Screening of Alternative Water Sources for Copenhagen's Lakes and Streams

MILJØ NØRREBRO

Miljøpunkt Nørrebro

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1. Overview

This report aims to identify water sources within close proximity to Copenhagen's network of rivers and lakes, so as to ensure security of water supply and to make savings on the expensive and needless treatment of clean water.

In the summer of 2018, Copenhagen's lakes and streams experienced massive water shortages. The impact of which was most obvious in the inner lakes, where huge sections of lake bed became exposed for numerous months. Superficially, this presents an eye sore and a source of unpleasant odour in an important recreational focal point of the city. However, the most concerning aspect of this is the diminished cooling effect brought about by this decrease in water surface area. This is particularly important in the city centre, where the urban heat island effect results in central parts of Copenhagen being up to 12 degrees warmer than the outskirts in summer months (Bühler *et al., KU,* 2010). The Serum Institute estimates that intense heat wave this summer resulted in 250 additional mortalities.

Although similar droughts have occurred in previous years, the intensity on this occasion was more extreme, with the loss of 90.000 litres of water an hour from the inner lakes alone (Michelsen 2018). The length of the drought also led to a watering ban and increased die-off of trees throughout the city, underlining the need for robust alternative water sources. With drought events predicted to increase in frequency with a changing climate, it is important to find feasible solutions to offset loss of water, both in existing and new blue and green infrastructural projects.

The preferred management option is to utilise water sources that are today needlessly subjected to sewage treatment. By prioritising the use of clean water which is currently lead to the sewers, this would lead to savings in treatment costs and increased space in the sewer network. The Danish EPA estimates that 25-30% of water in the sewage system is from extraneous sources and does not require treatment, leading to additional costs of approximately 500 million DKK annually (Miljøstyrelsen 2018).

Another effect of a changing climate is more rain, heat waves and rising groundwater. Rising groundwater levels are predicted throughout the city, threatening the foundations of our existing building mass, while at the same time representing a significant robust water resource for the city's needs, if harnessed in a public regime of groundwater control.

It I assessed, based upon studies conducted in Frederiksberg, that an active groundwater control regime in Copenhagen could save billions of DKK in the most likely future climate and groundwater scenarios.

1.1 Copenhagen's Water Network

The city's inner lakes are primarily fed by Utterslev Mose and Emdrup Sø. Their water flows to central Copenhagen via Lygte Å and Ladegårds Å - two former above ground rivers which are now carried in submerged pipes (proposals are in place to daylight these rivers in the future, creating blue-green infrastructure). In warm dry summers, such as in 2018, the water level in Utterslev Mose becomes too low to feed Emdrup Sø, hence curtailing the supply of water to the inner lakes.

