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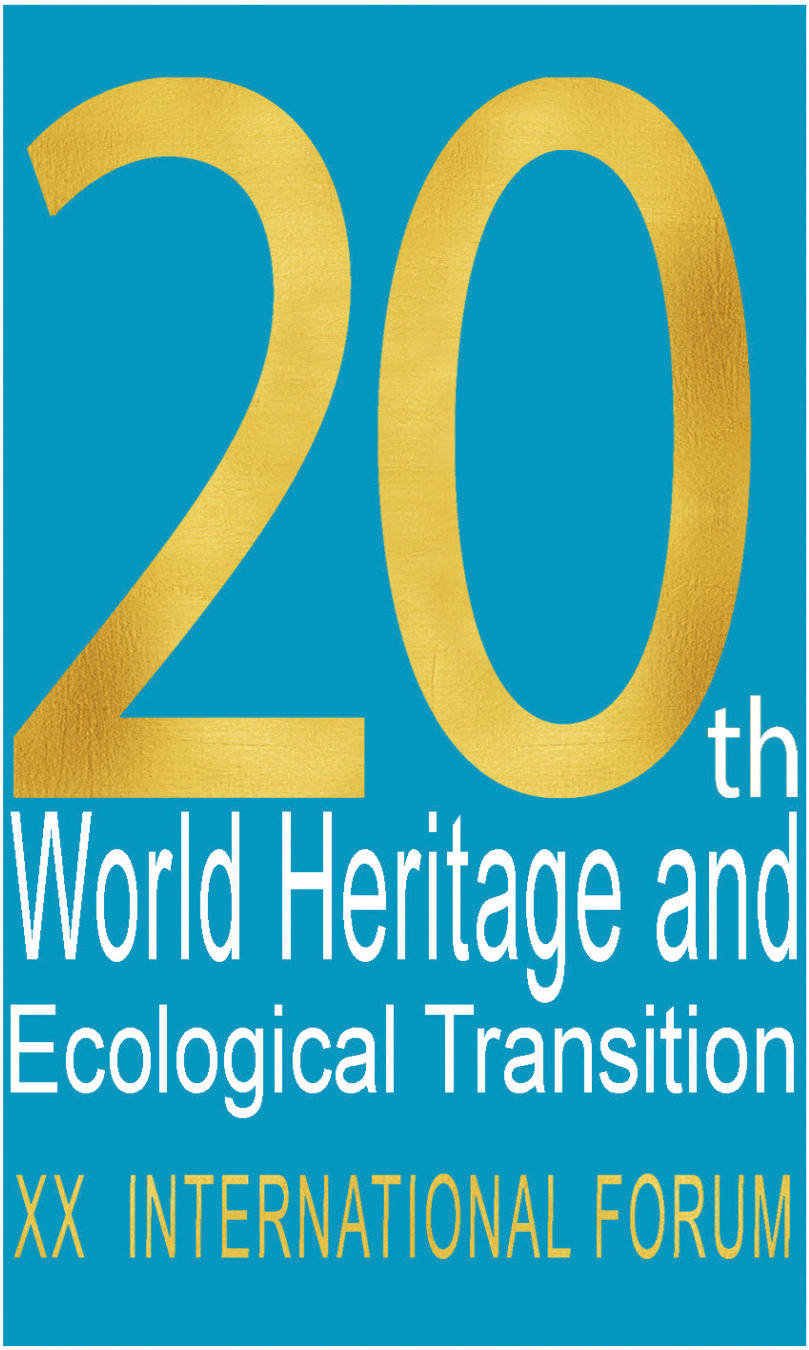
Le Vie dei Mercanti



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Le Vie dei Mercanti
XX International Forum

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Restoration of the Østerå river system as an ecosystem service for the ecological transition of Aalborg

