DELTA BRIDGE

- a natural approach towards a third Limfjord connection

Master Thesis | Urban Design

DELTA BRIDGE

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Abstract

The discussion of the "Third Limfjords alignment" has been an ongoing discussion since the 1969 with several discourses and placements during the years. The latest discourse came in the summer of 2014 where the Government, following the recommendation from the EIA, decided a western connection crossing the smaller island of Egholm was the best solution. As it was described it is seen as the best solution in a socioeconomic sense, even though it crosses several valuable and vulnerable landscapes. This decision created a lot of steer and demurs, from local citizens, experts within the fields of mobility and biology which resulted in the most complained EIA-report in the history of Denmark.

This master thesis takes it point of departure in the latest discourse of the third Limfjords alignment, and seeks to understand the decision making behind the chosen alignment and the potential impact it will have on its surrounding landscapes and urban areas through an analytical and theoretical process. Resulting in a proposal for a new overall mobility strategy for the municipality of Aalborg and the proposal of a more central placement in a urban context - between the developing areas of Stigborgsbrygge (Nørresundby) and Østre Havn (Aalborg).

Furthermore does the thesis seek to explore the common perception of larger infrastructures, transforming them from singular mono-functioning urban spaces performing to a minimum of engineering standards towards multi functional infrastructural and urban spaces, capable of triggering complex and unpredictable urban effects, with a natural-inspired approach. This result in what we deem the "Delta Bridge", a landscape element that strenghtens the relationship between Aalborg and Nørresundby, while facilitating both private and public transportation, natural experiences and reconnects the city with the water.

DELTA BRIDGE

-illustration 1

-illustration 2

Preface

This master thesis is completed by Michael Thorø and Hannah Nielsen during the period of February the 1st to the 25th of May as a part of Architecture and Design, Design and Media Technology at Aalborg University. This master thesis takes its point of view in the official project of the Third Limfjord Alignment. In 2014 the politicians of the government consented their final decision for the connection – an alignment crossing the island Egholm. The decision was popular amongst the politicians but not the citizens and many mobility experts, architects and biologists. The placement and design of the consented alignment are based on the mobility planning of the past and not the future. This master thesis deals amongst other with the future development of Northern Jutland and Aalborg Municipality as regional and local scale. The future possibilities and planning of mobility is seen as a powerful motivator for creating a new, strong and urban connector of the two sides; Aalborg and Nørresundby.

We would like to thank our two supervisors, Simon wind and Thomas Ruby, that has provided us with great guidance and knowledge throughout the master thesis. Furthermore we would like to thank Niels Melchior for dropping by and provide us with a little piece of his great insight within the subjects traffic planning and The Third Limfjord Alignment.

Content List

Reading Guide

This Master Thesis consists of five chapters; Introduction, Theoretical Framework, Analysis, Design Toolbox and Presentation. Each chapter deals with relevant text, diagrams and pictures and the overall structure is a chronological narrative of the master thesis. Theoretical Framework provides the reader with a profound understanding of the relevance of mobility and landscape in urban planning and our perception of the two components. Analysis consists of analysis of the official project, municipality plans, climate changes, mobility modes and future possibilities of mobility. The Analysis relates to the regional and local context of Aalborg whereas the Theoretical Framework deals with the overall theory within the subjects mobility and landscape. The Design Toolbox is a composition of design parameters, strategies, selection of site and site analysis. The toolbox provides a fundamental understanding of the design context of today - how does the social understanding effects the field of urban planning… Furthermore this chapter leads towards the presentation of the master thesis. Presentation contains narrative, site and context plan, collages, sections, elevation, technical aspect and lastly conclusion and reflection.

Delimitation

The two supervisors represent two of the fields that this project concerns; mobility and hydrology. Hydrology gives the master thesis an extra dimension to the technical aspect and supports the idea of a holistic approach to mobility planning that does not only concern accessibility but public spaces as well. This master thesis deals with bridge design and the programming of it and does not concern design of the full alignment.

MOBILITY **HYDROLOGY**

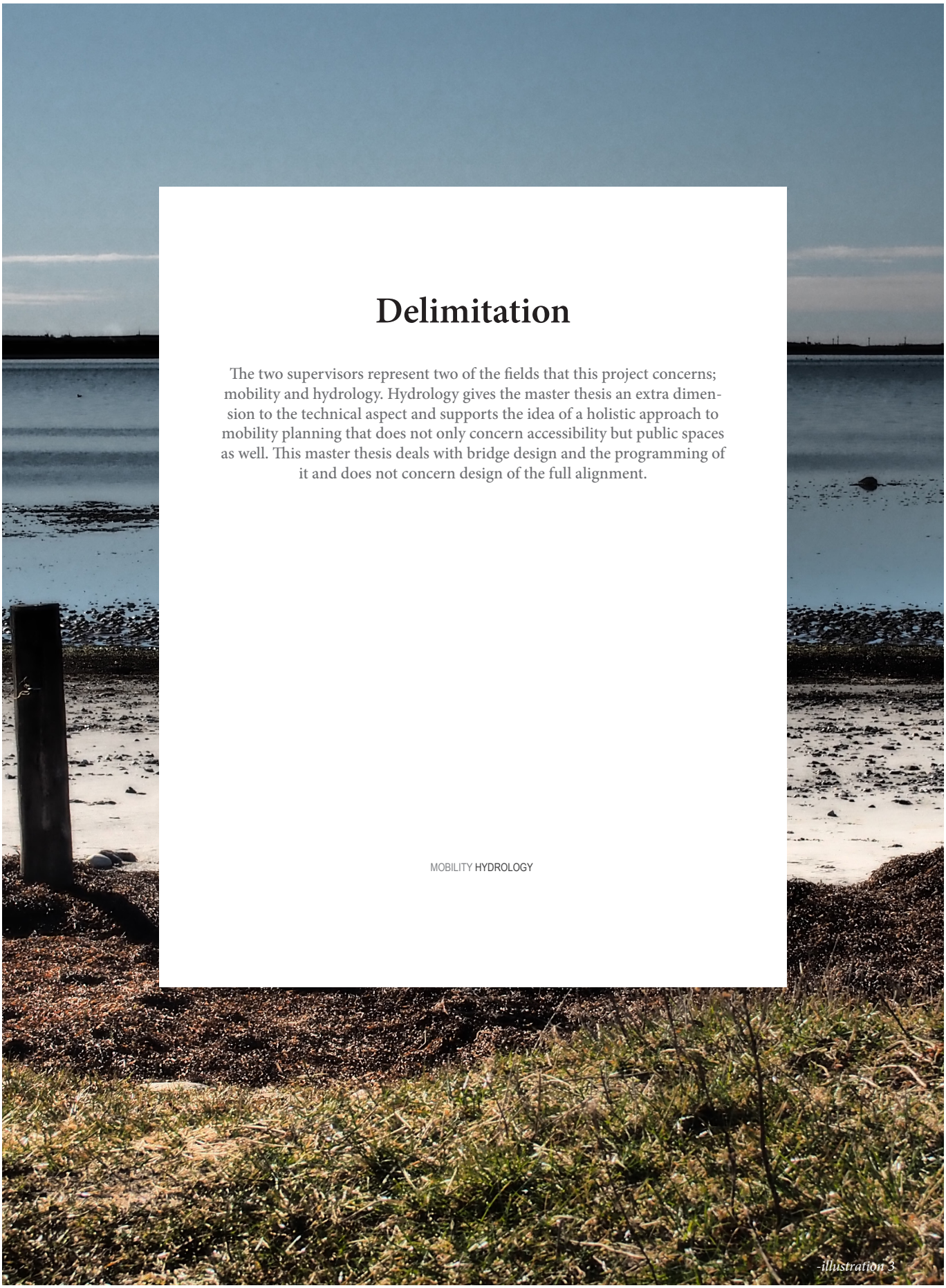


illustration 3

Methodology

This project is theoretical and design related study of how an existing project can be thought and redesigned in a new urban context. This project deals with studies of mobility and landscapes and the combination of the two as a Mobility Scape. Since the project is based on a theoretical evaluation of the existing project of a third Limfjords connection it is important to understand that there lies a great deal of text analysis which demands the hermeneutic method of understanding and interpretation.

The design is very much inspired by the Bird Foot Delta which has been a visual factor throughout the design process. During the semester we have visited the harbor fronts of Nørresundby and Aalborg, Egholm Island and used our field trip as an active part of the analysis of the existing project as well as the understanding of the potentials that lies within the fjord. The design process reflects both the iterative process as well as the integrated design process (Knudstrup and Hansen, 2005). The many iterations and technical approach has provided us with a better understanding of the topic and holistic approach which the meetings with supervisors have supported.

-illustration 4

Introduction

ISSUES OF LARGER INFRASTRUCTURAL PLANNING AND URBAN DEVELOPMENT

"MANAGING URBAN AREAS HAS BECOME ONE OF THE MOST IMPORTANT DEVELOPMENT CHALLENGES OF THE 21ST CENTURY. OUR SUCCESS OR FAILURE IN BUILDING SUSTAINABLE CITIES WILL BE A MAJOR FACTOR IN THE SUCCESS OF THE POST-2015 UN DEVELOPMENT AGENDA," JOHN WILMOTH

Aalborg has for a longer period of time discussed the necessity of a third Limfjords connection. A discussion which has taken many shapes and political discourses over the years, the latest of which involved the decision of a highway going west of the city through valuable natural areas. In recent years has the discourses mainly been seen as a highway, due to the financial aspect of a third Limfjords alignment. A highway will be financed by the government, while a local bridge would be financed by the local authorities in the form of its municipality.

But is this really a decision that should be solely based on financial aspect? And would the construction of a new highway, including a tunnel and bridge, really be the best solution in terms of financial aspects? Or would an expansion of the existing infrastructures with a bridge taking local aspects into consideration give higher value to both the regional and local demands?

Urban infrastructures are long-lasting and highly influential in terms of how a city grows and how its urban fabric will evolve over time. The official project The Third Limfjords Alignment considers only private and goods transportation where people are physical embodied in a car. Such project would likely make it more attractive to live further away from the city, leading towards urban sprawl and lower density in urban areas. Urban densification is in many situations linked to the issue of sustainability (this will be elaborated in the Theoretical Framework). Dense urban structures creates smaller distances which supports walking and cycling and creates a larger passenger basis for efficient public transport systems which will reduce the use and need of cars in urban areas and thereby reduce the energy use of transportation. Dense urban areas often promotes collective and resource-efficient solutions related to heat supply, waste management and recycling, as well as providing more social interactions and various social and cultural aspects of city life. However densification can also create potential problems and potentially harm urban life as the competition of land-use increase the reduction of green areas and affordable housing in urban areas. (Naturstyrelsen, 2016).
Modern urban development rarely occurs in wilderness areas, but in agricultural hinterlands, where the natural vegetation have been removed or restricted to minor boundaries. However agricultural lands retains some of the characteristics of natural landscapes in the form of streams, field margins, woods and tree belt. Even though the agricultural lands might have lost most of its biodiversity, they might still have relatively healthy soils and watercourses which provide a range of ecosystem services and goods. When urban development occurs in agricultural lands it often results in the clearance of all existing vegetation and thereby also biodiversity and ecosystem services. But the many citizens of the larger cities have an indirectly impact of the environment through the demand for food, raw materials and energy. As cities grow larger so does their ecological footprint and the demand for more agricultural land, which essentially means less natural areas. (Grant, 2012).

Today around 54 percent of the world's population lives in urban areas, by 2050 that number is expected to increase to 66 percent (Un.org, 2016). The increasing movement from rural towards urban areas together with a higher amount of children born in cities increases the demands of new developments in our cities and thereby also the agricultural, rural and natural landscapes surrounding them. Cities must therefore in a larger extend densify the area within their own periphery in order to protects its rural counterpart. During the middle age were similar issues addressed, due to the limited amount of land within walled cities. Here were any valuable and firm foundation turned into housing opportunities through creative solutions, one of which lead to the creating of the inhabited bridge. France is known to have had 35 bridges with housing on them, while three of them were placed in Paris on top of the Seine. (Historyworld.net, 2016)
The planning of larger infrastructures has for a long time been seen as a matter of course to growth but even with the larger motorway network of relatively small Denmark we start to see problems in the periphery of the larger cities. So what is the real quality of the larger infrastructures of Denmark and how can we consider new approaches where the planning processes are in dialogue with ecosystem services or social systems for that matter? Instead of seeing infrastructure as single-minded hit-and-run interventions it is time for rethink our built environment and how we relate to the nature we build in. (Topos, 2015)
Infrastructure, such as The Third Limfjord Alignment, should support smart growth which is contained through established urban corridors and connected to the urban center or downtown through proximity if not mass transit systems. It should be planned to be self-supportive over a long time through its multifunctional uses and ease of access via walk ability, bike trails and public transit systems. Urban infrastructures are long-lasting elements, that determine cities futures and should be build to create opportunities for resource-efficient and more competitive lifestyles, rather than singular backward thinking. It shouldn't solely be depended on automobile use, but should be capable of facilitating various transport modes and human activity, rather than their cars. (Berggren, 2014).

Focus

MOTIVATION AND DESIGN AREAS

"IN DENMARK WE HAVE A POOR AND PROVINCIAL APPROACH TO NATURE." RASMUS EJRNÆS, 2016 (INFORMATION.DK, 2016)

Our motivation for the project is to rethink and design the Third Limfjords Alignment. We want to create an urban connecter that incorporates state-of-the-art research about mobility and landscape design. We want to provoke the idea about what a bridge structure can be in an Aalborg context and we want to create spaces that facilitate everyday life in close relation to city, nature and architecture.

Bridges have for a long time been a portal to new territory - a link between two worlds that before were inaccessible. Modern materials and new manufacturing processes allow us to rethink and work bridges in new manners. Most bridges are designed for a single use but over time changes to facilitate multiple users and functions. (Denison and Stewart, 2012) The innovative use of bridges can be seen throughout history and especially later examples mark a shift in paradigm.

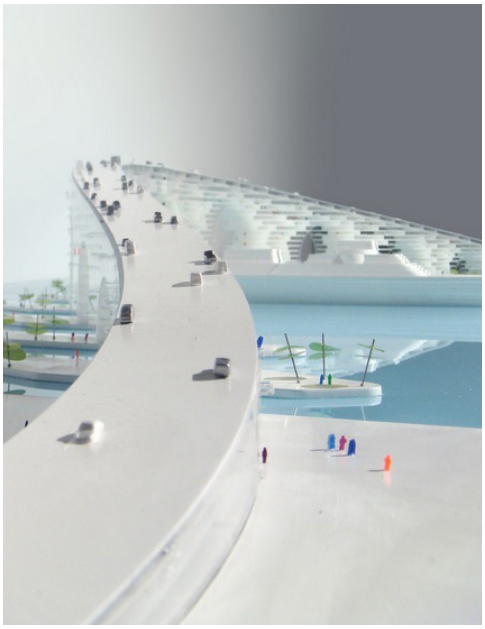
It is only natural for human to expand and build new territory but can we work with nature in the sense that none exclude another. We process our context to our benefit and shape our cities and landscape in endless networks; ecological, social and economical. The tendency is that we seem to limit and reduce the many ecosystems of our planet with the build and cultivated environment (globalissues.org, 2014) but over the last hundred years many urban developers and thinkers has started to question the role of nature in our cities. As Olmsted explains it:

"No single park, no matter how large and how well designed, would provide citizens with the beneficial influences of nature." (Olmsted, 1899) (Austin, n.d.)

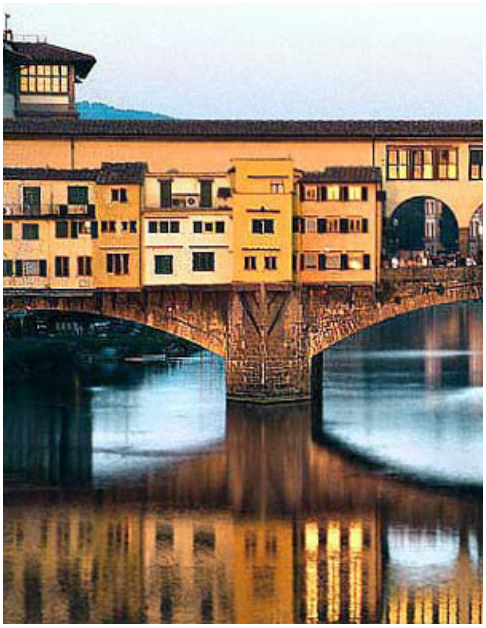
Olmsted talks about how important it is to link green spaces so they can become green infrastructure and by that gain the beneficial influences such as well functioning ecosystems.

A third Limfjord connection is both a necessity and reality but so are the wildlife and the scenery landscape that surrounds the inner city of both Aalborg and Nørresundby. In the project our focus will be combining the complex processes of mobility and nature to gain a better understanding of the way we plan and develop the future of Aalborg and its surroundings.

5. Gardens bridge by Thomas Heatherwick and Arup is under construction in London and is expected open in 2018



6. BIG's idea about the self financing bridge that utilize the beams for residential structures, shops and parking.



7. The famous bridge Ponte Vecchio in Florence connects two pedestrian streets and creates a public space.

Research Question

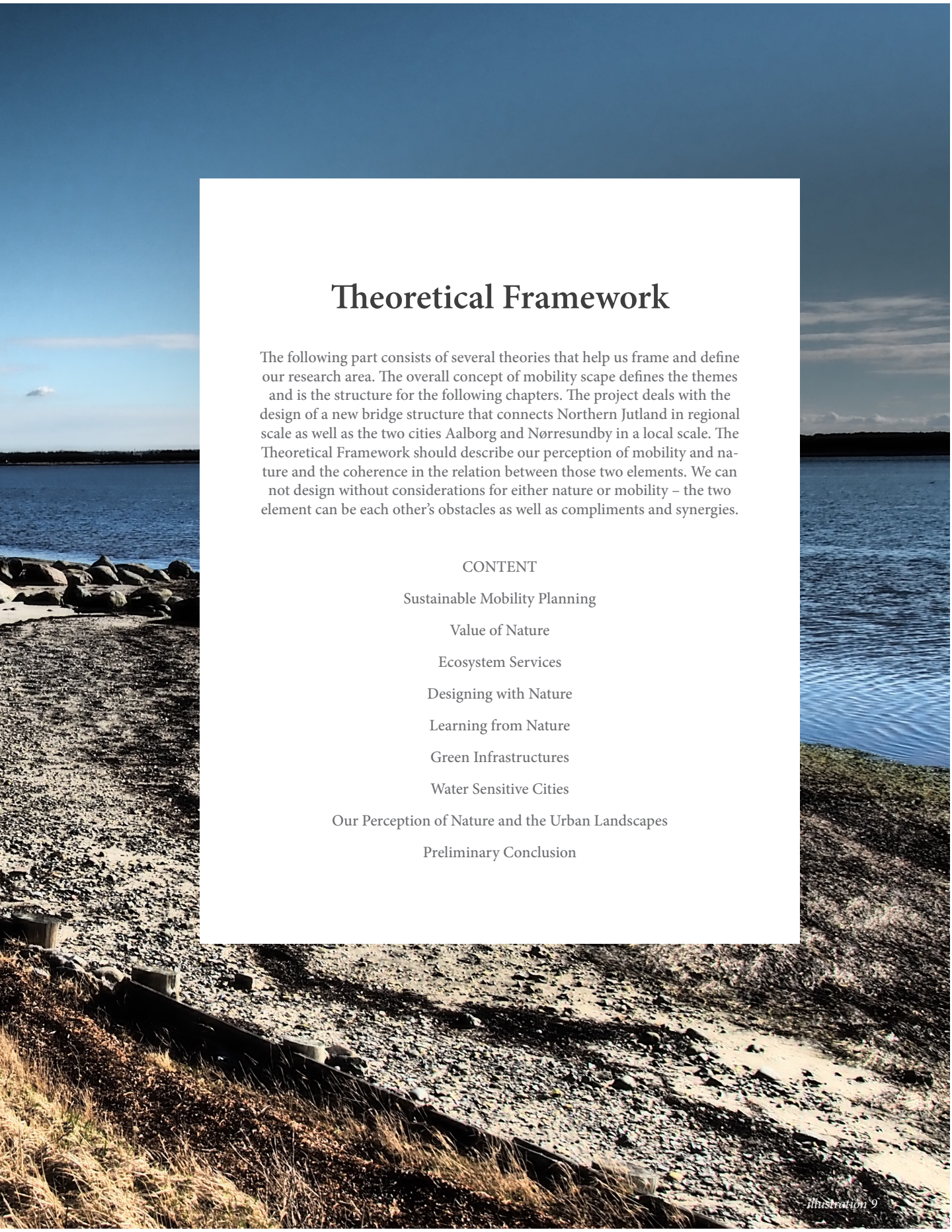
"How can we rethink the Third Limfjord Alignment and create a space that increase the value and potential of traditional infrastructure, benefitting both local and regional demands, while facilitating everyday life in close relation to the built- and grown environment?"

Sub Questions

How can we combine the process-related aesthetic of landscape with its ability to provide answers concerning technical issues of hydrology?

How can we enhance the relation to nature through the bridge as a 'medium for rethinking urban conditions'?

-illustration 8



Theoretical Framework

The following part consists of several theories that help us frame and define our research area. The overall concept of mobility scape defines the themes and is the structure for the following chapters. The project deals with the design of a new bridge structure that connects Northern Jutland in regional scale as well as the two cities Aalborg and Nørresundby in a local scale. The Theoretical Framework should describe our perception of mobility and nature and the coherence in the relation between those two elements. We can not design without considerations for either nature or mobility – the two element can be each other's obstacles as well as compliments and synergies.

CONTENT

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Sustainable Mobility Planning

A THEORETICAL APPROACH TO SUSTAINABLE INFRASTRUCTURE

"THE TWENTY-FIRST CENTURY WILL BE ONE OF CAR CONSTRAINT, AND OF INVESTMENT NOT IN ROADS BUT IN PUBLIC TRANSPORT INFRASTRUCTURE, AND IN INTEGRATED TRANSPORT SYSTEMS RATHER THAN INDIVIDUALS MODES OF MOVEMENT."
BRIAN EDWARDS (EDWARDS, 2011)

This chapter consists of three parts, one describing the shift in paradigm that infrastructural planning and mobility deals with, a second part describing the network city and the which design-related problems we must face in our cities of today and thirdly a part dealing with sustainable infrastructure. The chapter should provide the reader a theoretical framework from where the rest of the paper originates from.

A SHIFT IN PARADIGM

The last hundred years infrastructure has been a key element in reformatting the built fabric and continuous on for the future. The awareness of the importance of not only well functioning infrastructures but also aesthetic ones is increasing amongst urban designers in Denmark. For a long time many infrastructures has been handled by engineers only with the goal of optimizing the processes but the increasing demand for integrated design solutions puts the urban architect in a new role as a part of that. As the infrastructure is seen as the groundwork for development we as designers are obligated to participate in the planning of it and renegotiate the form and the performances of infrastructural spaces is a part of that! (Stoll and Lloyd, 2010)

"*What is required is a new mindset that might see the design of infrastructure not as simply performing to minimum engineering standards, but capable of triggering complex and unpredictable urban effects in excess of its designed capacity.*" Stan Allan (Allan, 2010)

Allan describes that even though new software is used to create building in biological forms it does make them organic or dynamic they are still fixed and limited constructions (Allan, 2010). The building is the body and the potential of co-existing or exchanging with its shifting context is limited. Allan describes a counter-trend that deals with some of the complex processes of the urban environment - described as artificial ecology by himself in 1997 (Allan, 2010). The idea of collective behavior of ecological systems as model for cities, buildings and landscapes describes and unfold the notion of a city as something that is unfixed and uncontrollable with its many social and cultural formations and complex processes. A notion already seen within the concept Landscape Urbanism as Allan together with Waldheim, Corner, Pollak etc. has been a part of.

As described, the last century has changed the way we see and experience infrastructure and the need for understanding it has become much more relevant in social terms – the notion of mobility turn has occurred in academia as well as practice (Jensen, 2014).

"…'the mobility turn' has come to document and explore how intimately mobilities are linked to issues of identity, culture, and social norms as much as to the instrumental acts of organizing flows of traffic, passengers, goods, information, or other types of mobilities." Ole B. Jensen (Jensen, 2014: 14)

As Jensen describes mobility has for long time been seen as instrumental acts of organizing flows but the shift in paradigm change the way we think of and experience mobilities in social terms.

NETWORK CITY

The increasing number of people living in urban areas is creating new demands for mobility planning and strategies. In 2010 more than half of the population lived in urbanized environments and the forecast is that 7 out of 10 of the population will live in larger urban areas by the end of 2050 (WHO, 2014). Anne Tietjen claims that today we are all urbanists (Tietjen, 2011). In Denmark everybody is living in cultivated areas and even though they don't live in a community every citizens are a part of the same processes and networks. The centralizations of our cities in Denmark impact the complexity of our cities even more –small as well as big ones. The developing technology and the general welfare allow many people to commute to and from work every day – in 2014 over 200.000 Danes have 50 km to work from home and that number has grown with 43% compared to 2003 (eof.dk, 2014). Duo to an increasing number of commuters and development of public transport as well as many new ways of travelling, such as car-pooling, mobility has become an

10. Steven Holl's solar Copenhagen Bridge is a example of two buildings facilitating sold as sustainable infrastructure. The bridge deals with the sorrounding environment and includes new technologies but takesvery litte considerations to social sustainability.

important element in the everyday life.

"We perform mobilities with our own bodies in time and space, and the way we position ourselves, sense the environment and other fellow mobile subjects, cannot be grasped without a firm understanding of the importance of the human body." (Jensen, 2014)

Jensen claims that mobilities are situations, real experiences, influenced by planners and designers but very importantly performed by the individual – a driver, cyclist or pedestrian for instance. The planned physical environment is working as enabler and generator for the many intertwining and complex meetings of networks. To understand and experience the network city, as an individual performer, it is crucial to have well-functional and linked public spaces. (Steffen, 2003) The public spaces work as the key elements and anchor points in our cities and as Hajer and Reijndorp explain:

"... we seem to think too much about public space in the sense of a fixed and permanent physical spaces, and we give insufficient consideration to the way in which public domain comes into being in flux, often extremely temporarily." (Hajer and Reijndorp, 2002)

Public spaces are not only materialised physical spaces but on the other hand very temporary and changeable. The challenges of urban designers are to create adaptable and healthy cities that are open and responsive to those changes – a notion already within the landscape. The growing number of people living in cities creates, along with a better standards of living, new demands to the functionality and livability and as Jan Gehl describes it; *"vibrant, safe, sustainable cities has become a general and insistent desire."* (Gehl 2010:16)

There is a conflict in the desire for living in larger cities with pollution, traffic etc. and the desire for greenery and the recreational element. But many think that the urban life can exist or even be enhanced by the presence of rural elements and none of them has to exclude each other. As Linda Pollak explains:

"Invest in the ground itself as a material for design, using landscape as both a structuring element and a medium for rethinking urban conditions, to produce everyday urban spaces that do not exclude nature. Its goal is to address simultaneously the concerns of architecture, landscape and city, without having one or more recede in importance." (Pollak 2006:127)

LANDSCAPE INFRASTRUCTURE

Over the last decade landscape has transformed as a model for contemporary urbanism and conditions for radically decentralized urbanization especially in the context of complex natural environments (Waldheim, 2006). Designers can activate space and produce urban effects by paying close attention to the surface conditions (Allan, 2001).

"… infrastructural systems and the public landscapes they engender as the very ordering mechanisms of the urban field itself…" (Waldheim, 2006:39)

The landscape has no exact way of programming and no predetermined design which is being the full potential of it, more importantly it has the potentials of facilitating or materializing the many complex infrastructure specificity of urbanization. Landscape and infrastructure has many similarities - they are both the sum of temporary processes and many activities. The infrastructural network of urban spaces continues to mutate as a result of the social, ideological and economic changes which leads to transformations in the built environment. The connectivity, both physical and invisible, of the world as we know it today creates new ecologies that strengthen communication and exchange. (Lloyd and Stoll, 2010)

Allan claims that the potential of landscape urbanism has not yet been unfold but instead led us to many beautiful harbor fronts and public spaces. Allan explains that an expanded institutional definition for design within the interdisciplinary field of infrastructure is required and he brings up the concept landscape infrastructures as a solution to that (Allan, 2010). Allan see infrastructure as static materials but their function is to serve movements and the terra flux examples three principles within the designing toolbox of infrastructures; Connectivity, Architectural Specificity/Programmatic Indeterminacy and Anticipatory Design. (Allan, 2010)

Connectivity:
Connectivity is the primary operation mode of infrastructure that serves movements of to move goods, people, energy, and information. Connections should be made out of surface and not lines while the line is single-minded where as surface is the territory of landscape and a contrast to the vertical dimensions that is materialized as building. Altogether it forms a continues matrix where both horizontal and vertical dimensions are understood as architectural material.

Architectural Specificity/Programming Indeterminacy:
Landscape is the connection between program and site and it is the programming of the open space. It is the limitations of design that needs to be strategically reworked to leverage architecture's potential to specify movements, create attractors and loosely steered programs. The site is never neutral and it is the infrastructure that creates difference manifests and the possibility of vital life over time in organized collectivity.

Anticipatory Design:
Emergence in the artificial ecologies is triggered by differences and imbalances in the initial conditions. The architect's obligation is to carefully design initial conditions with a high degree of precisions and specificity remains. As James Corner explains it: "The preparation of surfaces for future appropriation differs from merely formal interest in single surface constructions. It is more strategic, emphasizing means over ends, and operational logic over compositional design." (Corner, 2006). The design of infrastructure is open and anticipatory – it is the design of systems that makes it possible to send a number of messages.

The three principles describe the programming of the surface and how it is the designer's task to operate the initial conditions and architectural materiality of the city.

SUSTAINABLE INFRASTRUCTURE

In 2016lector in traffic planning Per Jespersen wrote in the Danish magazine Byplanlab that there is no such thing as sustainable infrastructure. Jespersen claims that transport is fundamentally a waste of time without value per se and that maksimisation of the speed and minimisation in waiting time is one of the most important goals of infrastructure. If transport should be assessed as a part of the purpose that it serves it can't be sustainable in itself. (Jespersen, 2016)

Instead Jespersen argues the importance of sustainable infrastructural planning, based on the work of Banister and the article The Sustainable Mobility Paradigm (Banister 2008), see for elaborated table, where the car-based solutions are no longer seen as key element but a part of a greater system of mobility modes. Furthermore he points out that streets should be seen as spaces instead of roads and thereby facilitate multiple functions. Danish transport planning is build up on three cornerstones; transport models, transport forecasts and socioeconomic analysis. Socioeconomic analysis works with 'costs' and 'benefits' and the sum of that is the present value which can be either positive or negative. If the project is negative it should by principle be turned down. The socioeconomic analysis deals with the economical aspects of the project, service and profit, but doesn't handle subjects as livability, landscape, nature, wild-life and recreative areas as a part of the calculations of the present value. (Jespersen, 2016)

The sustainable transport planning marks a paradigm where all three dimensions of sustainability are considered – eco-

11. Queen Louise's Bridge in Copenhagen is a place for people in transit but also a place for people relaxing in the sun - in informal settings.

nomical, social and environmental. It suggests that the three cornerstones should be supplemented with visions, scenario planning and multi-criteria analysis that does not oversimplify the complexity.

As described in this chapter several urban architects and planners state the need for new perspectives within the field of infrastructure. A new mindset is demanded and state-of-the-art interdisciplinary solutions are a necessity for further explorations and sustainable thinking of the urban field. Infrastructure is social structures that creates many connections and by that defines the underlying settings for urban planning. The many movements is planned out in regional scale but acted out as embodied performances as the individual in the large scale scenery of the network city. The holistic approach to mobility and the infrastructural networks makes demands for our cities when it comes to experiencing and understanding the city and the infrastructural network of public spaces plays as key element to that.

The monotonous approach to infrastructure as A to B-experiences has created large scale motorway systems that facilitates nothing else than motoring. To create sustainable infrastructure we must look at the single-minded linearity and try to rethink the situations in relation to social norms and economies of today. What are we connecting with the ongoing city planning and even more importantly what are we not? When it comes to the third Limfjord Connection some of the main reason to build it is to create a united Northern Jutland where time does not pay a role in the connectivity, but as the plans are today the linking network between public and private traffic is very week and almost non-existing. This can result in a polarization of different mobility modes and to create better infrastructural systems it is important to plan for a build environment where none exclude each other. By investing in the ground and see the surface as a medium for rethinking urban conditions we can design for better infrastructural systems where architecture, nature and landscape is addressed simultaneously.