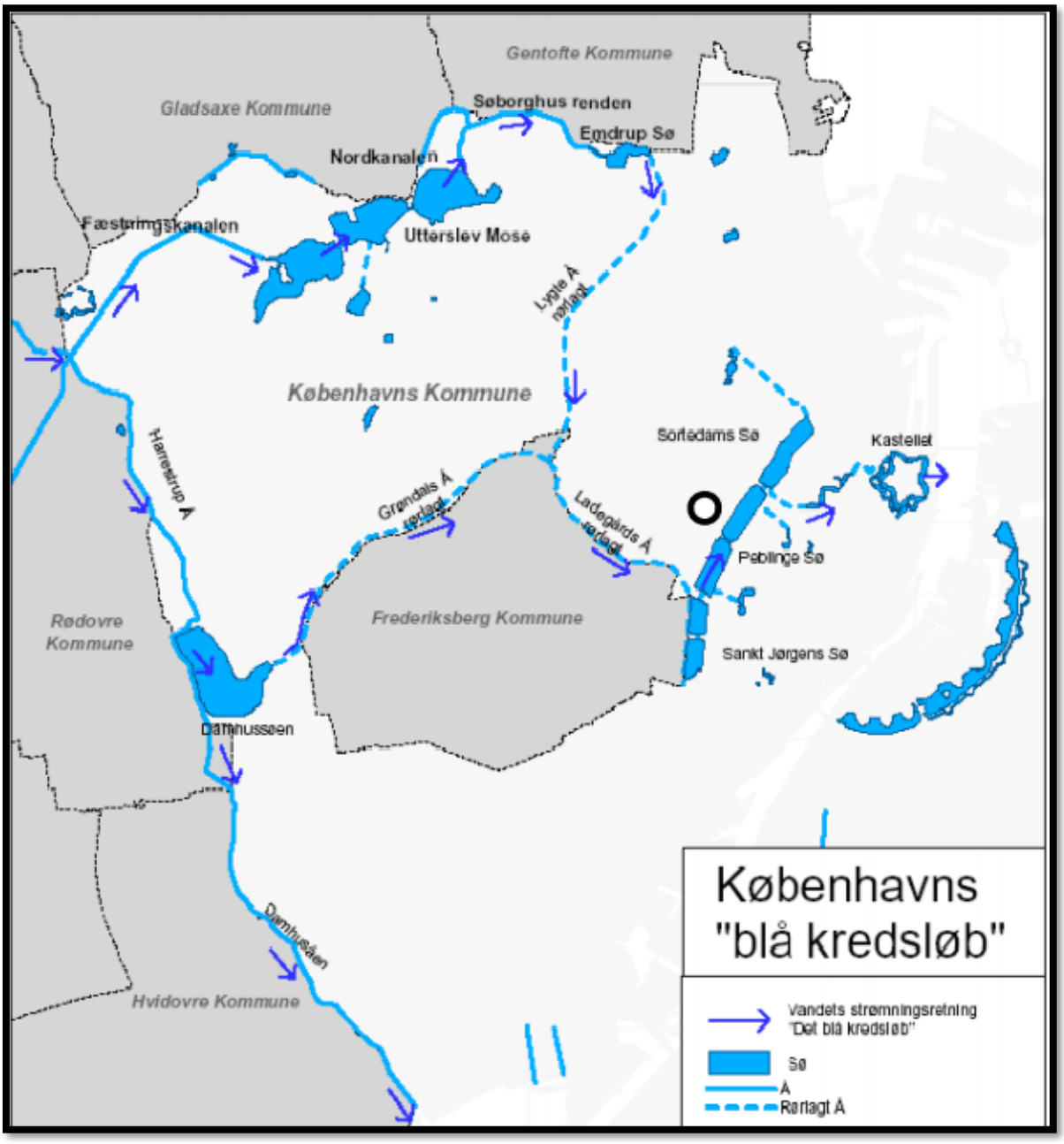

Figure 1: Copenhagen's water network (Image: Orbicon/KK)

2. Available Water Sources

2.1 Groundwater and Relief drillings

In order to combat high groundwater and control water pollution, drilling, drainage and pumping is being conducted at various locations in the city. This is done by both private residents and regional and other authorities.

Region Hovedstaden have been extracting contaminated groundwater in small quantities for filtration treatment at several locations in the city (figure 2). In many cases, this is allowed to re-infiltrate back into the ground water or is discharged to the sewer.

Similarly, in order to combat rising groundwater, private residents have the right to remove groundwater in order to safeguard their basements via the establishment of 'omfangsdræn' systems. There are currently no restrictions and charges on leading this water to the sewer systems.

If groundwater levels continue to rise in the future, as is expected by climate models, far greater extraction will be required, to safeguard buildings and infrastructure. This could lead to it becoming a significant water source in the coming years.