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Abstract
The first document approved by the European Community on sustainable urban development was drawn up in Aalborg in 1994. The Danish city has distinguished itself on the international scene for pursuing sustainable growth through energy transition, nature conservation and urban regeneration.
To increase the city's resilience to climate change and to improve the quality and ecosystem balance of urbanized environments, Aalborg has launched projects for the reactivation of interrupted natural cycles and the renaturalisation of abandoned urbanized areas. One of the most significant projects is the restoration of the Østerå, the river that ran through the city and which, at the end of the 19th century, was channelled into underground pipes to make room for urban growth. The entire course of the river will be brought back to the surface, redeveloped and equipped as a new ecological corridor according to an innovative approach that rediscovers the aesthetics of wild nature.
The project will increase the multiple benefits that a river can bring in an urbanized context as an ecosystem service. The opening of the river will contribute to the mitigation of flood risk with Rainwater Harvesting and Management systems, will increase the value and quality of public spaces and will allow residents to have a direct experience of nature in the city.

Keywords: Sustainable Urban Development, Ecological Corridors, Green Wedges, Rainwater Harvesting and Management (RWHM), Aalborg.

1. The opening of the Østerå river
The Østerå River is a 15 km long watercourse in Northern Jutland (Denmark) that originates north-east of Størving and flows into the Limfjord. In Viking times, the river was wide and deep enough to be navigable, which is why its mouth was identified for the construction of a port settlement on which the city of Aalborg later developed.
Originally the river flowed through the city of Aalborg from south to north, at the present Østerågade road (Fig. 1). Its waters were used for domestic purposes and to power the operation of the mills. The river was also used as a place for washing and draining sewers.
When in 1869 the railway line connecting with southern Denmark reached the city of Aalborg, it was necessary to divert the river to be able to build the railway station. In 1872 the river was channelled into pipes which, flowing under the current Kanalstien road, convey its waters into the Limfjord (Fig. 2).

Fig. 1: Plan of Aalborg, published in *Resen Atlas Danicus*, 1677.

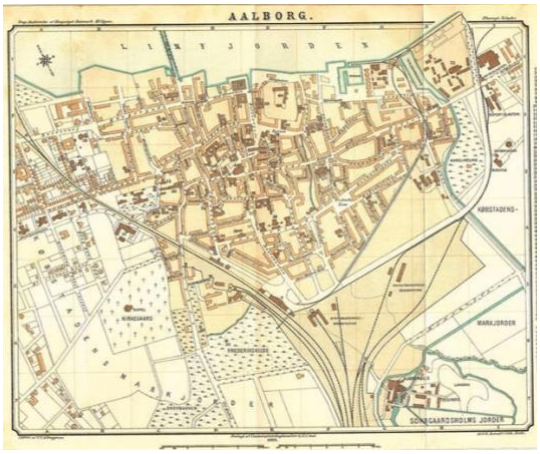

Fig. 2: Aalborg, 1900. Kort over købstaden. V.F.A. Berggreen.

For over a century, the river disappeared from the urban landscape and continued to flow under the city. At the beginning of the 21st century, when a greater awareness of sustainable urban development was established, the hypothesis of bringing the river back to the surface began to emerge, evaluating the multiple benefits it could bring in terms of ecosystem rebalancing in the urban environment (Fig. 3). Therefore, in 2008, the municipal administration started studies for the construction of an ecological corridor within which to bring to light the waters of Østerå, in a continuous path that starts from the natural area of Østerådalen south of the city, enters the district of Østerådalen Kærby near the Gabriel textile factory, passes through the transformation areas of the railway freight yard and the Karolinelund Park and ends with the outlet of the waters in the Limfjord near Mussikens Hus (Fig. 4).

Fig. 3: The fjord and the river valley of Østerå [1].