Key Points:

- The bridge structure should embody sustainable transport planning of the everyday mobility where the intertwining mobilities are taking into considerations

- The bridge structure should be seen as node in the series of public spaces in Aalborg and not as a single minded linear space

- The bridge structure should be seen as a surface that works as a medium for rethinking urban conditions

- The bridge structure should work with infrastructure as a potential enabler for activities both in terms of the structure itself and the surrounding environments such as the Limfjord

12. Aerial photo of the border between Haiti and the Dominican Republic

The Value of Nature

WORKING WITH ECOSYSTEM SERVICES

"EVERY DAY, WE USE MATERIALS FROM THE EARTH WITHOUT THINKING, FOR FREE. BUT WHAT IF WE HAD TO PAY FOR THEIR TRUE VALUE: WOULD IT MAKE US MORE CAREFUL ABOUT WHAT WE USE AND WHAT WE WASTE?" - PAVAN SUKHDEV (SUKHDEV, 2016A)"

One of the most difficult things about incorporating and working with nature is that it is very difficult to describe the value of it. This chapter deals with the "The Economics of Ecosystems & Biodiversity" initiative as a tool to elaborate what normally is described as "fluffy" and "green".

VALUE OF NATURE

The hidden economics of the ecological services surrounding our everyday life is a complex, and until more recently unknown factor in an economical sense. Pavan Sukhdev (WOODWORTH, 2011) believes this arise from the common way of thinking nature as a common good, that's accessible to all, until its services begins to disappear. The fact is that when we destroy biodiversity, we simply don't know the true value of what we are destroying. The term "Natural capital" deals with this issue and can be understood as an "economical reflection of biodiversity and ecosystems" (WOODWORTH, 2011).

"The Economics of Ecosystems & Biodiversity" (or simply put TEEB) initiative works with this way of thinking nature and how to implement it into a strategically planning tool for local and regional policy makers around the world (TEEB, 2011). The TEEB initiative's goal is to end the economic invisibility of nature, to help key actors recognize the value of ecosystem services, a term which covers the benefits that nature provides to the human economy, while rewarding initiatives which takes responsibility of Earth's ecosystems and biodiversity (Sukhdev, 2016b). The TEEB initiative also highlights the understanding of the complexity of biodiversity loss in its social, economic and policy dimensions, as a necessary requirement for any proposed solution, and see this as their guiding philosophy (Sukhdev, 2016b).

THE VALUE OF NATURE FOR CITIES

Nature was previously seen as the counterpart to the more negative aspects of urbanization; it were generally seen to provide salve and respite from the deleterious effects of urbanization (Corner, 2006). Even though we now perceives landscapes and urbanism way differently after several paradigm shifts within the field, the notion or benefits of the urban landscapes is very much the same. Urban areas needs nature or more importantly they need its ecosystems and the services they bring along.

The ecosystems and the services they bring along are the foundations for sustainable cities, as they influence and affect human well-being and most economic activities. In this way, can cities make some very positive changes by considering ecosystem, which for example includes; savings on municipality expenses, boosting local economies, enhancing the quality of life and securing livelihoods for its citizens. At the same time will a lack of information, understanding and planning of the consequences of decisions made on behalf of the environment lead to the loss of essential and beneficial ecosystem services. As a result can poor decisions on environmental laws or planning lead to a sub-optimal use of cities "natural capital", which leads to unnecessary losses in local welfare, city budgets and business opportunities. It is therefore necessary to keep and maintain healthy environments, as there is a "tipping point", at which a degraded ecosystem will cease to supply ecosystem services that we rely upon. Restoring these ecosystem services can be extremely expensive, time-consuming, or even deemed impossible. Therefore is it necessary to factor ecosystem and their services into city planning, -management and -budgets to outline the true costs and benefits of various possibilities in order to take better and more informed decisions. (TEEB, 2011).

By being aware of the benefits that nature provides, and by understanding the true value of these, from the beginning of a process can planners, educators and managers create decisions that moves their cities towards a more sustainable path, with healthy ecosystems. As maintaining healthy and functioning ecosystems is the most cost-effective solution to meeting human needs, and handle some of the current problems the cities around the world are facing, such as climate changes, land degradations, extreme event etc. in the long term, is it necessary to incorporate this way of thinking in the early phases of decision making. (TEEB, 2011).

To help incorporate this way of thinking has "TEEB" created a method, which introduce the subject of ecosystem services and how to determine their value, and maybe more importantly how to incorporate a consideration of ecosystem services into city planning, as a long-term investment to enhance the existing management of cities. (TEEB, 2011).

Ecosystem Services

PROVISIOING SERVICES REGULATING SERVICES HABITAT OR SUPPORING SERVIES CULTUREL SERVICES

The ecosystem services method is divided into four categories: Provisioning services, Regulating services, Habitat or Supporting services, and Cultural services. The provisioning services are defined by ecosystems services that has a material or energy output/benefit. The regulating services describes services that regulate quality of air and soil or providing flood and disease control etc. The Habitat or Supporting services, describes ecosystem services that provides living spaces for plants or animals, while the cultural services includes the non-material benefits people obtain from contact with ecosystems. (TEEB, 2011). This sub chapter derives from the TEEB manuel.

Provisioning services; this services describes the material or energy output from ecosystems (TEEB, 2011).

FOOD: Some ecosystem services transform energy and nutrition's into eatable plants through the photosynthesis. These ecosystems comes in various shapes and provide various conditions, however they all have the same thing in common; they provide the conditions necessary for growing food. These ecosystems stretch from marine- and freshwater systems, forests or urban horticulture and arguably the most common for human consumption; managed agro-ecosystems.

Urban agricultures, such as urban gardening and community gardens are now accounting for between 15 and 20 percent of the worlds food production, which are grown by more than 800 million people in cities around the world. The city of Philadelphia, and its 226 community and squatter gardens grew roughly 2 million pounds of mid-summer vegetables and herbs in 2008, worth around 4.9 million US. dollars (Royte, 2015). A number which didn't include the natural capital and savings provided by the many new ecosystems created by the city's urban gardens.

RAW MATERIALS: Ecosystems also provide various conditions for extractions of raw materials for constructions and fuel, including; wood, biofuels and plant oils that are directly derived from wild and cultivated plant spices.

The forest stewardship Council (FSC) is an organization which certify and promote sustainable forestry around the world. Sustainable forestry is a way of forestry management, which conserve biological diversity and its associated values, water resources, soils and unique and fragile ecosystems and landscapes, while maintaining ecological functions and the integrity of the forest. Recent studies revealed that a FSC certified forest earned 1,80 US. dollars for every cubic meter on average, due to price premiums, increased efficiency, and other financial incentives compared with non-approved forestry (FSC United Kingdom, 2016).

FRESH WATERS: Fresh water is a vital resource for cities around the world and ecosystems play a vital role in providing it, as they ensure the flow, storage and purification of water. Vegetation and forest influence the quantity of water available locally, while the health of local ecosystems determines the quality of it.
From an economical perspective does the 1990's experience of the New York City agency illustrate the benefits of healthy ecosystems in terms of availability of fresh water sources. During the 1990's were the potable water supply source for New York City was becoming increasingly polluted due to agriculture, urbanization and the discharge of effluent from wastewater treatment plants within the watershed. The agency had to chose between two solutions; the constructing of a 6-8 billion US. dollars filtration plant, with an additional operating cost of hundreds of millions of dollars or restoring and protecting the catchment area through watershed protection. The agency chose the latter and earmarked a total of 541 million dollars to land acquisition and purchase of conservation easement. They added 49,000ha of land to the 18,000ha it already owned and by doing so restored valuable ecosystems and saved the city billions of dollars (Austin, 2014).

MEDICINAL RESOURCES: Throughout history has plants been used to treating various diseases, and knowledge of plants has been an important part of communities around the world. Ecosystems that has a rich biodiversity provide many plants that can be used directly or indirectly as raw materials for the pharmaceutical industry. All ecosystems are a potential source of medical resources.

The use of and treatment with herbal medicines has been a vital and traditional part of the human history. The use of herbal medicines includes herbs, herbal materials, herbal preparations and finished herbal products, which contain either an active ingredients parts of plant, plant materials or a combination of the two. According to the World Health Organization (2006) were the economic output of traditional medicine in the Republic of Korea 7.4 billion US. dollars in 2009, while "out-of-pocket" spending for natural products in the United States was 14.8 billion US. dollars in 2008.

Regulating services; These ecosystems provides services that regulate the quality of air and soil or providing extreme events, such as flood and disease control. (TEEB, 2011).

LOCAL CLIMATE AND AIR QUALITY REGULATION: Plants, trees and vegetation play a vital role in regulating and maintaining both a good climate and air quality in cities and rural areas. Trees, plants and vegetation has the ability to lower the temperature through evaporation and shadowing of heat absorbing surfaces, while they also play a vital role in regulating air quality by removing pollutants from the atmosphere (TEEB, 2011).

The urban heat islands phenomenon is defined by a metropolitan area that's a lot warmer than the rural areas surround it. It's caused by extended heat in an area with many heat absorbing surfaces, a lack of green areas and "waste energy" created by people, cars, busses etc. These areas tend to have bad air and water quality and according to the "Heat Island Group" are "Urban heat islands" costing the city of Los Angeles, California 100 million dollars a year in extra energy usage (National Geographic Education, 2011).

In China, has air pollution become so extensive that its impacting everything, health, tourism, industrial output, and the country's Gross domestic product (GDP). Emissions from traffic, factories and burning coal are cloaking entire cities under heavy smog, forcing citizens to wear masks in order to filtrate the polluted air. The healthcare cost of the excessive air pollution is estimated by the world bank to cost China around 100 billion us dollars, or 3 percent of the country's GDP, a number which is calculated based on illnesses and premature deaths. Bad air quality contributes to 4,400 deaths a day, or 1,6 million deaths a year, which is roughly 17 percent of all yearly deaths in China (Yuanyuan, 2015).

CARBON SEQUESTRATION AND STORAGE: Ecosystems play a vital role in regulating the global climate by storing greenhouse gases. When trees and plants grow, they absorb and remove carbon dioxide from the atmosphere and store it in their tissues, and thereby functioning as carbon storage (TEEB, 2011).

Urban trees also play an important role in terms of carbon sequestration. In the United States are urban trees annual gross carbon sequestration 22.8 million tons per year, a number which is equivalent to the entire USA population's emission in five days. The trees sequestration is valued at 460 million US dollars per year and 14,300 million US dollars in total (TEEB, 2011).

MODERATION OF EXTREME EVENTS: Ecosystems can help reduce the impact of extreme events, as they can create natural buffers again natural disasters by preventing or reducing damage from extreme weather events or natural hazards such as floods, storms, tsunamis, avalanches and landslides. For example, can plants stabilize slopes and thereby preventing larger landslides, while coral reefs and mangroves help protect coastlines from storm damage (TEEB, 2011).

A study by the Natural Capital Project (2016) showed how the current ecosystems on the coastline of Belize protects the shorelines from about 5 billion US dollars in erosion damage every year. Furthermore did the ecosystems coral reef and mangroves protect the coastline from severe storm damage, which prevent property damage and further damage costs.

WASTE-WATER TREATMENT: Through the biological activity of microorganism in the soil are ecosystems capable of filter effluents and thereby eliminating pathogens (disease causing microbes) and reducing the level of nutrients and pollution in the water. Ecosystems can therefore act as a natural waste-water treatment system, while affording other ecosystem services (TEEB, 2011).
Wetlands can function as a natural alternative to the conventional way of wastewater treatment. A study in 1995 in the American state of Louisiana estimated cost saving benefits of wetland to be between 785 to 37,700 US dollars per hectare of wetland (TEEB, 2011).

EROSION PREVENTION AND MAINTENANCE OF SOIL FERTILITY: Vegetation provides a vital regulation service by preventing soil erosion, which is a key factor in the process of land degradation, desertification and hydroelectric capacity. Soil fertility is essential for plant growth and agriculture. Well-functioning ecosystems supply nutrients required to support plant growth and maintain a healthy soil fertility (TEEB, 2011).

POLLINATION: Wind, insects and some birds and bats pollinate plants, which is essential for the development of fruits, vegetables and seeds. Important cash crops such as cocoa and coffee is part of some 87 out of the 115 leading global food crops, which depends upon animal pollination. The ecosystem service of pollination is mainly provided by insects, but also birds and bats (TEEB, 2011).

Coffee is grown in over 50 countries in Asia, Africa, Caribbean, south- and central America, however 67 percent of the world's coffee is grown in the Americas alone and support the livelihood of over 25 million people worldwide. Coffee is a worldwide exporting business with an estimated yearly export worth 20 billion US dollars. All of which is supported by the ecosystem service of pollination (Goldschein, 2016).

BIOLOGICAL CONTROL: Ecosystems are important for regulating pests and vector borne diseases by affording the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural controls and play a vital part of a healthy ecosystem (TEEB, 2011).

The Water Hyacinth, a highly aggressive invasive species was brought under control in southern Benin using three natural enemies of the plant. The biological controlled project costs 2.09 million dollars in present value, however it accumulated a value estimated to 260 million US dollars in present value. So by using a biological control and ecosystem services were there accumulated 124 million for every million spent on the project (TEEB, 2011).

Habitat or Supporting Services: Ecosystems provide living spaces for plants or animals. These services underpin almost all other services, as they maintain a diversity of plants and animals (TEEB, 2011).

HABITAT FOR SPECIES: Ecosystem provides various habitats that can be essential for a species' lifecycle. They provide everything that is essential for an individual plant or animal to survive; food, water, and shelter. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movement and throughout their lifecycle (TEEB, 2011)

Natural habitats and the many ecosystem services they provide, is worth far more being left intact than exploited, even if the converted habitat brings apparent economic gains. The yearly loss of natural habitats from practices such as logging and farming is estimated to cost around 250 billion US dollars (Economic reasons for conserving wild nature, 2002). At the same time is the loss of natural habitats one of the greatest treats towards species, biodiversity and the variety of life. It is identified as a main threat towards 85 percent of all species described in the IUCN's Red list. A list, which describes the species officially classified as "Threatened" and "Endangered" (panda, 2016).

MAINTENANCE OF GENETIC DIVERSITY: The variety of genes between, and within species populations distinguished different breeds or races from each other provides the basis for locally well-adapted cultivars. Habitats with an exceptionally high number of species are known as "biodiversity hotspots", as they are more genetically diverse. These ecosystems also provide the opportunity for commercial crops and livestock (TEEB, 2011).

An initiative to conserve local varieties of rice in the Philippines helped researchers in the development of rice strains that were better adapted towards the local conditions. By using local and native plant, did the researcher create rice strains, which gave greater yields, a quality seed supply, and decreased the dependence on plant breeders, all of which at a much lower cost than that of formal plant breeding. (TEEB, 2011)

Cultural service: The aesthetic, spiritual and psychological benefits of ecosystems are defined as the cultural services that ecosystems affords. The services describes all the non-material benefits people obtain from contact with ecosystems and natural areas (TEEB, 2011).

RECREATION, MENTAL AND PHYSICAL HEALTH: Green spaces benefits for people goes far beyond the recreational value its often is associated with. The role green spaces plays in maintaining the physical and mental health for people are becoming increasingly recognized, despite the difficulties of measuring the benefits green spaces has on people. For example is walking and playing sports in green spaces a good form of physical exercise, while also having a relaxing effect on people (TEEB, 2011).

Nature has the ability to reduce stress, to enhance a positive mood, to improve cognitive skills and academic performance, and even help in moderating the effects of ADHD, autism, and other childhood illnesses. A Danish study from 2009 demonstrated the importance of access and proximity to parks and nearby green spaces and related the proximity to associate with lower stress levels and a lower likelihood of obesity. A similar Swedish study suggested that green features in urban areas acted as so called "pull factors for physical activity" and that green spaces thereby helped us outside and drove people to live more physically lives, which will give huge benefits in terms of good health (Beatley, 2011).

A British mental health charity called MIND compared the benefits of walking in natural areas with a walk in a shopping mall. Their results showed how people walking in natural areas reported improvements in self-esteem (90% improved), while those walking in the shopping mall showed rather small improvements, with 44 percent of indoor walkers reported a decline in self-esteem. In the same way, did the study showcase improvements for the outdoor walkers in mood, which were measured in six factors: depression, anger, tension, confusion, fatigue, and vigor). 71 of the outdoor walkers reported a reduction in tension, while 50 percent of the indoor participants reported an increase in tension, compared to zero percent of the outdoor walkers. (Beatley, 2011)

The medical costs of obesity in the U.S. was estimated at 147 billion US dollars in 2008 (Cdc.gov, 2016), while the cost of stress related illness in the U.S. is estimated to cost American businesses up to 300 billion US dollars a year (Jobs, 2012).

TOURISM: Tourism is a vital source of income for many countries and ecosystems and biodiversity play an important role and support many kinds of tourism. While there is considerable economic benefits of tourism, global earnings of up to 944 billion US dollars, can it also be used to educate people about the importance of biological diversity, and create a stronger connection with nature in both cultural and eco-tourism (TEEB, 2011).

TEEB (2011) estimated the Coral reefs in Hawaii's value in terms of tourism to 97 million US dollars per year, based on the amount of money people spent on travel and local expenditures in order to visit the Coral reefs. The study implies that Coral Reefs, and other natural areas can result in significant income generation for locals, companies and countries.

AESTHETIC APPRECIATION AND INSPIRATION FOR CULTURE, ART AND DESIGN: Throughout human history has the natural environment, language and knowledge been intimately related. Our curiosity for biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art, culture and increasingly for science, with more and more designed based on nature through biomimicry design and ecological awareness (TEEB, 2011).
The 500-series bullet train in Japan could travel 300 km/hour, however the sound levels exceeded the legal environmental standards. The engineers had difficulties reducing the noise, which were mainly caused by atmospheric pressure waves forced in front of the train as it traveled through a narrow tunnel, creating a sonic boom at the exit. However, Eiji Nakatsu an engineer and birdwatcher, used his knowledge of the how kingfishers enter waters without creating a splash and the silent flight of owls to redesign the nose of the train and thereby decrease the sound generated by the trains. As a result of the redesign, did the train not only reduce its noise levels, but also managed to travel 10 percent faster, while using 15 percent less electricity. All of which was a result of one man's interest in nature, and the biodiversity of ecosystems (Asknature, 2016).

SPIRITUAL EXPERIENCE AND SENSE OF PLACE: Natural habitats and areas is a common element of all major religions and traditional knowledge, and associated customs are important for creating sense of belonging to a certain place or natural feature - such as specific forests, caves or mountains, all of which are considered sacred or to have religious meaning (TEEB, 2011).

The Maronite church of Lebanon maintained a rare remainders of intact Mediterranean forest, as it was in line with the Maronite culture, theology and religion. The religion, and not scientific or legal arguments, saved the area from deforestation, because it was a significant part of religion (TEEB, 2011).

In Norway the Norwegian Highway authority launched a project called the "National Tourist Routes project", which aimed to make Norway a more attractive tourist destination and revert the declining economy in rural areas. This is done by working with the existing landscape, it's potentials and by exploding it through spatial installations, which works with the landscape and captures the sense of place. The network of installations and the improved connectivity with the picturesque landscapes create a surplus value, which increase leisure and experience economy in the peripheral rural areas. (Laursen, 2012).

Designing with Nature

WORDS CONTENT CONTENT

"LONG-TERM SUSATINABILITY NECESSIITATES AN INHERENT AND ESSENTIAL CAPACITY FOR RESELIENCE - THE ABALITY TO RECOVER FROM DISTURBANCE, TO ACCOMODATE CHANGE, AND TO FUNCTION IN STATE OF HEALTH." -NINA-MARIE LISTER (LISTER, 2015)

How can we design with nature, its biodiversity and ecosystems in mind? This chapter will seek to reach an understanding of various notions within landscape architecture regarding these subjects, in order to reach a broader understanding of how this can be achieved through design with nature.

There has been a paradigm of control, where cities have dealt with climate changes through built systems, such as dikes and flood protection areas, in what is deemed the "Sustainability City". However the term "Sustainability" is based on the idea of maintaining the status quo, by protecting the manmade environment from natural incidents such as rain, flooding and droughts. When these systems fail, we restore them back to their original state and thereby erasing all traces of devastation and indications of the city's physical weaknesses (Andersson, 2015). Dirk Sijmons (2015) believes we have to move past the idea of the sustainable city and the idea of maintaining the status quo and into a new paradigm where we work with nature instead of retaining it, in what he describes as the notion of "Resilient city". He avoid using the term "sustainability" as its mostly informed by the subtext that it express: stability, everlasting equilibrium, endurance of systems and a steady state. The issues with this is that we can't simply go back to what was or have been, our cities can't remain a steady state we have to make our cities adaptable in order to work with and not against external influences. This is what resilient cities is all about; creating a city where there is no destruction, only adaptation and optimization. In a resilient city, there is no steady state the city is constantly changing in order to optimize its physical appearances in relation to and depending on various occurrences (Andersson, 2015).

Instead of a traditional, final and static master plan, the resilient city is dynamic - it describes how the city can adapt, change and incorporate external influences into new and improved states. The physical development plan thus consists of two complementary elements: the physical state plans and the built plan. The built plan describes and shows the shape and form of the built environment. It consists of its functionality such as infrastructure, the spatial organization of built form, as well as the level of density. The physical state plans describes all growing, living, changing and biotic matter, and can be referred to as the grown environment - the opposition of the built environment. Hence, the physical state plan doesn't referrer to a final image of a city, but rather a stage in its constantly changing physical appearances. It's the grown environments ability to restore itself, while providing a series of ecosystem services, that lays the foundation of the resilient city. It allows the resilient city to combine amenity value and utility value into a unified and flexible system, capable of adapting itself. The built environment and the grown counterpart are not seen as being in a "balance" or "harmony" but as two complementary elements. The grown environment follows and adapts to the processes and systems of the natural world, while the built environment in its essence is a stable (yet in process over longer periods of time), rational and man-made structure. (Andersson, 2015).

Nina-Marie Lister (2015) believes that long-term sustainability necessitates an inherent and essential capacity for resilience in order to recover from disturbance, to accommodate change and to function in a state of health. As long-term sustainability often refers to the dynamic balance between social-cultural, economic and ecological domains of human behavior necessary for humankind's long-term surviving and thriving, design shouldn't control the environment as an object separated from human action, but instead incorporate it in terms of social-cultural, economic and environmental parameters (Lister, 2015). The natural landscape or grown environment, has the ability to facilitate social interacting and becoming a gathering element in urban areas through the recreational activities its facilitates (Andersson, 2015). Furthermore, as discussed in earlier chapters can the grown environments "natural capital" also add an economic aspect into the notion of resilient. Hence does the notion of resilient cities, physical embodied in the present of natural environments, becomes a dynamic frame balancing both social-cultural, economic and ecological elements in urban areas.

Dirk Sijmons (2015) believes the notion of resilient cities has the ability to change how we perceive urban landscapes and its rural counterpart. He states that two boundaries are being blurred in modern time; the boundary between the city and the countryside and the fading of the boundary between nature and society. The hybridization between the tech-

13. Thornton Creek, Seattle, incorporates wetlands and creek into high-density mixed-use urban development.

no-sphere, the realm of human technological activity, and the biosphere, the living organisms and their environment, are forming an understanding of the urban landscape and the rural landscape as one. This hybridization is causing a new way of thinking about our urban landscapes, and the many negative impacts cities has on the surrounding landscapes. However if we consider the urban landscape as a hybrid between the biosphere and the techno-sphere, and accept future cities necessity to become more changeable and its service more flexible, does the urban landscape has its first overall resilience in the capacity of the underlying ecosystems to respond to perturbations or disturbances (storms, flooding, quakes or fires) by resisting damage and recovering quickly. A design for resilient cities is therefore in many ways a design with ecosystems, and the fundamental idea of bringing nature-based solutions into the planning discourse. If we do this, future planning can take a dialog with nature instead of a single, hit-and-run, interventions. By using nature-based solutions, and systematically learning from how nature "answer" human interventions, we can create solutions that promote biodiversity as a planned side effect, instead of creating solutions which decrease project areas ecosystems and biodiversity (Sijmons, 2015).

Working with ecosystem services also means that the notion of resilient cities is a matter of regional planning, in order to remain life supporting systems function under the stress of sudden disasters or slow disasters like the effects of climate change. These ecosystems are not only beneficial or vital for biodiversity and the natural real, but also vital for the urban metabolism that keeps the social tissue in our cities alive (Sijmons, 2015).

A design with ecosystems, is a design with nature's processes and systems. Process urbanism is a way of working with ecological processes, rather than aesthetics in an urban context. It combines scientific knowledge about nature, ecosystems, vegetation, metabolism, CO2, growth, water, earth, food chains, and chemistry, with an creative and artistic will to find a more long-lasting, sustainable and holistic approach towards the design of our cities. Or in other words, it's a focus on natural processes rather than on the aesthetics of the city and nature. In this way becomes the procedural, the changeable, non-completed and unknown, key elements in the work with process urbanism. Like nature, where ecosystems mutual adjustments ensures balance, survival and development. By learning of natures ecosystems can the design of nature and the city, which are often seen as two contrary elements, be designed as one unit - as something that complement each other. Process urbanism sees the city as a unified ecosystem, where every structure and element interact and exchange with each other, across common "structure's". There is no longer any blue, green or grey structures, but only one ecosystem. The city now collaborate with nature and thereby create a new expression, a new aesthetic. (Andersson, 2011).

The notion of resilient cities and the idea of working with nature is already being transformed into design and natural restoration projects, as seen in both "The Delfand Sand

14 and 15.The Delfand Sand Engine project. Above; the project in its early phase, 2011. Right; the project in 2015

Engine" project in the Netherlands and the Thornton Creek in Seattle, which incorporates wetlands into high-density mixed-use development.

The Delfand Sand Engine projects is a shoreline maintenance project, which uses natural processes to distribute a 25.5 million m3 amount of sand along the coastline of Zuid-Holland. The main idea behind the project is to collaborate with nature in order to avoid disturbance of fragile ecosystems along the coast. Traditional shore maintenance projects aim of sandy nourishment with a medium volume of sand, typically have a lifespan around 5 years. Which means that every 5 years the nourishments has to be redone, resulting in a frequent disturbance of fragile ecosystems. The Delfand Sand Engine project uses the power of winds, waves and currents to help protect valuable flora and fauna associated with them, meaning their strategy uses a climate-robust and environment-friendly means of countering coastal erosion. Their strategy also has the benefits of a significant lower disturbance frequency, which gives the natural environment longer time to develop new ecosystems with augmented biodiversity. The projected started back in 2011 and have already shown remarkable results. Sand sediments has been transported along the coast and into the dunes, seals and other animals has been visiting the area, while rare plant species has been found growing on some of the newly formed juvenile dune. Furthermore has it also proved to be a hotspot for wind, wave and kite surfers. (Ecoshape.nl, 2016). The restoration of the Thornton Creek in Seattle lead to the transformation of a former parking lot into a high-density mixed-use urban development, which incorporated wetlands and water management. It treats urban storm water runoff from 680 acres within a series of channels, pools, and terraces designed to mimic the performance of a natural creek. However the creek's alignment and the planting scheme is designed to adapt and transform over time to adapt towards changing climates and dry and/or wet periods. To increase biodiversity and resilience, the planting scheme consisted of 85 percent of native plants. As a whole the project served multiple functions, such as improving water quality, provide public open spaces, native vegetation, and facilitate economic development.

Key Points:

- The bridge structure should be adaptable towards external influences

- The natural environments shall be the dynamic frame that's balancing both social-cultural, economic and ecological elements

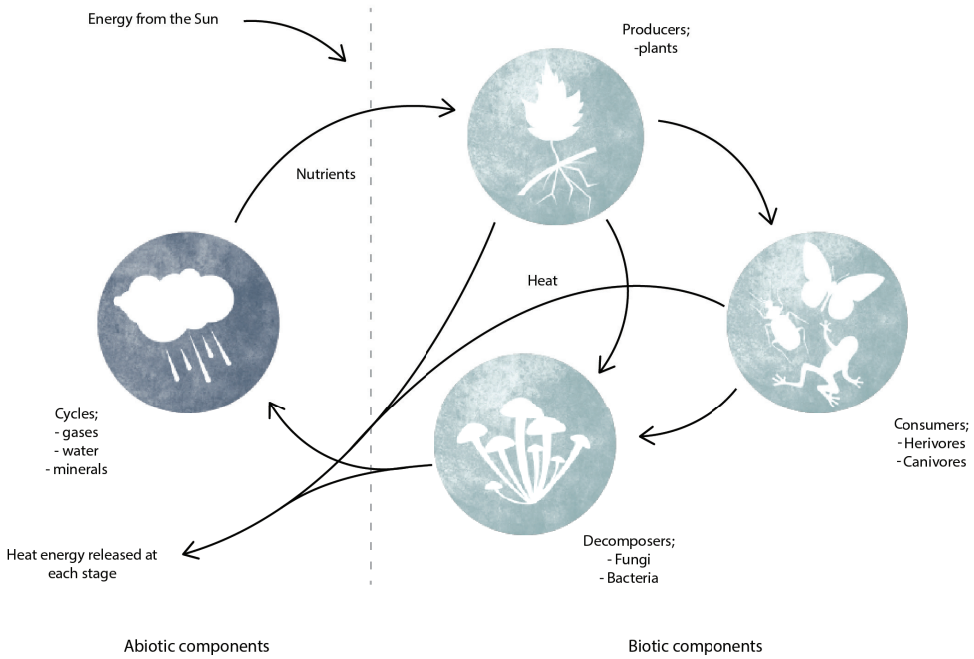
- The urban areas and its rural counterparts shall be seen as a single unified ecosystem - both artificial and natural ones.

- Planning shall have a dialog with nature, by using nature-based solution, and systematically learn from how nature "answer" human intervention in ecosystems.

- Work with one ecosystem, rather than traditional structures, such as blue, green, grey structures etc.

Learning from Nature

VEGETATION ECOLOGY PLANT SOCIETIES LANDSCAPE ELEMENTS



16. Abiotic and Biotic components interaction and effects on vegetation

In order to reach an understanding of how landscape can become resilient, will the following page go into ecological vegetation and describe which parameters and processes that plays a role in the formation and transformation of existing and new landscapes.

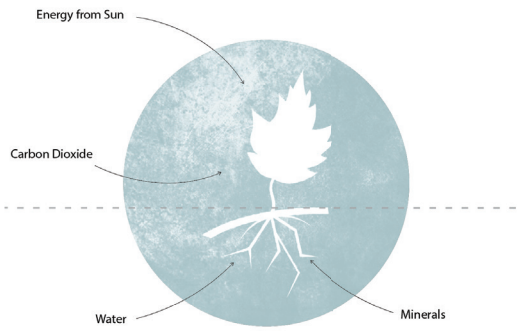
Ecology is about the interaction between organisms and their surroundings, as well as between the organisms themselves. Ecology can be studied on several levels; individual-, population-, society-, ecosystem-, landscape- and global level. However the processes at one level, affects and interacts with the levels above and below. Vegetation ecology is about ecology on a plant community level, which means the knowledge of the relations between vegetation and the various external environment variables, and between species of vegetation among themselves. The plants and vegetation is an essential and indispensable part of the terrestrial ecosystems, as it's only the green plants that can convert beam energy from the sun into chemical energy, which can be used by the other organisms in the ecosystem. It's also the green plants and the vegetation who synthesizes organic substances, which are necessary for other organism that are not capable of forming it themselves. Finally does the vegetation also affect the physic-chemical environment above and below ground and thereby promotes a differentiation of the environment in a variety of habitats. On the other hand, does the other organism also affect the combination of vegetation and the species within them. Knowledge about the vegetation and their ecology is therefore important in the understanding of ecosystems structures and their way of functioning. (Petersen and Westergaard, 2006).

The composition of vegetation is determined by two factors; the abiotic external environment factors, such as geology, climate, topography and the biotic factors, such as the plant- and animalspecies, as well as the microorganism that's present in the area, and the interaction between them. Hereto comes the human influence and impact on the vegetation in form of exploitation and production. Finally is it also determined by how long various processes have been in cycle in a specific area. (Petersen and Westergaard, 2006).

The green vegetation have certain basic demands to its surroundings, demands that have to be meet, in order for

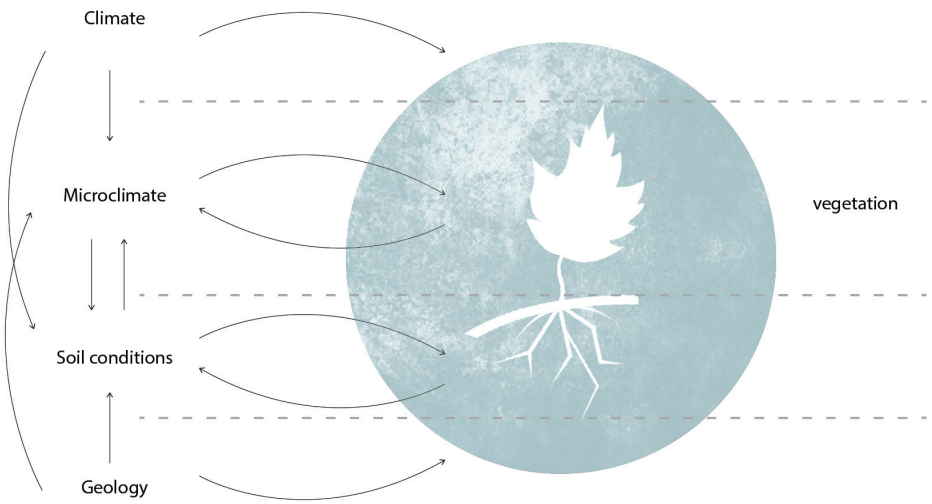
their growth, development and reproduction can proceed normally. These demands is; Energy and carbondixoid to photosynthesis, water to photosynthesis and nutrient transportation within the plant, inorganic nutrients, oxygen for respiration and the temperature has to be within a certain range. (Petersen and Westergaard, 2006).

