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River restoration in an urban environment; sustainable flood defence combined to floodplain reservation

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ABSTRACT: Recently, New Year's Eve 2002, citizens of the town of Breda hardly managed to keep their feet dry. The centre of the town was almost confronted with inundation by the river Mark.

During the last decennia the inundation risk has become more severe and the potential economical damage did so as well e.g. because of the increase of underground infrastructure. The increase of the risk of inundation of the town of Breda is caused by several phenomena. The river Mark and it's tributaries have been channelized. In profit of agriculture the rural landscape has undergone a very effective drainage program. Expansion of impervious surfaces due to the increase of urban populations and industrial developments causes a rapid surface runoff of precipitation water. Global climate changes worsen these phenomena.

To reduce the inundation risk the Waterboard of Brabantse Delta and the Municipality of Breda co-operate in a three stages strategy of retention – storage – discharge. Retention is restored in the upstream river basin and – because of physical circumstances - downstream polders are arranged to function as overflow basins. The river Mark discharges in the Zeeland estuary and a sea level rising is making the stream gradient more and more flat. In an intensively populated area solutions always should be combinations of water management, environmental sustainability, nature conservation and restoration and recreational opportunities for the urban population.

KEYWORDS: flood defence, urban environment, floodplain



left: River Aa of Weerijs entering the town of Breda, New Year's Eve 2002 right: Ring canals almost flooding

Inundation risk of the town of Breda

Breda is one of the five major towns of North-Brabant, one of the southern provinces of the Netherlands. It has 164.500 inhabitants. Because of the fact that the urban conglomeration of Amsterdam, the Hague and Rotterdam is getting intensively populated, maybe

over-crowded, urbanization is expanding in the direction of North-Brabant and well ... Breda is the first town they meet.

Geographically Breda lies on the boundary line between Pleistocene sands and Holocene clay. Lowland rivers, gentle gradient combined with a big discharge, flow from the south to the north, bending to the west where they meet the clay region.

The name Breda can be explained as - in Dutch - Brede Aa and means 'broad river'. In Breda the river Mark flows together with the river Aa of Weerijs. In former times Breda was a fortification, with city walls and a moat, a ring of canals around it and also nowadays the canals are still characteristic for Breda. In fact, through these canals the rivers Mark and Aa of Weerijs pass the town.



Map of Breda, rivers and rivulets and the overflow basins in the north

Formerly the rivers secured living in this place, but once in a while they are a threat. The river Mark originates from Belgium. The gradient of its origin up to Breda consists of a difference in height of 20 m, from Breda up to the Zeeland estuary it's only 1 m! Northern town quarters of Breda have a polder regime, situated below high water levels of the river Mark and depending on pumping engines to get rid of precipitation and seeping water.

In Breda the stream stops up, looses its load of sand and smaller particles. In a way Breda is a natural bottleneck in the stream of the Mark and its tributaries.

The waterboard managed to reduce the inundation risk to 1/50 years, but even that is nowadays not an acceptable risk. Breda is in the present time highly developed and densely populated. New town quarters are being built. A lot of modern infrastructure finds its place in the ground e.g. glassfiber communication networks, telephone, electricity, sewers. New buildings have basements; in one case it's even a hospital with its operating rooms below waterlevel. Our ambition is to bring back this risk to 1/100 years.

Changing circumstances

The past decades there have been a lot of environmental changes ... man-made! Departing from the sixties we have met an intensification of agriculture. This has had serious consequences for the landscape. Nature has been pushed back to the nature reserves. All kinds of small nature elements in the landscape were eliminated. The rivers and rivulets have been straightened, have been channelized. By removing sharp meanders the length of the river Mark was shortened with almost 10%. In the mean time the agricultural land has been drained very effective. Farmers preferred drought rather then wetness.



Climate changing; public awareness

The water of a heavy summer shower, falling in the upstream area, is within a couple of hours in the town of Breda, causing a peak flow with a great flooding risk.

In the overall stream basin of the river Mark the built-up area increased from 7 to 95 km². Expansion of impervious surfaces also causes a rapid surface runoff of precipitation water, which contributes to critical peak flows.