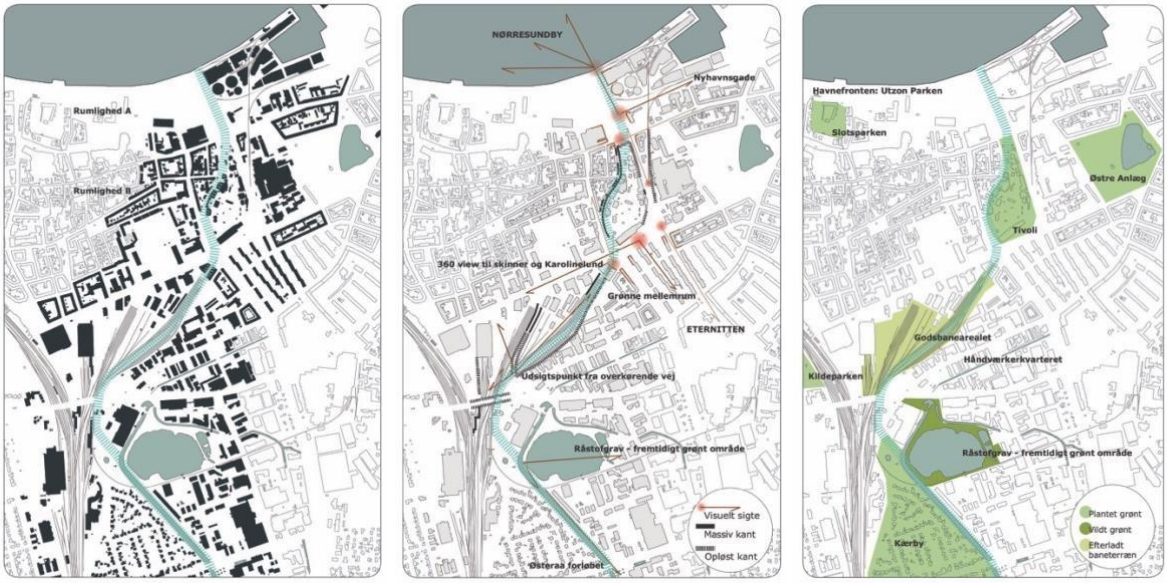

Fig. 4: Studies to bring the Østerå river back to the surface and create an urban ecological corridor. From left: new route of the riverbed; stretches of river to be designed with natural bed or with protective barriers and visual interconnections; types of vegetation to plant [2].

For the construction of the ecological corridor, it was necessary to change the intended use of the soils affected by the passage of the river. Therefore, between 2010 and 2020, the municipality developed four local urban plans for the transformation of the area overlooking the Limfjord between Musikkens Hus and Østre Havn (2010); the disused railway areas of Godsbanen (2010); the disused amusement park of Karolinelund (2016); the southernmost area near the Kaerby district and the suburban area (2020).

2. The first step: bring the mouth of the Østerå river back to the surface

The first part of the project was the reopening of the northernmost stretch of the river between Musikkens Hus and Østre Havn, completed in 2018. The reopening of the final stretch, where Østerå flows into the Limfjord, is part of the regeneration project of the Aalborg waterfront [3] (Figg. 5-6).

The opening of Østerå has helped to increase the attractiveness of the area and, consequently, to increase the real estate value of the soils. The property development company Enggaard A/S, owner of the soils and contractor of the works, benefited from this increase in value and, as negotiated with the municipality, participated in the reopening project of Østerå co-financing the works for the removal of the slab of coverage of the canal, arrangement of the embankments, planting of trees and plant species and lighting systems [4].

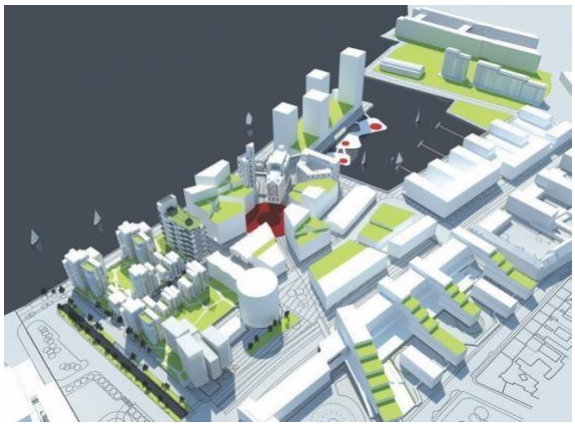

Fig. 5: Overview of the redevelopment project of Østre Havn [5].

Fig. 6: Reopening of the terminal section of the Østerå river between Musikkens Plads and the Limfjord.