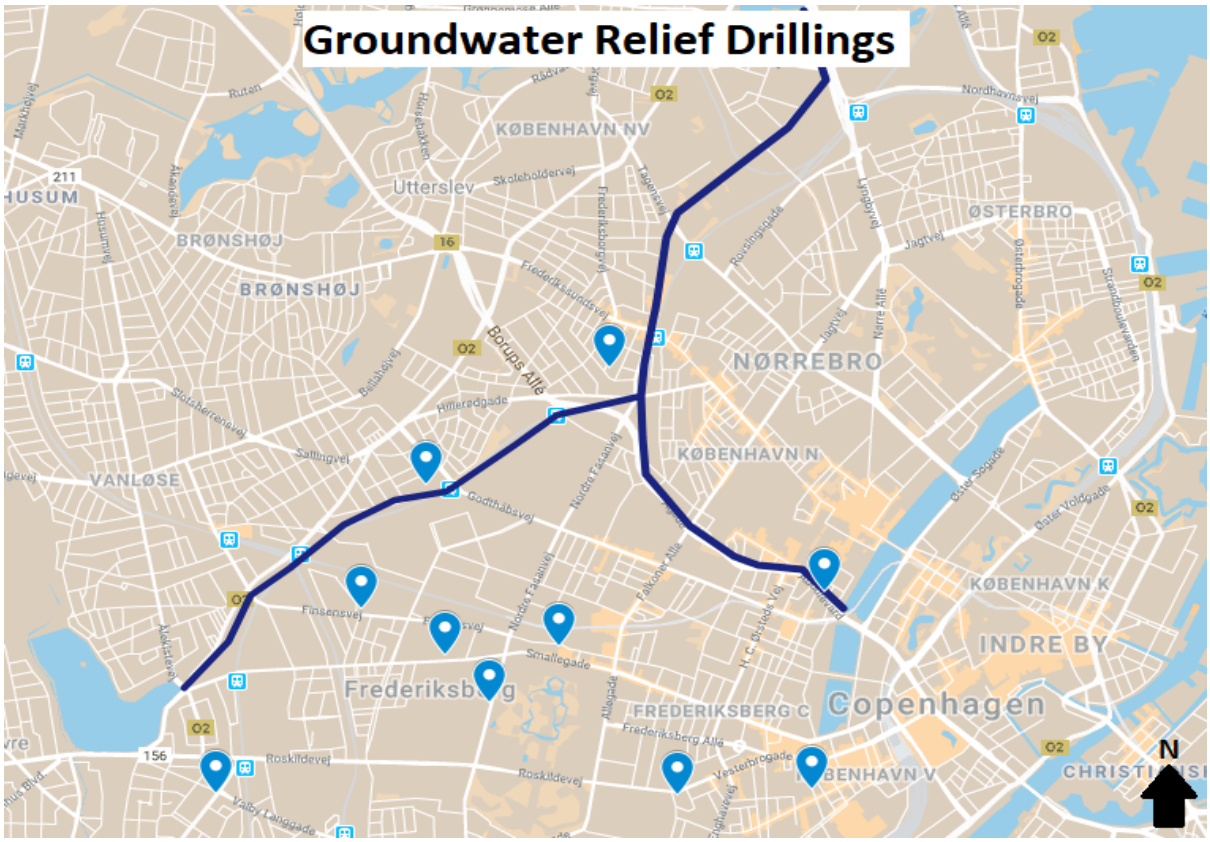

Figure 2: Location of Region Hovedstaden's relief drillings in relation to piped rivers

As much of this rising groundwater eventually ends up in sewers of rainwater pipes, it threatens to hollow out significant investments in adapting the sewer system for a changing climate with more intense rain events. These investments are carried out to avoid major urban flooding such as in 2011.

A more extensive and systematic regime of groundwater level control would eliminate the threat rising groundwater poses to infrastructure and buildings, while solving the problem of drain water filling up the sewer system, which negates investments in climate adaptive sewerage infrastructure.

We can assess the magnitude of economic value of groundwater control by looking at an analysis of a number of different scenarios in Frederiksberg. Frederiksberg estimate that cessation of groundwater pumping would result in a loss of 880 million kr., mainly due to deep basements needing drainage, increased cost of the cloudburst plan and securing of buried infrastructure (Frederiksberg Kommune et. al. (2018) & Frederiksberg Forsyning (2018)).

