FloodProBE Pilot Sites - An Introduction

An overview

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FloodProBE is co-funded by the European Community Seventh Framework Programme for European Research and Technological Development (2009-2013)
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Disclaimer

Summary

The report is summarizing the overview of pilot sites of the project FloodProBE and relevance to pilot activities, which are carried out there, under the different workpackages of the project. The contacts to main pilot site stakeholders are documented.

Representatives from all these sites are members of the associates programme and are involved in the discussion of the pilot activities.

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1 Introduction

The FloodProBE project is under WP5 (PILOT SITES) focusing the integration of RTD around pilot sites at Prague (Czech Republic), Orleans (France), Dordrecht and Rotterdam (The Netherlands), Oslo (Norway) and Hull (UK).This is helping to ensure that direct end user needs are met and that outputs are practicable. This task is organized to 'tuning' of the research needs at the start of the project in order to achieve a consistent approach for the pilot activities in all work packages and integration of effort.

The pilot sites integration includes following activities that are reflected in the report:

- setup and maintenance of contacts and communication with authorities at pilot locations
- organization of stakeholder involvement in the definition of overall pilot objectives
- planning and scientific coordination of integrated pilot actions
- final compilation of pilot results and lessons learned.

2 Prague Pilot Site

2.1 Pilot site description

Figure 2-1 Flooding in Prague, May 1872 (Charles Bridge)

Prague is the capital of the Czech Republic with about 1.5 million inhabitants. It is located at the river Vltava (Moldava). In 2002, Prague received significant damage from what were deemed to be the worst floods to hit the capital in 200 years. Among the regions of the capital city most severely affected were: Karlín, Kampa and Holešovice, where there was significant risk of building collapse. Most of Prague's art work was saved due to advanced warning of high water levels; however, there was significant damage to the Prague metro subway system whose tunnels were completely flooded.

There are several kinds of local flood protection measures in Prague including lines of mobile barriers, which are used uniformly on the entire area of Prague, primarily in the historic urban centre. The total length of these mobile barriers is about 7 km in Prague. The dam bar system was created by the firm Eko-System and was finished only 5 months before the flood in 2002. If a flood is announced in time, appropriate precautions can be taken. There is planned every year training for the correct installation of the mobile barriers in case of a flood.

Following the experience from the 2002 floods, mathematical models, and other background materials, further changes were carried out to the protection system and to projects to provide for much more perfect protection of Prague.

2.2 Pilot site relevance to FloodProBE project

Main relevance to FLOODPROBE project tasks:

- Concepts and technologies for multifunctional flood defences (Task 4.1)
- Dissemination of the best practices - use of demountables (Task 6.2)

Relevance to Task 4.1:

In the majority of larger towns (as is Prague), watercourses are regulated in their full length. To regulate them, systems of flood control dikes, embankments, bank walls and defences and river channels are used. In the course of a year, water level often significantly fluctuates and the majority of such structures are periodically at least partly flooded. This may result in gradual deterioration of protective structures and their surroundings. Similar loads may concern also certain structures in the close vicinity of the rivers, for example, bridges, metro tunnels, etc.

From time to time, there occur extraordinary flood situations – as in 2002 in Prague, requiring for the protection of a town to use also **mobile elements of flood control**, such as mobile walls, temporary dams and protection elements for individual structures. They should be used to protect a built-up area including mostly historically valuable objects against flood.

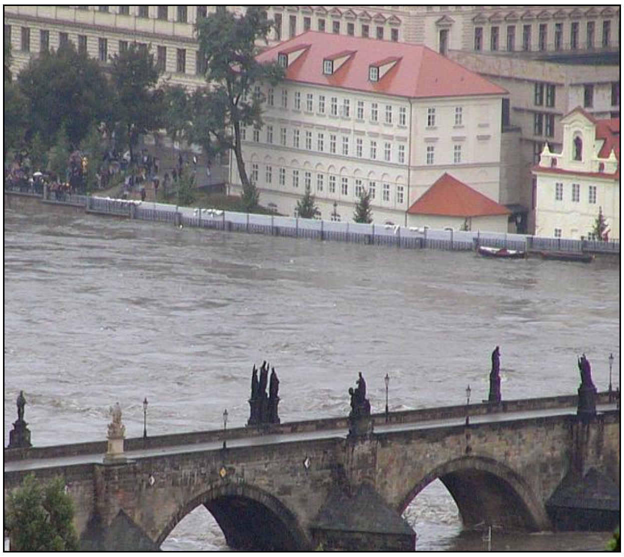

Figure 2-2 Flooding in Prague, use of the mobile barriers

Relevance to Task 6.2:

All the flood control facilities that Prague has constructed since the catastrophic floods of 2002 were erected and tested in July 2006 in real time and life conditions, similar testing is planned for the 2011, where the participation of the project team could be assured.