Variation in the composition of the vegetation is caused by each plants specific demands to the external environment factors and resources, and that these factors varies from place to place. The abiotic external environment factors can be divided into climate- and soil factor. The climate factor can be subdivided into two further categories; the microclimate, which is defined from long term measurements two meters above ground level and the macroclimate, which is the climate in the vegetation cover and topsoil. The micro climate is a result of the interaction between the macroclimate, topography, soil and vegetation cover. An example of the interaction between the macro- and microclimate is the wind. As a macroclimate factor is the wind modified by the topography, the roughness of the ground surface and by the structure of the vegetation cover. The wind also have a significant influence on the vegetation, as it enhances the vegetations transpiration and heat dissipation, in connection with the pollination and seed dispersal. Wind can also affect the vegetation cover indirectly, through changes of physical conditions, such as the formation of dunes, soil flight and the transport of salt dust from the ocean. The amount of precipitation and its distribution through the year, like the temperature, an essential macroclimatic factor. Within a geographical area is the amount of precipitation partly decided by the topography. An example on this is the higher level of precipitation in middle- and western Jutland, which is caused by the movement of moist air masses from the western sea traveling east, over Jutland is forced up in the air and cooled down. If the humidity is greater than the saturation, is precipitation released as a result of the compression of water vapor. (Petersen and Westergaard, 2006).



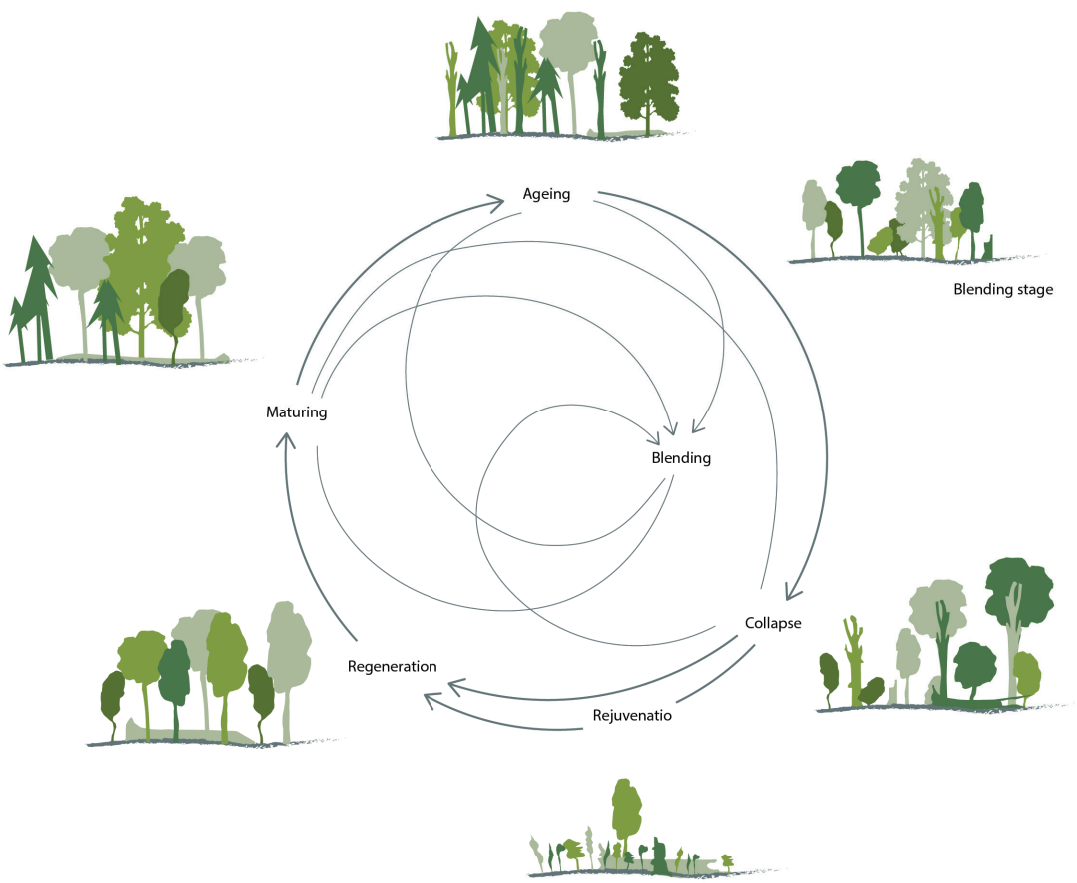
17. Components necessary for plant growth

All vegetation is in constant transformation, even where the vegetation over a longer period maintain its qualitative and quantitative composition, some individuals/shoots continuously die, while new one are establishing themselves. In climates such as the Danish one, where there is a clear seasonal variation will the vegetation show a corresponding seasonal variation. A plants expressions of life (Foliation, flowering, seed set, løvald) in relation to the seasons are called its "phenology". Fluctuations from year to year, in for example precipitation, temperature, water levels or grazing pressure, can cause changes in the vegetation. The vegetation ability to change back to its original composition (resilient) for such



18. Interactions between climate, micro-climate, geology, soil and vegetation

fluctuations depends on the adaptation of the plants to do so, and the fluctuations size and duration. If the environment changes permanent, will it always in the longer run result in a change of vegetation. In the context of pollution is there a notion of "critical load", which can be defined as the amount of pollution exposure that offers significant harmful effects on specific sensitive elements of the vegetation. A succession is a directional solidification of changes in a vegetations composition and structure over a longer period of time. Because of the phenomenon frequency and diversity has the study of successions lead to a range of various conceptualizations and theories. One of these theories has lead to the perception of vegetation as a continuum, leading to mintage of the term "climax pattern". The stability that per definition is the distinctive emblem for a vegetation as a whole, over larger areas and for longer periods of time. So called stabile vegetation is often a mosaic of surfaces with various successions stages, where the later stages properly dominate, but earlier successions stages are still represented. With the division into primary and secondary successions are there focused on a succession's starting point. A primary succession takes place where there haven't previously been a vegetation cover, and where the starting point is the geological material, as for example a newly formed beach ridge or moraine, from which the ice has just retreated. A secondary succession occurs where there previously has been a green cover, and where the soil therefore contains organic matter and a seed pool, and possibly other living parts of plants. This is, for example case in a field where cultivation has ceased, or in a forest after a fire. In the later stages of stages of the succession is it no longer relevant to distinguish between primary and secondary successions. By dividing successions into autogenous and allogeneic successions are there focused on the factors which are causing the succession. In an autogenous succession is it changes in the conditions caused by previous succession, for example the peat formation in marshlands. In an allo-



19. Cyclical succession in forest environment

20. Example of Costal Vegetation, salt marshes

geneic succession is it the external forces which creates the succession. An example on this is the isostatic uplift which in Denmark is highest in Northern Jutland. Here has there over the last 2000 years been an isostatic uplift on approximately 2 meters. Such uplifts gives rise to changes in salt marshes, as they are raised in relation to the surface of the ocean. Most succession processes exhibits both autogenous and allogenic features. (Petersen and Westergaard, 2006).

The term "plant communities" can be used on two levels: specific about the combination of species that occur together in an ecologically homogeneous area, or abstract about the combination of species that often occurs under certain ecological conditions within a region. According to the "continumm-school" does each species distribute itself independently of each other, individualistic, relative to the site-to-site variation in environmental conditions. However this is not inconsistent with the existence of plant communities. The distribution of vegetation types and plant communities in the landscape reflects, as previously mentioned, the variation of the ecological conditions. When an ecological factor varies continuously from one point in the landscape towards another, is it called an ecological gradient. Often, more ecological factors correlated with each other and thereby affect the vegetation in combination, rather than as single factors. In accordance with the individualistic conception of the plant species spatial distribution in relation to global factors will vegetation composition change gradually along such an ecological gradient - giving the vegetation a floristic gradient, called coenoklin. The combination of an organic gradient and the associated coenoklin is called a "økoklin". When a plant community within an area is forming more or less parallel or concentric belts, can it be described as zoning. By zoning goes the organic variation in one direction, but unlike "økoklinen" is the variation not continuously. Each of the zones constitute an ecologically homogeneous area, while the border between the two zones represent an ecological discontinuity - an abrupt change of the ecological conditions. The transition between two plant communities is called a "økoton". A vegetation mosaic is formed, when two or more plant communities within a region is are grouped in an more or less irregularly way between each other, as the organic variation are in many directions rather than one. As with the zoning are each of the mosaic plant communities a ecological homogeneous area, while the boundaries between the two areas represents an ecological discontinuity. Each plant community is represented only "once" along an ecological gradient, while it occurs several places within an area of mosaic vegetation. In most landscapes will the character of the ecological variation cause the vegetation to form coenokliner, while it in other places will be differentiated in zoning or mosaic landscapes. (Petersen and Westergaard, 2006).

The Danish landscape can be divided into a number of relative well defined landscape elements, as man exploits in different ways and with varying intensity, and which placement in the landscape is largely determined by the geomorphologic and topographical conditions. Within each of these landscape elements, the variations in ecological conditions cause a variation in the plant communities and ceonokliner. Which ecological variables that play the biggest role for the differentiation of vegetation, varies from one landscape element to another. The Danish vegetation can be divided into five landscape elements; costal vegetation, marsh vegetation, heath and grassland, forest and farmland biotopes. (Petersen and Westergaard, 2006).

The costal vegetation can be found at sea coasts and covers an approximately 2 percent of the Danish land area. The

21. Example of Heath and grassland, grassland in Ryegaard Dyrehave

22. Example of the small biotopes of the farmland

character and composition of the vegetation varies with the costal type. In places exposed and strongly influenced with strong winds and waves, are there developed stone, sand and dune shores where the geomorphologic processes of erosion, transport and accumulation are important ecological variables that play a crucial role in the vegetation, which in its nature is highly dynamic. On the protected coasts are salt marshes developed where salt impacts as a result of periodically flooding with seawater together with hydrological conditions are important ecological variables. (Petersen and Westergaard, 2006).

Marsh vegetation, including grassy meadows, occurs all over the country, usually in hollows in the terrain, often associated with lakes and streams. These landscape elements covers roughly 4.5 percent of the Danish land area. The vegetation

23. Example of a forest landscape at Suserup forest

24. Example of marsh vegetation in a High Moor

can have vastly different characters, since mosses, grasses and other herbs or shrubs and trees can be dominant. The soil is partly or fully covered with water. In addition to the hydrological conditions are the nutrients conditions an important ecological variables. (Petersen and Westergaard, 2006).

Heath and grasslands on dry ground covers around 2.5 percent of the Danish land area. These vegetation types are found where soil, terrain, or the location makes the cultivation can't - or no longer can be cultivated. Optionally is the areas used in the form of grassing. The vegetation composition varies from heath, dominated by dwarf shrubs, with elements of lichens and mosses, to various and different types of grasslands, dominated by grasses and other herbaceous plants, and through bushes and low trees. Usually occurs heat on leached, nutrient-deficient soils and is commonly in the west and northern part of Jutland. Grasslands are most common in the rest of Denmark, and are often found on slopes and hills. (Petersen and Westergaard, 2006).

Forest is found scattered in all parts of the country, expect for a few smaller islands, and covers approximately 11 percent of the Danish land area. Larger contiguous forest areas are usually localized to the higher-lying parts of the landscape, but also in low-lying, moist areas can there occur areas with forest. A forest consists of trees with a continuous crown cover. As a result does the micro-climate varies in important ways from the microclimate in the open country. The forest floor vegetation is dominated by herbs and mosses and the most important ecological variables is light and soil conditions. (Petersen and Westergaard, 2006).
The small biotopes of the farmland has a various amount of characters, such as roadsides, burial mounds, marl pits and hedgerows, and are spread out all over the country, but consist of less than 2 percent of the Danish land area. They are usually not cultivated, but exposed more or less regularly for various forms of interventions; mowing, pruning shrubs and trees, and the influence of the cultivated fields as fertilizer and spraying. Succession conditions and the ecological variables that are most important depends on the given biotope and its placement in the landscape. Since they are all small and scattered in arable landscape, the boundary effects and island biogeographically factors a significant meaning for the composition of the vegetation. (Petersen and Westergaard, 2006).

Key Points:

- The Bridge shall facilitate various soil conditions and microclimates in order to host a variety of plant communities, habitats and biotopes.

- The topography should differ from place to place in order to afford different ecological gradients and vegetation mosaics and thereby habitats and biotopes.

- Vegetation and plants shall be planted in various life-cycles and succession, in order to mimic the natural landscape and its processes

- Vegetation shall be placed accordingly to its "critical load" in terms of pollution, for example, plants fragile towards oil spills shouldn't be planted alongside roads.

- The bridge should afford multiple types of Danish landscape elements, which consist of costal vegetation, marsh vegetation, heath and grassland, forest and farmland biotopes.

Green Infrastructures

WORDS CONTENT CONTENT

This part of the report deals with the knowledge of how green infrastructures relates and how big a infrastructure should before it can become a stepping stone for habitats.

Green infrastructures is defined as the connectivity between areas large enough to sustain healthy and functioning ecosystems and human use or activity (Austin, 2014). The concept emphasizes the importance of multi functioning urban areas, that facilitate a wide range of ecosystem services. It's a full consideration of existing landforms, biodiversity, flood management ,water conservation, maintenance of microclimates and climate adaptations, as well as more traditional recreational activities and functions (Grant, 2012).

Green infrastructures is increasingly important in order to maintain a healthy biodiversity, which refers to the number and distribution of species living in a given area. Species and stocks are distributed frequently throughout the landscape in complex patterns. Immediately, individuals and populations occur geographically and functionally separated from other individuals and population, at once, however there are functional genetic links between various species. To conserve biodiversity is it therefore not enough to only look at natural areas separately, but as part of an overall landscape as a network where natural areas, and individuals and/or population spreads and interact. (Naturstyrelsen, 2016)

A network of natural areas can help connecting the landscapes, fragmented by various human activities, in order to strengthen the biodiversity of the given landscapes. A network can strengthen the relationship between various green areas, and help species in the ecosystems to spread out between distinct habitats, helping to exchange genetic material between isolated subpopulations. This is especially important, when climate changes forces species to adapt and relocate in order to overcome changes made on their habitats. The green infrastructures is often composed by both small and larger natural areas, or what is referred to as small natural areas and core areas. The networks of natural areas, are often composed of both small and larger natural areas or what is referred to as small natural areas and core areas, together with corridors, buffer zones and natural development zones, which is all embedded in surrounding areas, with distinctive nature that differs from themselves. The network of natural areas exist at all geographical scales, from the global and continental, to the regional and local level and in all habitats (Naturstyrelsen, 2016)

Green corridors or infrastructures can have several shapes and consists of a variety of landscapes and biotopes. The EU habitats directive uses both a structural and functional approach towards defining a green corridor. A corridor is defined as a "element with its linear and continuous structure, as with rivers and their banks, or their function as stepping stones, as with small lakes and woods, which are essential for wild species migration, dispersal and genetic exchange". Green infrastructures can divided into three subcategories: core areas, smaller natural areas/small biotopes and buffer zones.

Core areas can be defined in two ways, either as a relative large area with a large and stable population of animals, or as area with a high growth rate within the populations it supports. However the definition of "size" varies accordingly to each species space requirements. For instance will one hectare seem very large for a beetle, while larger species would seen is as rather small. A large area is therefore an area, where its birth rate succeeds its deaths. These area can therefore in some instance be seen as small, but would however still function as a core area for specific species (Naturstyrelsen, 2016).

Small natural areas or small biotopes include, for example ponds or outlaying areas, typically surrounded by intensively cultivated areas in the landscape. Small biotopes are often too small to contain a stable population of several species, but may be important for maintaining the biological diversity of an area. This could be through their function as stepping stones between core areas and additional act as food basis and habitats for species from the surrounding core areas (Naturstyrelsen, 2016).

Buffer zones are areas surround natural landscapes in intensively cultivated areas, typically fields in crop rotation, which are regularly fertilized and sprayed. The purpose of these buffer zones is to provide additional habitats, while reducing the negative effects that inputs from the production landscape, such as input of substances or unwanted species from the surroundings (Naturstyrelsen, 2016).

Key Points:

- The bridge structure should be seen as a stepping stone for habitats and greenery

Water Sensitive Cities

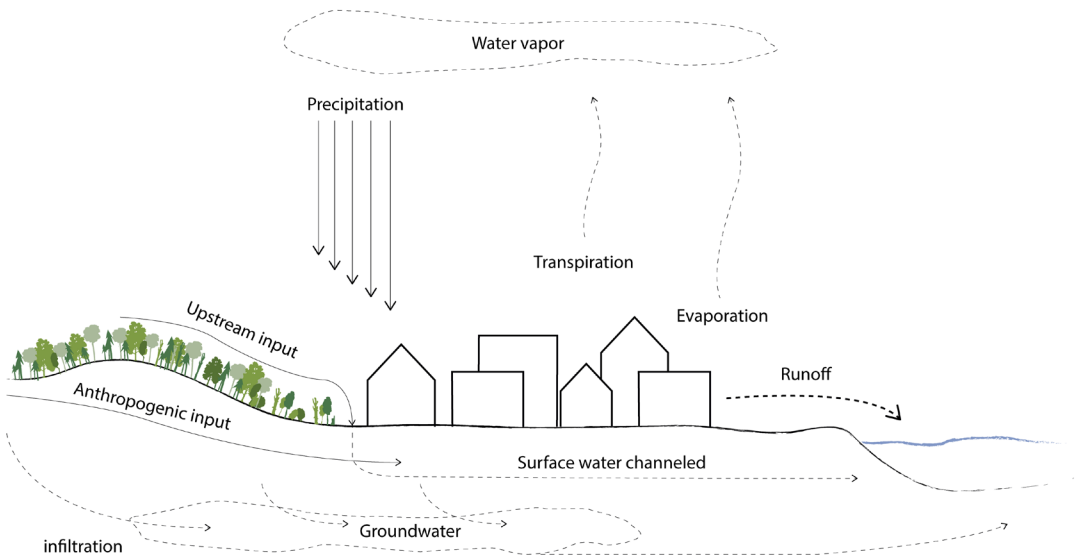
WATER SENSITIVE CITIES URBAN HEAT ISLAND

This chapter will look into how urban areas deals with rainwater management and effect the overall water cycle, in order to understand how a bridge structure can have a positive impact on the city's water cycle and rainwater management.

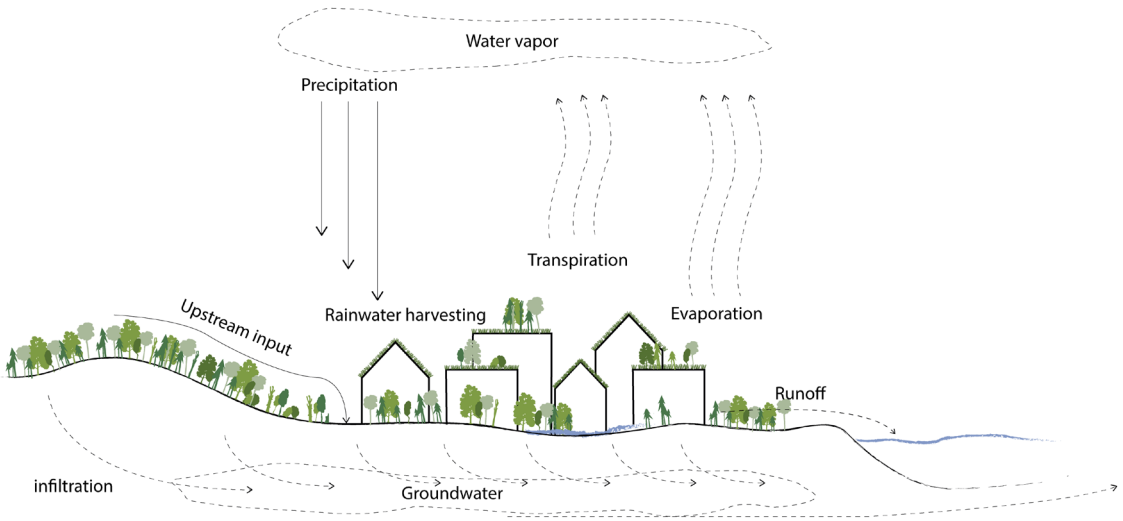
The traditional or more conventional approach in dealing with the increase of rainwater in cities is to channel it into drains and watercourses in order to send it out of the city and downstream as quickly as possible. As much of our urban runoff comes from streets, pollutants from vehicles, including oils, oil combustion products and heavy metals accumulate on sealed surfaces and are washed into drains and ultimately into streams, following rainfall. Hence the discharge is often heavily polluted, unless it's been treated, and can cause severe flooding downstream. At the same time can drains be overwhelmed during storms, and where polluted water sewers are connected with surface drains (what is referred to as combined sewers) leave to wastewater leaving the sewage and threatening potable water supplies and aquatic ecosystems. Furthermore can it also lead to severe health problems for people living in or around the flooded areas. (Grant, 2012).

Sustainable urban drainage systems or SuDS have been developed in recent decades as a way of overcoming these problems. The aim with SuDS is to reduce the volume and speed of surface water runoff, to improve water quality and to increase amenity. The idea of SuDS is to intercept rainfall locally, where it lands on green roofs or rainwater harvesting systems, such as water butts or storage tanks. Water that flows beyond green roofs or rainwater harvesting systems, may enter rills, rain gardens, swales and various ponds, to be detained, attenuated (slowed) or cleaned. Where soils and underlying geology is suitable, surface waters may be allowed to percolate into the ground and recharging aquifers. In contrary to traditional way of dealing with rainwater, does the SuDS separate sewage water with rain water, and thereby prevent clean water to fill up in water treatment plants, and sewage to rise towards the surface or streets of the city. (Grant, 2012).

However the concept of "Water Sensitive Urban Design", WSUD, goes beyond the aims of SuDS and recognizes that surface treatment of water is an opportunity to bring ecosystem services back into the cities. WSUD is also an intention to reduce potable water demand and therefore water abstraction, increase biodiversity, increase evapo-transpirative cooling and, where possible and appropriate, store and clean grey water for reuse. The concept considers the whole water cycle and not just the urban surface runoff. It therefore begins with the conservation of nature, where streams, rivers and wetlands are protected, restored and/or enhanced. Maintaining good water quality and healthy ecosystems by cleaning the water that drains from urban areas before they



25.Traditional Urban water Cycle



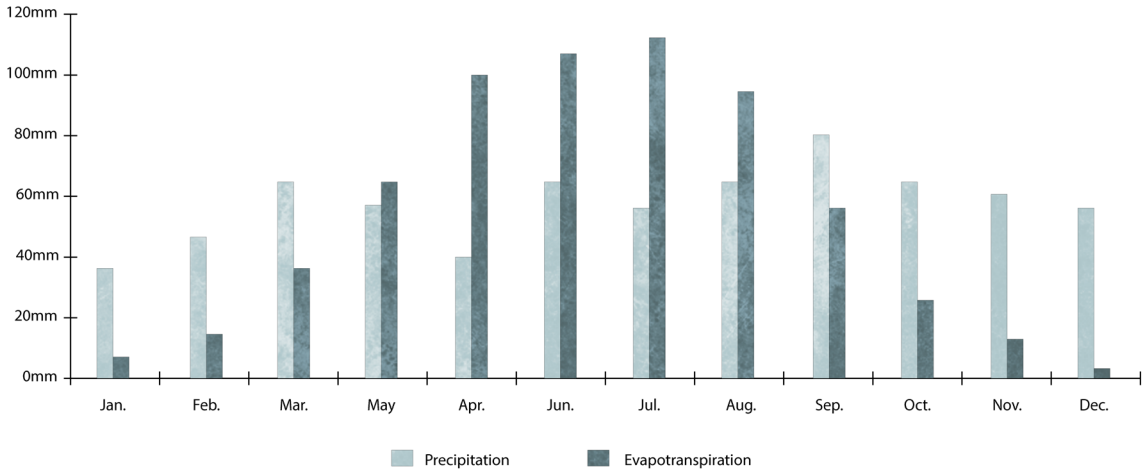
26. Water cycle for cities with *"Water Sensitive Urban Design"*

are discharged into natural environment. Thereby protecting ecosystems and natural environment, in rivers and streams, as well as the oceans that lie beyond. As with SuDS, the concept of WSUD seek to keep surface water within multi-functional landscapes, which provides wildlife habitat and open space for people. The main idea is to mimic the predevelopment conditions of an built area, with similar runoff rates, water quality and biodiversity. Even though it is not possible to match these pre-development conditions, there is much to be gained by setting high standards in regard to the management of water in cities. (Grant, 2012).

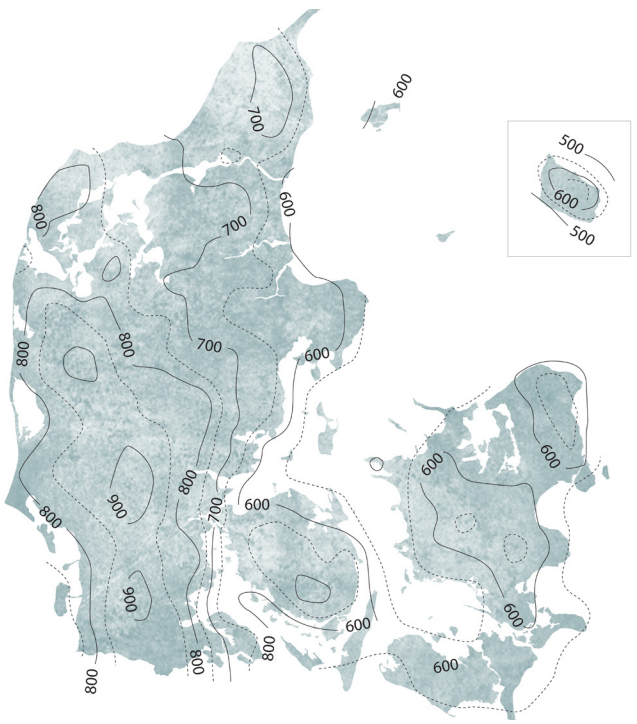
The WSUD works with vegetation and ecosystems to treat surface water and restore the water cycle in cities (Grant, 2012). In nature is an significant part of the climatic influences on the vegetation attached to the water cycle. Locally does especially the water balance, which is the relationship between precipitation, evaporation and infiltration play a role. Part of the precipitation evaporates from soil and plant surfaces, evaporation, and part of the precipitation evaporates through the plants' stomate and cuticle after being absorbed through the roots and transported up to the leaves, which is called transpiration. The total evaporation is called evapotranspiration. The amount of evapotranspiration is dependent on factors such as temperature, wind, soil moisture and vegetation composition, structure and level of development. A distinction is made between the actual and potential evapotranspiration. The potential evapotranspiration can be defined as evapotranspiration under condition in which the inflow of water is not limited. The difference between the precipitation and evapotranspiration roughly defines the Earth's climate zones. In so-called humid climates, is the precipitation greater than the actual evapotranspiration (which is of the same magnitude as the potential evapotransoration). The excess amount of precipitation flows of the surface (rivers) or seeps into the groundwater (infiltration). In arid climates, does the potential evapotranspiration exceed the current and there is a precipitation deficit. Some climates are characterized by the fact there is only precipitation deficit part of the year and depending on the length of the period with precipitation deficit, is there talk about semi-arid, respectively sub humid climates. In Denmark is the climate in the "storebæltsområdet" and around southern kattegat be classified as semi-arid, while the climate in the rest of the country is semi humid. (Petersen and Westergaard, 2006).

In cities and urban areas are the rapidly exposure of hard and impermeable surfaces at the expenses of vegetation and the grown environment, causing enormous problems, not only for the urban areas but also on the rural and natural areas surrounding them. The relationship between temperature and land use is expressed very clearly with city heat maps, where built-up districts is several degrees warmer than adjacent green areas, causing a phenomenon which is called "Urban Heat Islands" (Grant, 2012).

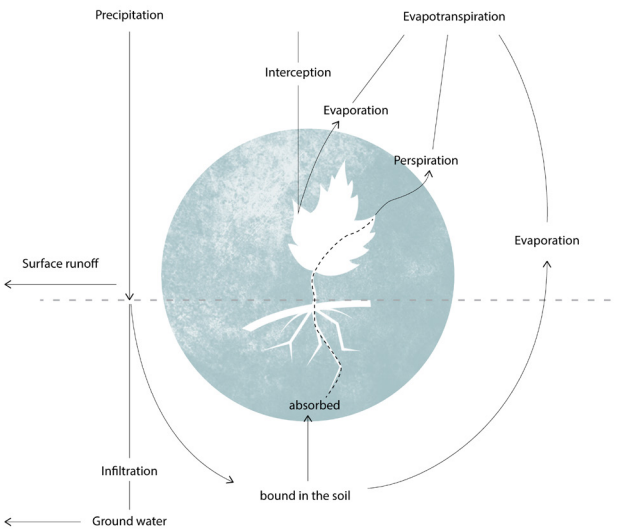
The changes made by mankind to the urban habitat, along with energy inputs and atmospheric outputs interact with



27. Precipitation and the potential evapotranspiration variation over the year in Denmark, as measured over a low grass vegetation. Other types of vegetations, will somewhat differ from here. (Petersen and Westergaard, 2006)



28. The average annual precipitation (mm) for Denmark, 1961 - 1990 ref. (Petersen and Westergaard, 2006)



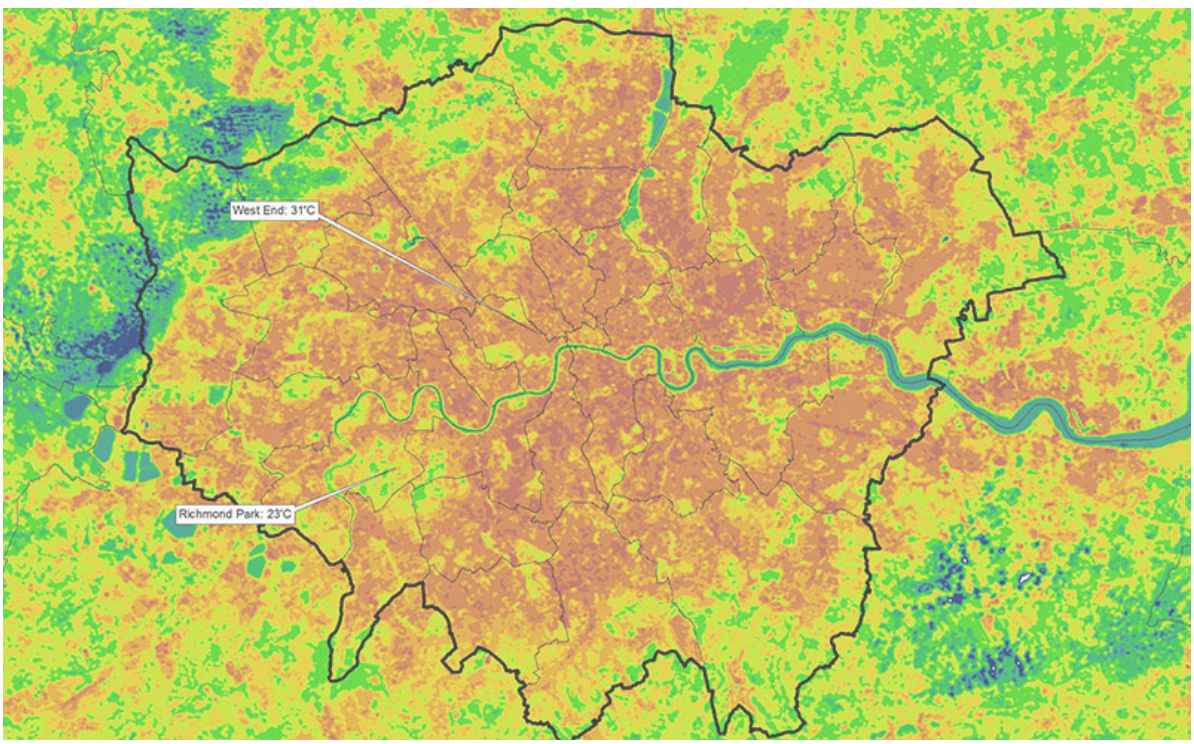
29. Model for the water balance of a vegetation covered area. The arrows indicate the movement of water (Petersen and Westergaard, 2006)

the physical properties of heat to create the urban heat island effect. Five major challenges underlie the unintended consequences of urbanization; 1) The replacement of vegetation with concrete, asphalt or other impermeable surfaces in the urban core leading to a decrease in the evapotranspiration of water; 2) Vertical surfaces are collecting incoming radiation for longer periods throughout the day and trap outgoing radiation at night; 3) Dark building materials are trapping and storing incoming radiation; 4) Anthropogenic heat production, heat generated by humans and human activity, can match or exceed solar energy input, particularly in the winter; 5) the more polluted the urban atmosphere can absorb and reflect more heat. (Adler and Tanner, 2013).