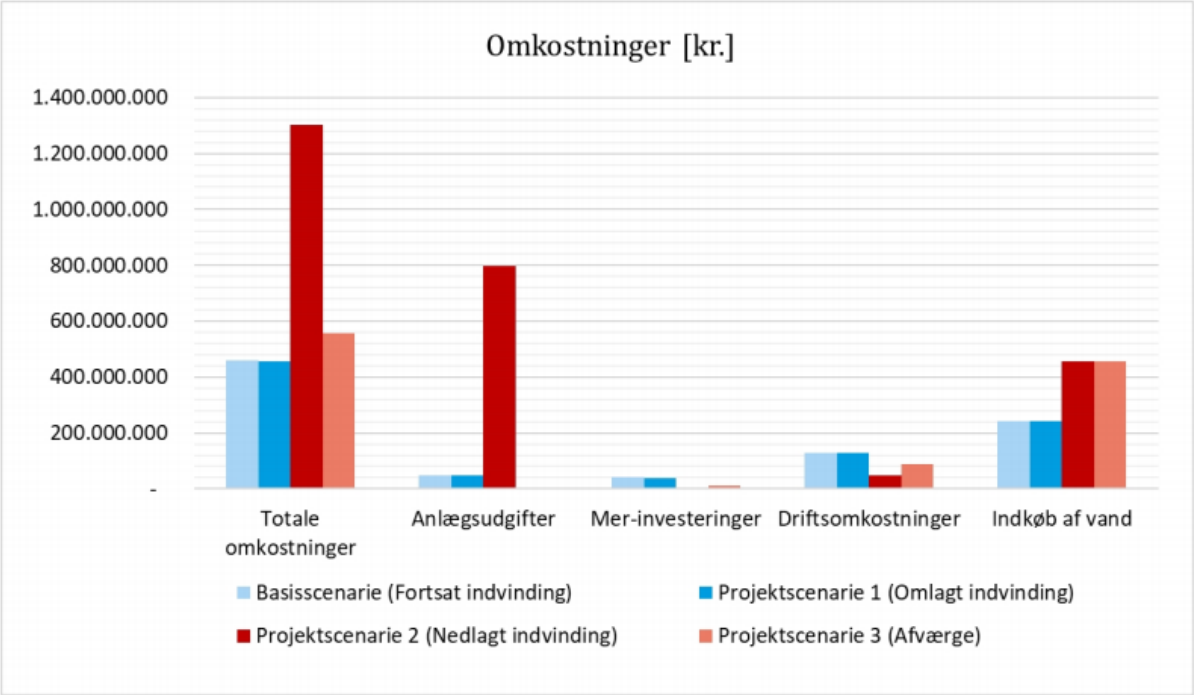

Figure 3: Costing figures for different Intervention scenarios Frederiksberg

No estimates for a reverse scenario in Copenhagen exist, but in future climate scenarios, the benefits of active groundwater control would likely be in the billions of DKK, based upon Copenhagen being a much larger municipality.

More careful management of groundwater would have significant other benefits for society, providing a large and steady source of water for the city's needs in extreme heat and drought.

Unfortunately, there is currently uncertainty regarding the legal status which applies to municipalities or utility companies undertaking these activities. This question is in stark need of clarification from the relevant authorities.

2.2 Natural Springs

Although not all documented, there are a number of natural springs which emerge in different parts of the city. There is great variation in the way such springs are managed. While some are utilized to feed water features such as those in Frederiksberg Have and Søndermarken, many others are seen as a nuisance and are pumped to the sewer system. A combination of historical maps, site visits and public consultation were used to ascertain the viability of utilising various springs.

Lersøkilde

Flow: 6.5- 10 L/s Total P: 24 µg/l Total N: 8.4mg/l (KK, 2006)

Lersøkilde's flow could compensate between 26-40% of the water volume lost through summer drought evaporation. Water from Lersøkilde is relatively low in phosphorus, meaning it could be suitable for direct discharge into other water bodies. Although total Nitrogen concentrations are higher, it is believed that this will decrease upon installation of proper sewage facilities for an adjacent group of allotment houses. Situated in Lerøparken (figure 3), this spring sits within close proximity to Lygte Å- a piped river which flows just two hundred meters away. Lygte Å then flows into Copenhagen's inner lakes via Ladegårds Å (see figure 1). The spring, which formally fed the now drained Lersø, currently has its water pumped to a sewage treatment facility.

Figure 4: Lersøkilde location

Other Springs

Although several were identified, they were not included in this report due to low flow volume or impractical location for connection to Copenhagen's river network. Alternative uses for this water should be explored, such as for gardening or cleaning. The current practice, where most of this water is pumped to the sewer creates a needless expense.

2.3 Surface Water

Street runoff and storm water

Copenhagen has a largely combined sewer where hazardous raw sewage and more benign drain water are treated by the same system. A long term solution would be the separation and utilisation of surface runoff. Although rain is lacking during droughts, collection of precipitation from the surrounding areas, before and after such events would safeguard from extreme water losses and increase the speed of recovery. Although rainwater from streets and rooftops is not of suitable quality to discharge into lakes due to its high potential to collect contaminants, several relatively low cost purification techniques are available.