The project was drawn up by the Polyform architecture studio. The banks of the canal have inclined planes covered with filter soil, where trees and vegetation have been planted, which act as a filter bed for the rain. At the bottom of the channel rocks have been placed at different heights to create an environment favourable to fish fauna and aquatic vegetation.
To offer the possibility of enjoying the river in a diversified and close-up way, the project envisaged the construction of stairs that allow reaching the water level. The limited size of the water channel, the murmur produced by the obstacle rocks on the bottom and the presence of a rich vegetation have the purpose of reproducing the image and the sensations of a stream [6].

3. The second step: create an urban ecological corridor

After the reopening of the mouth, in 2019 a tender was launched for the proposal of a masterplan for the area between Teglgårds Plads and Gabriel Erhvervspark, with the aim of reconnecting the end of the river with the urban crossing section up to the natural areas of Østerådalen (the competition was won by the design studios Rambøll and SLA Architects).
This area is located in a transition zone between the dense city and the green wedges. The masterplan intends to re-establish the continuity of the river by aiming at the dual objective of creating an ecological corridor in the urban environment and re-functionalising parts of the city that are no longer used.
The intervention area was divided into three sectors, characterized by the presence of large green areas: the former Karolinelund amusement park, the former Godsbanearealet railway area and the Gabriel Erhvervspark industrial area (Fig. 7).
The Karolinelund park, which originally housed a military garden and then an amusement park, is a green lung awaiting redevelopment; after the rides closed, the park was simply opened to the public as an urban park, but without a renovation project. The context is characterized by the presence of centuries-old trees and historical traces of past functions; the park is intensely used by the inhabitants of the neighborhood.
Godsbanearealet is a vast railway area left to itself; between the tracks, the cranes and the lampposts that characterize this residual railway landscape, a luxuriant spontaneous vegetation grows whose biodiversity has been enriched over time by the passage of trains that transported seeds from other regions to the city, wedged between the wheels and the wagons.
Gabriel is the area where the river meets the city, where water mills and, later, industrial plants used the water and hydroelectricity of the Østerå River. The area opens up to the natural areas of Østerådalen, characterized by an intact and lush natural environment, populated by numerous species of fish, birds, animals and wild plants.
The masterplan has identified three main objectives to be achieved: environmental redevelopment, adaptation to climate change and urban regeneration. As regards the first objective, in each of the three parks the environmental requalification must be based on the enhancement of the characteristics of the local vegetation, in order to restore the natural ecosystemic balance. To achieve the goal of climate adaptation, the Østerå catchment area will have to be valued as an ecosystem service: the renaturalization of the riverbed, the provision of rain beds and the modelling of permeable soil can greatly contribute to making the city more resilient to extreme rain events, phenomena that are recorded more and more frequently. Finally, as regards urban regeneration, the presence of a redeveloped watercourse within the city can contribute to the attractiveness and enhancement of the urban parts it crosses.

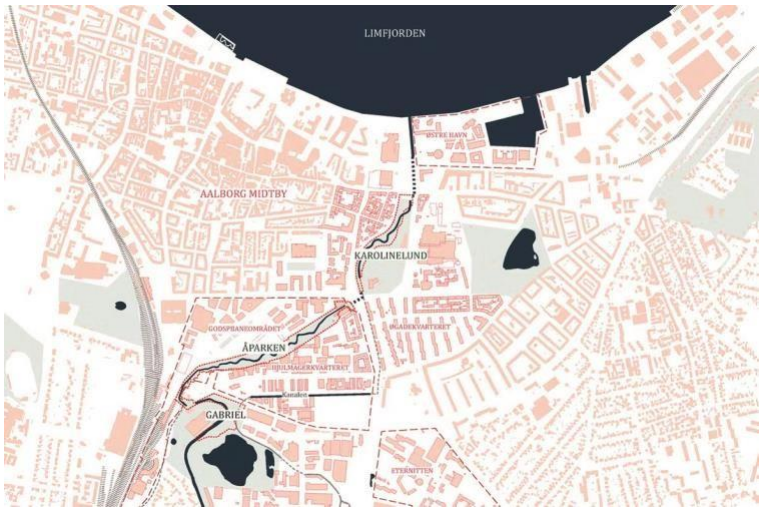

Fig. 7: The three new riverside parks of the Østerå River: Karolinelund, Åparken and Gabriel [1].