Global climate warming makes our climate wetter. A moderate expectation of the temperature rising for the 21st century is 1 to 3.5 °C. The consequences may be wetter winters. Longer periods with heavy rainfall; up to 2050 an increase of 10%. Summers will be dryer, but more frequent with heavy showers. These precipitation figures result in different river discharges: in winter + 40% and in summer - 30%. In the 20th century we have measured a sea level rise of 20 cm, for the 21st century we are expecting a rise of 60 cm. Compare the last figure with the gradient of the river Mark from Breda to the Zeeland estuary: 1 meter! Few years ago a policy maker of the municipality of Breda shocked the public with an article on this subject, heading 'Breda-on-sea'. Then it seemed to be rather surrealistic, but with the knowledge of today ... (In 1953 a flood disaster happened. Great parts of the province of Zeeland and the western part of North-Brabant were flooded by a devastating seawater flow. The combination of south western storm and high tide made breaches in the sea dikes. The flood reached to the borders of Breda.)

Three stages strategy

The Dutch government has made a publicity offensive under the slogan 'Nederland leeft met water', which could be translated as 'water takes part in the lives of the Dutch people'. The government appeals to the fact, that in the Netherlands water is in everyone's vicinity, either seawater, water from the rivers or ground water. Up till now we relied on technocratic solutions. In reaction to higher water levels we've built higher dikes. Sometimes this is still a proper solution, but in the same time we are convinced of the fact, that we have to anticipate on the fact we're living at the border of the sea, where rivers form delta's or estuaries. We cannot continue putting rivers between dikes, we have to create opportunities for the rivers to expand: room for water!

This policy demands commitment of the general public. We have to ask the public to participate in our projects from the very beginning. They should be participants in finding solutions, even solutions in cases that we are the professionals. Otherwise it will not be



left: Bavelsche Leij – restored **right:** Water retention in the smallest tributaries

accepted, that we predestine room for water instead of urban expansions, or even worse that existing houses, farms, industrial plants have to move to make room for water. It's believed that the most important quality of water managers and policy makers is the ability to communicate!

Retention

It's not accepted anymore that in dry periods farmers pump up ground water whenever they need it. In upstream areas we are confronted with the effect of water table depletion. Pumping up groundwater greatly exceeds recharge by infiltration. Symptoms of this phenomena are especially recognised in the nature reserves.

In co-operation with farmers organizations we have been studying the upstream landscape per parcel where precipitation water can be retained. In this co-operation local government, province government, waterboard and farmers organizations work together. Water can be retained by stopping the drainage measures.

We started with re-meandering rivulets, not only in the rural environment but also in the urban environment, reaching up to the city centre. Examples are the Bavelsche Leij, the Molenleij and the Bethlehemloop, smaller tributaries of the Mark system.



Restoring the floodplain of the river Mark; 'Bieberg'

Recently, in 2003, we finished the restoration of the Mark floodplain, just upstream to the town of Breda. This project was called 'Bieberg'. The channelized river has regained it's floodplain, it is slightly meandering and a bypass has been constructed. In the bypass a fishladder has been created, to make fish migration possible again. Up till then fish migration was not possible because of the presence of barrages. An oxbow lake is reconstructed. Also in 2003 we made a beginning with the restoration of the river Mark in a neighbouring part, in the town of Breda. This part is called Stadsmark. In this part we are restoring natural riverbanks. In a town park this is not too difficult, but it took a lot of talking to get owners of private gardens co-operating. At high flood stages the area of Bieberg is flooded and even in the urban area, Stadsmark, the river finds room to expand.

Not mentioned yet: the river Mark and its river banks are making part of a so-called ecological main structure (in Dutch EHS), a network of linked nature reserves, connected by ecological corridors, stepping stones and nature development areas. Mammals like polecats, martens and in future maybe also badgers should be able to migrate from the south to the north, passing the town of Breda.

Studying the map of Breda one can notice another major lowland river entering the town of Breda: river Aa of Weerijs. Also this river is undergoing a floodplain restoration. The combination of finding room for water, nature development and possibilities for recreation.

Storage

Outsiders expect that water storage would be more logical in the upstream area. That's right, but in the case of the river Mark we have a rather steep gradient, a narrow floodplain and little room. In the mentioned Bieberg area the river has the possibility to expand, to flood controlled. More or less the Bieberg area functions as an overflow basin.