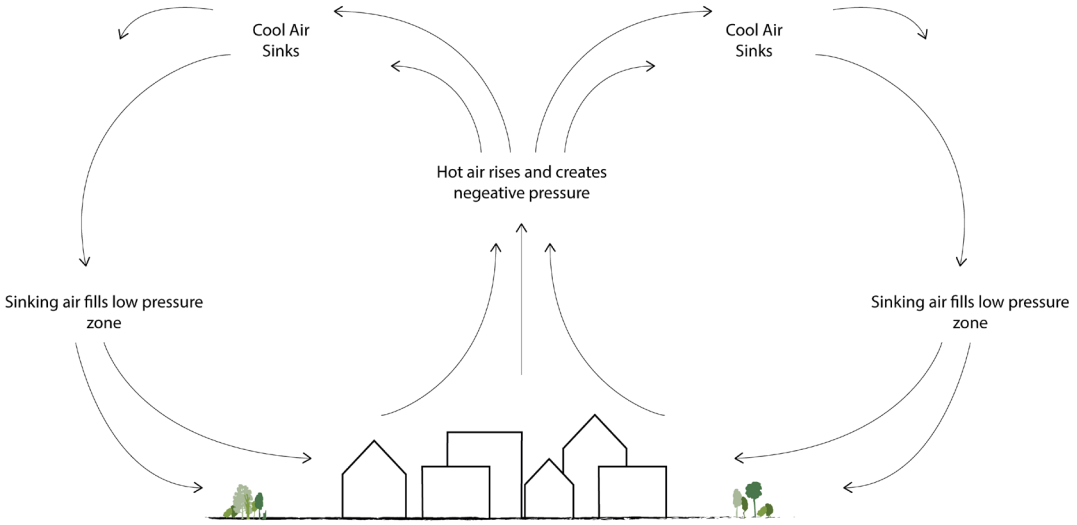
Although the Urban heat islands creates a relatively simple change in the regional climate, can they lead to significant changes in many other aspects of the climate and ecology of a city, such as affecting air circulation, ecology and humans well-being. (Adler and Tanner, 2013).

In the absence of synoptic weather conditions, the warmer air created by the urban heat islands rises. The rising warm air expands and cools down, which reduces local air pressure at the surface and suck air from the urban periphery into the resulting low pressure areas created in the urban periphery. The cycle of rising, replacing and descending creates a circulation cell that can trap urban air and accumulate pollution, an effect which is referred to as the urban dust dome. Another effect of the constantly rising and cooling down of the warm air is the airs ability to hold water. This is due to the warm moist air decreases its ability to hold water when its cooled down, this leads to condensation and formation of clouds. The clouds can initiate urban-induced convective thunderstorms or precipitation, especially when synoptic conditions do not disperse them. The strength or temperature of the urban heat island correlates with the amount of induced precipitation, however the precipitation induced in urban areas will fall outside of the city, when storms are pushed downwind by synoptic events. (Adler and Tanner, 2013)

Urban heat islands also has an ecological effect on cities and can have a negative effect on cities' ecosystems. This is due to many organisms are limited by temperature, especially by extreme maximum and minimum values. Temperature can create both heat stress and cold stress and although animals, including humans, suffer from heat stress, does the higher temperatures have the greatest effects on plants. When stressed by heat, plants reduce photosynthesis in order to conserve water. This reduction affects the local environment and microclimate. Trees over asphalt, which can be 20 degrees hotter than turf, have much warmer leaves even when air temperatures are relative small. This is probably due to the increase of long-wave radiation. However these hotter trees do not lose much more water compared to trees in cooler temperatures, as they respond by closing their stomata, leading to less evaporative cooling, drier air, and potentially even more stomal closure. All of these factors com-



30. Urban Heat Island Map of London, showing West End having 31 degrees celcius, while the Richmond park is 8 degress lower at 23 degrees celcius.



31. Illustration of "The Urban Dust dome"

bined add to the further heating of the urban area, as they can intensify the already increased temperatures. (Adler and Tanner, 2013).

As with trees and vegetation does heat has an substantial effect on human health. More people die from heat waves than floods, tornados, or hurricanes. The discomfort of the extended periods of high temperatures, exacerbated by urban pollution and heat absorption, creates intense stress on city-dwellers. Stress leads to a decrease in both physical and mental health, social problems, and can even increase the amount of violent crimes. Urban residents experiences higher highs and lows, relatively drier air, and more rainfall. Like plants and animals can people respond with a change in behavior, however we can also use the power of ecosystem engineering to locally modify our environments. In order to improve our local climate and counter the effects on ourselves and our laws or gardens, does people use more water when temperatures increase. Air conditioning is used to create cooler environments for a longer fraction of the day and often well into the nights. All of which leads to increase of heat and temperature, as the usage of energy leads to an increase of energy production and more heat input to an already warm system. (Adler and Tanner, 2013).
These issues highlights the significance of green areas in urban spaces. It is therefore extremely important that natural areas, trees and vegetation are conserved and or restored in the urban environment. This is not only to reduce the risk of flooding or improving the quality of water in our watercourses, but also to maintain evaporative cooling and thereby preventing urban heat islands. All of these elements are helping hanging our perception of surface water and evaporation from being a nuisance and loss to being an enhancement of the quality of urban life. (Grant, 2012).

Key Points:

- Water runoff shall be limited, delayed and treated locally

- Surface treatment of water shall be used to bring ecosystems services back into the city

- Surface water shall be kept in multi-functional landscapes which provide wildlife habitats and open spaces for people

- Vegetation and ecosystems shall be used to treat surface water and restore the water cycle in urban areas

- The use and exposure of hard impermeable surfaces, as well as heat-absorbing surface shall be kept at a minimum

- Natural areas, trees and vegetation should be conserved and restored in urban environments

Our Perception of Nature and the Urban Landscape

BIOPHILIA PERCEPTION OF NATURE

"FOR THE 99 PERCENT OF THE TIME WE'VE BEEN ON EARTH, WE WERE HUNTER AND GATHERERS, OUR LIVES DEPENDENT ON KNOWING THE FINE, SMALL DETAILS OF OUR WORLD. DEEP INSIDE, WE STILL HAVE A LONGING TO BE RECONNECTED WITH THE NATURE THAT SHAPED OUR IMAGINATION, OUR LANGUAGE, OUR SONG AND DANCE, OUR SENSE OF THE DIVINE". - JANINE M. BENYUS

This chapter will look into humans connection and affiliation of nature and other living organism, in order to understand people's need for nature, while defining our perception of the aesthetics of the urban landscape and vegetation.

The notion of biophilic, as described by Timothy Beatley (2009) is the innately emotional affiliation of human beings to other living organisms. As innate means hereditary, does biophilic describe nature as part of "ultimate human nature". Biophilic is a set of "complex learning rules" developed during thousands of years of evolution and human-environment interaction. For most of our evolution, or more than 99 percent of it, has human-beings lived in hunter-gatherer bands totally and intimately involved with other organisms. Over this period of time, did humans depend on exact learned knowledge of crucial aspects of natural history. Our brain evolved during this time, in what can be described as a biocentric world and not the machine-regulated one we find ourselves in today. It would therefore be quite extraordinary if all these learning rules, related to the biocentric world would have been erased in a few thousands year - even in the tiny minorities of people who have existed for more than one or two generations in wholly urban environments. However as the global population becomes more and more urban, ensuring contact with the grown environment becomes more difficult. At the same time do planners, architects and similar people, somehow have to defend and rationalize our need for contact with nature. (Beatley, 2009)

"The profound connection with the natural world has been for most of human history something pretty obvious. Yet today we seem entrenched in the view that we have been able, somehow, to overcome the need for nature, that we can "transcend" nature, perhaps even that we have evolved beyond needing nature - Timothy Beatley (2009)"

We see ourselves, not longer as a part of nature or its processes and ecosystems. However more than ever before do we effect the surrounding landscapes, directly or indirectly through countless interventions and destruction of ecosystems and natural landscapes. Humans has, like some other creatures become ecosystem engineers that change larger areas, convert deserts to larger green cities, forests to larger empty areas and reclaim land where there once were oceans. These changes human-beings has unleashed on nature, has been deemed measurable on an geological scale and lead to a new age, "anthropocene", which means the age of man. (Sijmons, 2015).

We can therefore no longer see ourselves as beside or above nature, we have to work with it in order to create cities that are more resilient and healthy - not only for ourselves but also the natural environment and the species that inhabit them. By realizing this and by starting to integrate nature into our cities can we transcend this and be reunited with nature, in the amenity of our cities. However nature should not only be viewed in terms of the ecological benefits it provides in terms of ecosystem services, but also the awe and wonders it brings to our everyday lives. Exposure to nature and natural experiences will help promote important values, such as living a healthier and more sustainable life, taking care of the environment and being involved in "nature-protective" initiatives, due to our emotional affinity for nature. Research suggests that our emotional affinity for nature, is related to the amount of time and frequency of natural experience. Experiences which are becoming more and more rare in urban environments, as availability of and access to natural areas diminishes. But it's exactly these experiences that are necessary, in order to understand and appreciate the nature around us. The flipping over of rocks to look after insects, or the dipping of one's feet in small streams. It's these experience with nature that creates a personal connection with and affinity for nature. On the contrary does a lack of personal contact with nature breed alienation and in turn apathy about future protection and conservation of nature. As cities and suburbs abandon their natural diversity, and their inhabitants grow more removed from personal contact with nature, does awareness and appreciation for nature disappear. This raise apathy towards environmental concerns, which leads to further degradation of the common habitat. If we want to change this and overcome the environmental apathy, at both global and local scale, do we have no better solution than to reconnect people with nature. We need the wonder and awe nature brings to our lives, how it amazes, stimulates and propel us forward in wanting to learn more about ourselves and the world we are a part of. These qualities

32. Qunli National Urban Wetland, Haerbin City, China

and the wonder and fascination of nature helps us to nature deep personal connections and involvements in something larger than ourselves, offer the potential for meaning in life few other things can provide. (Beatley, 2009).

We need the planning of cities to include wonder and awe, fascination and an appreciation for the wildness that every city has or are capable of having. The extraordinary and rich nature, which surrounds every city, represents an important antidote to the boredom and sameness that otherwise characterizes much of our built environments and lives. We need local nature and in order to do so we need to overcome the perception of cities being biologically and biophilically impoverished places. Nature is an essential part of our lives and well-being. We need it for our emotional health and well-being, but we also need it for planetary health. Nature shouldn't be something that we periodically visit, but an ever-present condition that delights, relaxes, soothes, replenishes, inspires, and uplifts us in our daily urban lives. It's something that's all around us, and something that we live in. (Beatley, 2009).

Our perception of nature and the urban landscape, can be seen in two ways. On a functional level, do we perceive all elements creating or being a part of the ecosystem as nature. In this sense are all elements and organism seen as one; they generate heat, evaporate water and contributive to and affect the overall ecosystem. The city and nature, the built and grown environment, are no longer seen as two separated elements, there is no biosphere nor is there any techno-sphere, only one homogenous ecosystem - in an healthy and balanced stage. On the contrary do we perceive the aesthetics of nature, as a separated element from the man made interferences. In this perception are lawns, fields and other natural elements kept in one stage due to human activities, no longer considered a part of nature, nor the aesthetics of it. A natural aesthetic, in our perception, is driven by natural forces and the vegetations adaption towards these exact forces. Like the trees along the west coast, formed by the harsh costal winds, or the temporary flooding of one vegetation, which leads to the transformation of another. The aesthetics becomes the procedural, as in the notion of process urbanism, but also the sensorial and experimental, as with the notion of biophilic. It's the awakening of humans interaction with nature, the way it stimulate and amazes us and how it adds a little bit of magic to our everyday lives.

Key Points:

- Urban areas shall be ensured contact with the grown environment and natural landscape

- The bridge structure shall support/or facilitate personal contact and natural experiences

- Planning of cities shall include wonder and awe, fascination and an appreciation for the wilderness and natural environment

- Nature shall be an ever-present condition, something that's all around us, and something we live in.

Preliminary Conclusion

SUMMERY KEY POINTS

SUMMERY

The Theoretical Framework gives a thorough understanding of the complexity between nature and city and should be seen as a tool to provide a common understanding of the work and relations with nature. In many ways nature will do better without cities but cities are dependent on nature. The change in landscape is during the day, month and year is an important element in the everyday life and so are the many ecosystem services that our cities provide without recognition. As cities in Denmark are growing and the demand for better living conditions, bigger and better housing, increases so does the municipalities and investors attend to oversee the necessity of good experiences with nature related conditions in the urban environment. Empty plots are transformed to building plots and not parks. The trees taken down in construction phases are not replaced or multiplied. This master thesis relates to a bridge structure in urban environments and the many problems related the 'water sensitive city' is important to investigate further in its context. Furthermore we want to investigate the processes and strategies that Aalborg Municipality has for the future development.

KEY POINTS

- The bridge structure should embody sustainable transport planning of the everyday mobility where the intertwining mobilities are taking into considerations

- The bridge structure should be seen as node in the series of public spaces in Aalborg and not as a single minded linear space

- The bridge structure should be seen as a surface that works as a medium for rethinking urban conditions

- The bridge structure should work with infrastructure as a potential enabler for activities both in terms of the structure itself and the surrounding environments such as the Limfjord

- The bridge structure should be adaptable towards external influences

- The natural environments shall be the dynamic frame that's balancing both social-cultural, economic and ecological elements

- The urban areas and its rural counterparts shall be seen as a single unified ecosystem - both artificial and natural ones.

- Planning shall have a dialog with nature, by using nature-based solution, and systematically learn from how nature "answer" human intervention in ecosystems.

- Work with one ecosystem, rather than traditional structures, such as blue, green, grey structures etc.

- The Bridge shall facilitate various soil conditions and microclimates in order to host a variety of plant communities, habitats and biotopes.

- The topography should differ from place to place in order to afford different ecological gradients and vegetation mosaics and thereby habitats and biotopes.

- Vegetation and plants shall be planted in various life-cycles and succession, in order to mimic the natural landscape and its processes

- Vegetation shall be placed accordingly to its "critical load" in terms of pollution, for example, plants fragile towards oil spills shouldn't be planted alongside roads.

- The bridge should afford multiple types of Danish landscape elements, which consist of costal vegetation, marsh vegetation, heath and grassland, forest and farmland biotopes.

- Water runoff shall be limited, delayed and treated locally

- Surface treatment of water shall be used to bring ecosystems services back into the city

- Surface water shall be kept in multi-functional landscapes which provide wildlife habitats and open spaces for people

- Vegetation and ecosystems shall be used to treat surface water and restore the water cycle in urban areas

- The use and exposure of hard impermeable surfaces, as well as heat-absorbing surface shall be kept at a minimum

- Natural areas, trees and vegetation should be conserved and restored in urban environments

- Urban areas shall be ensured contact with the grown environment and natural landscape

- The bridge structure shall support/or facilitate personal contact and natural experiences

- Planning of cities shall include wonder and awe, fascination and an appreciation for the wilderness and natural environment

- Nature shall be an ever-present condition, something that's all around us, and something we live in.

Analysis

The following chapter consists of several analysis related to mobility, environment, the municipality plans and future technologies. The broad variation of the analysis describes the broad amount of parameters that affect the Third Limfjords Alignment. The chapter will be rounded off with a summery and a sub-conclusion of the design parameters which are described in the end of each section.

CONTENT

-illustration 33

The Third LimfjordsAlignment

HISTROY EIA (NO 380) PEOPLE OF INTEREST

"WE WILL PRIORITISE ECOLOGICAL JUSTIFIABLE TRANSPORT MODES (MOBILITY AT FOODS, BIKE AND PUBLIC TRANSPORT) AND MAKE A COMBINATION OF THOSE TO OUR MAIN GOAL IN FUTURE PLANNING. MOTORISED, INDIVIDUAL TRANSPORT SHOULD IN THE FUTURE HAVE A SECONDARY FUNCTION."
Aalborg Charter, 1994

To understand the process of the project The Third Limfjord Alignment it is important to understand the history of the existing connections crossing the Limfjord. This chapter deals with the EIA (Environmental Impact Assesment) and some of the many complaints regarding the final political decision; that the connection is a car-based solution crossing Egholm.

HISTORY

For centuries the Limfjord has worked as facilitator and generator for the industrial and urban environment around Aalborg and Nørresundby. No other place in Denmark has been characterized by so comprehensive extraction of raw material. For a long time Aalborg was the only market town in the area and the need for transportation with goods over the fjord was therefore extremely important. The growing need for better connections resulted in a new pontoon bridge in 1860 followed by the railway bridge between Aalborg and Nørresundby in 1879. The industrial development in the beginning of the 20th century and the growing car industry demanded new and better solutions and the first permanent car based connection was build in 1933. The new bridge redirected the infrastructure of the two cities and generated many urban renewal projects. As many other cities the growing regional and national traffic afforded even bigger and better solutions and in 1969 a larger motorway and tunnel are built in the eastern part of the Limfjord and Aalborg. (VVM 2011)

The same year the eastern tunnel was build the municipality of Aalborg started to talk about a western connection. A smaller regional committee was gathered to investigate five alternative alignments and suggested in 1973 a bridge structure placed at Lindholm. The initial ideas about a western alignment resulted in a sketch project and the affected plots were reserved to avoid nuisance for the many residents and owners of the nearby areas. The first EIA (Environmental Impact Assesment or VVM in Danish) was finished in 2003 by the former county authorities of Aalborg and concluded that an alignment over the island Egholm would be the best solution. The EIA was overturned in 2006 by the Danish Environmental Board of Appeal because a lack of investigation into the impact the alignment will have to important protected species in the affected areas. (VVM 2011)
In 2011 the second EIA was finished by the National Road Directorate and obtained the lacking data that was needed for a well-founded decision. The National Road Directorate had the same conclusion as the EIA in 2003 which the politicians of the region consented in July 2014 - the Third Connection is going to be a western connection with an alignment over the island Egholm.

EIA (NO 380)

The second EIA is the most expansive EIA in Danish history and sums up the huge amount of time and work put into the discussion of a potential third alignment. After the Municipality Reform the second EIA was still unfinished and the money for the completion was difficult to find. In 2009 the government and several of the parties of Denmark made an agreement for better green mobility. The agreement consisted of several initiatives and one of them was to complete unfinished EIA's including the one for the Third Limfjords Alignment. As described; The National Road Directorate completed the EIA in 2011 with help from Aalborg Municipality, The Danish Nature Agency, Danish Coastal Authority and Region of Northern Jutland who all were represented in a technical committee. (VVM 2011)

The EIA expounds the possibilities of moving the traffic away from the tunnel and into a new alignment and in the same time relieve the pressure on the traffic-related situation in the center of Aalborg and especially the Limfjord Bridge. Furthermore EIA is clarifying the impacts on the effected environment in relation to the suggested alignments. The report works with 3 suggested alignments for a third Limfjordsconnection, at Egholm, Lindholm and an additionally Eastern connection, and accounts for the traffic-related and economical consequences of the alignments. Additionally the EIA describes the needed area for the aliments and the amount of noise affecting those areas.

34. AALBORG MAP
The Third Limfjord Connection (Black Line) and the existing connection

The vision for a third alignment is to ease the stressed traffic situations in and around Aalborg and to unite the northern Jutland. A new alignment will create the opportunity for the natives of Northern Jutland to live in smaller cities and commute every day to work. Furthermore it will make northern Jutland even more attractive for companies if the transport of goods were better. The arrangement of the existing road networks of Aalborg results in a close relation between the roads of the city and the motorway. Even the smallest disturbance in one system can create large effect on the other. The many delays and queues results in much discomfort for the road users which is one of the main reasons to built an additional alignment.

The EIA compares the three alignments and their affect on ADT (Annually Daily Traffic) calculated on the basis of year 2020. The general factors of increasing traffic in the period from year 2009-2020 are; transit traffic (2.4%), from city to region (2%), city to suburbs (0.5%) , city-related traffic (-1%) and last traffic between suburbs and region (2%). The total sum of increasing traffic is therefore 1.75 % per year. (VVM 2011)

It is clear that the tunnel (ADT: 90.600) takes the most of the traffic compared to the bridge (ADT: 34.500) and that most of the traffic related to the Nordjyske Motorway is related to the traffic to and from Frederikshavn which underpins that

35. BASIS YEAR 2020 - ADT
ADT (black numbers), Development areas (red dashed lines), extra traffic caused development areas (red numbers)

the Egholm and Lindholm alignments is facilitating a new purpose – to connect Aalborg and the western part of Northern Jutland which is most likely a political purpose.

The three suggested alignments have different impacts on the landscape. The two western alignments, Egholm and Lindholm, deal with valuable and vulnerable open landscapes (§3 areas) whereas an eastern connection will connect to the existing network of roads and have very small impact.

The EIA is an important tool in the discourse of the third alignment and has been misused in many political situations – for instance when the mayor from Jammerbugt Municipality claims that the EIA concludes that an Egholm Alignment is the best alignment considering the surrounding nature and landscapes. But the EIA describes the three alignments and the consequences for the contextual environments and does not contain a conclusion of which alignment is better than other – nonetheless The National Road Directorate, who have finished the EIA, consider the Egholm alignment to be the best solution in a socioeconomic sense.

Over the years there have been much complainant and demurrer in relation to the EIA from both local citizens and experts within the fields of mobility and biology. The main complainants are about the fact that the overall governmental strategy Green Transport Policy (author's translation) from 2009 explains how the public transport system

should be the main factor when it comes to handle future growth in traffic. The EIA 2011 obtains very little strategic planning when it comes to handle the complex situations of this growing traffic-related problems. Many experts (Morten Nicolaisen, Peter Næss, Gitte Marling etc.), believes that the planned connection over Egholm will only avert the problem for 10 years and there will always be a growing need for new roads as long as the main transport mode is by car. Today the unacceptable traffic load is the state of reason for the chosen alignment and it is seen as the natural outcome of the overall development of society. According to a demurrer from the members of staff at Department of Development and Planning we must achieve sustainable mobility by shift from 'predict and provide' towards 'predict and prevent'. That should be achieved by working with a decrease in private transport (not car-pooling included) for the benefit of public transportations. Furthermore the large improved road capacity in the western part of Aalborg will impact the amount of people using a car instead of public transport or bike – also called induced traffic. The traffic jump explains an increase in traffic quantity as a consequence of the improved road capacity. More specifically the 4-lained motorway is estimated to create an increasing capacity with 40% which will result in an increase of road users with 12-20% short termed and 20-40% long termed. Aalborg Municipality plan for increased motoring, accessibility and mobility, even though they would argue otherwise, without considering that mobility is about so much more. The people excluded, the disabled, students and elder that do not own a car, has to deal with an exacerbated public transportation system and mobility facilities (docs.denbedstevej.dk, 2011).

PEOPLE OF INTEREST

The Third Limfjord connection has many players involved. Some are against the final decision for an Egholm Alignment and others want to clarify the problems of the EIA. The involved ones have different backgrounds since the alignment has influences on a broad variation of life aspects.

The third Limfjord connection is as described planned to be aligned with the Egholm. Egholm is a 605 ha island located in close relation to city and nature. It is cultivated with arable land, salt marsh and woods which altogether creates a magnificence nature. A unique plant and wildlife is related to Egholm and more than 100.000 is visiting every year. (Aalborg.dk, 2016) There are several unions, Facebook groups and internet pages were people against the Egholm Alignment express themselves.

In general the citizens of Northern Jutland wants better motoring infrastructure but the additional alignment going east is the most popular alignment. The specific number says that 27 % wants a Egholm alignment whereas 53 % wants a improvement of the existing eastern tunnel. The data is based on quantitative analysis made in 2014 and describes the distribution of for and against respectively an Egholm and an eastern alignment. (Jysk Analyse, 2014)

The chairman of the Region Council Ulla Astman (Social Democrat) is one of the leading proponents for a third alignment crossing Egholm and is a part of the association 3limfjordsforbindelse.nu. Furthermore most of the regional politicians are happy with the deal and describes the situation as a starting point for more growth in the Northern Jutland. Even the Mayor of Aalborg Thomas Kastrup-Larsen started to suggest an alignment crossing Egholm shortly after his selection despite of being against it for a long time (egholmsvenner.dk, 2005).

SUMMERY

As described earlier the alignment will have a huge impact on the everyday life for many different types of people and it is therefore very difficult to conclude which alignment is the best or the worst. But instead of combining a high quality transport solution with the modern planning within public transportation the government have chosen a single-minded solution that favors motoring at the expanse of Egholm – a significant and unique piece of landscape.

The following chapters will be an investigation of the overall municipality plans and valuable natural areas that to understand the general development of Aalborg Municipality and the many impacts on our grown environment.

Key Points:

- Investigate whether a third Limfjords Connection should be located at Egholm or if other alternatives should be validated

- Work with the criticized aspects of the VVM

- Look at the overall strategies of development of Aalborg and Nørresundby and see if there is potential linking

- Work with a mobility strategy that facilitate both regional and local demands and city planning

- Work with a mobility strategy that does not only includes motoring but other mobility modes as well

- Work with a bridge structure that has minimal impact on the environment of the Limfjord and gives back potentials for new habitat areas

Municipality Strategy Plans

MAIN STRUCTURE PLAN GREEN-BLUE STRATEGY

To get an understanding of the political agendas for the future of Aalborg as a city, will the following pages analyze various plans made by the municipality of Aalborg. Even though they are created by various departments within the municipality, does the overall municipality plan set the agenda for the city, as a whole. Therefore will there in the following chapter be analyzed; "Green and Blue structures" and the "Municipality plan".

MUNICIPALITY PLAN

The municipality plan is divided into three elements; a main structure, guidelines and the municipality plan framework. In our case is the interesting aspect the main structure, as it describes the overall, strategically and comprehensive physical plan for the future development of Aalborg. It defines the overall objectives for the development within individual sectors, communities and specific areas. (Kommuneplan, 2016).

Aalborg sees themselves as the "growth dynamo" of northern Denmark, and acknowledge this as an important part of their own development to strengthen that position - by ensuring correlation between growth and welfare, innovation and collaboration towards a holistic and sustainable city policy. Their goal is to sustain a strong university, robust occupational structure and qualified workforce. It's therefore necessary to ensure essential infrastructures, that links the city with the rest of the region and make it accessible globally. Attractive urban environments is also an important element for the city, in order to attract an qualified workforce. It is therefore necessary to create good accommodation opportunities, good urban venues and ensure cultural and accessible recreational offers. (Kommuneplan, 2016).

The collaboration within the city region is an important part of strengthening Aalborg and thereby also northern Denmark in the national and globally competition occurring between cities. They therefore no longer see any sense in highlighting the contradiction between urban and rural areas, and instead want to focus on coherence and cooperation between the city and the regions towns and rural areas. It is in the new way of collaboration between the city and the region, they will find their competitive edge. (Kommuneplan, 2016).

The municipality sees the focus on ensuring coherence between growth and welfare is an important aspect in the efforts of strengthening Aalborgs competition conditions. They don't believe Aalborg's growth potentials can stand alone, but must be incorporated into a whole, where growth is not an end in itself but a means to create attractive, sustainable cities with well-functioning municipal services where people thrive. In the overall city policy for Aalborg is it therefore necessary that public services, culture, mobility, accommodation is planned together and transformed directly into long-term, sustainable solution in the city's physical appearance in the creation of applicable urban spaces, green venues, safe and inclusive neighborhoods, new innovative jobs and diverse experiences. (Kommuneplan, 2016).

An important element in the coherence and cooperation between the region and Aalborg, as the main city is largely depended on a good infrastructure that connects Aalborg with the out world: highways, railways, airport and harbor. However climate changes and an increase focus on sustainability challenge the traditional view of infrastructure. The municipality therefore believes that it about putting people in focus and that infrastructures never should be a goal in itself, but a medium to reach the municipalities goals for mobility, where the citizens and business community are ensured opportunities for reaching their destination in a proper way. Where the transport often will be a series of various motility modes, where the nodes interlinking the modes hold great potential as social meeting places. (Kommuneplan, 2016).

As the center of northern Denmark Aalborg takes the role as the region's most important cultural, service and trade center. The municipality believe the center of the city should be open and inclusive, while offering a multitude of new and unique experiences. The experiences should at the same time capture Aalborg's identity as what they describe as "The tough little big city" - an identity rooted in a traditional working culture, but live in a present in an international knowledge and network society. At the same time is it important for the municipality to keep a cultural-rich and entertaining, that appeals to both tourists and conference quests as young students and researchers, in order to create a city where graduates want to stay and eventually start their own business. (Kommuneplan, 2016).

Aalborg sees attractive urban environments and opportunities as a way of competing with other cities on a international scale and maintaining a qualified workforce. Aalborg therefore need to offer attractive urban environments with good housing offers and exciting venues, service, trade and experiences. City life with soul, meeting venues with social unifying effect, innovative experience all matters in terms of

36. Aalborg Harbor Front, C.F. Møller

37. GROWTH AXIS WITH CURRENT AND FUTURE LARGER INFRASTRUCTURES
Growth axis (Green), Light Rail (orange), Rail (black dottet line), Major roads (red dottet line), three potential allignments (black line), Infrastructural nodes (circle), potential nodes (dottet circle)

attracting and retaining innovative businesses, skilled workers, students, other citizens and visitors from around the world. (Kommuneplan, 2016).

The main element in creating a "attractive big city" is accordingly to municipality to ensure a focused and targeted urban growth combined with high standards of public transportation and mobility. They created what they refer to as the "growth axes" which goes from the airport west of the city, through the city center and all the way out towards the eastern harbor. The previous separation of functions should be replaced with the goal of integrating functions within the growth axis, so people, businesses, culture, education, recreation and environment is brought into the city in one big melting pot. (Kommuneplan, 2016).

Within the growth axis is the main keywords: densification, transformation and development. It's the municipality's plan to maintain the coming growth of the city within the axis, in order to create the foundation for a sustainable city with high accessibility. The many development areas within the growth axis highlights the potential for the further development of the city in the form of housing, jobs and enhanced green qualities. The growth axis must be simultaneously concentration, identity and clarity. A small city where urban features are combined with identity giving urban venues, which combined gives the growth axis character, meaning and overview. (Kommuneplan, 2016).

The densification along the growth axis also lays the foundation for a mobility belt with various mobility elements, as the higher population creates a larger target group for public transportation systems. The belt consist of compounds like light rail (or bus rapid transport system), bicycle highway and recreational natural corridors linking the port in the east, college, university, city center, residential and experiences with the airport in the west. The transition between various mobility elements is essential in the growth corridor and where private passenger traffic meets its environmentally friendly transport alternative must there be ensured park and ride areas enabling interchanges between mobility modes. (Kommuneplan, 2016).

The municipality of Aalborg reckons the transformation

38. GROWTH AXIS WITH POTENTIAL DEVELOPMENT AREAS
Growth axis (Green), Potential velopment areas (dark fill), three potential allignments (black line)

and densification of its inner part is the foundation of a sustainable Aalborg. The densification of the city will not only create more urban life, enhance the quality of urban areas and better opportunities in terms of solving transportation needs with more sustainable solutions. Densification will also protect the surrounding landscape and wet lands, which is necessary in order to handle a weather climate. As the city densify, does the need of maintaining recreational qualities and connection towards the city's inner parts increase. In some cases may green areas be put in better harmony with the city, through, for example green corridors. (Kommuneplan, 2016).

Another part of the municipalities plans is to ensure a overall planning of the city, which takes climate changes into consideration. Aalborg's placement along the limfjords river and the many low-lying areas makes the city particular vulnerable towards rising sea levels and streams. Their climate strategy is to stop urbanization of low-lying areas and start climate adapting buildings build below level 2,5m. The climate adapting strategies can be construction which secures against flood, or constructions which can withstand being flooded. Furthermore is it also the strategy to use the increasing amount of water as a recreational element in and around the city. (Kommuneplan, 2016).

The overall infrastructure of the city are made out of a series of various mobility modes. There is no real connectivity or coherent element that ties it all together. If you compare the three alignments from the EIA-report is it only the Egholm alignment, which doesn't contribute to a potential infrastructural node, while its only Lindholm which creates a potential new infrastructural node. The Egholm alignment is too far away from the city, while the eastern alignment is an expansion of the existing infrastructure. The potential new infrastructural, between the light rail and Lindholm alignment adds to the possibility of creating a "park and ride" function where citizens can change mobility mode into the city. In terms of the growth axis does all of the three alignments lay too far out of the city, however the Lindholm corridor could connect the airport with the rest of the city, by incorporating the light rail into its structure.

The development areas within the growth axis is all rather larger areas that are either currently under transformation, has been transformed or are planned to be. The three align-

ments are not incorporated into the growth axis or supporting these developments. They are seen as two different project, which also highlight the current discussion of the third limfjords connection as regional project and not a local one.

GREEN AND BLUE STRUCTURES

With the municipality reform back in 2007 did the municipality of Aalborg start to be resposible for the planning of its rural areas. To ensure a holistic planning approach towards the planning of its rural areas, did the park department create the "Green-Blue structure report, which had the goal to strengthening Aalborg's nature, landscape and recreational availability. The report were an input to the municipality's work with the open country, the urban landscape and urban green areas and where considered as a tool for the future planning of the city. (Aalborgkommuneplan.dk, 2016).