3.1 The first sector of the ecological corridor: the Karolinelund Park

The area on which the Karolinelund Park stands was originally owned by the municipality of Aalborg. In 1824 the municipality ceded the property to the officers of the city army who, on the initiative of Colonel Louis le Normand Bretteville, transformed the area into a romantic garden dedicated to music, entertainment and garden management. In 1839 the park was dedicated to Princess Carolina, wife of Crown Prince Ferdinand, on the occasion of the visit of the princes to the city. Originally reserved for soldiers, the park has been open to public use by citizens since 1840.

In 1946 the land was bought by the Lind family who built the Tivoliland amusement park, which was opened to the public in 1947 (Fig. 10). The park has been in business for about sixty years, becoming one of the largest and most famous tourist attractions in Aalborg. In 2007 the park was closed due to a general change in entertainment tastes. In 2010 the municipality bought the property and definitively dismantled the amusement park [7].

The park's once peripheral location had become central to the city's expansion and was close to two new urban centralities, Nordkraft (the disused power plant transformed into a health and sports centre [8]) and Musikkens Hus (the new concert hall designed by Coop Himmel(l)au). The municipality has therefore started a process of transformation of the site by activating a wide public involvement. From 2011 to 2015, before the start of the transformation works, the park was opened for temporary use, as requested by the citizens [9].

The park's temporary activities were coordinated on the basis of an agreement between the voluntary user association "Karolines Venner" (Friends of Caroline) and the municipality of Aalborg.

In this phase, a slight redevelopment of the park was carried out: the surrounding wall was partially demolished to create four new entrances and the remaining fragments of the wall were made available for the creation of graffiti; easy to maintain sports equipment, such as a skateboard track and a bowling green, have been built; a part of the park has been granted for the cultivation of urban gardens; the Påfuglen building was reused as a bar and meeting place for debates and workshops.

The project for the transformation of the park was drawn up by the architectural firm Cobe in collaboration with the municipality of Aalborg and with the contribution of the users of Karolinelund. Based on the contents of the project, in 2015 the municipality drew up the local urban plan 1-1-124 (Fig. 8) to make the transformation of Karolinelund feasible [10]. The local plan envisages the construction of an urban park with multiple functions, the opening of Østerå River and the location of a kindergarten of about 700 square meters (Fig. 9).

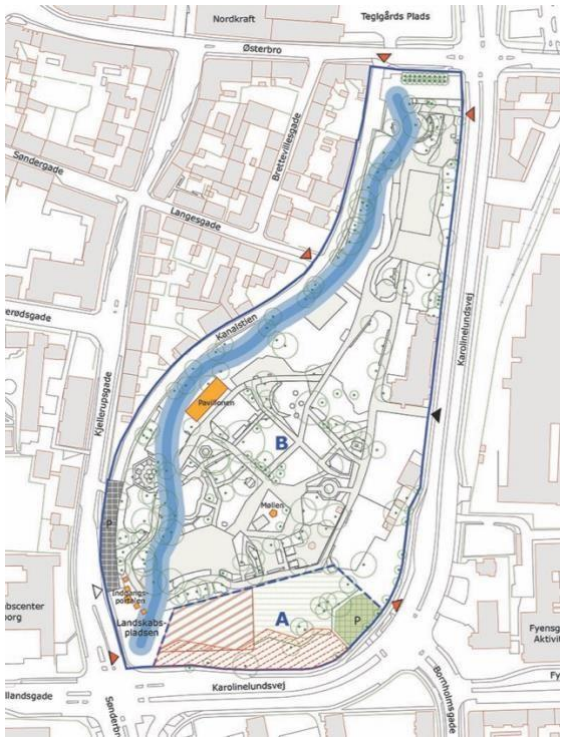

Fig. 8: Local urban plan 1-1-124 for the Karolinelund Park: area for the construction of a kindergarten (A) and area for the park (B) [10].

Fig. 9: Karolinelund Park recovery and renovation project [10].