Potential relevance:

Relevance to Task 3.2 (if the stakeholders in Prague are interested and could co-finance the measurements)

Geophysical measurements proposed to be applied within FLOODPROBE project.

In Prague, the geophysical methods can be applied to monitor the disturbances of protective structures (their routine maintenance), and also to diagnose damage after extensive floods. The design of application of the geophysical methods could be based on experience gained by REC CR team in addressing the consequences of disastrous floods in Prague in 2002. However, for the financing of such activities, the additional funds must be found (national, from different RTD projects, etc.); without this additional financial support the geophysical measurements will not be carried out, on the pilot site Prague.

In application of the geophysical methods in the towns, it has to be kept in mind that the use of certain methods is limited by frequent occurrence of underground distribution systems, building foundations, by the existence of stray electric currents and high level of vibrations caused by traffic. In maintenance of protective flood control structures, complex of the following methods is mostly applied:

- geological radar GPR,
- resistivity tomography,
- seismic methods including seismic tomography,
- microgravimetry.

For the diagnostics of damage in geological layers below the structures and roads, combination of microgravimetry with GPR turned out to be the best. For example, after the floods in Prague in 2002, „mass“ application of these methods served for control of cavity occurrence in the layers below the roads prior to their putting into operation. Only during the first 2 months after the floods, measurements were performed for approx. 200 km of flooded roads in Prague. In this period of time, the team performed 600 km of radar measurements and measurements of approx. 2000 gravimetric points.

Our experience clearly shows that the interpretation of the diagnostic measurements is of higher informative value if comparison of the measured data before and after flood can be done. For the event of Prague flood, in certain cases we could use as a starting point the database of radar measurements on roads which is administered by TSK Praha (Technical Administration of Roads). The database mainly served to complement building documentation and as the grounds for road maintenance system. Its exploitation in relation with the floods was entirely new and unexpected application.

Within the FLOODPROBE project, based on the pilot site Prague experiences, REC CR could prepare a draft of coherent methodology of the geophysical measurements for the monitoring and maintenance of protective flood control structures in the towns (relevant to WP3).

Based on the experiences from Prague pilot site, we propose to test the use of geophysical methods also on the other pilot localities of FLOODPROBE, as Trondheim, Orleans and/or Rotterdam, if local partners are interested and could support these activities. The geophysical investigation on the other test sites would respect the specificities of flood control measures at a given location or the specificities of built-up area in the river floodplain.

Possibility of the transfer of geophysical experiences from Prague to the other pilot site(s):

Use of the GMS (Geophysical Monitoring System) on the pilot site Humber estuary, in the frame of the cooperation between the FloodProBE project and EUREKA project E!4584 eGMS (Development of the modular system for application in the IWRM practices and floods prevention, organization of eGMS database.

The scope of fieldwork was agreed by eGMS project consortium at the meeting in Prague on 17 – 19 March 2010 and the geophysical measurements were conducted between 7 June and 14 June 2010 in three localities as follows:

- locality A – Tidal embankment Humber Estuary
- locality B – Fluvial embankment of Ancholme River
- locality C – Coastal Embankment Immingham.

The results are reported as the independent report WP03-01-10-02.

2.3 Stakeholders

Representatives of pilot site PRAGUE:

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3 Humber Estuary Pilot Site

3.1 The Humber Estuary

The Humber estuary (see Figure 2.1) is very dynamic with a tidal range of up to six metres near the mouth at Spurn Head. High water levels vary along the estuary, being up to one metre higher (and one hour later) at Goole than at Spurn. Severe storms can raise water levels by up to 1.5 metres above normal and result in waves up to four metres high near the mouth, although upstream of the Humber Bridge waves are rarely more than one metre high.

Figure 3-1 Humber estuary

Sea levels have risen relative to the land at an average rate of about one mm per year over the last 4000 years, although over the last 100 years the rate has almost doubled. About 6 million tonnes (dry weight) of sediment enter the estuary each year, most of it from the North Sea and the eroding Holderness Coast with less than three per cent from the rivers. Much of the material brought in from the sea returns on the subsequent tide but it appears that enough stays to ensure that the estuary remains roughly in balance. Nevertheless the foreshore is eroding and threatening the defences in places, particularly along the Immingham frontage, near Winteringham and in the rivers (where regular works are needed to protect the banks).

In the future sea levels around the UK are predicted to rise more rapidly and severe storms to become more frequent, increasing the risk of tidal flooding on the coast and near estuaries. In the Humber, the rate of rise is expected to average about six mm per year over the next 50 years, so that sea levels will be about 300 mm higher than they are now. As a result there will be a dramatic reduction in the standard of protection provided by the estuary’s defences. In addition, model studies of the estuary indicate that seaward of Trent

Falls the inter-tidal area in front of the defences (the area between high and low water) will decrease by up to 600 ha over the same period due to the predicted rise in sea level, a phenomenon known as ‘coastal squeeze’.