A promising recent development has been the successful implementation of dual porosity filtration, a simple but effective process which utilises layers of varying porosity to remove unwanted substances from the water. The process is primarily driven by gravity and does not require chemical input. This technology has recently been utilised in Ørestad (figure 4), where a large system was installed to treat road runoff over an area of 30ha. The system, which can treat up to 105 litres of water a second, greatly improves the chemical quality of this runoff, reducing the phosphorus content to a level low enough for discharge to freshwater ecosystems. The facility will be concealed underground upon completion and cost in the region of 8 million kroner. The plant does not have operating costs beyond pumping water to the facility. Far smaller instances of this purification technique do exist and could be scaled down to appropriate sizes for a more condensed setting, such as in Allerød where a much smaller unit treats 3L/s at a cost of 0.6 million DKK. (M. Bergen Jensen, Personal Communication, 12/12/18)

Figure 5: Dual Porosity Filtration Facility in Ørestad, prior to covering

2.4 Hospitals

Copenhagen's two major hospitals, Bispebjerg Hospital and Rigshospitalet are now required to install advanced wastewater treatment facilities in order to remove substances which would otherwise not be dealt with by conventional treatment plants. This will include the use of membrane filtration and activated carbon treatments, resulting in treated water clean enough for direct discharge to the environment. These hospital water sources are particularly valuable due to their reliability in output of water. While rainfall and spring pressure will vary seasonally, these hospitals will provide a constant water supply.

Bispebjerg hospital

A specialised treatment plant for hospital waste water is under development and should be operational by 2022.

The 2013 environmental impact assessment for the renovation and expansion of the hospital, estimated that the completed hospital would produce wastewater at a rate of 9.4L/s (KK, 2013). In addition to this, there was plans to separately collect rainwater and runoff, keeping them out of the sewer system.

The Hospital lies within close proximity to Lygte Å, to which there is a favourable downhill gradient.

Rigshospitalet

The treatment plant for Rigshospitalet is due to be completed by 2023. Earlier figures suggested a wastewater creation rate of 7.5 L/s (Miljøstyrelsen, 2016). However, renovations and changes in practice over recent years mean that this figure may have changed.

Additionally, a steady amount (2L/s) of clean groundwater is removed from the foundations of the hospital in order to keep its basements dry. The hospital has obtained a temporary permit to discharge this water into Sortedams Sø. A permanent discharge licence is in the application process.

This flow could probably compensate approximately 60% of the water volume lost through summer drought evaporation

3. Recommendations

The Lersøparken area presents a variety of potential water sources, all in close proximity to Lygte Å, which eventually flows into Copenhagen's inner lakes. This makes it a primary target for intervention.

Lersøparken is currently earmarked for development under the city's major cloudburst plan, the municipal development plan (Pleje & Udviklingsplan for Lersøparken) and the Local Council's strategy (Bispebjerg Bydelsplan). Although not yet finalised, it is proposed that a small lake will be created in the park, acting as a storage basin. Additional variations of the plan involve opening the piped Lygte Å. These steps would both increase the area's capability to deal with excessive rainfall and create a new recreational feature in the locality (figure 5). A robust water supply is required in order to prevent this opened water course drying out completely in summer months. Miljøpunkt Nørrebro has been in dialogue with relevant stakeholders about incorporating alternative water sources referenced in this report in the plans for redevelopment of this area.