The project has the river as its strong point: it involves hydraulic reconnection to the north with Musikkens Plads and to the south with the former Godsbanearealet railway area. Inside Karolinelund, the watercourse will be brought back entirely to the surface and will have a sinuous path to favour the rooting of aquatic vegetation and ensure a favourable microhabitat for fish fauna, contributing to the enrichment of biodiversity and environmental regeneration.
One of the most relevant aspects of the project is its contribution to adaptation to climate change. The global increase in temperatures and increasingly recurring extreme weather phenomena cause more and more flooding with extensive damage and inconvenience, which can be felt to a greater extent in urban areas. The project extracts the benefits of the river into the urban environment as an ecosystem service for the disposal of excess rainwater. To this end, the profile of the riverbed has been designed on several levels, in order to guarantee both the regular flow of the river water in periods of regular rainfall, and to receive a greater inflow of water in the event of extreme rainfall.
Already in its transition phase, Karolinelund has proven to have much more added value than when it was used as an amusement park. The park is used at different times of the day and by a very different audience, from children to adolescents, from university students to the elderly. The urban gardens have been so successful that the municipality had to create a waiting list for the concession of cultivable flower beds; the owners of the garden love to share their products even in collective banquets set up in the areas equipped with benches and outdoor tables (Fig. 11). The park, in addition to offering citizens a space to reconnect with nature without leaving the city, has a peculiar local property that manifests itself in the ability to accommodate differentiated functions, a sort of underground culture of living in collective spaces even with spontaneous uses [11].
The project took note of these considerations and envisaged the differentiated and flexible use of the park areas that can be used at different hours of the day and night. For this reason, no area of the park will be used for residential functions, considering this function incompatible with the recreational activities, shows and musical events that are planned in the park.

Fig. 10: Entrance pavilions to the disused amusement park of Karolinelund.

Fig. 11: Urban gardens created within Karolinelund cultivated by the inhabitants of the neighborhood.

3.2 The second sector: the disused railway areas of Godsbanearealet

Godsbanearealet (the freight train parking and loading area) is a predominantly flat area southwest of the historic centre of Aalborg, where a branch of Østerå flowed. At the end of the nineteenth century the area was levelled and the river channelled into an underground pipe for the construction of the freight train terminal [12]. An industrial district has developed on both sides of the railway area. At the end of the 90s, the railway functions ceased and almost all the industrial activities were closed or relocated, freeing an area of about 23,000 square meters [13].
The area is very interesting for the urban growth and sustainable development of Aalborg because it is located near the historic centre and acts as an ecosystem connecting corridor between the Østerå river valley and Karolinelund Park.
The municipality of Aalborg has started a process of transformation of the area with the aim of creating a zero emissions eco-district in which residential and commercial functions are integrated with the recovery of the naturalistic values present in the area [4]. As regards climate sustainability, the goal is to create a climate-friendly district in which CO2 emissions deriving from the district's energy consumption are minimized.

Fig. 12: Masterplan for the re-functionalization of the Godsbanearealet area [1].

Once again, the river is the main design theme: it is brought back to the surface to bring new natural qualities into urbanized areas, to enrich the biodiversity of the urban context, to contribute to adaptation to climate change and to create new places for socialization [1].
In 2010, the local urban plan 1-1-110 was drawn up for the transformation of the area [14]. In 2014, the architecture studios Rambøll and SLA prepared the masterplan of the new urban park, called Åparken, and provided specific indications for the recovery of Østerå [15] (Fig. 12).
The masterplan will make Aalborg more resilient to climate change: to this end, greater rainwater drainage capacity is planned throughout the Østerå catchment area [16].
Normally, rainwater is disposed of through the sewer system, where the white water flows along with the black and grey water into the underground pipes. This solution has been questioned both by a greater ecosystemic attention to the recycling of rainwater, and by climate changes which, causing a significant increase in rainfall, would require an expensive dimensional adjustment of the sewage system.
The low open spaces of the former freight railway area are one of the largest flood prone areas in the city. Instead of channelling rainwater into the sewer networks, it was decided to manage it over the entire urban surface using Rainwater Harvesting and Management (RWHM) solutions. The rainwater will be collected in the rain beds where it can evaporate or be filtered and subsequently recycled for irrigation of green areas.
Åparken will be able to handle large amounts of water. The park will have the shape of a river valley and the impluvium towards the river will give space to even high flow rates. In the lower areas, where the railway tracks used to run, no buildings will be built but a linear park with sports fields, children's play areas and outdoor picnics. These areas are designed to be flooded in case of heavy rain.
All non-built surfaces must be covered with draining soil and modelled with suitable slopes, while all built surfaces must have green roofs. In situations of even more intense rain, rain beds must have an overflow to drain excess water into pipes connected to deeply excavated areas, used as collecting tanks. In the event of exceptional rainfall, the collection tanks, in turn, can overflow and flood the rest of the park, thus gaining extra volume. When this volume is exhausted, in the event of a storm, an underground overflow channel will be activated to accommodate the excess flow (Fig. 13) [4].