The main concept in the green-blue structure is to create a physical plan that connects the main landscapes, including farmland, dry and wet natural areas, cultural environments and recreational paths into coherent network of wedges and ribbons. The goal is to create a green-blue backbone throughout the rural and urban landscape, based on both the special values and development potential these areas holds, while ensuring recreational accessibility. Their desire is to integrate the green-blue structure into the overall physical planning of both the rural and urban planning, where its content is included on an equal level with other interests in the overall balance of interests in the daily planning decisions, as well as in the planning of future projects. (Aalborgkommuneplan.dk, 2016).

The municipality of Aalborg has an exciting and varied landscape and a diverse range of natural areas, cultural environments and excursions, with some unique features. At the same time is there a huge pressure on the natural areas, due to a combination of more or less conflicting interests in many places. This calls for a common position where nature should be and how it should develop over time. The Green-blue structure is a holistic contribution to a coherent policy and structure for nature, landscapes, environments and outdoor recreation, where there is thought across traditional sectors. (Aalborgkommuneplan.dk, 2016).

With a focus on the totality, cohesion and accessibility, is the intention to create a tool, which in the ongoing planning can strengthen natural areas, and increase the connectivity and availability of them. The Green-blue structure ambition is to put nature and the recreational potential on the agenda and contribute to the green-blue interests and structures are being supported and secured in the competition with other interests in terms of land-use. When prioritized efforts are made in green-blue structure, is the objective to achieve several benefits and synergies of each intervention in natural environments and outdoor recreation. Thinking in physically contiguous nature is important, both in terms of biological and recreational values. Both the biological and recreation values are considerable higher if natural and rural areas are linked into larger units and experienced as a coherent landscape. For the citizens of Aalborg is the accessibility to green and blue wedges and ribbons, as well as access to larger contiguous landscapes of great recreational value. Just as the presence of unbroken wilderness areas give animals and plants greater diversification, opportunities and the chance to find food and sustainable habitats. (Aalborgkommuneplan.dk, 2016).

The plan consist of three elements: Wedges, ribbons and ecological/recreational connections. A wedge form a coherent landscape that stretches from the rural landscapes and into a major town/city. It consits of green spaces and natural areas that can be anything from forest, nature, agriculture, streams, parks, green spaces, allotments, marinas. The recreational use plays a big role in the wedges and the balance between use and protection of the wedges natural areas is particularly important. (Aalborgkommuneplan.dk, 2016).

The ribbons from a coherent landscape that stretches throughout the rural areas, however they are not linked to a city/town. A ribbon consists of green areas, natural areas and water bodies that can be anything from forest, nature, agriculture, streams and fjord. (Aalborgkommuneplan.dk, 2016).

The ecological/recreational connections creates links between wedges and ribbons and supplement the green-blue structures. The connection in itself is not necessary a coherent landscape, some places are merely a path connection or a narrow dispersal corridor, while the connection elsewhere may be larger natural areas. (Aalborgkommuneplan.dk, 2016).

The green-blue structure is a vision from the municipality which aim to increase the coherency between urban areas and the rural landscape, by bringing natural corridors in form wedges into the city. However the three alignments from EIA-report, doesn't take these vision into consideration. Out of the three alignments is it only the eastern one, which wouldn't create a new barrier, as its enhancing an existing one. Both western alignments will with its highway going west of the city create a new highway and thereby a significant barrier towards the rural landscape in this area. The two western alignments cuts through several wedges and ribbons and would therefore make the connection between the rural landscape and urban areas even more difficult and cost-full. The green corridors will therefore be less attractive, not only in terms of recreational use, but also for spreading corridors and animal habitats.

39. GREEN-BLUE STRUCTURES
Wedges (Dark Green), Ribbons (brighter green), Recreational paths (green line), Planned pathways (green dotted line) three potential allignments (black line)

Key Points:

- Ensure essential infrastructures, that links the city with the rest of the region and make it accessible globally

- Public services, culture, mobility, housing should be planned together and transformed directly into long-term, sustainable solution in the city's physical apperance

- Offer attractive urban environments with good housing offers and exciting venues, services, trade and experiences.

- Interchanges between mobility modes and the transition between various mobility elements is essential, especially between private passenger traffic and its environmentally friendly transport alternative.

- Densification of the inner city is necessary to protect the surround landscape and wet lands

- Climate changes shall be taken into consideration in the overall planning of the city

- Aalborg's nature, landscape and recreational availability shall be strengthen and serveral benefits should be obtained with each intervention

- The main landscapes, including farmland, dry and wet natural areas, cultural environments and recreational paths shall be connected into a coherent network of wedges and ribbons.

Valuable Natural Areas

VALUABLE NATURAL AREAS DESIGN PARAMETERS

40. VALUABLE NATURAL AREAS
Paragraph 3 green areas and protected forests (Dark green), Paragraph 3 lake areas (Dark blue), Sea grass and Eelgrass (light blue), three potential allignments (black line),

This analyze will investigate the potential impact the third limfjords alignments will have on their surrounding landscapes, in order to incorporate to understand the impact a possible alignment will have on the city's natural capital. The Two western alignments will be partly described together, as they for a larger part share the same alignment. When the Lindholm Alignment and Egholm alignment separate will they be described separately until they meet up and merge together again.

The two western alignment goes through several valuable areas, Østerådalen, Skalborg Bakke and Hasseris Enge, before dividing itself into two.

1. Østerådale: Provides following ecosystem services; Local climate and air quality regulation, Carbon Sequstration and storage, Erosion prevention and maintenance of soil fertility, Pollination, Biological control, Habitat for species, Maintenance of genetic diversity, Recreation, mental and physical health, Tourism

The landscape laying south west and south of Aalborg is char-

acterized by large hills that forms the edges of the distinctive Østerådal. The area has an important landscape characteristic and is highly visible fragile, towards larger interventions. The flat and wide area around the river valley, cuts through the hilly landscape and creates valuable biological spreading corridors towards the south. The area today is already highly defined by the main road Hobrovej and the existing highway structure going east of the city. (VVM, 2011)

The area consist of several paragraph 3 areas, areas protected by the Danish protection act, which prevents changes in an area's natural state in order to protect its natural habitats (Naturstyrelsen.dk, 2016). The Østerådale wedge continuous course alongside Østerå, the varied flora and fauna, as well as the agricultural cultivation all the way into the inner city, gives the wedge its characteristic identity and important role in creating an important link between urban and rural areas. The wedge has a special value as it's a peri-urban natural area, that creates good accessibility towards green areas and an impressive bird, animal and plant life (Aalborgkommuneplan.dk, 2016).

2. Skalborg Bakke: Provides following ecosystem services; Fresh water, Food, Waster-water treatment, Recreation, mental and physical health

The landscape at Skalborg Bakke is characterized by a hilly terrain with several north south-cutting windbreaks. The landscape is mainly used for agriculture and has touches of previously tree nursery occurring in the area. The area is laying high in the landscape, providing view towards Hasseris Enge and Østerå dalen (VVM, 2011).

The area has a special value as a state of the art project for protection of groundwater in Aalborg. The underground around Drastrup is an important aquifer, however it's not natural protected, which makes it highly vulnerable to pollution. Because of this were there completed an a forestation project and other state of the art groundwater protection measurements (Aalborgkommuneplan.dk, 2016)

3. Hasseris Enge: Provides following ecosystem services; Local climate and air quality regulation, Carbon Sequstration and storage, Pollination, Biological control, Habitat for species, Maintenance of genetic diversity, Recreation, mental and physical health,

The landscape west of Aalborg is a flat, large-scale plains plain landscape, defined towards the north by the fjord and towards the east of Aalborg's urban edge and it's hilly terrain in the district of Hasseris. To the west bounded area of Hasseris forest, which closes for further views of the rural landscape. The landscape stands with its horizontal surface in great contrast to the city and hills, largely kept free of buildings. The Hasseris river or stream flows in a regulated channel through fields and meadows before entering into the fjord. The stream is an important biological spreading corridor for certain species, while creating important habitats through the area (VVM, 2011).

The landscape appears simple with few elements, where the large surface and the relatively open spaces dominate the area. From the surrounding high-laying areas are there wide views of the open and large plains, and only two road construction at the edge of the meadow towards the north and south are disrupting the calmness of the large plains. The area has a high landscape character and visual vulnerability, due to its large plains and openness, while also having some valuable natural areas in the form of some paragraph three areas (VVM, 2011).

After Hasseris Enge does the two alingments divide itself into two, where the Lindholm alignments goes inwards towards the city, through Mølholm and Lindholm, while the Egholm alignment crosses the fjord and goes through Egholm before the two meets up again at Høvejen.

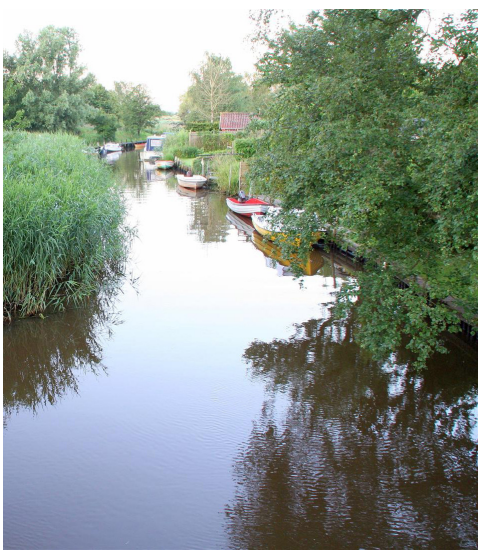
4. Egholm, Mølholm and Lindholm: Provides following ecosystem services; Food, Local Climate and Air quality regulation, Carbon Sequestration and Storage, Erosion Prevention and maintenance of soil fertility, Pollination, Biological Control, Habitat for Species, Maintenance of Genetic diversity, Recreation, mental and physical health, Tourism, Aesthetic appreciation and inspiration for culture, art and design, Spiritual experience and sense of place

Limfjordens low and flat coasts and reclaimed land along the fjord, at Lindholm, Mølholm on the opposite sides of Egholm, is an overall and partially unspoiled scenic whole. The area with the fjord has a great recreational value for the inhabitants of both Aalborg and Nørresundby (VVM, 2011).

The costal edge south of the fjord is a low, drained area defined by natural salt marshes along the coast. The fjord marshes longer towards the west is used for grassing and valuable recreational use, while there are various minor woods and hedgerows spread out in the area. (VVM, 2011).

The landscape of Egholm, the Limfjord island, is characterized by being an open, flat and simple landscape, with large field plots and intensively utilized arable farming. There is often vegetation around the islands settlements, but the landscape is otherwise largely kept free of vegetation. From the island are there many good visual connections across the

41.. Østerådalen, with Aalborg in the background



42. Recreational atmosphere at Lindholm Å

43. Saltmarshes at Egholm

fjord, towards north at Lindholm and east towards the city edge of Aalborg (VVM, 2011). The island is quite significant in terms of recreational use. The island is visited annually by approximately 70,000-80,000 visitors, mainly day visitors who come to experience Egholms unique nature and wildlife (www.nordjyske.dk, 2009).

Egholm is of significant important in terms of ecological factors, due to its various habitats and wetlands, which has resulted in half the island being protected by EU bird protection acts. The island is a habitat for several species, including several protected and threatened species, such as the Light-bellied Brent Goose, which is one of the smallest goose populations in the world (VVM, 2011).

Around Egholm is there many areas with eelgrass and one larger area with sea grass, which are particularly valuable areas in the fjord. Eelgrass and sea grass are important for a variety of fish, either as permanent habitats, spawning areas and/or nursery areas for juveniles. They also serve as a larder area for a variety of birds. Several birds feed on bottom plants like eelgrass, sea grass and sea lettuce, as well as the fish living in them (VVM, 2011).

The landscape around Lindholm stream is characterized by being a closed landscape space that opens up towards the fjord and is of significant importants, both in terms of ecological and recreational factors. The coasts at Lindholm is shallow and suitable for fishing, kayaking, windsurfing and other forms of easy sailing, while the inner parts of the streams has several residential units laying down towards the stream. Furthermore is the adjacent areas on one side an important paragraph 3 area, while the other side hosts a series of football field for local football unions. The stream is also a significant ecological spreading corridor for several species, including the otter, which is one of Denmark's most endangered mammals (VVM, 2011).

At Høvejen does the two alignments merge together once again and goes through Høvejen and Vestbjerg before merging together with the E39 going north towards Hjørring.

5. Højven: Provides following ecosystem services; Food, Recreation, mental and physical health

The landscape around Højven is characterized by being a medium-small scale landscape with a smaller hilly terrain. The dense planting define the landscape spatially and makes it appear partially closed. The landscape is mainly used for agriculture and recreational purposes around Voerbjeg Kær, where a 20-hectare lake is used for water skiing (VVM, 2011).

6. Vestbjerg: Provides following ecosystem services; Fresh water, Food,

The areas landscape is characterized by being a vast, flat plains landscape and its terrain is defined by Hammer Bakker to the northeast and the Sundby hill towards the south. The landscape is mostly used for farming or plains, with plants scattered in small parcels and some broken windbreaks of varying heights. Furthermore is the area an important aquifer (VVM, 2011).

The eastern alignment is an expansion of the existing highway with an establishment of a new tunnel tube, which makes its impact on the natural areas significant lower. The eastern alignment affects Kridtbakken, Limfjorden and two industrial areas before and after the tunnel. However its only at the crossing of Limfjorden, the alignments will have an effect on the existing landscape.

7. Limfjorden at the eastern alignment: Provides following ecosystem services; Recreation, mental and physical health

The landscape is a hilly moraine landscape, which rises behind the flat coast with striking docks, tank depots and industrial areas. The existing highway cuts significantly into the hill and is therefore surrounded by significant sloes that are densely planted. The area is of small ecological and recreation value, as the existing highway already have made its impact on the area. However there is a small marina, which can be seen as having a small recreational value for the area.

The two western alignments cuts through valuable natural areas, with several paragraph three areas, important aquifer areas, as well as significant and protected animal habitats, which also have a significant recreational value. On the opposite site, does the eastern alignment only to a small degree effect valuable natural areas. The two western alignments both affects around 200.000 square meters of valuable natural areas, while the eastern alignment "only" affect 1150 square meters of valuable natural areas.

Key Points:

- Valuable natural areas, such as Eel- and sea grasses, protected paragraph three areas, as well as ecological areas shall be taken into consideration and enhanced through the planning and design of the bridge structure

Climate Changes

LANDSCAPE FORMS RAISING SEA LEVELS

44. AALBORG'S LANDSCAPE FORM
0-5m (sand color), 5-20m (brighter green), 20-40m (bright green), 40-60m (green), 60+m (dark green), three potential allignments (black line)

As our climate is rapidly changing is it altering the composition of our existing landscapes; low-lying areas will become rivers or streams, green marches will turn into salt marches and residential areas can be more vulnerable to flooding either by rising sea levels or increasing storms. This chapter will investigate how the rising levels of the water in our sea and streams, as well as increasing storms will affect the three alignments and the city as a whole.

AALBORG'S LANDSCAPE

The shape of the city's landscape and its characteristics features have played a major part of how the city has evolved in relation to housing patterns in both urban and rural areas, agriculture, extraction of raw materials and the industry that is derived from it. (Aalborgkommuneplan.dk, 2016).
The landscape can be divided into two types; the hills and the low plains, which includes the coastal areas. Towards the north of the Limfjord is it the low-lying plains, only broken by the hills at Hammer Bakker, Aslund plantation and towards Ulsted, which is the dominant type of landscape. Towards the south of the Limfjords is it the hilly highland with is many streams and characteristic river valleys which is the dominant landscape form. However the most characteristic part of Aalborg's landscape is the Limfjord and its flat marshes, which create a open landscapes that provide the city with broad views and larger open spaces.

The landscapes contour lines can be divided into five zones; 0-5m, 5-20m, 20-40m, 40-60m and 60+m

RISING SEA LEVELS

The global sea level has risen by 10 to 20 centimeters over

the past century, while it in the last 20 years annually has risen with an average of 3,2 millimeters. The main reason behind the rapidly rising sea levels is the rising temperature on the Earth's surface, which is due to both human and natural activities, and most significant the burning of fossil fuels. These emissions, and heat-trapping gases in the atmosphere are accumulating and holding onto a excessive amount of additional heat, which the ocean are absorbing around 80 percent of. (Society, 2016).

The rise in sea levels is linked to three primary factors, which are all induced by the ongoing global change in climate; Thermal expansion, Melting of glaciers and polar ice caps and Ice loss from Greenland and West Antarctica. (Society, 2016).

The rising temperature on earth's surface is causing water to heat up and expand. This is referred to as thermal expansion, which has caused half of the past century's rise in sea level, due to the simple fact that warmer oceans occupies more space. (Society, 2016).

Glaciers and the polar ice caps naturally melts back a bit each summer, however snow, made primarily from evaporated seawater, is generally enough to balance out the melting during the winter. But the persistently higher temperatures caused by global warming has led to a significant increase of the ice, while later winters and earlier springs have diminished the amount of snowfall. This extensive amount of runoff water from melting ice caps has surpassed the amount of snow and evaporation from the ocean, causing sea levels to rise. (Society, 2016).

In a similar manner, as the glaciers and polar ice caps is the increasing heat causing massive ice sheets that cover Greenland and Antarctica to melt at an still increasingly rate. Additional to the increasing heat, is it also believed that melted water laying on the ice surface and the seawater from below is seeping beneath Greenland's and West Antarctica's ice sheets, causing them to move more quickly into the ocean. Finally are the higher sea temperatures weakening the massive ice shelves by melting them from below, which leads to them breaking off and falling into the ocean. (Society, 2016).

The rising temperature of the oceans can have huge consequences for the oceans habitats and ecosystems, however the rising sea levels as a result of an increase of the ocean temperature can be devastating. The rising sea levels can cause destructive erosions, flooding, contamination of aquifers and agricultural soils, and lost habitat for fish, birds and plants. Higher sea levels can also create areas more vulnerable towards flooding and cause more powerful and bigger storms. Furthermore can it also submerge low-lying areas, causing people to relocate and abandon their homes. (Society, 2016).

Predicting or estimating the amount sea levels are going to rise is a difficult task, which are related to a large amount of uncertainty. However a recent study suggests to oceans to rise between 0,8 and 2 meters by 2100, while a more dire estimate, which include a complete meltdown of the Greenland ice sheet, estimate it to reach 7 meters by 2100. (Society, 2016).

CLIMATE CHANGES IN A DANISH CONTEXT

The water levels observed around the Danish coasts, expect the ones measured in Northern Jutland is increasing, and is expected to increase even stronger in the next hundred year due to climate changes. The reason the levels aren't increasing in Northern Jutland is due to the soil uplift, which is greatest in the northern and eastern part of Denmark and lowest in the southwestern part of the country. When the raising water levels are corrected with these uplifts in soil is the Danish average of 1,7 to 2,22mm/year raise in sea water quite close to the global average. (Realdania, 2016).

The projected sea level rise for Denmark is built on scenarios from the IPCC, the international panel on climate change. The coming analyses is based on the A1B scenario, which is the one the Ministry of Environment, among others recommend municipalities to use in the modeling of future floods. A1B is a medium scenario in which greenhouse gas emissions peak around 2050 and then fall (Orbicon, 2016). A1B shows a mean rise in the sea of 0,61 meter, with a range between 0,2 and 1,1 meter in 2100. Numbers, which are based on measurements from 1986 towards 2005 (Realdania, 2016). The maximum level of sea rising is therefore 1,1 meters, as its the maximum in the interval. This will therefore be used as the baseline for the level of sea rising in the coming analyses.

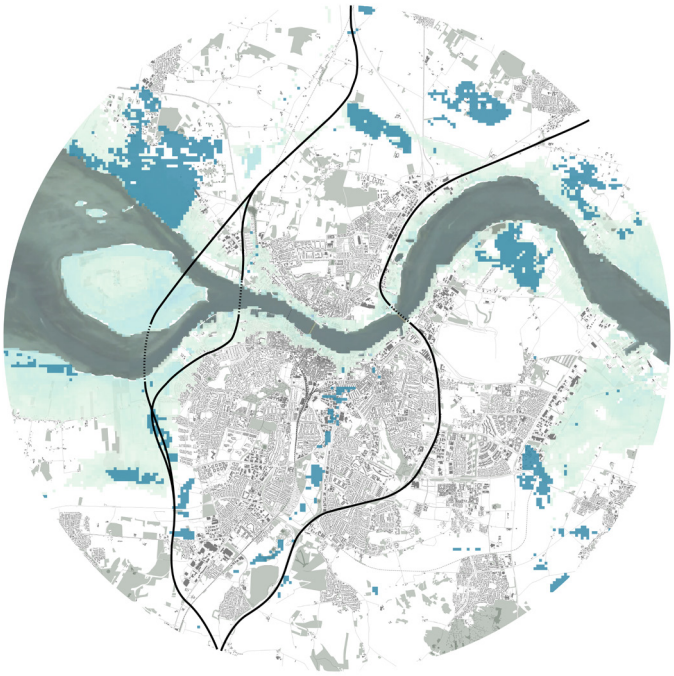
As mentioned before does the movement of land and uplifting of soil counter the rising sea levels. The smallest uplifting of soils occurs in the southwestern part of the country, which a rise of around 2mm/year, while the uplifting of soils enhanced towards north and east. In the most northern part of the country is the uplifting of soil around 2mm/year, equivalent to 0,2 meters over hundred years. The area around Aalborg is experiencing a yearly rise of 1,4-1,5mm/year, which in 2100 is roughly equivalent to a elevation of the ground of 121,8mm or 0,12m. (Realdania, 2016).

The total rise of sea water in Aalborg in year of 2100 will therefore be 0,98 meters (1,1m - 0,12m) in the maximum interval.

STORM SURGES

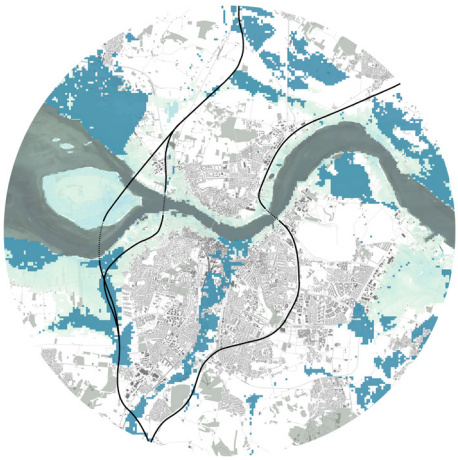
Storm surges occurs with the passing of a stormy low pressure and is a combination of tides, atmospheric pressure and standing water in situations of onshore winds. When all

45. CLIMATE CHANGES BASIS YEAR 2100
A rise of 0,98 meters in the year 2100 will affects areas marked with a blue/yellow gradient. Yellow areas indicate low-lying areas that can be overflooded due to its height over sea, but might be protected by dams or other flood protection, while the blue indicate areas that will be flooded.



46. CLIMATE CHANGES WITH A 20 YEAR EVENT IN 2100
A rise of 0,98 meters in the year 2100 and a 20 year event with a rise of an extra 1,3 meters (green/light blue) alongside a 40 cm rise in smaller watercourses and streams (blue)

47. CLIMATE CHANGES WITH A 50 YEAR EVENT IN 2100
A rise of 0,98 meters in the year 2100 and a 50 year event with a rise of an extra 1,39 meters (green/light blue) alongside a 70 cm rise in smaller watercourses and streams (blue)



48. CLIMATE CHANGES WITH A 100 YEAR EVENT IN 2100
A rise of 0,98 meters in the year 2100 and a 100 year event with a rise of an extra 1,46 meters (green/light blue) alongside a 100 cm rise in smaller watercourses and streams (blue)

49. Saltmarshes at Egholm

three parameters have their maximum at the same time, are the highest water levels obtained. However there is a big difference in the importance of each factor across the country, due to external climate factors and geographical elements. (Realdania, 2016)

The tide water can cause raised water levels of one meter at Højer on the western side of Justland, which falls to 0,1 meters in the inner waterways of Denmark. A drop in air pressure during storms can cause sea level rise of 0,3-0,4 meters and in addition can standing water in situations of onshore winds cause water levels of up to approximately 3 meters. (Realdania, 2016).

Changes of the oceans mean sea level, alongside changing wind patterns will lead to increasing flood heights. It is estimated that the storm surge height along the west coast can be increased by 0,3 meter by the year 2100, while there in the inner Danish waters not are expected an increase in storm surge heights. Increased water levels does also play a vital part for how often a given threshold will be exceed in terms of flooding. Copenhagen will statistically experience a raise of its sea water level of 1,5 meters every 100, however a raise of the average water levels at 0,5 meters will make the 100 year event occur every second year. An increase in water level will also propagate in groundwater level at some distance from the coast and inland, resulting in the groundwater level in low-laying areas will ascend to the terrain. The effect will diminish with its distance from the coast and will therefore primarily affect the coastal towns. Future measures should therefore not only take raising levels into consideration, but also the ascending groundwater. (Realdania, 2016).

Storm surges in Aalborg/Nørresundby will cause a raise of sea water levels between 1,30 and 1,46 meters depending on the year event. For a 20 year event will the sea water level rise 1,30 meters, a 50 year event 1,39 meters and a rise of 1,46 meters will occur every 100 year. (Masterpiece, 2016)

CHANGES IN WATERWAYS

The change of water levels in streams due to climate changes can be difficult to predict, as there are many local parameters which influences the water level, such as; the physical char-

acter of the watercourse, catchment area (rural or urban), specific runoff and the amount of vegetation. However the combination of rising groundwater levels, rising sea levels and increased discharge from stormwater discharge, is the main reason for rising levels in streams and smaller watercourses. (klimatilpasningsplan, 2016)
For an initial screening of the potential danger the flooding of smaller watercourses can bring, has the municipality of Aalborg made a rough estimate of how floods at various stationary water depths of streams will be spread out into the landscape. They have estimated the following relationship between water levels and frequency of the situation in 2050; 5 year event - 10cm, 10 year event - 20 cm, 20 year event 40 cm, 50 year event 70cm and 100 year event 100cm. (klimatilpasningsplan, 2016).

SUMMERY

Based on these estimations will there be made mapping of climate changes with the basis water level rises in 2100, alongside three storm surges in both waterways and ocean for a 20 year event, 50 year event and a 100 year event, in order to understand the effect climate changes will have on the physical landscape in Aalborg.

The analysis shows minor flooding of some of the low-lying areas south and north of Egholm, as well as around Egholm itself and the eastern part of the city in the basis year of 2100. Of the three alignments is it only the one crossing Egholm, which would experience some issue due to rising sea levels around the tunnel on the Aalborg side. Both the 20, 50 and 100 year event shows severe flooding of the low-lying areas in case of storm surge towards the west and eastern part of the city's rural areas. The rising levels in the minor waterways and streams will cause flooding in some major areas, including the area west of the city, at Hasseris Enge, and in the center of the city at Østerå wedge.

The notion of resilient cities states that water should be invited in and made room for in the rural and urban space, hence would the western part of the city's natural areas be temporal flooded in periods of 20-, 50- or 100 year event and be transformed into wetlands. A highway, as the two western alignments suggest, would therefore be more expensive for two main reasons; firstly will pollution from road runoff end op much quicker in the wetlands and fjord, which much be taken into consideration and be intervened before it occurs, which will create a more cost full solution. Furthermore would the flooded areas create new habitats suitable for some of the endangered species already existing on and around Egholm, such as the red listed Brent goose. Secondly will the severe flooding and temporary submerging of Egholm and the area south and north of the island, also cause flooding in the proposed tunnel, from Aalborg to Egholm, and access towards it, as well as the entire corridor. To avoid this would it be necessary to incorporate dams and other flood protecting elements, which would have to be maintained accordingly to damage during flooding and storms. This will add further costs towards the project and especially this alignment. The eastern alignment is beside minor flooding around the fjord and isn't affected by the climate changes.

Key Points:

- The chosen alignment or placement of the bridge structure shall take the 20-, 50- and 100 year event into consideration, both in terms of flooding of the structure itself and its surroundings.

Aalborg Mobility Modes

BUS BIKE CAR

50. CITY BUS TRAFFIC IN AALBORG 2013
Bus lines stop (cirkel) and bus lines continuing (arrows)

The city of Aalborg and Nørresundby is intertwined in many mobility strings and the networks are scattered and crossing to later end up at the same destination. The initial analyses showed that the many mobility modes could be better connected or strengthen in relation to each other. This analysis will clarify the path and nodes of the primary mobility modes of Aalborg.

BUS

The network of busses are characterized by one centrifugal node, John F. Kennedy Plads, where all busses meets and exchange passenger to later on continue the route. Kennedy Plads is also a starting point for many long distance busses – regional, national and international routes.

The number of busses in Aalborg is in general increasing but the number of busses in the suburbs and country is decreasing but there is only one possible connection crossing Limfjorden when it comes to the busses which are a part of the bottleneck problem that occurs around the Limfjord Bridge.

BIKE

Aalborg and Nørresundby have in general great biking facilities with many larger bike lanes that ensure a safe ride along larger roads. The inner city of Aalborg has roads that are closed for private motoring but instead opens up the space for bikes among public transportation, taxi and pedestrians. Aalborg and Nørresundby have 19 stations with city bikes

51. BIKE LANES IN AALBORG 2015
The existing bike lanes (black line), the planned super bike lanes (pink line) and city bike stations (pink dot)

52. LARGER ROADS IN AALBORG 2015
Motorway (black bold line) and larger roads (black medium line)

where you can use it for free for a small deposit (20 kr.). The stations are located in combination with larger nodes and placed where there normally would be many tourists.

The bike connections between Nørresunby and Aalborg are over Limfjordsbroen with double bike lane in both directions and the new pedestrian addition to the light rail bridge. The addition will not be a bike lane but you can drag your bike along.

CAR

There are very few roads where the car is not allowed in Aalborg and Nørresundby. In general are the parking spaces scattered over the two cities with a dozen major underground parking lots and few car parks. The motorway is build very close to the city and creates an easy access to Aalborg's inner city and the system of larger roads connects the city from east to west. There are two accessed connections over Limfjorden – the Limfjord Bridge and the tunnel in east.

SUMMERY

Kennedy Plads has a strong impact on the entire transport network and should in the future development of Aalborg and Nørresundby be an even stronger node. The plan with the new light rail was among other things to transform some of the space reserved for cars to safe spaces (inspired by shared spaces) where the light rail, bikes and pedestrian can interact safely and thereby create new transport alternatives for the citizens and tourists of Aalborg.

Key Points:

Create a strong mobility intervention that gathers not only the public transportation but bikes and motoring as well.

Work with existing important nodes of Aalborg and Nørresundby and add several intertwining mobility modes.

Future Mobilities

TECHNICAL POSSIBILLITIES REGARDING FUTURE MOBILITIES

This chapter unfolds some of the potentials that lie within the available and future technology. Are there any game changers in urban planning when it comes to motoring technologies?

MOBILITY MODES IN DK

In 1960 in Denmark there were 90 cars for every 1000 citizens (Klimadebat.dk, 2016) whereas the numbers today are 641 cars pr. 1000 citizens (Norden.org, 2016). The increasing welfare and globalization result in 72% of private transport is handled by motoring (Denstoredanske.dk, 2016). In Denmark we have an infrastructural network that crosses the landscape and connects our cities as small islands in the sea. Bigger cities, such as Aalborg, are well known as difficult to drive in, find parking spaces in or there often occurs longer waiting time in the mobile situation such as queues. In general the desire for better livability in cities is growing but so is the desire for smoother mobility and especially in relation to motoring. The municipality of Aalborg brand itself as city that works with green infrastructure such as LRT and BRT solutions. As describes in the Analysis of the Municipality Plans the municipality believes in putting people in focus and that infrastructure shouldn't be a goal in itself. Nonetheless the municipality work with mobility as a back bone strategy for growth (Kommuneplan, 2016) and even though there are or planned for several larger mobility networks, motorway, LRT, BRT, rail line, main roads, bus lines etc., there is no link between those modes. The capacity of the road system in Aalborg is almost full or close to which seems to be a problem in consideration to our existing pattern within motoring. It is therefore very interesting to look into new technologies and predictions within the field of public transportation and motoring. The motoring of today is build upon the values defined during the modernity and is seen as true freedom within mobility but the paradox is that it motoring forces us into specific structures with unintended consequences and therefore makes us unfree (Andersen et.al, 2012).

The general mobility planning of today is to construct new motorways as soon as the need for it occurs which is what we have done for the last hundred years and led us to a motorway system that connects Denmark in many good ways but unfortunately also have many downsides such as environmental damages, traffic barriers, noise nuisance, gas emission and induces traffic.