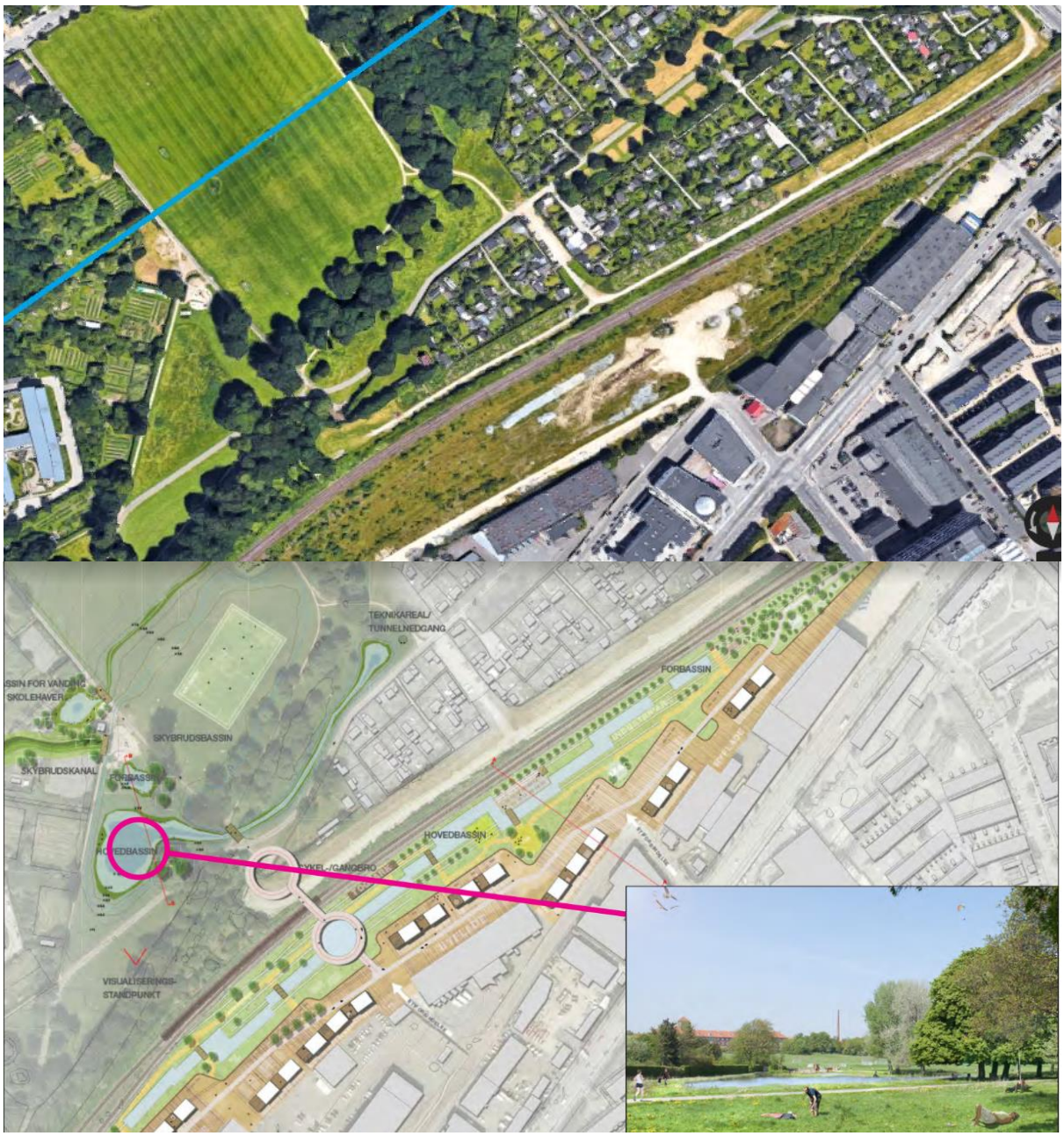

Figure 7: Lersøparken in its current state, with the piped Lygte Å in blue (top image). Bottom image: the proposals for its development as part of Copenhagen's couldburst plan (Københavns Kommune).

This specifically would involve the use of the available water from Lersøkilde and Bispebjerg hospital. These two features are situated within just 200 meters of Lygte Å, on opposite sides of a public park (figure 6). Any connective works would cause minimal disruption to the local area, as there are no roads or buildings in the immediate vicinity. The incorporation of the water from these two aforementioned features would account for almost all of the inner lakes' summer water losses. The separated rainwater from the hospital facility could also be used to augment any surface water features created in the development. In order to lower costs, these connections could be made at the same time as the construction of cloudburst water features in the park.

As Copenhagen plans to open more of its rivers and create blue infrastructure as part of its cloudburst plan, it will become more important to properly harness available water in order to safeguard these features from drought. This is necessary to preserve the water bodies' recreational integrity and to maintain their cooling effect. Future plans for the development of the city's waterways should constructively utilise these available water sources to support blue-green infrastructure.

Although treated hospital water provides a robust supply, it is important to invest in suitable infrastructure to utilise runoff from streets and urban areas - a huge contributor of extraneous water in the sewer system. Additionally, as groundwater levels become more problematic in the future, the extraction and utilisation of this water as a resource will become of vital importance for the city. The sensible management of this water will safeguard urban lakes and rivers while saving millions in unneeded treatment costs.