The model studies also indicate that moving defences located seaward of the Humber Bridge (Figure 2.2) will have little effect on estuary processes or defences elsewhere. Modifying defences landward of the bridge however, would lower flood levels if extra flood storage is created as a result. The lower levels could postpone the need for other works.

Figure 3-2 Humber Estuary showing Humber Bridge

The estuary’s defences protect nearly 90,000 ha of land from flooding, about 85% of which is farmed and is among the best and most productive agricultural land in the country. More than 300,000 people live or work in the floodplain (see Figure 3), mostly in the towns and cities that occupy about eight per cent of its area.

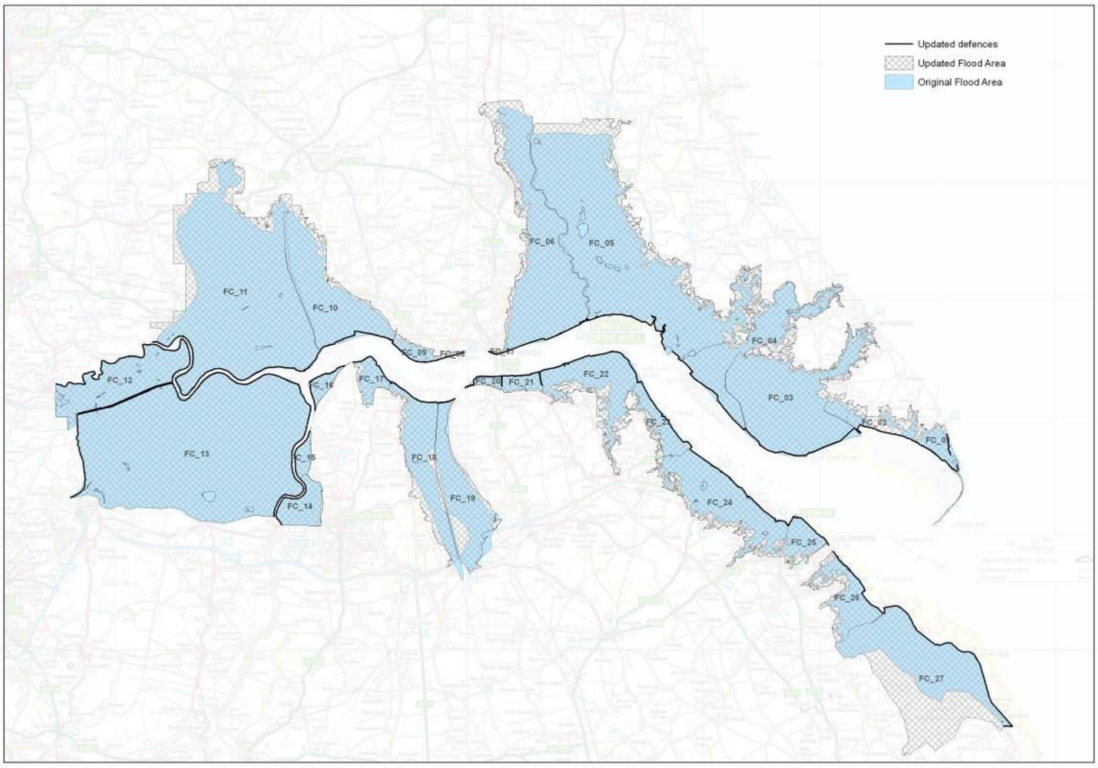

Figure 3-3 Parts of the Humber estuary subject to flooding

The floodplain also contains major concentrations of industrial and commercial properties, particularly between North Killingholme, Immingham and Grimsby, near Hull and at Goole and Flixborough. These include power stations generating much of the country's electricity, refineries producing much of its oil and the country's largest port complex, which handles over 80 million tonnes of cargo each year.

Future development aims for the area are set out in current structure and local plans, which are due to be replaced by a new system of Regional Spatial Strategies and Local Development Frameworks. The Yorkshire and Humber Assembly's Regional Economic Strategy indicates that the estuary, its assets and its hinterland are integral to the delivery of sustainable economic growth for the area. Substantial areas of the floodplain near Hull and Immingham have been earmarked for industrial development, and there are increasing pressures for residential development in various places on the floodplain.

3.2 Pilot sites within the Humber Estuary

Sites within the Humber estuary have been selected for UrbanFlood to take advantage of being able to set the localised UrbanFlood studies within the context of wider strategic studies being carried out across the whole estuary. These whole-estuary studies are supported by parallel UK-funded research programmes (Flood Risk Management Research Consortium 2 - FRMRC2; FLOODsite into Practice; Modelling and Decision Support Framework 2 - MDSF2). The studies involve carrying out a Risk Assessment for Strategic Planning (RASP) flood systems analysis study for the whole estuary to obtain an overall picture of the residual floodplain risk and the contribution to this from individual assets. In addition to this present day view, and following the logic set down in Tasks 14 and 18 of the FLOODsite project, future flood risk across will be explored for two well-defined management strategies for the existing defences over a 100 year timeframe.