As described in the chapter Mobility there is a serious need for new strategies and thinking within this field. If we want to create more sustainable solutions for future mobility issues we will have to incorporate new technology and knowledge. As Per Homann Jespersen explains it, there is no such thing as sustainable infrastructure but instead we must think in sustainable mobility planning with all three aspects of sustainability; social, economical and environmental (Jespersen, 2015) which he bases on the work of David Banister of Oxford University. It is not Jespersen's conviction that the car should be excluded to achieve sustainable mobility planning but on the other hand that public transport should be included in a bigger sense – a notion already familiar within the mobility strategies of NT (The Transport Services Organization of Northern Jutland). NT is currently working with an app that helps the user finding the best and most sufficient travel including multiple mobility modes – private as well as public ones (Universe.ida.dk., 2016b). The visions of the app has similarities with the project Ubigo launched in Stockholm, Sweden, in 2013 which deals with an service that offers the users alternatives to private motoring (Information.dk, 2015). The service consists of an app that helps the users find, rent and pay for alternative mobility modes; city bikes, light rail, shared car, rental car and taxi. Up to 80 % of the involved test persons wanted to continue the service if it was a possibility and over 50% would even consider to quite the idea of owning a car (Information.dk, 2015).

SELF DRIVEN TECHNOLOGIES

The growing industry of self driving cars shows a glimpse of the reality that we will experience within few years.

"Within the next five years we will see commercial solutions [self driving cars] from all the big car industries. Within 10 years we will see dominant solutions. My own forecast is that children born today will never drive a car." Henrik Christensen, Georgia Institute (Universe.ida.dk, 2016)

The self driving technology does not only concern cars but also busses or metro lines as we see them today. Aalborg Municipality works with the implementation of self driving busses located in an area with many elder residents and smaller children, Astrupstien (www.nordjyske.dk, 2016). The implementation should find place in 2018 in relation to the new Super Hospital in the eastern part of Aalborg. The technologies of the self driving car creates the potentials of a much safer traffic environment for everybody - 90% of all car-involved traffic accidents is caused by the driver (Ingeniøren, 2014). Besides higher level of safety this technology will also affect higher capacity of the existing roads of to-

53. An example og a self driven car - the same one that Aalborg Municipality wants in Aalborg

day and traffic model calculations indicates that the capacity will increase fourfold if all motorised vehicles is self driven (Ingeniøren, 2014). If you combine Aalborg Municipality's work with SMART cities and the implementation of it in an Aalborg context with the new possibilities in our future regarding motorised vehicles and public transportation we will start to see a new reality in our cities and our mobile situations. Today the Danish Government gets almost 50 billion Danish kroner from motorists consisting of taxes (Politiken.dk, 2016) which are a high incentive to keep building roads and improve the accessibility for motoring as we know it today.

SUMMERY

The technologies of today and the future will definitely change the way we experience our cities and mobilities and so does the way we use urban planning as a tool to understand and interact with our context. Aalborg is today well-known for being a knowledge and culture city and it is therefore natural that Aalborg would be a part of this development. The existing planning of the third Limfjords connection is an example of old-school planning with 'business as usual'. The construction time of the connection is calculated to be 7-8 years (VVM, 2011) and even though the alignment is approved by the government the project is not yet financed. If the alignment is being financed and then build it would be in a completely new context and every existing analysis and calculations is outdated. Our vision in this project is to work with an alignment that does not only consider motoring but also takes public transportation and knew technologies into consideration!

Key Points:

- Work with a connection that consider all mobility modes

- Work with a mobility strategy that is a surplus for both the local and regional context

Priliminary Conclusion

SUMMERY KEY POINTS

The analysis builds on the Theoretical Framework and deals with the nearby context of Aalborg. All analysis showed that Aalborg needs an improved infrastructural network and that a bridge structure in the periphery wouldn't benefit the city. Next step is to study the infrastructural strategies and see if any new connections can fulfill the demands for better relations between the various mobility modes. The official project the Third Limfjord Alignment is planned out as a single-minded space that only facilitates motoring. Instead there are underlying potentials of bringing in new functions and connect the land fields with an extension of the city that contains housing, culture, trades and experiences. As the climate changes effects the weather there are growing demands for new solutions to flooding situations and extreme rain. The grown environment can affect the way we perceive our cities and how the city is interacting with the climate changes instead of being defenseless. The infrastructure, both green and grey, is the key element for activities and should be perceived as one sum of flows that creates potential for the bridge to be a public domain.

Key points

- Investigate whether a third Limfjords Connection should be located at Egholm or if other alternatives should be validated

- Work with the criticized aspects of the VVM

- Look at the overall strategies of development of Aalborg and Nørresundby and see if there is potential linking

- Work with a mobility strategy that facilitate both regional and local demands and city planning

- Work with a mobility strategy that does not only includes motoring but other mobility modes as well

- Work with a bridge structure that has minimal impact on the environment of the Limfjord and gives back potentials for new habitat areas

- Ensure essential infrastructures, that links the city with the rest of the region and make it accessible globally

- Public services, culture, mobility, housing should be planned together and transformed directly into long-term, sustainable solution in the city's physical apperance

- Offer attractive urban environments with good housing offers and exciting venues, services, trade and experiences.

- Interchanges between mobility modes and the transition between various mobility elements is essential, especially between private passenger traffic and its environmentally friendly transport alternative.

- Densification of the inner city is necessary to protect the surround landscape and wet lands

- Climate changes shall be taken into consideration in the overall planning of the city

- Aalborg's nature, landscape and recreational availability shall be strengthen and serveral benefits should be obtained with each intervention

- The main landscapes, including farmland, dry and wet natural areas, cultural environments and recreational paths shall be connected into a coherent network of wedges and ribbons.

- Valuable natural areas, such as Eel- and sea grasses, protected paragraph three areas, as well as ecological areas shall be taken into consideration and enhanced through the planning and design of the bridge structure

- The chosen alignment or placement of the bridge structure shall take the 20-, 50- and 100 year event into consideration, both in terms of flooding of the structure itself and its surroundings.

- Create a strong mobility intervention that gathers not only the public transportation but bikes and motoring as well.

- Work with existing important nodes of Aalborg and Nørresundby and add several intertwining mobility modes.

- Work with a connection that consider all mobility modes

- Work with a mobility strategy that is a surplus for both the local and regional context

Design Toolbox

The Design Toolbox is a summary of the Analysis and consists of design parameters, strategies and selection of site. Furthermore it is an introduction to the overall mobility strategy and the site analysis. The Design Strategies is a toolbox to the built and grown environment and provides overall strategies that can easily be implemented in the final design.

CONTENT

WORDS CONTENT **CONTENT**

-illustration 54

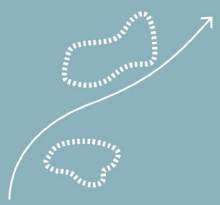
Design Parameters

WORDS CONTENT CONTENT

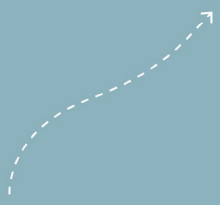
This chapter is a summary of all design parameters presented during the report in the end of each chapter. The parameters deals with the overall theme resilient and are summed up in three categories; Function, Mobility and Materiality. Structure describes important functions that the new connection should enhance, facilitate and take into consideration. Mobility consists of parameters that deals with a larger mobility strategy and how the bridge structure relates to the city and different scales. Materiality describes the material related issues both in hard materials and vegetations. The relation between the design parameters will be describes in a final part in this chapter.

FUNCTION

CONNECT – A series of nodes
The Bridge structure should be seen as a part of the city's network of public spaces and interact with those. The bridge structure should not be seen as a single-minded linear space but a series of spaces that frames multifunctional rural and urban experiences.



AVOID – important natural areas
The alignment must avoid important and valuable landscapes that connect the rural and urban life of Aalborg and Nørresundby.



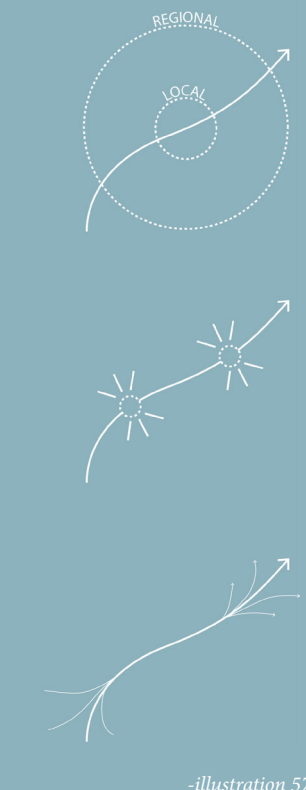
IMPACT – with minimal footprint
The alignment should have minimal impact on the environment of the Limfjord. This is especially important when it comes to the structural system of the bridge.

-illustration 55

-illustration 56

CONNECT - Development Areas
The alignment should be a part of the overall development strategies of Aalborg and Nørresundby and connect new densification areas. Furthermore the bridge structure should facilitate new development areas and thereby link the two cities together and create interesting architectural experiences.

CONNECT - Recreational Areas
The bridge structure should be a green infrastructure for important recreational areas and provide place for the contextual habitats. Aalborg and Nørresundby's nature, landscape and recreational availability should be strengthen by multiple types of landscapes element.



-illustration 57

MOBILITY

CONNECT - Local, Regional and Global Scale
The alignment should ensure essential infrastructures that link the city of Aalborg and Nørresundby with the region and make it accessible globally. Furthermore the alignment should relate the need for a third Limfjord connection with the need of the further development of Aalborg and Nørresundby.

CREATE - New Activities
The bridge structure should work with infrastructure as a potential enabler for activities both in terms of the structure itself and the surrounding environments such as Limfjorden.

GATHER - All Mobility Modes
Create an overall mobility strategy that enhances not only motoring but all mobility modes. Furthermore the bridge should facilitate these various modes and create functional and aesthetic spaces that enhance the multifunctional experiences.

MATERIALITY

PROVIDE - Ecosystem Services
Surface water must be handled localy and kept in multi-functional landscapes to provide wildlife habitats and open spaces for people. Vegetations should be an ever present condition and create wonder and awe and appreciation for its observers.

USE - Permeable Surfaces
The use of impermeable surfaces should be kept at a minimum to avoid polluted run-off from the roads. Furthermore the bridge should facilitate various soil conditions and microclimates in order to host a variety of plant communities, habitats and biotopes.

USE - Minimal Heat Absorbing Materials
The materiality should provide the frame for well-functioning spaces that handles today's issues of dense cities.

ADAPT - Towards External Influences
The bridge structure should be adaptable towards external influences such as; wind, sun, extreme storm scenarios and rising sea level. Furthermore the planning should keep a dialog with nature, by using nature based solutions, and systematically learn from how nature answer human intervention in ecosystems.

-illustration 58

OVERALL DESIGN PARAMETERS

The vision for the project is to create a bridge structure that in a large mobility intervention enables a series of spaces that facilitates a various palette of functions such as recreative spaces, private and public buildings, boat houses, harbor bath, blue and green gardens, kayak facilities, roof gardens etc. in overall connector of the local, regional and global scale. The densification of the inner city and the increasing need for better mobility facilities in the regional as well as local scale creates the potential for a state-of-the-art project that includes the qualities of the city instead of the single-minded linear alignment that the Third Limfjord Connection is today. In that process it is important to think the physical and built environment together with the rural and natural environment as one single ecosystem where all processes affect each other. The tool to understand this process better is the non-fixed plans which describe how the built and physical state plan changes over years where the bridge structure should be seen as 'a medium for rethinking urban conditions' of today (jf. Pollak, 2006). The bridge should facilitate and offer an attractive urban environment with good housing and exiting venues, services, trade and experiences where public and ecosystem services, culture, mobility and housing should be planned together and transformed directly into long term sustainable solutions in the city's physical appearance.

Design strategies - Grown Environmnet

GROWN ENVIRONMENT BUILT ENVIRONMENT

This chapter will describe the design strategies for both the grown- and built environment. Such as which programs will be implemented, types of vegetation/biotopes and the shapes of buildings.

STRATEGIES FOR THE GROWN ENVIRONMENT

A broad type of various landscape elements will be implemented along the bridge structure in order to facilitate various natural experiences. The landscape element which shall be implemented is; Moor, high grasses and flowers, coniferous forest, deciduous forest and wetlands. Each landscape element will have sub landscapes and forms, however these landscapes will relate to the overall theme of the main landscape element.

Moor: The moor grows on nutrition-poor areas, which are dry, due to their soil conditions and is a product of man-made interventions in the natural environment. Over time will moors, if left for itself transform into a deciduous forest. Moors has a broad range of colors and plants, such as the Calluna vulgaris, Deschampsia flexuosa, Empetrum nigrum and Erica tetralix.

59. From left to right, Calluna Vulgaris, Deschampsia flexuosa, Erica tetralix, Nardus stricta

High Grasses and flowers: The high grasses and hurbs/flowers will create a broad range of colors in a open landscape, which will allow views towards the surrounding urban and natural areas. The typography will vary with small hills and indentation, which will allow various flowers and grasses to grow. A mixture of hurbs which flowers during the spring, or fall/summer, will create a variation during seasons throughout the year. Plants such as Scabiosa columbaria, Hybericum perforatum, anthoxanthum adoratum, holcus lanatus, as well dwarf shrubs, will be implemented in the grasslands.

60. From left to right, Calluna Vulgaris, Deschampsia flexuosa, Erica tetralix, Nardus stricta

Coniferous forest: The coniferous forest will consist mainly of scotch pine. The Scottish pine forest is the earliest trees formed in Denmark. The trees has a in-depth pole root system, which makes the species less sensitive towards wind, and as its winter green, will break the wind all year around. The open branch structure of the tree also means the forest to the forest floor, which results in a well-developed ground flora.

61. Example of a scotch pine forest

Deciduous forest: The ash forest can both be adapted towards a humid habitat, such as lakesshores or stream slopes, where ash are forming ash marshes most commonly with red el, but also towards dry habitats, such as street trees or as planting on parking lot and other living areas.

62. Example of a wet ash forest in an Ash marsh

The wetlands will consist of both low- and high-lying bogs, as well as coastal landscape elements such as salt marshes and eelgrass. The High and lowlying bogs are areas which are temporary or permanently flooded. The low and high laying bogs has many similarities in terms of vegetation, however the low-lyingbogs has a little higher amount of species. The vegetation, may include some shrubs like (krybende pil) and (mose-pors). Among the herbaceous plants does plants like (kær-ranunkel), (kragefod), (benbræk), (tormentil), (børste-siv) and (blåtop) occur. With increasing nutrition does species like (vandnavle), (kær-tidsel), (kær-svovlrod), (lysesiv), (næb-star), (rørgræs) and (knæbøjet rævehale) occur.

63. From left to right, Rhynschospora Alba, Eriophorum angustifolium, Trichophorum caespitosum, Eriophorum vaginatum, Empetrum nigrum, Erica tetralix, Vaccinium oxycoccos

Salt marshes: Salt marshes is a costal landscape element, which is a wet landscape that's regularly being flooded by salt water. It's a wetland and is a commonly landscape element along the coastline of Aalborg and the Limfjord as a whole. Based on the dominant species and micro-topographic conditions can a salt marsh typically be divided into a lower, middle and upper salt marsh.

Flooding at high tides is frequent in the lower salt marsh and the bottom is wet. The main species is Puccinellia maritima (strand-annelgræs), Spergularia media (vingefrøet hindeknæ), Aster tripolium (Strand-asters), Plantago maritima (Strand-vejbred), Limonium vulgare (tætblomstret hindebæger). In the middle salt marsh, is the number of high tides reaching this part of the salt marsh, far less than in the lower salt marsh. The main species are Juncus gerardii (Harril), Glaux maritima (Sandkryb), Festuca rubra (Rødsvingel), Agrostis stolonifera (Kryb-hvene), however a variety of other species also plays a role, locally. The upper salt marsh often has rather dry soil, lower salt content and the vegetation much more varied, as its rarely flooded at high tide. The main species are Trifolium fragiferum (jordbær-kløver), Armeria maritima (Engelskgræs), smalbladet kællingetang, Centaurium erythraea (strand- og liden tusindgylden), Festuca arundinacea (strandsvingel), Festuca arundinacea (fjernakset star), Hordeum secalinum (engbyg), nula britannica (soløje-alant).

64. Example of a Saltmarsh

Eelgrass: Eelgrass or "Zostera marina" is a plant that grows on the sandy bottom in coastal waters. The plant consists of a branched rhizome, from which narrow, green leaves grow up in the water. The leaves can be up to 120 cm long. The flowers on eelgrass has no petals, and they never come out of the water, which makes them difficult to see. In addition to the sexual reproduction using flowers, does eelgrass also reproduce through its side shoots. (Dn.dk, 2016)

Eelgrass requires a lot of sunlight to grow, and today is eelgrass mostly seen down to five-six meters in the open Danish waters, and out to approximately three meters in the Danish fjords. The depth of the eelgrass is dependent of how clear the water is, at the place where the eelgrass grows. (Dn.dk, 2016)

Eelgrass forms dense, so called eelgrass beds. These Eelgrass beds is home to abundant wildlife including crabs, snails, mussels and fish, while also serving as important nursery areas for juvenile fish. Eelgrass is also food for many marine birds such as swans, widgeon and mallards. It thus contributes in several ways to promote coastal biodiversity, and if eelgrass disappears, would it have major consequences for a area's wildlife. Additionally does the eelgrass stabilize the sea bed to form a kind of natural coastal protection. Eelgrass also play a positive role in the regulation of the climate, as they absorb and retain significant amount of CO2, and contribute positively to the marine environment, as they store large amounts of nitrogen and phosphorus. (Dn.dk, 2016)

65. Eelgrass

66. Example of a rain garden, in an urban context

Rain gardens are depressions areas, landscaped with native vegetation that increases the amount of local evapotranspiration and infiltration. They are strategically located to capture runoff from impervious surfaces, such as rooftops and streets. During rainfall, will the rain gardens fill up with storm water and then filters it into the ground or through the evapotranspiration. Successfully increasing local infiltration and evaporation, reducing the amount of amount of storm water runoff, while cleaning the water from any unwanted pollutions (nrcs, 2016a).

The rain gardens will be combined with some of the chosen biotopes, suitable for wet conditions, such as the bogs or swamps, while also incorporating plants more suitable for removing pollutions, in order to clean the polluted water from road runoff.

Types and amounts of pollutants from road runoff can vary widely from place to place, but does most commonly include; dirt, oil, grease, toxic chemicals, heavy metals, road salt, pathogens and trash. Many of these pollutions are deposited on roadways as a result of ordinary traffic activities, such as fluid leakage and the wear and tear of vehicle parts. For instance, is brake pad wear a source of copper and zinc, which are metals most commonly found in road and highway runoff. Furthermore may wintertime salting and sanding practices deposit chloride, sodium and calcium onto roads, while roads themselves may generate pollutants as their pavement degrade. (nrdc, 2016b).

Rain gardens can capture and hold back pollutants, but are not able in themselves to effectively break them down. However if mushroom are implemented in rain gardens, can they be able to both hold back and break down harmful pollutants, while transforming them into carbohydrates and nutrients, which are useful for the surrounding plants and soils. (Opb.org, 2013). The Garden Giant Mycelium (Stropharia rugosoannulata) is found to break down heavy metals and polycyclic aromatic hydrocarbons, or PAHs. However it's not the mushroom itself, but a fungal root-like material called mycelium, which is a microscopic, cobwebby, fungal thread, that can decompose bacteria and break down pollutants. Mycelium can convert PAH's into fungal carbohydrates and may help absorb heavy metals. The Garden Giant is also found to be particular good at remov-

ing E-coli bacteria and fecal bacteria (Opb.org, 2013).

Other mushrooms is also found to be able to break down pollutions found in storm water runoff. The "white rot" fungi can colonize fuel tanks, by using enzymes to consume petroleum products and transform them into nutritious carbohydrates. The Oyster Mushroom (Pleurotus Ostreatus), an aggresive white-rotter, which can grow practically anywhere, can convert oil and similar chemical products and effectually break down Aromatic hydrocarbons. (Discover Magazine, 2016).

67. From left to right, Stropharia rugosoannulata, Pleurotus Ostreatus

Green Roof tops

68. From left to right, Green roof for urban gardening, Animal habitat/rain water mangement, recreational use

A green roof improves the climate conditions in the urban environment, by reducing runoff and enhancing evapotranspiration. Furthermore can it also play a vital role in the urban rainwater management, by delaying runoff time and reducing the runoff velocity. The water retention capacity of a green roof is related to the thickness of the roofs soil. During longer periods without interruptions, does the green roof gradually lose its ability to absorb and retain water. Rain water that is not absorbed is led to infiltration zones, such as rain gardens. Beside acting as a part of urban rain water management, can green roofs also functions as urban gardens, habitats and stepping stones for animals, as well as recreational use. (vannportalen, 2016)

Urban farming

Urban farming is a notion, which covers activities related to the production of food and useful plants in the city or in the periphery of the city. Urban farming covers both plant cultivation and animal husbandry. It can be both eatable productions and crops, such as cereals, vegetables, mushrooms and fruits or non-edible products, such as aromatic and medicinal herbs, ornamental plants and trees. Urban farming also covers all the traditional activities linked to the production, processing, marketing, distribution and consumption of food, but it also includes environmental initiatives like recycling, rainwater

69. Left; Example of Blue gardens, Right; example of urban farming

harvesting and the education and organization of local citizens. Urban farming is therefore a term common notion for many various forms of growth in the urban environment. (SLA, 2014)

Urban farming, and the growth of food in urban environments, can create the foundation for new social relations between people and support a healthy lifestyle with physical activity, outdoor life and locally produced food. Urban farming can give people living in urban environments opportunity to find peace and get in touch with nature, and facilitate a series of recreational benefits. (SLA, 2014).

Urban farming can occur on both land, as the more traditional form of urban gardening or farming, but increasingly also in waters, where fjords or oceans, part of the urban environment, are becoming part of a growing community.

In Ebeltoft, Denmark is one of the first Danish Blue gardens being founded. The idea is that people can rent small allotments to either grow seaweed and mussels, and perhaps Oysters, for themselves or sell them to local restaurants or other people interested. The blue gardens creates a recreational ecosystem services, just as the allotments on ground, however it also allow people not used to sail or swim to have a relationship with the water. Furthermore does the growth of seaweed and mussels also have a positive effect on the marine environment, as both mussels and seaweed captures some of the excessive amount of nitrogen and phosphorus, in the Danish coastal waters. (Orbicon.dk, 2016).

70. Harbor bath, at Island Brygge, Copenhagen.

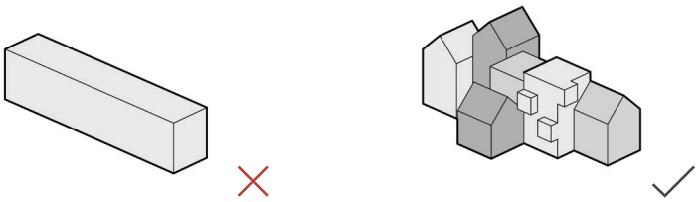
Harbor Bath

As the watercourses in urban environments are becoming clean enough for recreational use, such as swimming and fishing, are more and more harbor baths occurring in the Danish cities. Harbor baths are a good way of strengthening the recreational value of the fjord, while creating natural experiences close the core of the city. They have the ability to become a cultural and social hub, sharing some of the same recreational qualities as a city's green areas. (Dac.dk, 2013),

Harbor baths, and their facilities such as dressing rooms and saunas can be combined with facilities for boats, kayaks and similar elements, for both rental and organizations in order to strengthen the recreational offers of the city and the local community.

71. A combined kayak center and harbor bath, in Vejle, Denmark

Varied edge and architecture



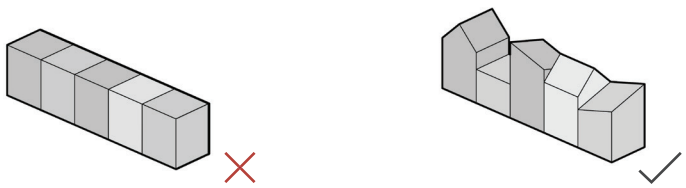
72. A varied edge and architecture with niches, variations and possibilities

Buildings at any given building zone is of great importance for the public space around it, not only visually but also in terms of the microclimate and experience of it. In order to ensure a varied architecture and edge, at the predetermined building zones, is it important to ensure that the construction field "edges" and buildings create spaces, niches, variation and street courses. This can be ensured by various regulations and strategies, as illustratet in the following steps:

73. Multiple programs/functions

Programming: A double programming creates a greater diversity and ensure life across the day. Public programs can be used in the ground floor, such as restaurants, cafes, detail, galleries and shops, to un-privatise the buildings and the adjacent urban spaces. Furthermore can common facilities or houses be incorporated to strengthen the local community within the buildings, which can house kinder gardens, urban farming, common kitchens/areas, and similar programs.

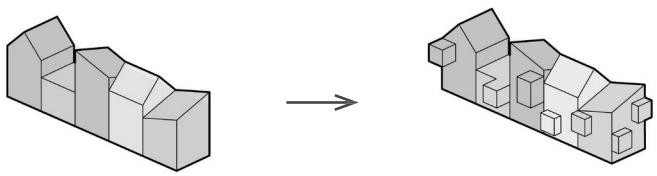
74. Multiple programs/functions, vertical and horizontal



75. Varied height and shapes of rooftops

Height: Changing floor heights and rooftop shapes creates a varying urban spaces, while being able to adapt the building volume to the surrounding urban environment.

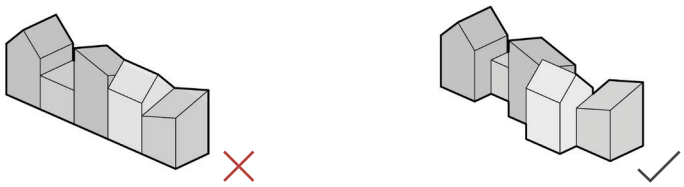
76. Multiple heights and rooftop shapes



77. Overhangs creates new spaces and increase the plot-ratio

Overhang: Individual building parts can be pushed out and occupy the space below or above, increasing the plot ratio and stage the surround context.

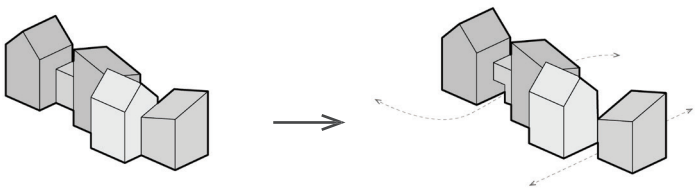
78. Examples of building parts being pushed out to create new spaces and increase plot ratio



79. Varied Indentation creates pockets in the urban space

The individual facade line can be pushed forward or backwards, in order to create small pockets in the urban space.

80. Examples of Indentation creating small pockets



81. Gates or gabs in the building opens up the building and invites people in or through

Gate: Gates can be made in the buildin, allowing passage through the buildings and into the inner courtyard and/or the other side. Gabs can un-privatise enclosed courtyards, as they opens up towards the public.

82. Examples of gabs and gates in buildings

83. Varying materials creates a diverse expression and diverse urban space

Materiality: Varying facade materials crates a diversity in the overall expression, and creates a more diverse urban spaces. Natural materials, such as wood, and green walls can be incorporated to create a fusion between the grown- and built environment. Heat-absorbing materials shouldn't be used for facades.

84. Exampels of buildings and materials, which can add a broad range of expression in an urban setting

The strategies will be implemented on the defined building plot in the later stages of the development phase, to ensure urban an architectural qualities, improvement of microclimate and ensure the right balance between build-ratio and urban space.

Courtyards:

The buildings shall be ensured with adjacent courtyards, that facilitate multiple functions and natural experiences, through recreational activities. They courtyards can contain; urban farming, playgrounds, common areas, kitchen etc. The courtyards should relate to the buildings and create a sense of belonging for the residents, while appealing towards by-passers.

85. Examples of programs that should be implemented in the semi-private courtyards

Parking strategy

The bridge structure and its residents shall be supported by environmental friendly transport modes, such as biking lanes, BRT/LRT-systems and pedestrians paths. Parking spaces will therefore be kept at a minimum to ensure a broader backing towards public transportation and environmental friendly alternatives. If necessary, shall the parking spaces be integrated in the building structure, however a few parking spaces will be made in adjacent courtyards for temporary parking and availability for moving trucks. Parking spaces will be made in permeable surfaces and integrated with greenery.

86. Examples of parking spaces integrated in buildings and green areas

Bike parking strategy

Bike parking shall be implemented around larger hubs, such as around the harbor bath, residential areas and LRT/BRT stations. The parking spots should, where possible, be placed close to the destination and lay in a logical place from the arriving points, and on the route towards where they are going to make them more efficient. Bike parking spots shall be integrated in the greenery where possible.

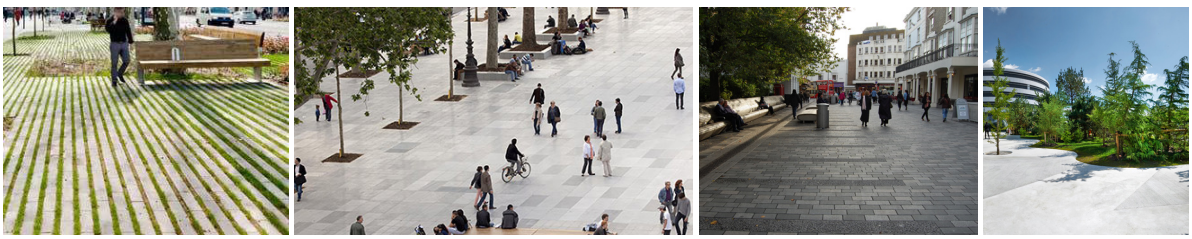
87. Exampels of parkingspaces for bikes integrated in urban environments, with greenery and indentation in the pavement

Materiality urban spaces

The main infrastructures, such as the main road and LRT-corridor, will be paved with asphalt, concrete tiles and grasses. The LRT-corridor will mainly be paved with grasses, however on stations will there be placed concrete tiles to improve the movement in and around the station. The main roads will be covered with noise-reducing asphalt, to sustain the wear and tear of heavy traffic.

88. Exampels of pavements, with noise-reducing asphalt, grass and paved LRT-corridor

The courtyards and minor roads will be paved with various formats of concrete tiles, incorporated with greenery, as shared space to minimize the domination of the car.



89. Exampels of pavements, for courtyards and smaller roads

pathways and bike lanes will be paved with various permeable materials. Main pathways will be paved with concrete tiles to ensure accessibility and easy transition between areas and functions, while minor recreational paths will be paved with bright gravel. Bike lanes will be paved with bright colored surface to guide the cyclists through the landscape.

90. Exampels of paved bike lane, graveled and paved pathway in natural and urban condition

Selection of Site

MOBILITY DEVELOPMENT

91. MOBILITY MODES
City Bus Line (colors) and car roads (black)

The bridge structure should be seen in a new context to fulfill its full potential so this sub chapter is a summary of the analysis where the focus lies on the network of motorized infrastructure, city bus network, natural valuable areas and development areas.

MOBILITY

There are several possibilities for connecting the existing road and bus network in a local context. Each connection has its own potentials and problems and the following part will elaborate those.

1. There is a great potential in connecting Aalborg and the airport which a western connection could facilitate. Furthermore it could kick start future development in this area on both the Aalborg and Nørresundby side. The downside is the very interesting activities and spirit that has its roots in that area which a big connection, new housing etc. could disturb. The bottom-up houses and maritime invironment is a free-space for many people and is therefore important. Furthermore is this connection not satisfying in terms of the predominant eastern catchment area of Aalborg.

2. This connection creates a potential link that surround the inner city of Aalborg in a circular road network. This connection already exists since the railroad has its crossing here and a bridge structure at this place should therefore incorporate the rail line.

3. This connection creates a great potential for connecting many mobility modes since it is near the inner city of Aaborg and Nørresundby and is an extension of one of the larger roads that is a main conectore to the University Campus in east. It facilitates the eastern catchment areas and has potential for release great amount of pressure on the existing bridge.

4. This connection creates a potential for linking Aalborg's eastern harbor with the northern part of Northern Jutland. It is a connection that will facilitate motoring and not several

92. RURAL AND URBAN DEVELOPMENT AREAS
Valuable Natural Areas (green and red, dashed line), growth axis (yellow line) and development areas (yellow areas)

mobility modes but with the larger development of the eastern harbor could also generate new public transportation in that area.

The two western connections are interesting in the terms of a connection towards the airport whereas the central connection facilitates several mobility modes. The eastern connection is currently related to motoring and has no greater value when it comes to the internal public transportation network.

DEVELOPMENT

The future development of Aalborg is centralized within the growth axis and the new development of Stigsborg Harborfront (Nørresundby) are especially interesting since it is a transformation of a 55 ha area (Stigsborghavnefront.dk, 2016). Furthermore are there several large scale densification projects in Aalborg that will expand the definition of the inner city of Aalborg.

1. A connection located as an extension to Sønder Alle is interesting since you can access that easily from the motorway and connects several larger development areas.
2. A connection located as an extension to Sohngårdsholmsvej creates potential of linking the eastern development areas such as the Super Hospital and campus densification projects with Nørresundby and thereby the future development of Stigsborg Harbor front.

The second placement of the bridge has the greatest potential for linking existing mobility and development networks of the city. It is a connection that holds the potential for creating not only an urban enabler for future densification and development of nørresundby and Aalborg but a potential relief and retelling of the existing bridge structure. With an overall strategy where the existing road network and connections will be improved by a new additional connection with multifunctional programming will the local and thereby the regional coherence be ensured in the future.