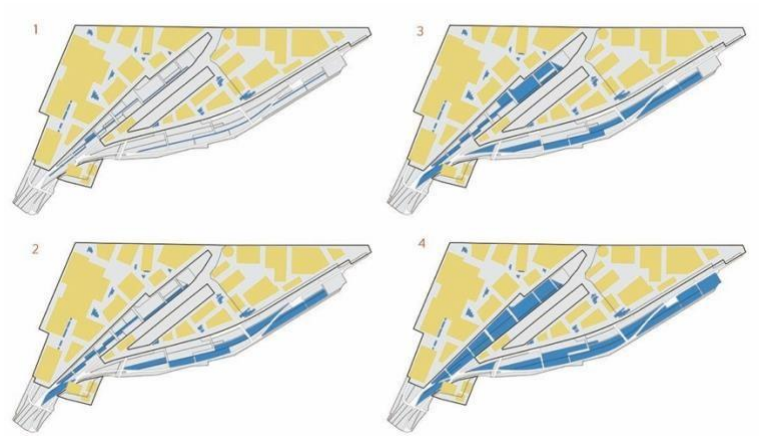

Fig. 13: Godsbanearealet floodable space filling scheme: 1 - the rest areas and the river course will be filled first; 2 - as the water level rises, the connecting channels between the cisterns and the areas adjacent to the river will be filled; 3 - a further rise in the water level will inundate sports fields and playgrounds; 4 - in the event of extreme weather conditions, that can occur 1-2 times every 10 years, all areas of the park will be flooded [17].

RWHM solutions can manage rainwater not only where it falls but also as it flows. Controlling the speed of the water and the direction in which it flows allows it to be directed and collected so that it does not cause damage. By delaying rain, for example with green roofs and rain beds, the urban space contributes to the hydrological cycle by increasing the evaporation time and delaying runoff. Delaying rain also helps in extreme situations, as a delay of just half an hour, for example, in a stormy situation can give the drainage system time to properly dispose of water without collapsing [4].
Thanks to the RWHM systems, the project fully achieves the objectives that the municipality has defined with the city water management plan. In the near future, the municipality plans to separate the white-water collection and management system from that of black and grey water. The reopening of the Østerå River will be part of the urban stormwater management system and will replace the settling ponds that currently filter the waters. Thanks to the rainwater collection and disposal capacity ensured by the restored catchment area, it will not be necessary to carry out works to adapt the sewer network. Kloak's sewage company will save the cost of expanding the capacity of the sewerage network and, in agreement with the municipality, will contribute to the co-financing of the works.
Another source of co-financing for the realization of the project could come from the real estate agencies involved. In fact, the project envisages the construction of houses and commercial activities with building rights of 38,000 square meters [18].
The masterplan also includes climate adaptation devices for built-up areas. To protect buildings from flooding, the height of the ground floors should be 35 cm higher than the park overflow. Along the perimeter of the buildings, grids must also be provided for the fall of rainwater which is collected by the park's canalization system.
In situations of normal water flow, the watercourse is located one meter below the ground level. To increase Østerå's recreational value, pedestrian walkways have been designed at the watercourse level. The whole area of the park is made up of terraces sloping down towards the river accessible to the public; according to the increase in the flow of the river, the terraces will gradually flood, always allowing access to the park.
In addition to the objectives of climatic adaptation and environmental redevelopment, the masterplan has indicated as a design criterion the maintenance of the historical memory of the place [13]. The executive project of the Godsbanearealet area (Werk architecture studio) has kept some tracks, large lampposts and container cranes, residues of the railway landscape, as elements of street furniture and recycled them to perform new functions [12]. Some sections of the tracks, for example, have been integrated into the design of the equipped rest areas: the rest areas are conceived as drainage areas that interrupt the waterproof pavement of the pedestrian areas. The tracks, laid on draining soil, act as separators of the flower beds, where various plant species are planted, and as a support for the benches made with wooden planks. In case of abundant rain, the flower beds are flooded receiving the water that falls on the waterproof floors and then slowly drain it towards the river (Figg. 14-15) [19].
The vegetation project, as previously mentioned, enhances the peculiarities of the local environment. The seeds transported by freight trains have given rise to a unique vegetative mix rich in biodiversity capable of withstanding local climatic conditions and which does not require special irrigation, maintenance, pruning and cleaning. The different plant essences born spontaneously in the area were then used as street furniture and create an appreciable landscape continuity along the entire course of the river, from wild nature to its urban path.