Two locations are being considered for evaluation within this study. The first is the city of Hull on the north shore which was subject to serious inundation and evacuation of residents for prolonged periods following major pluvial floods in June 2007. Here the focus of the study is likely to be on the damage and repair measures to properties rather than on the defences. At the second site, the industrial town of Immingham on the south shore, the focus will be on the flood defences. These defences protect both residential property and heavy industry including oil refining. The focus of the short note is on the approaches being considered for evaluation of the defences

3.3 Pilot site relevance to FloodProBE project

Along the Humber there are a number of simple earth embankments of uncertain age, the composition and performance of which is not known. Under WP3, the development of improved understanding of failure processes, the piloting of the use of geophysical methods and the development of integrated assessment methods can all be trialled on the Humber embankments and provide feedback as to their usefulness/appropriateness, particularly in regard to understanding fragility and breach.

3.4 Stakeholders

The principle stakeholder is the Environment Agency and the engineers who have been identified as the principle point of contact are:

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4 Orleans Pilot Site

4.1 Pilot site description

Figure 4-1 Last flood event in Orleans Region, December 2003

The Conseil General du Loiret has a strategic role in a territory of 7,000 square metres with 620,000 inhabitants, holding responsibilities for the larger community, namely:

- Ensuring the continuity of public services: social security benefits, school transport, interurban transports, road infrastructure, electric power supply, schools, rest-homes,
- Reducing the damage to properties owned by the “Département” and to its employees,
- Speeding the return to normal for the Département and for the services it provides after the crisis.

In this respect, the “department” wants to reduce the cost of the economic damage due to flooding and to expedite the return to normal after the crisis by

- Re-opening the roads for the transport of goods and the movement of workers
- Securing electricity supply customers
- Fulfilling its strategic role with respect to the wellbeing of businesses and the community.

The “Département” sets out through good financial management practices to provide good support at reasonable cost to the generators of employment of wealth within its boundaries. The minimisation of the cost of rebuilding and re-establishing infrastructure and networks after a flood is part of its action plan.

The Community of Orleans City-Loire is a local government organisation bringing together 22 municipalities within the vicinity of Orleans which serve a total population of 270 000 inhabitants. The agglomeration constructs, owns and\or administrates a range of assets including; administrative sites, roads, wastewater treatment plants, networks, technical centres and economic zones. It also supplies a variety of services to the population and to the local organisations such a waste collection and treatment and public transport.

Because the Loire flood plain lies at the heart of the agglomeration it is important that flood risk management and the reduction of flood vulnerability should become and integral part of all activities.

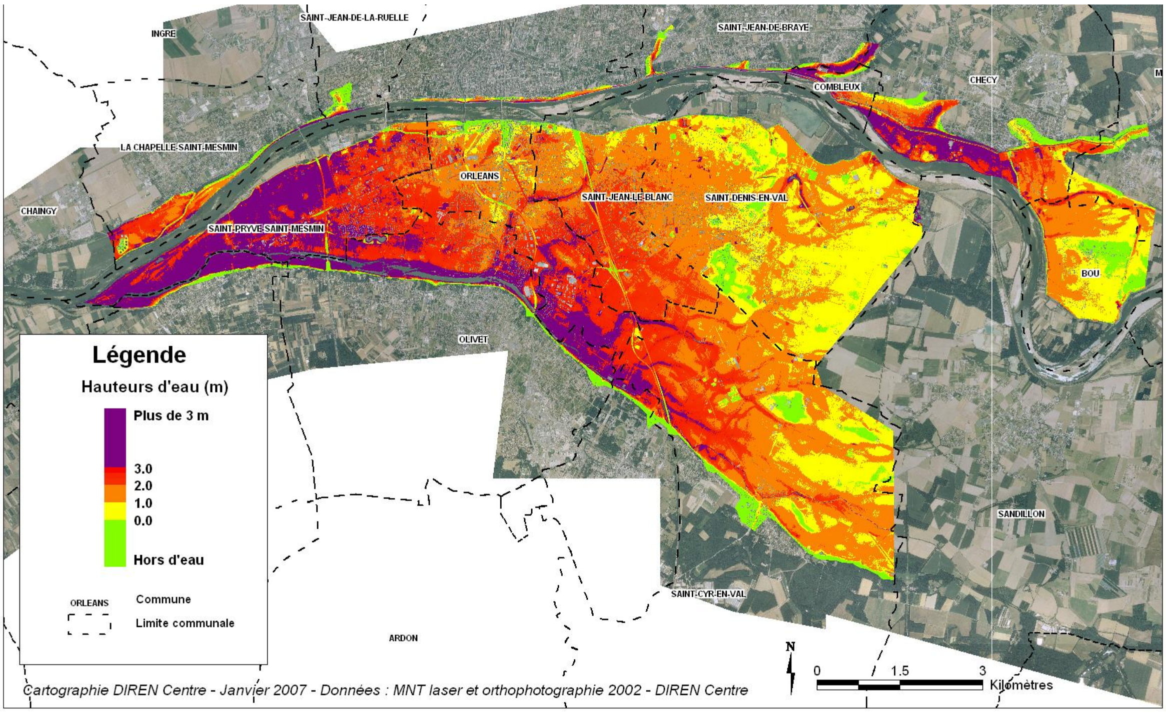

Figure 4-2 Expected height of water in the Orleans Agglo (based on highest water level known)