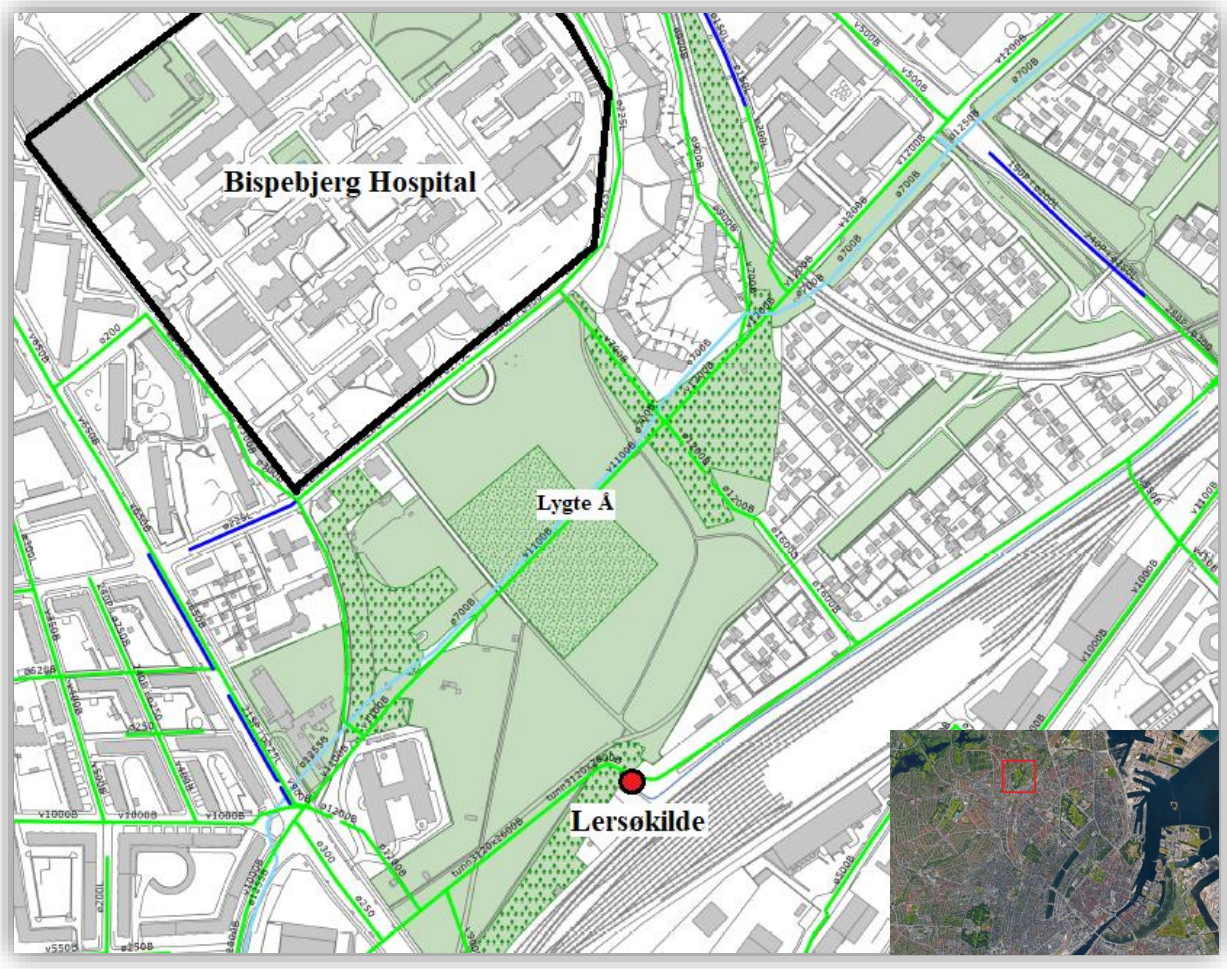

Figure 8: Lersoparken area with Lygte A in light blue and rainwater tunnels in light blue. (Basemap: Hofor)

Rising groundwater is a threat to our existing building mass. Increased drainage (omfangsdræn) to sewers to protect buildings represents a potential hollowing out of investments in adaptation of our sewer system to at changing climate. A more extensive and systematic public regime of groundwater level control would eliminate the threat rising groundwater poses to buildings and solve the problem of drain water filling up the sewer system, which negates investments in climate adaptive sewerage infrastructure.

Based upon other studies, an active groundwater control regime would have an economic benefit worth billions of DKK, in the most likely future climate and groundwater scenarios. Unfortunately, there is currently uncertainty regarding the legal status which applies to municipalities or utility companies undertaking these activities. This question is in stark need of clarification from the relevant authorities.

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