Mobility Strategy

MOBILITY DEVELOPMENT

93. MOBILITY STRATEGY
Mobility Strategy (yellow line)

The main idea about the mobility strategy is to bring up the idea of a high class transport system that connects the outer points of Aalborg and Nørresundby. The outer points are connected to the regional and global network in terms of motorways, airports and larger roads.

The H-structure will ease the traffic in the inner city by an upgrade of the public transportation and a division of the traffic crossing the fjord. The existing Limfjord Bridge will be upgraded from a bridge with four lanes to a bridge with two lanes of high class transportation and two with roads as we know them today.

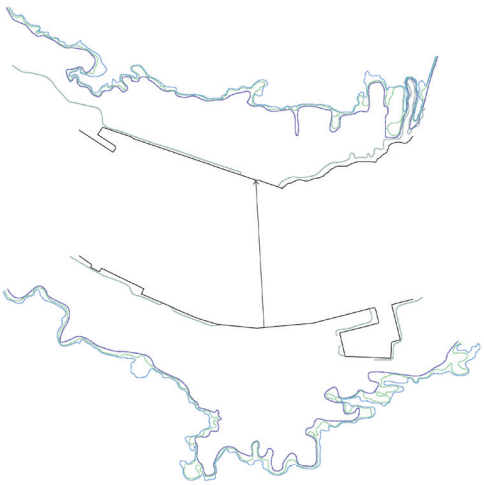
The new bridge structure should facilitate the same; two lanes with high class transportation and two lanes to ordinary bus, goods and car traffic. The strategy lies within the urban context to support the densification of the city and meanwhile keeps a distance to valuable and vulnerable natural areas. The strategy relates to existing and important mobility nodes such as J. F. Kennedy Square and seeks to strengthen Jyllandsgade as string between the two main nodes. The main nodes, J. F. Kennedy Square and Bornholmsgade, will enhance the smooth transition from one transport to another. Here there can be a shift between course and mobility mode.

The smaller park'n'ride facilities along the strategy can be seen as an option for faster transit through the city. The mobility strategy can be seen as a new potential for linking the many diverse elements that Aalborg and Nørresundby consists of and be an ever present part of the townscape.

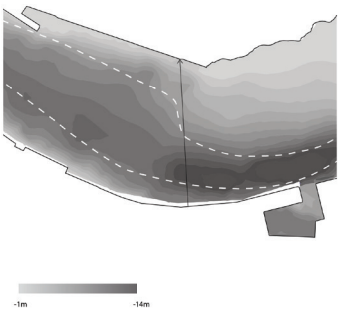
94. Mobility Strategy

Site Analysis

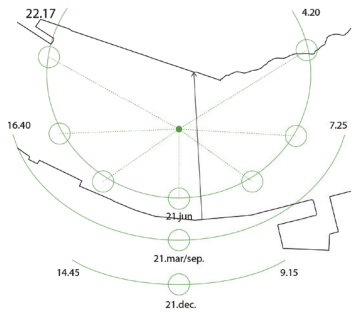
POTENTIALS PROBLEMS



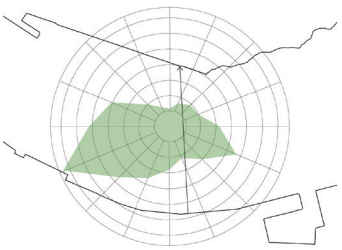
1 FLOODING
The lines shows the flooding at 20, 50 and 100 years avent.



2 CHANNELS
The dept of the fjord is shown in graduating black and relates to the side closest to Aalborg.



3 SUN
The sun is an ever present element of the fjord since there are no contextual buildings.

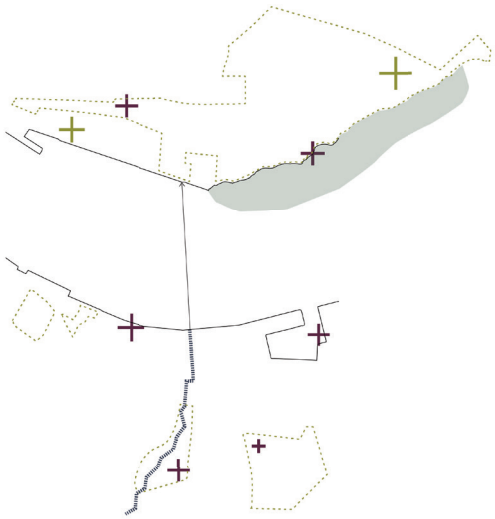


4 WIND
The fjord is today a strong corridor for wind and is one of the largest factors for uncomfortable experiences at water.

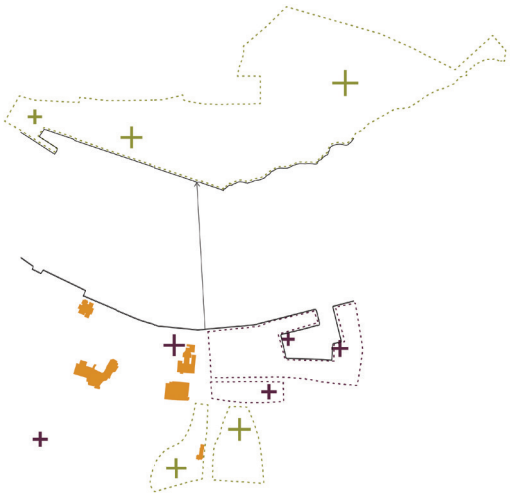
- illustration 95

5 SCALE
The scale around the fjord is both quite large as well as high but the most of the building lies under 5 storages.

6 ROADS AND BIKE LANES
The existing road network points towards a connection.



7 RECREATIONAL AREAS
There are several recreational areas in the nearby context with both natural and cultural experiences.



8 DEVELOPMENT AREAS
There are several development areas in the nearby context. The biggest one is Stigsborg Brygge in Nørresundby.w

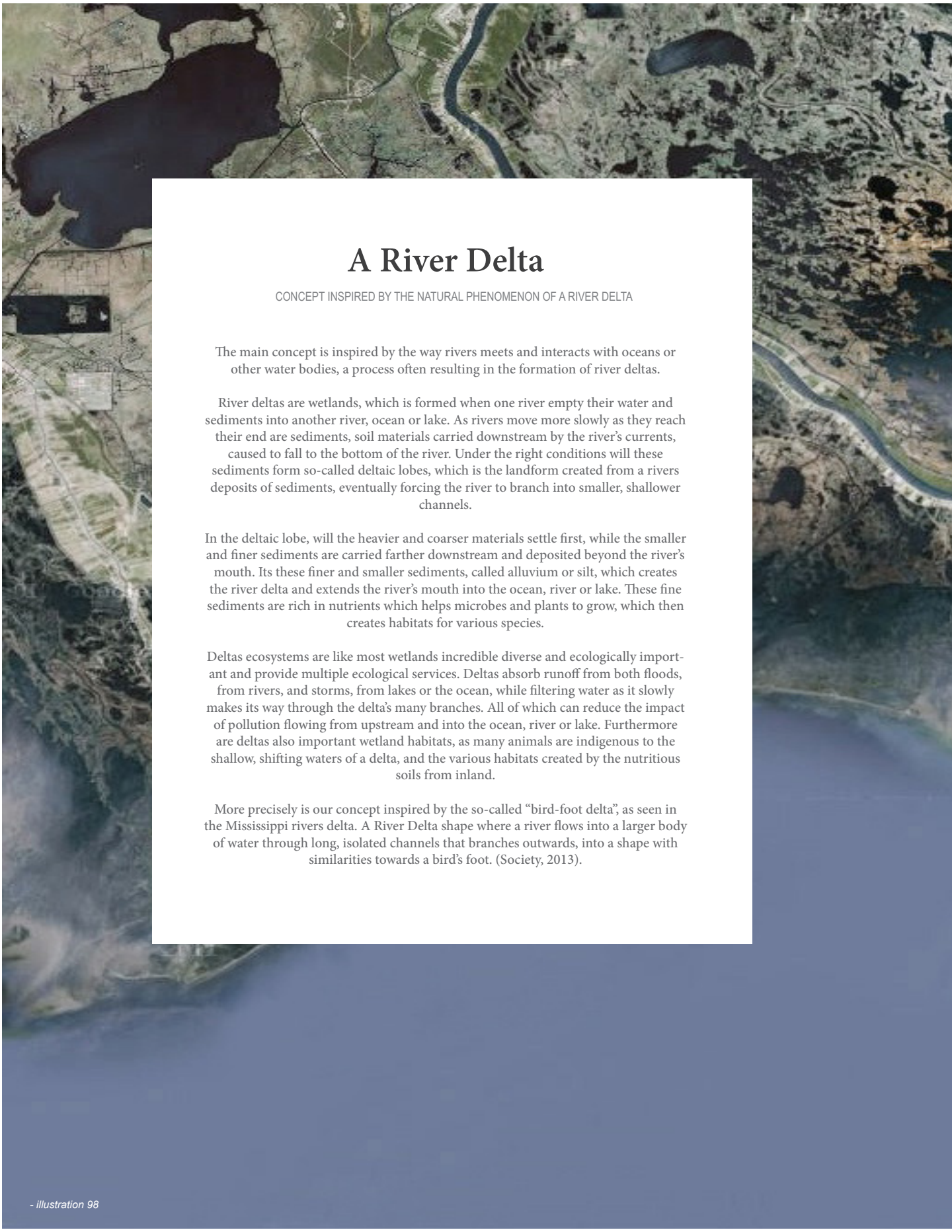
- illustration 96

Presentation

This chapter is the presentation of the final design. It is a design related summery of all theories, analysis and design tools. The chapter consists of narrative, plans, renderings, sections, elevations, technical aspect, conclusion and reflection.

CONTENT

- illustration 97



A River Delta

CONCEPT INSPIRED BY THE NATURAL PHENOMENON OF A RIVER DELTA

The main concept is inspired by the way rivers meets and interacts with oceans or other water bodies, a process often resulting in the formation of river deltas.

River deltas are wetlands, which is formed when one river empty their water and sediments into another river, ocean or lake. As rivers move more slowly as they reach their end are sediments, soil materials carried downstream by the river's currents, caused to fall to the bottom of the river. Under the right conditions will these sediments form so-called deltaic lobes, which is the landform created from a rivers deposits of sediments, eventually forcing the river to branch into smaller, shallower channels.

In the deltaic lobe, will the heavier and coarser materials settle first, while the smaller and finer sediments are carried farther downstream and deposited beyond the river's mouth. Its these finer and smaller sediments, called alluvium or silt, which creates the river delta and extends the river's mouth into the ocean, river or lake. These fine sediments are rich in nutrients which helps microbes and plants to grow, which then creates habitats for various species.

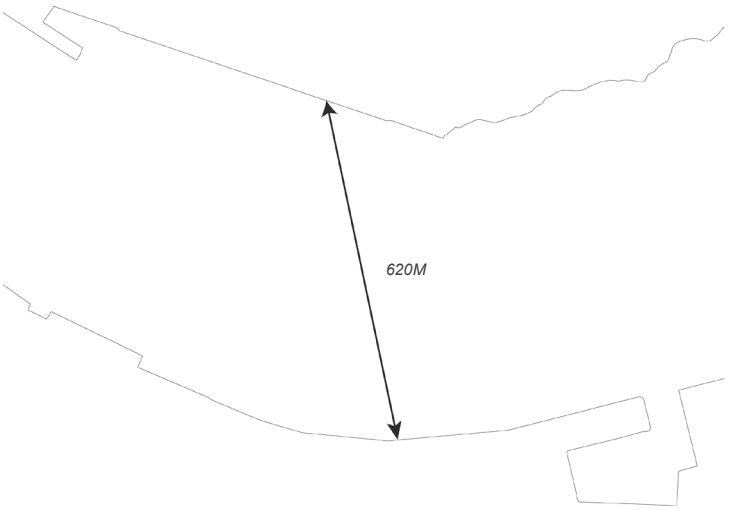
Deltas ecosystems are like most wetlands incredible diverse and ecologically important and provide multiple ecological services. Deltas absorb runoff from both floods, from rivers, and storms, from lakes or the ocean, while filtering water as it slowly makes its way through the delta's many branches. All of which can reduce the impact of pollution flowing from upstream and into the ocean, river or lake. Furthermore are deltas also important wetland habitats, as many animals are indigenous to the shallow, shifting waters of a delta, and the various habitats created by the nutritious soils from inland.

More precisely is our concept inspired by the so-called "bird-foot delta", as seen in the Mississippi rivers delta. A River Delta shape where a river flows into a larger body of water through long, isolated channels that branches outwards, into a shape with similarities towards a bird's foot. (Society, 2013).

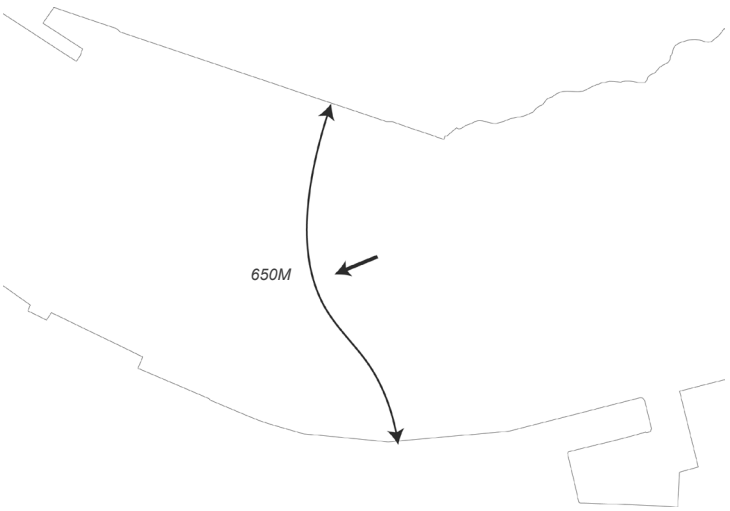
- illustration 98

Concept Development

STEP BY STEP

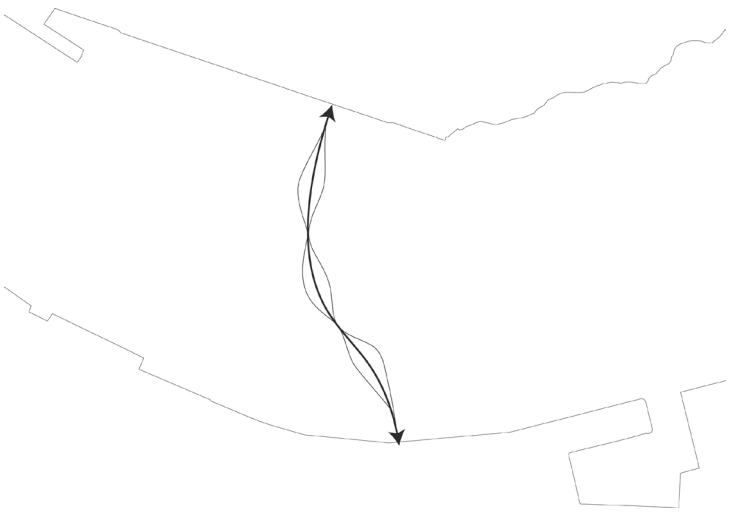


1 CONNECTION
two main roads are connected through the main channel, which consits of bikelanes, sidewalks, road and light rail corridor

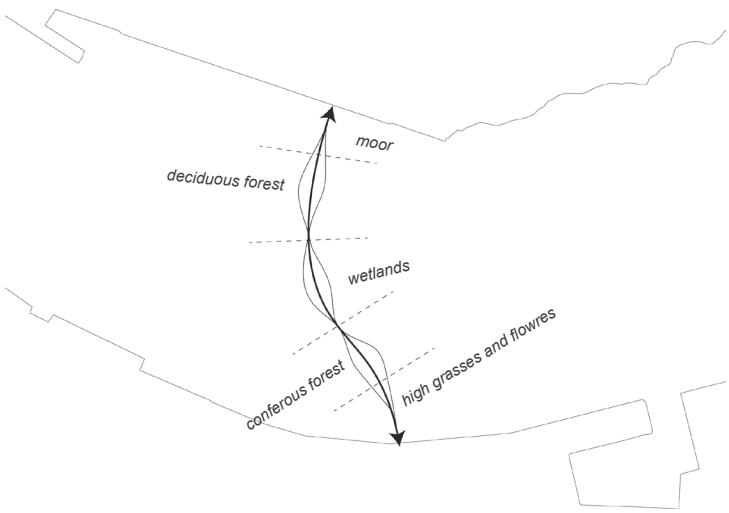


2 ADJUSTMENT
the main channel is adjusted towards each side through a slight arch along the structure

- illustration 99

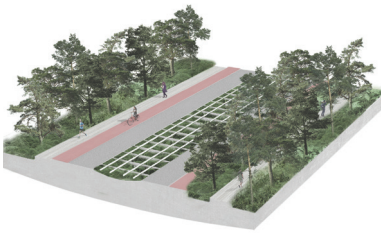


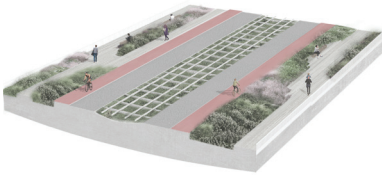
3 PIERS
three larger piers, with a diameter of 25m is constributed along the structure, which creates larger spaces or pockets along the corridor



4 LANDSCAPE ELEMENTS
The main channel is divided into five different landsacpes types; moor, high grasses and flowers/ hurbs, wetlands, coniferous forest, deciduous forest. Forest and wetlands, which are the heavier landscape forms are placed near the larger piers, while the open grass- and moorland is placed inbetween, which creates an open view towards the harbourfronts

- illustration 100





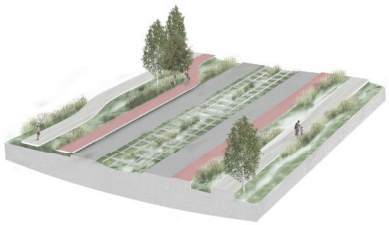
Coniferous forest

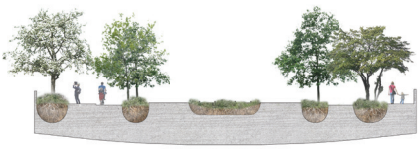
The coniferous forest principle represent a dense vegetated area, where the trees and vegetation embraces the viewer in an more enclosed space. The long narrow trees, ferns and other plants/vegetation creates a lush and green space, which is staged through the varying bike and pedestrian path.

Moor

The moor landscape is an open space, with colorfull plants and bushes, that opens op towards the city and the harbor fronts. The color full plants creates a strong contrast to the flora of de deciduous and coniferous forest. Benches and more paved surfaces creates viewpoints and breaks along the stretch.

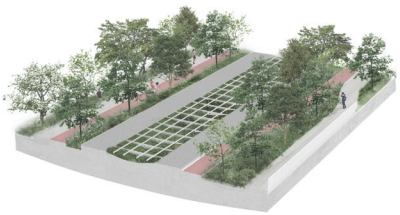
This page conceptualise the five landscapes elements along the bridge structure, with a "typical" 33m wide section, the smallest along the structure. The bridge consits of a light rail corridor (which is used as a rain garden, aswell), road, a bike and pedestrian path.





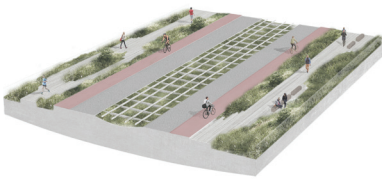
Wetlands

The low- and/or high laying bogs creates flooded or partly flooded areas, with various plants and vegetation, which will attract a variety of species. The pedestrian path can be lowered to stage the water, and create a greater experience of the wetland.



Deciduous forest

The deciduous forest creates an enclosed space with its broad crowns and dense vegetation. The trees various from colorful cherry trees and more lush and green species. The pedestrian and bike path is "cutting" through the vegetation and creates a lush and embracing experience.



Grassland

The grassland with herbs and flowers is an open landscapes, that opens up towards the harbor front and surrounding areas. The mixture of plants should secure a variety of colors over the seasons, and create a varying experience over the seasons. Like the moor, does the grassland offer more paved spaces, with opportunities for pauses and viewpoints along the stretch.

5 BIKE AND PEDESTRIAN PATH
An bike and pedestrian bridge branches out of the main channel, and connects the bridge structure, with a direct connection towards the natural and future development area of Stigsborgsbrygge

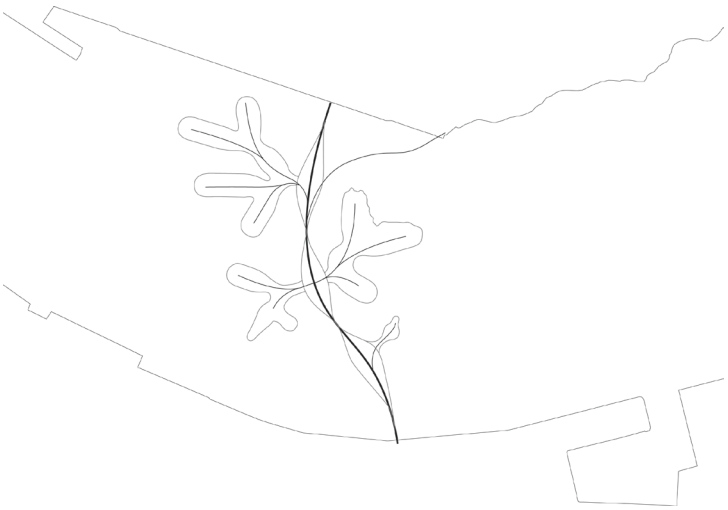
6 NEIGHBOURHOOD FOREST
A larger area branches out in the northern part of the site, where the depth of the fjord is lower, which makes room for a larger neighbourhood and landscape

- illustration 102

7 WETLANDS
two areas branches out of the wetland landscape element, which goes down and forms wetlands with saltmarshes and eelgrasses

8 VIEW POINT / PARK
a smaller viewpoint branches out in the bottom of the structure, which creates spaces for recreation and stage the harbour front

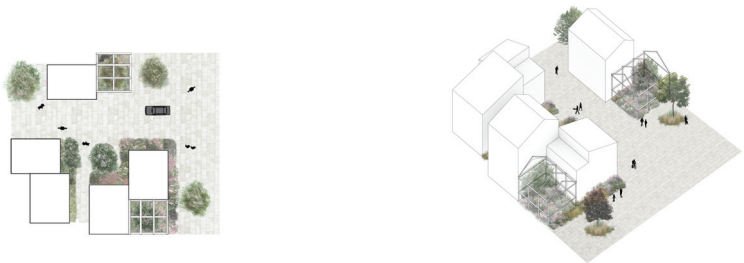
- illustration 103



9 BRANCHES CREATES MINOR ISLANDS
The branches, which comes out of the main channel, creates minor "islands", which creates the foundation for housing and other programs. The larger "islands"/and or branches are placed where the depth is at its lowest

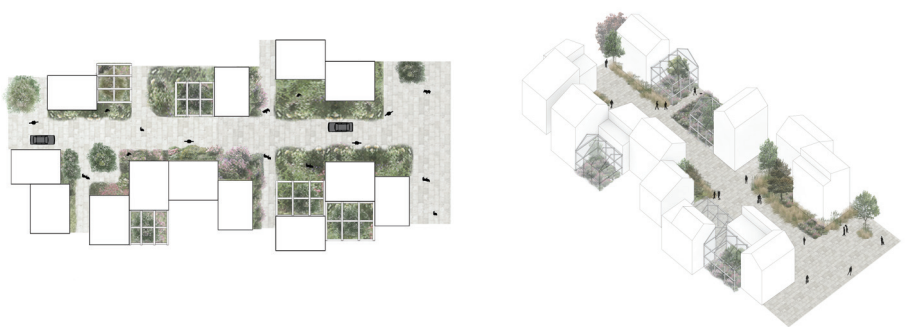
10 DISTRIBUTION OF THE BUILT ENVIRONMENT
three various sizes of enclaves are being distrubuted around the islands, spanning from S, M and L enclaves. Each enclaves takes its characteristic from the main landscape element from the main channel, hence some enclaves will be placed in wetlands/salt marshes and others grass/forest landscapes. A water activity center is placed in the south western part of the wetland.

- illustration 104



SMALL ENCLAVE
The small enclave consits of 5-8 housing units, 1-2 green houses (which can be used both as common houses or urban gardens) and a small courtyard, which formed by the buildings and an extension of the road, which goes through it as a shared space.

MEDIUM ENCLAVE
The medium enclave consits of 8-12 housing units, 2-3 green houses (which can be used both as common houses or urban gardens) and a medium courtyard/shared space

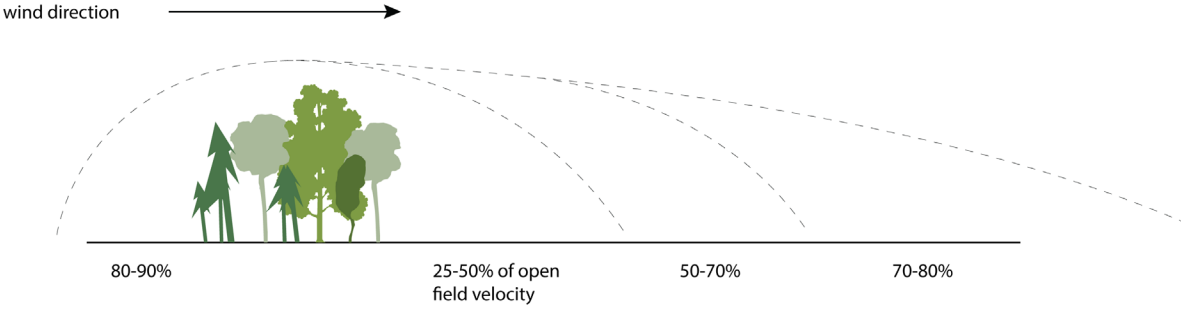


LARGE ENCLAVE
The large enclave consits of 13-15 housing units, 2-4 green houses (which can be used both as common houses or urban gardens) and a larger courtyard/shared space

- illustration 105

11 VEGETATION AS SHELTER TOWARDS THE WESTERN WIND
Pine trees, which are winter green will be used as shelther towards the harsh western wind. The further towards the edge, the more entense will the vegetation be. Alongside the sheltering effect, will the vegetation also provide natural expereince, in close proximity to the enclaves.

- illustration 106

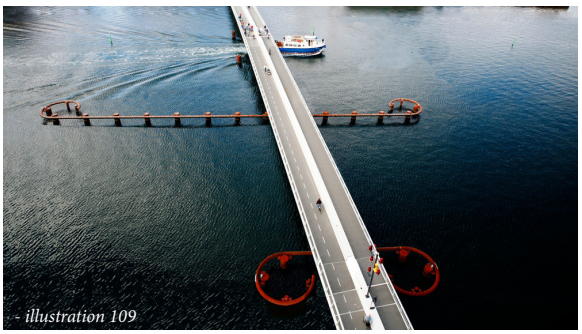


VEGETATION AS SHELTER TOWARDS THE WESTERN WIND
A green belt can lower the wind velocity with up to 75%, dramatically increasing the local climate, which alongside the compact enclaves and courtyards will create a more pleasent experience of the area

- illustration 107

12 OPENING
The bridge structure will have a free height underneath of 4,5m around the main channel, while some of the branches will have smaller height, and some none. The bridge structure will therefore have one part which can be open for larger or taller ships, which will open the same way as the the "brygge broen" in Copenhagen (seen to the right). The opening will be 30m wide, which is similar to the current limfjords bridge

- illustration 108



- illustration 109

- illustration 110

OPENING
The "Bryggebroen" in Copenhagen opens by turning part of the construction 90 degrees to allow boats and ships to pass through. This solution, in the contorary to a bascule bridge, will allow vegetation to be planted ontop.

Site Plan

The Limfjord is the ever present element of Aalborg and Nørresundby and by the implementation of Delta Bridge the two cities will be connected in a strong mobility intervention that gathers not only cars but several mobility modes into one string. The delta is the flow organizer and emphasizes the roads together with the light rail corridor as the backbone for transit.
Along the bridge five landscape principles; Coniferous Forest, Moor, Wetland, Deciduous Forest and Grassland, are implemented to frame multifunctional and natural experiences. The pedestrian path and bike lane interacts with the landscapes and becomes the enabler for activities to enhance the relation between user and nature.

The branches of the delta catch out into the water and lead the water in to enhance the fjord experience. Along the branches three sizes of enclaves are implemented, Small, Medium and Large, to imitate and connect the cities. The enclaves are gathered around the branches and lie scattered in green spaces. The branches frames the court yard with a multifunctional and flexible space for both relaxing and transit. The small green houses can be occupied by multiple functions; it can be open spaces for kindergartens, common houses or common green houses, business etc. The variation in use of the green houses creates together with the variation in enclave size, landscape principles and different view a broad spectrum of relatable identities and experiences.

The bridge structure connects to Nørresundby in three ways; a large mobility intervention, a small pedestrian bridge and a larger bike path. The three connections should be seen as the framing for the future development of Stigsborg Brygge and the strong connection between future development areas of both sides.

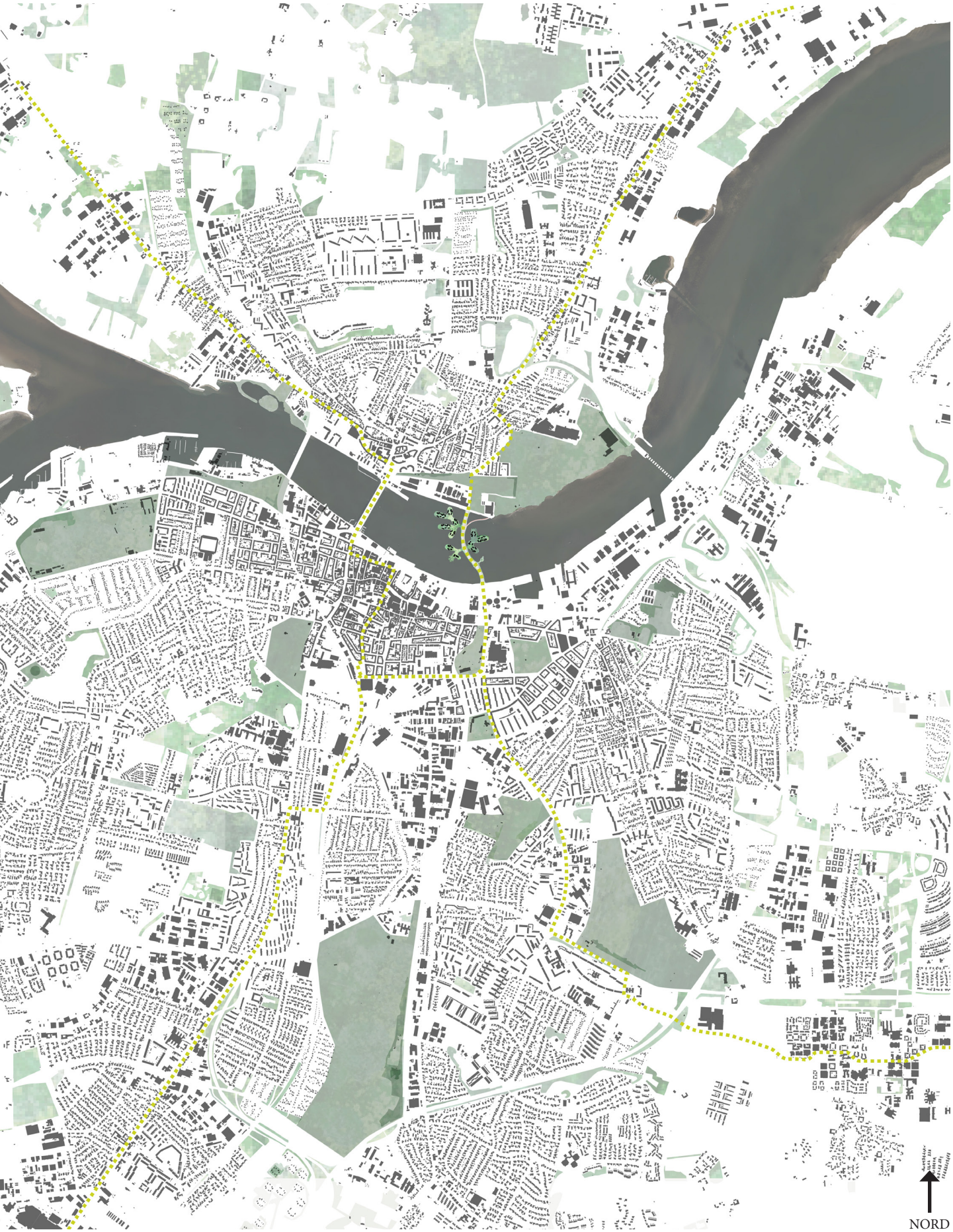
- illustration 111

Context Plan

Delta Bridge lies between the existing bridge structures and the eastern tunnel in an urban context. The bridge is an essential infrastructure in the future development of the local, regional and global scale and links the two sides in a strong mobility intervention.

The large structure relates to a new way of thinking bridges both in use and appearance. It is a contrast to the hard harbor front and relates to the design of nature. The delta appears from Aalborg and lies in the historical delta of Aalborg and moves towards Nørresundby where it connects the two sides.