Because of the extent of the Loire flood plain, the **Ville d'Orleans** has established Flood Risk Management as one of its top priorities. Today, Orleans is committed to reducing its vulnerability by taking new adaptive approaches to sustainable flood risk management and flood risk management planning. During the recent years, the City of Orleans has been working on flood issues through information campaigns, spreading knowledge about floods in the communities and raising awareness. It is also putting in place rescue and recovery plans for the population and public services. The aim is to minimize damages and enable the City to recover as quickly as possible after flood events.

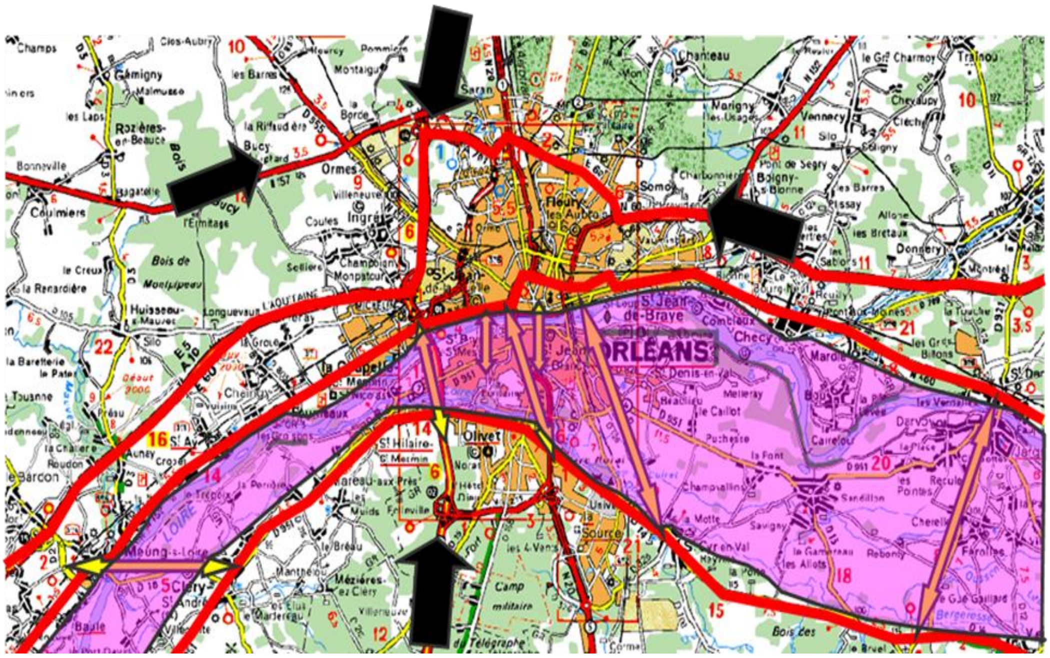

Figure 4-3 Vulnerability of mobility

Scope of Orleans demonstration project

The three organizations which are working together have the following aims:

The Conseil Général de Loiret started a preliminary investigation of flood risk and its management in the “Middle Loire” shortly after the turn of the century. This preliminary stage which scopes and quantifies the work associated with flood risk management has also identified the organisational requirements within the Conseil Général de Loiret which employes over 2,000 people. The second, operational stage of the project is now under way. This work is being carried out in parallel with the Agglomération d’Orléans” and Ville D’Orleans which work at different scales. The State (Prefecture) is also carrying out similar work and the “Etablissement Public Loire” which works over all the Loire river basin and which includes 19 “départements”, has included actions in its priorities which financially and technically support the resilience of public infrastructure networks. The aim is to develop the emerging dynamic at all grades of the administration to address this issue of resiliency within the public services, utility organisations and the wider public.

The work with the wider public aims to increase their awareness of flood risk and how to reduce their vulnerability to flooding. This will be achieved by means of modelling to identify the probability and consequences of flooding within flood plains within which some 48,000 people lived and work. Other work will help to speed the process of restore normal life once a flood occurs, including the resumption of sewerage services by reduction of their vulnerability. It is also intended to raise awareness and resilience though the promotion of a civil defence reserve that will be integrated with the Local Flood Rescue Authority.