Downstream the town of Breda there are three polders, which are flooded naturally at certain flood stages. These overflow basins are called Rooskensdonk, Weimeren and



Actual situation; floodpain restoration in the vicinity of the town of Breda

the Terheijdenpolder. These polders are supposed to mitigate a flood hazard. Because of the incidental flooding, these polders have a limited function in agriculture. They form part of the EHS, the ecological main structure. Their aspect consists of meadows with a rather high biodiversity. Traditionally they are important for over wintering fowl like geese and wild swans. Wading birds are breeding in these meadows.

A project team, consisting of policy makers of the town of Breda, the province of North Brabant, nature conservancies, water managers are working at a project of a fourth overflow basin. Our goal is to bring back the inundation risk of the town of Breda to 1/ 100 y. This area, Haagse Beemdenpolder, consists of 300 hectares agricultural land, directly neighbouring the town. A destination as overflow basin excludes future urban expansions, which implicates a great economic loss. The quality of life in a densely populated town is, however, seriously improved by the presence of parks and nature in the direct surroundings. The fourth overflow basin should get an important function as a recreation outlet area. Their should be place for walking, biking, skeelering, skating etc. The aspect will stay agricultural, but with restrictions to the land use. There will be little room for growing Mays. We prefer flowery meadows. In part of the polder an historical parcel pattern can be recognized. We will restore this pattern and in the mean time the eutrophic top layer of the soil will be removed to improve the return of wild flowers. A rather dull woodland, consisting of a Poplar plantation gradually will be changed in a natural woodland. The main part of the polder will remain an open landscape, especially suited for birdlife. At the moment we are investigating the possibility of removing the only farm in the area. It is however a modern livestock farm, situated here in the sixties or early seventies of the last century.

The fourth overflow basin will be different in comparison to the others. The other polders get flooded spontaneously and the fourth will have high dikes. An inlet work makes it possible to use the fourth overflow basin as an active instrument to lower a critical peak flow. 300 hectares of land will be inundated to lower the flood stage in the town of Breda with approximately 20 cm. When the peak flow has passed the town, the fourth overflow basin will be pumped empty within 24 or 48 hours, to be ready for a next peak flow.

It should be emphasized once more: realisation of this fourth overflow basin can only be done with sufficient support of the population of Breda. Citizens should be drawn into the project from the very first charcoal drawing.



left: Overflow basin 'Weimeren', Year's Eve 2002 **right:** Future fourth overflow basin (Polder Haagse Beemden)

Discharge

With an ongoing climate change, it will become difficult to discharge the river basin of Mark and other comparable rivers. Studies are necessary. Maybe larger overflow areas are needed, maybe technical solutions can be found in the flood defence works in the Zeeland estuary.

Nowadays we have problems with the quality of the water which is discharged. The eutrophic water causes algae bloom in summer. Especially cyanobacteriae are a threat to the health of recreating people, livestock drinking the water and waterfowl.

The use of fertilizers is restricted. Body wastes of livestock should directly be ploughed into the land to prevent overland flow in combination with rain or a frozen soil. We make quite an effort to improve the quality of the effluent of sewage plants.

It will take some time before the effects of improved water quality will be effective in the estuary since there is a natural accumulation of nutrients in these waters.

Conclusions

Together we, water partners as we are called, are progressing in realizing a sustainable solution to prevent inundation of urban areas where the risk of flood hazard is not acceptable.

Especially in an urban environment it takes huge financial offers to take adequate measures e.g. to restore natural floodplains.



Clay sediment in the downstream region

The economical climate can make it difficult to raise enough funds. Nevertheless, the risk of inundation of a densely populated area can be invaluable.

We realize fair enough that environmental sustainability contributes to the quality of life in towns. When we wish to concentrate living and working in towns, we have to take care of green and nature in the direct vicinity of this town. In Breda we are talking of so-called green (bluish) fingers, reaching to the city centre. The spine of these fingers are the rivers Mark and Aa of Weerijs and their smaller tributaries.

The green fingers are important for active and inactive recreation.

The rivers and their banks constitute the corridors of a country wide ecological network of nature reserves, corridors and nature development areas.

A pitfall for water managers, policy makers, is a lack of communication with the inhabitants of the urban environment. We are used to start with finding technical solutions, then we are going to talk with persons directly involved in our plans e.g. landowners and afterwards the inhabitants are invited to express their opinions. Far too late!

Communicate with the inhabitants from the very first charcoal drawing! Let them share in finding solutions. That's the best base for durable commitment.

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