Fig. 14: Equipped rest area in Godsbanearealet. The disused tracks were used for the composition of seats and flower beds which, in case of rain, act as rainwater storage tanks.

Fig. 15: Rainwater collection and channeling system in Godsbanearealet.

This approach to urban green design based on respect for nature, which prefers to use spontaneous vegetation rather than ornamental plants, is increasingly winning the favour of designers who deal with urban design.

3.2 The third sector: the Gabriel Park

The system of interconnected parks ends with the Gabriel sector, at the southern edge of the compact city. Since the Middle Ages there were mills in the area that exploited the motive energy of the Østerå waters. Since the mid-nineteenth century, industries have established themselves that have benefited both from the proximity to the city and from the use of hydroelectric energy produced by the river. One of the oldest factories, still present on the site, is the Gabriel textile factory (hence the name of the locality), built in 1851, which used the waters of the river to wash and dye fabrics.
The area is characterized by high naturalistic values and by the presence of historic industrial buildings, including the Limfjordsbanen locomotive depot, now used as a museum.
According to the municipality's plans (Fig. 16), the transformation of the Gabriel sector is expected to begin in 2023 and be completed by 2025 (Fig. 17).

Fig. 16: Local urban plan 1-1-110 for the transformation of the Gabriel sector [14].

Fig. 17: Rendering of the natural park project to be built in the Gabriel industrial district [1].

4. Conclusions

Quite often the rivers that flowed through cities were diverted or channelled into underground pipes to make room for urban growth and to protect settlements from the risk of flooding. Today there is a greater awareness that rivers are an important factor in the rebalancing of urban habitats and can contribute in an ecological way to the mitigation of risks caused by climate change.
The case study of the reopening of Østerå, the river that flowed in the centre of the city of Aalborg and which had been channelled in underground pipes, highlights the benefits that can be drawn from the presence of a watercourse in the city.
The river reopening project has created an urban ecological corridor, uninterrupted from the natural suburban areas to the mouth, which restores the ecosystem balance of the river valley, helping to improve the quality of the urban environment.
The project enhances the benefits of the river as an ecosystem service: the river constitutes the main infrastructure of a local stormwater management system that provides effective solutions for the disposal of precipitation, which is increasingly abundant due to climate change.
For the construction of the ecological corridor, the project has identified a path that intercepts urban areas no longer in use; the river becomes an element of redevelopment of abandoned areas, increasing their value. The new green wedge is equipped with paths, rest areas, playgrounds and sports equipment, offering public spaces and places for socializing in close contact with nature.
Attention to environmental ecosystem balances and a new aesthetic sensibility of wild nature are the innovative aspects that characterize the project, offering new food for thought for the resilient and sustainable design of cities.

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