In addition to the risk associated with river flooding, there are also concerns about the impact of rising ground water levels. Therefore it is intended to carry out ground water modelling to help assess the joint probability of flooding from both sources. Finally, a communication strategy will be developed to raise the awareness of the politicians, professionals and the general public to take adaptive measures in association with the spatial planning and development of the city.

4.2 Pilot site relevance to FloodProBE project

Conseil Général du Loiret, Agglomération of Orleans and City of Orleans are involved in a policy of vulnerability assessment and reduction. They focus theire activity in reducing vulnerability of:

- Buildings (houses, flats, companies...);
- Networks (energy supply, drinking water, sewer, roads...);
- Public services like waste management.

FloodProBE WP2 is focused on such activities and these three stakeholders are very interested in the deliverable that will be produced. Testing and assessing the results of WP2 on Orleans Region is wished by the three stakeholders.

Also, due to the extent of the Loire flood area, the three stakeholders would like to test the deliverable of task 4.2 dealing with concepts and technologies for damage mitigation and improved flood resilience and for integrated shelter functions in the urban built environment.

DREAL Centre is managing the flood defence assets in the Orleans Region. Most of the flood defences are earth embankments, with a lot of particular infrastructures integrated in the embankments and creating weak spots at the interfaces.

Under WP3, the development of improved understanding of failure processes, the piloting of the use of geophysical methods and the development of integrated assessment methods can all be trialled on the Orleans Region embankments and provide feedback as to their usefulness/appropriateness, particularly in regard to understanding fragility and breach.

4.3 Stakeholders

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5 Dordrecht Pilot Site

5.1 Pilot site description

To deal with increasing flood risk and increasing uncertainty, there is a growing call for integrated flood risk management and climate proofing. However, the actual delivery of an integrated approach and subsequently its mainstreaming faces many barriers and is in its infancy. The EU Floods Directive shyly ebraces the integrated approach, but is yet to be implemented at national level. The EU whtie paper 'Adapting to Climate Change'sets outs a framework to improve EU's resiliency, but is yet to be brought to practice.

The Dutch government recently started pilot projects to test its Multi Level Safety (MLS) approach; for integrated strategies combining 3 safety layers: prevention, spatial planning and crisis management. Key barriers to define and implement truly integrating, long term strategies point towards wicked or persistent problems for which participative strategies deem paramount. This paper proposes and evaluates a design for a participative discision making processes for an official Dutch pilot project for weveral key policy processes: Multi Level Safety, the Dutch implementation of the Floods Directive and first experiences with a climate proofing framework. The pilot area is the island of Dordrecht, an exemplary case study to draw lessons from for the Netherlands and other deltaic regions.

5.2 Pilot site relevance to FloodProBE project

This paper proposes and evaluates a design for a participative decision making processes for an official Dutch pilot project for several key policy processes: Multi Level Safety, the Dutch implementation of the Floods Directive and first experiences with a climate proofing framework.

5.3 Stakeholders

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6 Trondheim Pilot Site

6.1 Pilot site description

The Trondheim Municipality is situated in central Norway on the Trondheim Fjord, 70 km away from the open sea, in Trøndelag County. With around 170.00 inhabitants is Trondheim Norways third biggest city after Oslo and Bergen. The Gulf Stream causes a moderate climate and keeps the harbour during the winter period ice free.

Since 1900 the Norwegian meteorological institute measures continuously temperature and precipitation in the Trøndelag County.

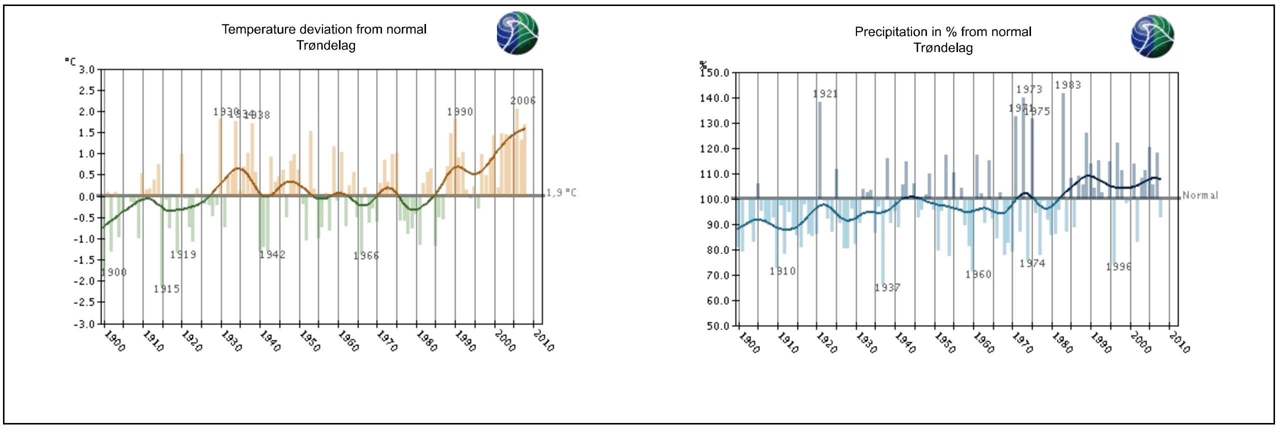

Figure 6-1 shows the deviation in temperature and precipitation according to normal. Nowadays, normal is the period with the average temperature and precipitation from 1961 until 1990. Since 1985 the temperatures were warmer than normal with a continuously increase. Another temperature peak was observed in the thirties. The precipitation increases and since 1982 the values lie continuously over normal.

