners, to protect our non-renewable cultural heritage resources.

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Directorate for Cultural Heritage in Norway (Riksantikvaren) sub-partner under NIVA

The Directorate for Cultural Heritage in Norway (Riksantikvaren) is responsible for the practical implementation of the Norwegian Cultural Heritage Act and the objectives laid down by the Norwegian Parliament (Stortinget) and the Ministry of the Environment. The Directorate's task is to facilitate sound and efficient heritage management throughout the country. Cultural heritage monuments and sites dating prior to 1537 and standing structures dating prior to 1650 are automatically protected through the Cultural Heritage Act.

The Directorate for Cultural Heritage is responsible for the management of all archaeological and architectural monuments and sites and cultural environments in accordance with relevant legislation. It is responsible for ensuring that a representative selection of monuments and sites from all periods is preserved for present and future generations. The selection of monuments and sites must provide an overview of historical developments, the way of life and the range of works of art and craftsmanship of each period. It ensures that cultural heritage considerations are taken into account in all planning processes, and that the interests of cultural heritage are safeguarded at all levels in the same way as the interests of society as a whole.

The Directorate for Cultural Heritage comes under the environmental management umbrella, and answers to the Ministry of the Environment. The Directorate collaborates with other directorates in the environmental sector wherever appropriate. Through education and information it is responsible for increasing awareness among the general public about the value of cultural heritage. It is also the appeals body for decisions made by cultural heritage authorities at county and regional levels.

The Directorate for Cultural Heritage participates in SKINT to increase knowledge and awareness among urban land and water planners and other professionals on the role of water in the preservation of cultural heritage. Cultural heritage is regarded as a non-renewable resource that in many cases is threatened by changes in the water balance. The Norwegian government states that it wishes to "preserve the 'underground archives' and at the same time establish conditions for continued use of the pertinent areas and the development of the vital inner cities". In order to achieve this, a more holistic and integrated approach to urban land and water management is necessary, where water needs to be considered early on in the development process.

The Directorate for Cultural Heritage in Norway is responsible for the implementation of a research and development and a maintenance programme at the World Heritage Site of Bryggen in Bergen, Norway.
In this volume, the exemplary case study "The water that buoys up Bryggen" is presented.

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THE GEOLOGICAL SURVEY OF NORWAY (NGU)

SUB-PARTNER UNDER NIVA

NGU is the national institution for knowledge on bedrock, mineral resources, surficial deposits and groundwater. NGU is a government agency under the Ministry of Trade and Industry (NHD).

NGU's mission is to actively contribute to ensuring that geoscientific knowledge is utilised for the effective and sustainable management of the nation's natural resources and environment. As a research-based agency, NGU also advises other ministries concerning geoscientific matters. NGU's main tasks are to collect, process and distribute knowledge of the physical, chemical and mineralogical properties of the country's bedrock, surficial deposits and groundwater.

NGU is the national institution for knowledge on groundwater, with responsibility for mapping groundwater resources, the National Groundwater Database, applied research and method development. As the national authority for water basins since the Water Resources Act, NGU collects well data and reports on groundwater investigations, conducts research and disseminates knowledge about groundwater to users in the public and private sectors, as well as to the general public.

NGU's motivation to participate in SKINT is to increase knowledge and awareness on the role of groundwater in urban land and water management. Urbanisation and (re)development lead to larger impervious areas. This changes the character of drainage basins and the water balance, posing new challenges that need to be addressed. Important, but often underestimated hydrological effects are reduced infiltration and lowering of the groundwater level. To quantify and address possible adverse effects, systematic urban hydrological data collection and a more holistic data interpretation are necessary. The strong relation between cultural heritage preservation and (ground)water is one of the drivers for a better integration of water in urban land development processes, which includes cultural heritage management.

NGU is one of the participants in the research and development project at the World Heritage Site of Bryggen in Bergen, Norway. In this volume, the case study "The water that buoys up Bryggen" is presented. NGU was responsible for research related to groundwater flow analysis and modelling, in cooperation with other participants in the Bryggen project. See also NIVA, main partner for the SKINT Norway team.

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Norwegian Institute for Urban and Regional Research (NIBR) sub-partner under NIVA

The Norwegian Institute for Urban and Regional Research (NIBR) is an independent social science research centre whose mission is to develop and publicise research-based insights for the benefit of decision-makers and other members of society.

NIBR's vision is to further develop urban and regional research as an inter- and multidisciplinary field of study with a global perspective, thereby strengthening the Institute's position as one of the foremost Norwegian and leading European environments for urban and regional research. The Institute aims to be a competitive contributor to research programmes under the auspices of the Research Council of Norway as well as to international research programmes, e.g. the EU framework programmes.

NIBR's core competency is in urban and regional research. This is a wide inter- and multidisciplinary field of social science research, encompassing inter alia:

- analyses of social conditions and societal changes in urban and rural areas, and across regions, sectors and levels;
- analyses of regional development and innovation, planning and management, and the development of democracy and welfare within and across local communities;
- territorial analyses of society, coupled with studies of sustainable development.

NIBR is one of the environmental research institutes of Norway. Through its competence in the field of social science, the Institute strives to contribute to the growing knowledge base required to better meet environmental challenges and the problems entailed by social development.

NIBR participates in SKINT because it links up to other similar projects: together with NIVA and other partners at CIENS, NIBR has for instance been involved in a large project initiative for adaptation to climate change in urban and sub-urban areas in the greater Oslo region.

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