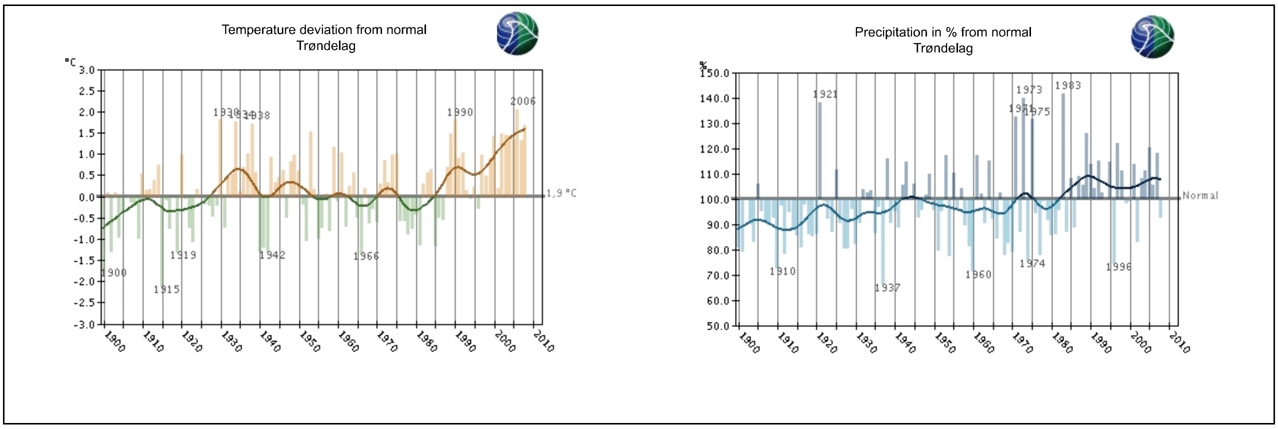

Figure 6-1 Annual average temperature and precipitation for Trøndelag County

Climate scenarios for Trøndelag predict an increase in temperature of 2,5 °C and annual precipitation of 10-20% in 2100. Intensive precipitation sometimes combined with periods of snow melting causes large runoff and flood events in Trondheim. Some historical data from the last main events in the last to decades are summarised in Table 6-1. In the beginning of 21st century, the extreme rain storms and resulting flood events concentrate in summer. Consequently the risk of flood in Trondheim expects to be increase in the future.

Table 6-1 Heavy precipitation, large runoff and flood events in Trondheim

Event	Characteristics for scenarios	Estimated return interval	Consequences
9-10.12.87	First 30-40 mm in 20 hours, 20-30 mm in the coming 6 hours; and snow on the ground equivalent to 20 mm.	10-30 year	Damages on the roads and houses
30-31.03.97	95 mm rain and snow melting in two days.	40 -50 year	About 100 houses flooded and some roads had to be stopped. One manhole cover was lift at one place due to high pressure in the sewers.
30.01-05.02.99	48 mm in 1 day on 04.02.1999	15- 20 year	The flood attacked the whole city. Flood warning on 30 January 1999. Flooding in basements and on roads was registered in large parts of the city, caused million crone of economic damages.
29.07, 2007	Rain from midnight to 7-8.00 in the morning with variable intensity in the whole city.	100 years	60 houses were flooded.
13.08. 2007	Intensive rain in 1 hour	> 100 years	Over 100 houses were damaged by floods.

Flood risk in Trondheim: Trondheim is exposed to three different sources for runoff and flood:

- **Flooding from the river Nidelva**
  Starting form the west-end of the biggest lake in South-Trøndelag the river Nidelva enter after 40 km the city centre of Trondheim and discharges into the Trondheim Fjord. Six hydroelectric power plants are located along the river.

  Due to the large catchment area of 3.178 km^2 the river carries a lot of water. Due to regulations measures which have reduced the discharge about 110 m^3/s compared to the normal conditions smaller floods could be prevented. However, the occurrence of huge flood events could not been avoided (NVE, 2001).

- **Flooding from the sea during storm events**
  Gale-force stroms in the Trondheim Fjord and spring-tides increases the sea-level up to 50 cm and the water level of the river Nidelva due to backflow.

- **Flooding in urban drainage systems**
  The sewer system in Trondheim consist of roughly 50% combined system built before 1965, 40% separate system and 10% non active separate system. About 100 combined sewer systems pollutes the river and the sea during heavy rain and snow melt. On many places in Trondheim the sewer drainage system is not designed for peak runoff discharge. The insufficient capacity of sewer system leads often to flooding.

Consequences of flood in Trondheim

Different generic risk and vulnerability analyses which were conduct already in the Trondheim Municipality show an increase risk for flood and flood related consequences. In periods of heavy rain and snow melting the residents in Trondheim have to expect flooding in houses, polluted drinking water, restriction in transport, power supply and with an increase risk of landslides due to special geological conditions.

Challenges for Trondheim in order to reduce the consequences of floods:

- Better weather forecast
- Advanced risk and vulnerability analyses
- Guidelines for area planning and land use with differentiated safety requirements
- Flood maps
- Safety measures against landslides

6.2 Pilot site relevance to FloodProBE project

Main relevance to FLOODPROBE project tasks:

Identification and analyses of most vulnerable infrastructure in respect to floods (Task 2.1)

Trondheim municipality has to pay sewer-related damage about 0.8 million NOK per year in average since 1981. During 1998-2008 insurance companies in Norway paid in total of 70.5 million NOK per year for flood damage according to the statistics of Finance Norway (www.fnh.no).

Floods in urban drainage systems are mainly due to increased extreme weather events plus highly imperviousness of urban surface, ageing or lower designed systems and slow pace of rehabilitation, which lead to insufficient capacity of storage, conveyance, and event treatment of combined sewage of the sewer systems. Moreover, any failure of the system components, e.g. stop operation of pumping stations due to lacking of electricity supply, collision of the sewers or sewer foundations, ice-blocked inlets and outlets in cold weathers or other operating accidents, may trigger flooding or deteriorate the flood situations, according to the administration annual reports and scientific investigations (Thorolfsson, 2003).

Frequency is used to describe the occurrence of hazardous events. In Trondheim flood risks are coming from rivers, the sea and over-loading of sewer systems. According to the current design standard for sewer systems (Lindholm et al. , 2008), rivers structures (NVE, 2003) as well as planning for buildings in dangerous areas along the rivers (NVE, 2008), the frequencies of potential risk events vary largely from once in one year to once in 1000 years.

6.3 Stakeholders

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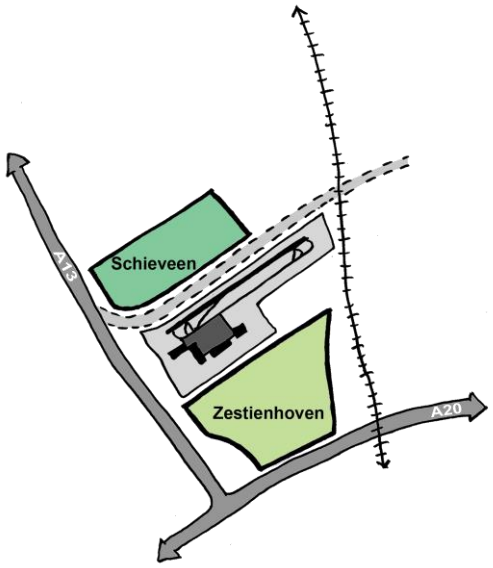
7 Rotterdam Pilot Site

7.1 Pilot site description

There are a few big spatial developments to be expected in the surrounding of Rotterdam Airport. These involve developments on the subject of housing, commercial, mobility and water. These developments can be roughly divided in a northern and a southern part, respectively the developments:

- **Polder Schieveen** into 'new' recreational nature and business park, combined with the construction of a bypass between highway A13 and A16 between this polder and the airport.
- **Park Zestienhoven** into a 'wealthy and green' suburban living environment.



These developments explicitly focus on water, in terms of water quality and water safety. Besides this the ambition of Rotterdam is to play a role in the development and anticipation on flood-risks. With different hot-spot studies, such as the UFM-project Rotterdam, the city tries to estimate the risks of flooding and the measures it can take to reduce damage and evacuation.

In this research vital objects are mapped and looked for locations which can stay (long enough) free of flooding, so called shelters.

Rotterdam Airport can be seen in this light as a vital object for evacuation, but maybe even as the first Emergency Airport in the world connected with a network of shelters!

This memo focuses on the spatial needs to make Rotterdam Airport an emergency airport, in conjunction with the foreseen future spatial developments in the surrounding area.

7.2 Pilot site relevance to FloodProBE project

Rotterdam Airport can be seen in this light as a vital object for evacuation, but maybe even as the first Emergency Airport in the world connected with a network of shelters!

It focuses on the spatial needs to make Rotterdam Airport an emergency airport, in conjunction with the foreseen future spatial developments in the surrounding area.

7.3 Stakeholders

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