The overall mobility strategy strengthens the cities and connect large development projects such as the new Super Hospital in east with the airport or the shopping area of south Aalborg to the shopping area of northern Nørresundby, Bouet.



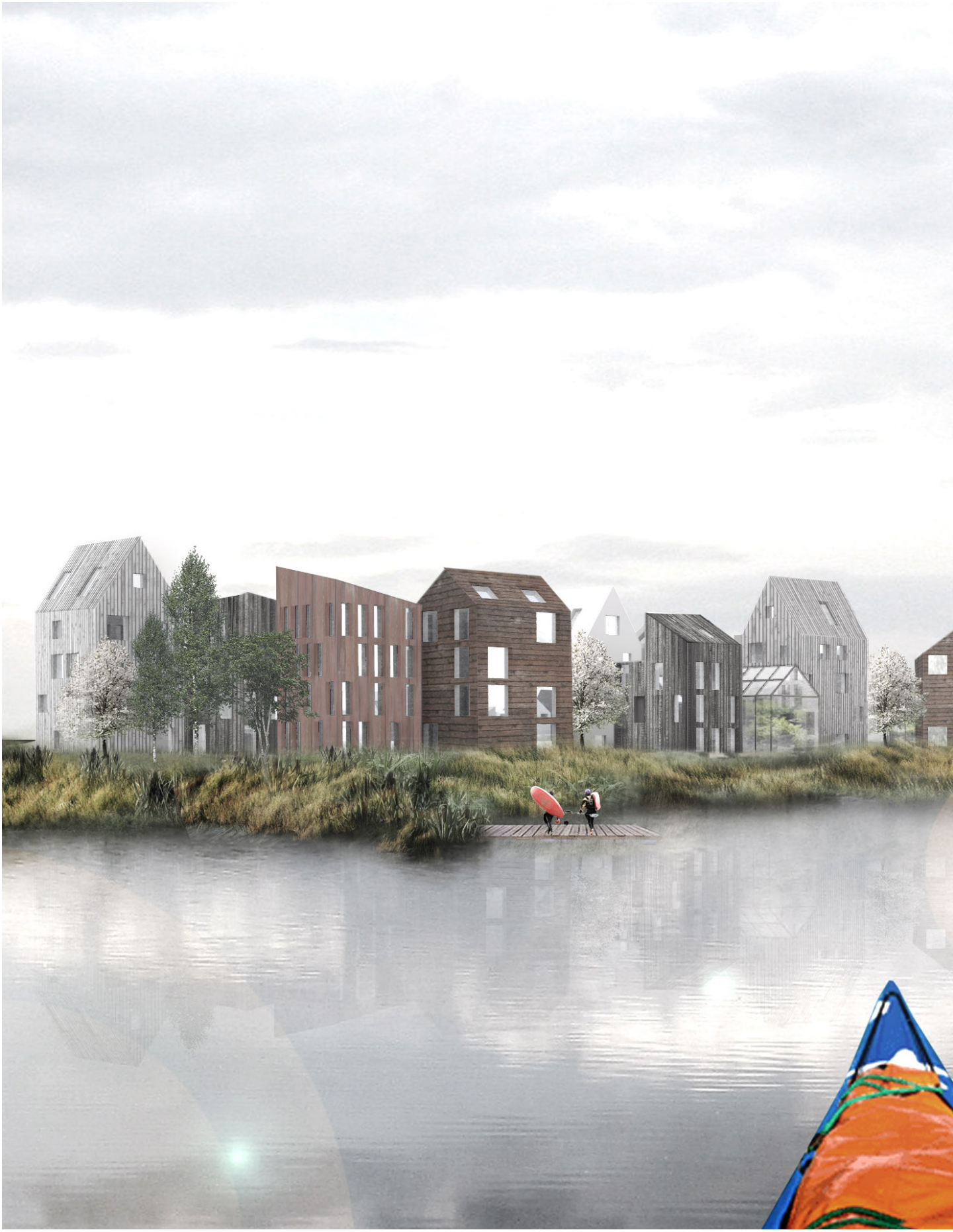
- illustration 112

– illustration 113

Collage 1
aalborg skyline

- illustration 114

Collage 2
harbor front

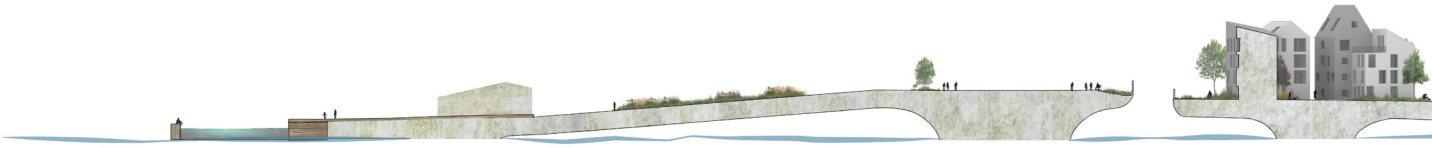


Collage 3
wetland

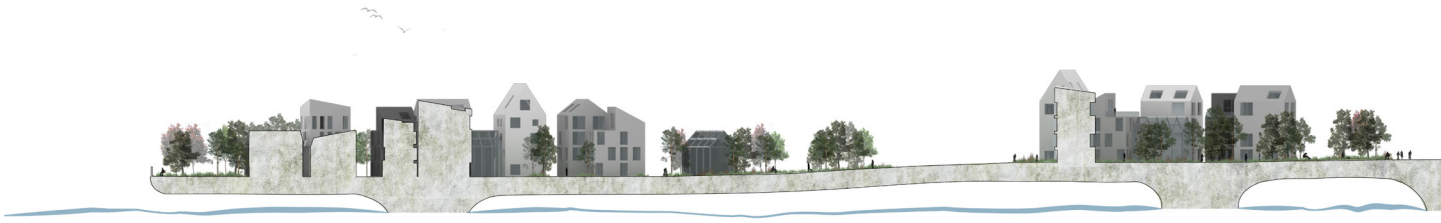
Sections

Section AA

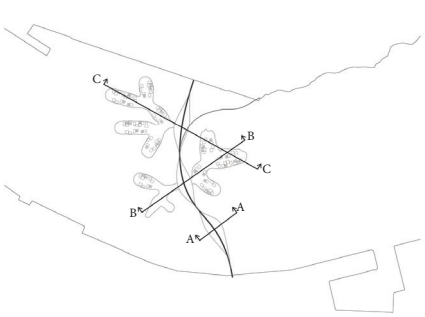
Section BB



Section CC

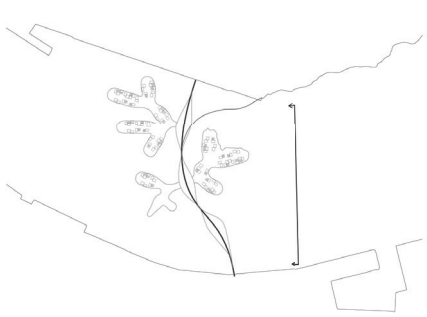


- illustration 116

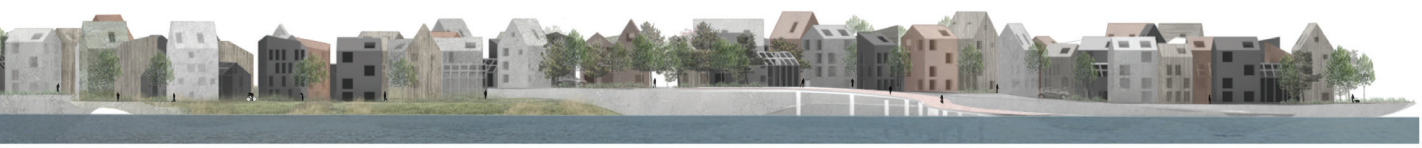

C
B
C
B
A
A

Elevation

- illustration 118



- illustration 117



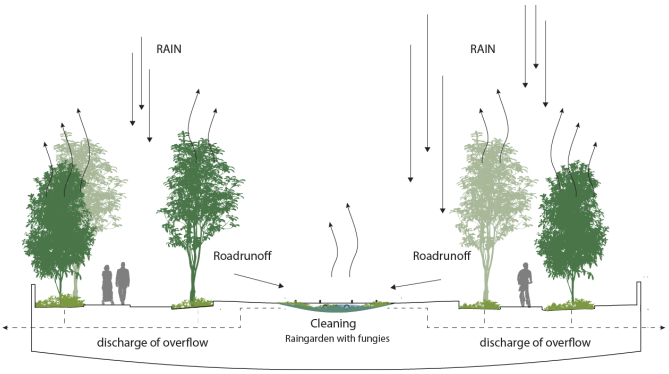
Hydrology Strategies

STRATEGIES SIMULATIONS

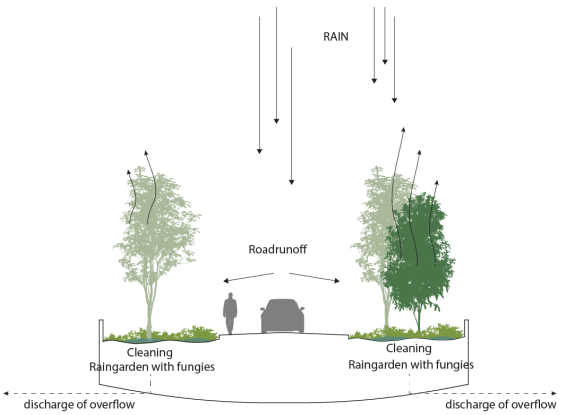
This chapter will present the overall strategies for the management of rainwater, changes of water levels with and without storm surges, and simulations of the impact the bridge structure will have on the Limfjord and its currents.

Management of rainwater: The rainwater landing on the bridge structure would normally end directly into the Limfjord, while detention and/or retention ponds add a significant weight towards the bridge structure. The management of rainwater will therefore not concern these aspects, but the purification of road run off from streets, which will be handled in smaller rain gardens. To break down the pollutants the rain gardens will be grown with the landscape element it's in, as well as mushrooms, which can break down heavy metals and pollutants. This will prevent pollutants, such as fluid leakage, copper, zinc among others to end up in the fjord and be distributed out into the river course, small rivers or natural habitats. The purified water, which haven't evaporated through the plants and infiltrated into the ground will be released into the river, alongside the discharge of overflow.

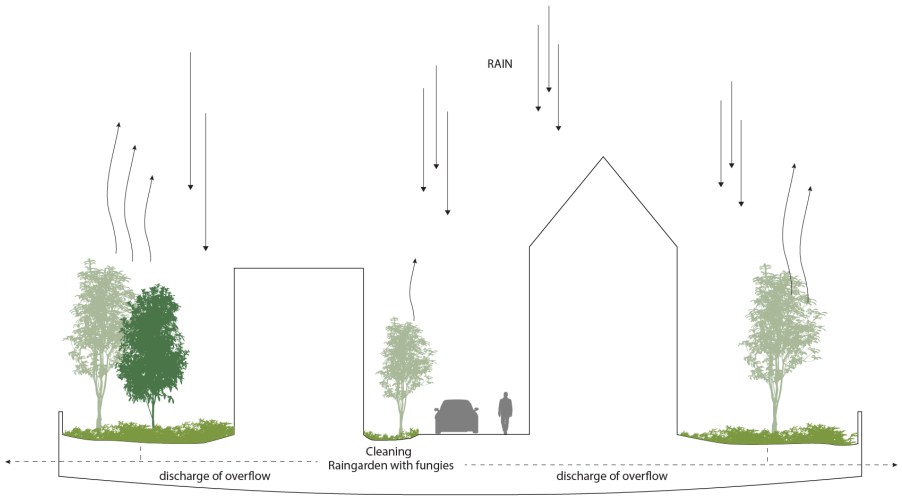
Along the main corridor the water from the two roads will be lead into the light rail corridor, which will have a multiple function, as it also functions as a rain garden. The water on the pedestrian path and bike lane will be lead into the adjacent green spaces. Overflow, in the case of overflow during heavy rainfall, will be lead directly into the riverbed. At the side streets, which are shared spaces for pedestrians, bikes and cars, there are green areas on both sides which filtrates the polluted rain water from streets before discharging it into the riverbed. The housing areas will have smaller green areas, which will act as rain garden for the purification of road runoff. Water will be lead away from houses and the discharge of water will happen after infiltration or during overflow. Water could be collected for watering plants in the common or green houses.



119. HYDROLOGY STRATEGY MAIN CORRIDOR

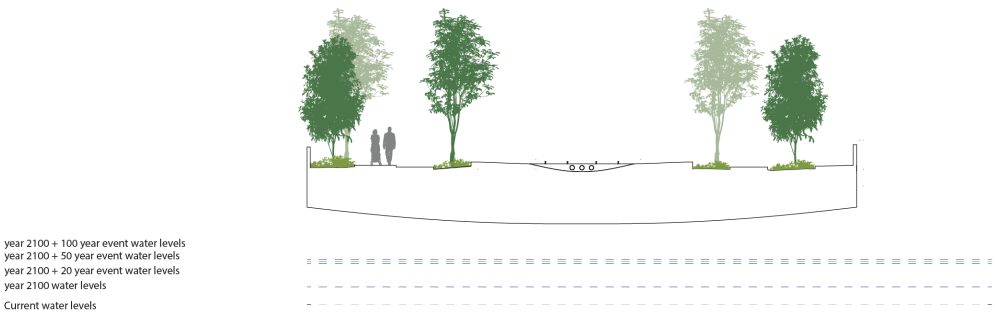


120. HYDROLOGY STRATEGY SIDE STREETS



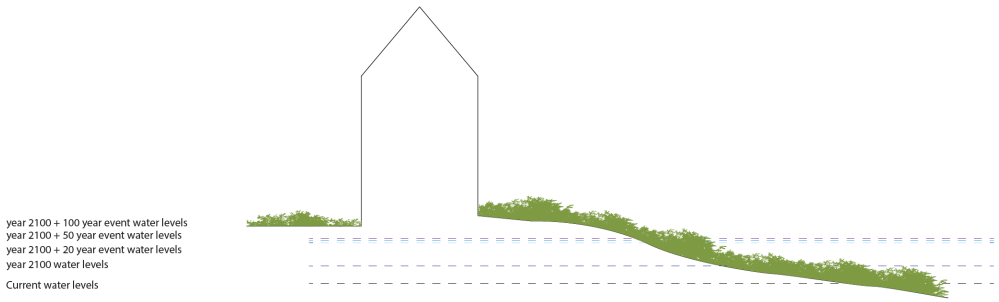
121. HYDROLOGY STRATEGY SIDE STREETS

Water levels: The bridge structure, housing areas and wetlands are placed accordingly to the height of current water levels, water levels in 2100 and water levels in 2100 with storm surges for a 20, 50 and 100 year event. The free height below the bridge structure will go from 5,5m towards 4,5m in the year of 2100, furthermore will 20, 50 and 100 year event increase the height, temporary with 1,3m, 1,39m and 1,46m. The wetlands, where the construction goes underneath the water, will go from -1m towards +3,5m and have eelgrass, salt marsh/wetlands and houses. The houses will be placed on the higher ground and be protected by the saltmarshes during storm surges. The saltmarsh itself will evolve and adapt towards the external influences during the season and evolve its vegetation accordingly. The other housing units will be placed 4m above the water, and will not be affected directly or indirectly by storm surges or raising water levels.



122. WATER LEVELS MAIN STREET

123. WATER LEVELS TYPICAL RESIDENTIAL



124. WATER LEVELS RESIDENTIAL WETLANDS

Simulation of the impact of a future bridge structure will have on the Limfjords currents: In order to understand the impact our bridge structure will have on the current flow of the limfjord, has there been made a series of simulations, with and without the bridge structure, in order to understand the changes a bridge structure will course.

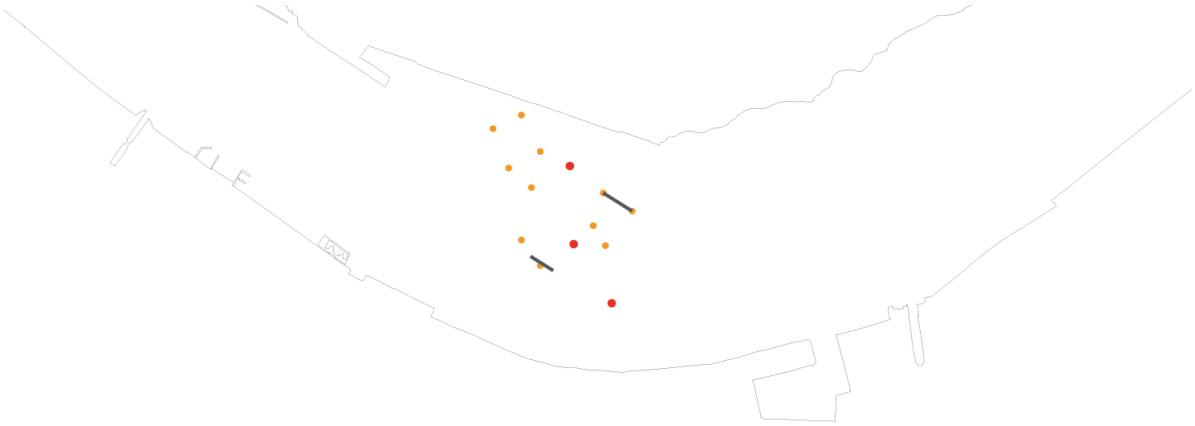
There have been made three different simulations, which all consists of a simulation with and without the bridge structure. The simulations have been made on the July 10th, 2015, with a western wind, one at July 17th , 2015, with a eastern wind, as well as a simulation made with the information during the storm surge of 2005, which caused severe flooding's in Aalborg.

All the simulations are made with and without the bridge structure, which consist of three larger circular piers with a diameter of 25m, eleven "smaller" circular piers with a diameter 20m, and two structures with goes 4m down under the water surface (see the placement on diagram 122)

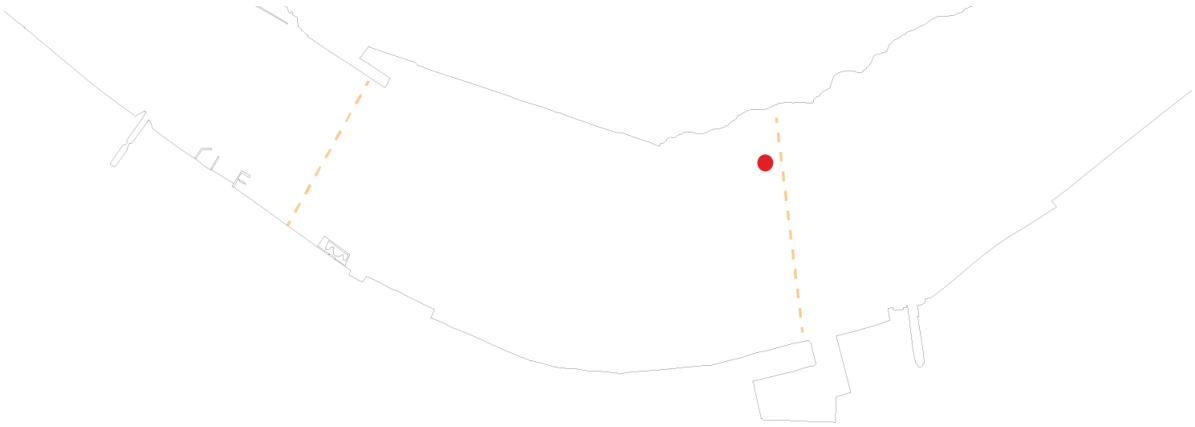
The simulations for the eastern and western wind is valuated through four results, two discharge analysis, one before and one after the bridge, a point in the habitat north/east of the bridge structure and an overall areal analysis of the flow of water (see the placement on diagram 123)

The water levels data used for the simulations have been found on http://www.dmi.dk/hav/maalinger/vandstand/, while the scatter points(depth in the Limfjord and the information of the 2005 storm surge has been provided by our Technical advisor, Thomas. The simulations have been made with the application "Mike Zero".

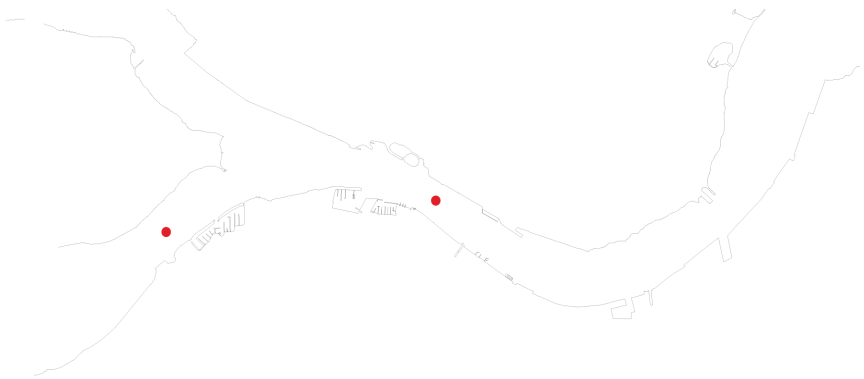
The simulation of the storm surge in 2005, has been analyzed with two points and an overall areal analysis of the flow of the water. One point is placed near Egholm and the other around the train bridge - two places that are valnuable towards storms (se diagram 124).



123. PLACEMENT OF BRIDGESTRUCTURES
MAINPIERS25MDIAMETER(REDDOTS),SECONDARYPIERS20MDIAMETER(ORANGE),SUBMERGED CONSTRUCTION (GREY LINES)



125. PLACEMENT OF ANALYSIS POINTS AND LINES FOR EAST AND WEST SIMULATION
HABITAT EAST OF THE SITE (RED DOT), DISCHARGED ANALYSE (ORANGE DOTTED LINE)

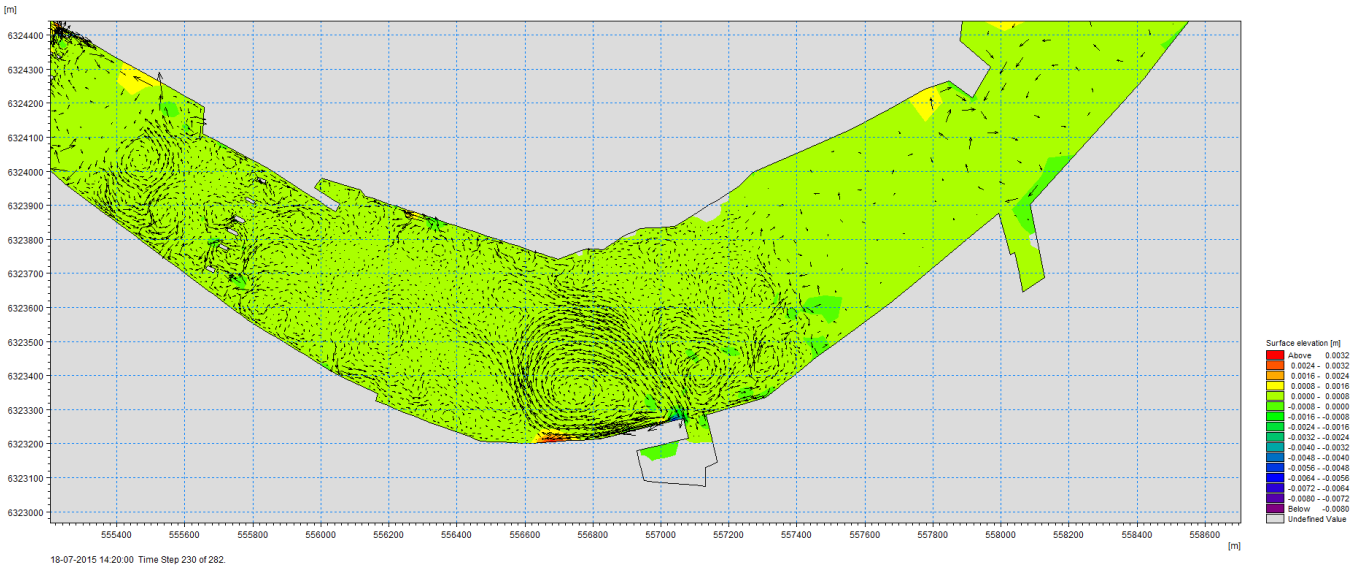


126. PLACEMENT OF ANALYSIS POINTS 2005 STORM SURGE
ANALYSE OF WATER ELEVATION (RED DOTS)

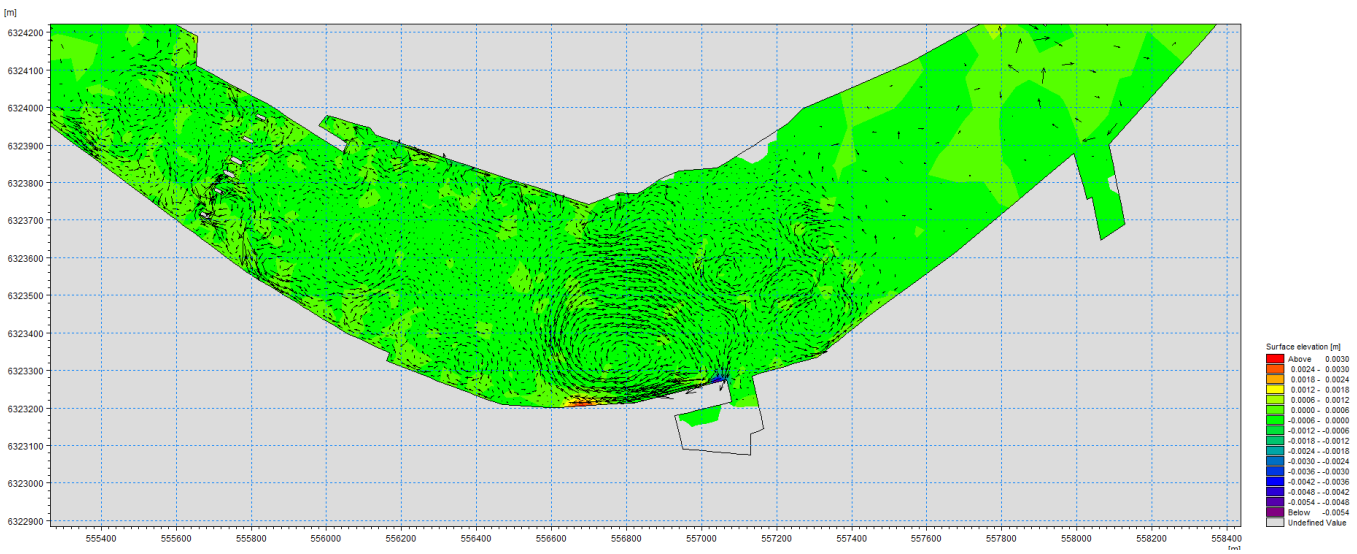
Eastern Simulation with eastern wind, 17th of July, 2015:

The simulation made with eastern wind, indicates a significant raise of amount of discharge water close to the current Limfjord Bridge. During the day simulated, does the discharge number goes from 54084906m3/sec to 68412730m3/sec, which is an increase on 126,49 percent. The proposed bridge structure, will therefore accelerate the current flow of the fjord significantly. This make sense as the many new piers and elements lowered into the water, will create a series of narrowings, which will accelerate and speed up the water flow.

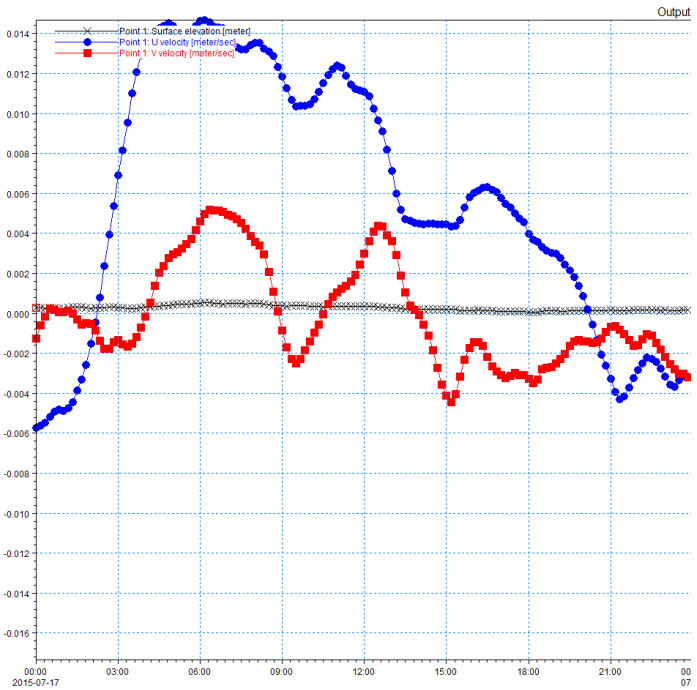
The habitat north-east of the site water levels remains quite similar, however the velocity changes and is generally higher than without the bridge structure. It's generally difficult to assess the impact this will have on the habitat, as various species will react differently to external influences. The water velocity is quite low in the area, which could indicate the changes wouldn't significantly impact the habitat.



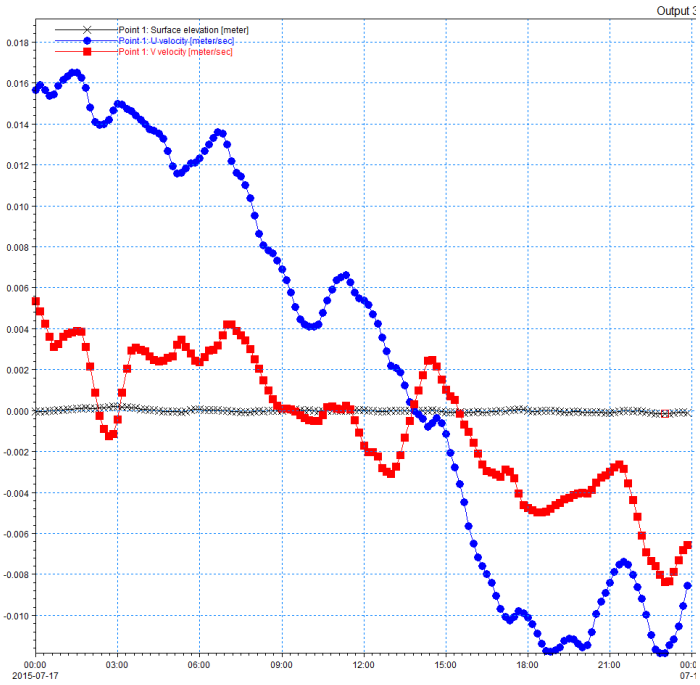
127. WATER ELEVATION, RESULT AREA, EASTERN WITH BRIDGE STRUCTURE



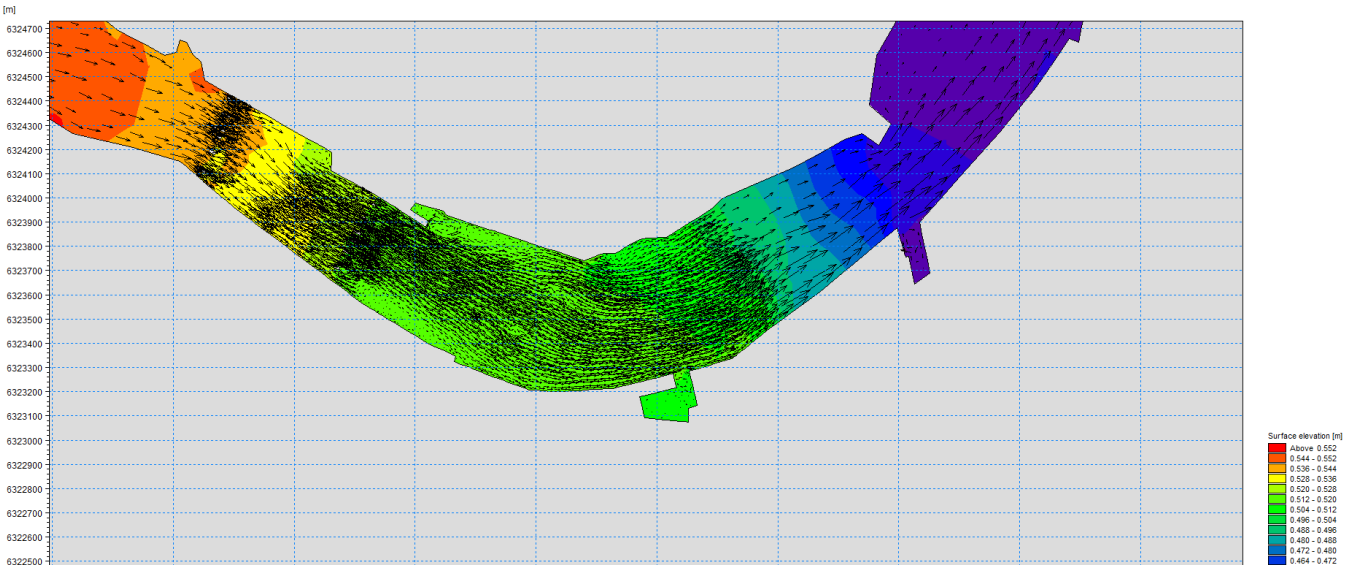
128. WATER ELEVATION, RESULT AREA, EASTERN WITHOUT BRIDGE STRUCTURE



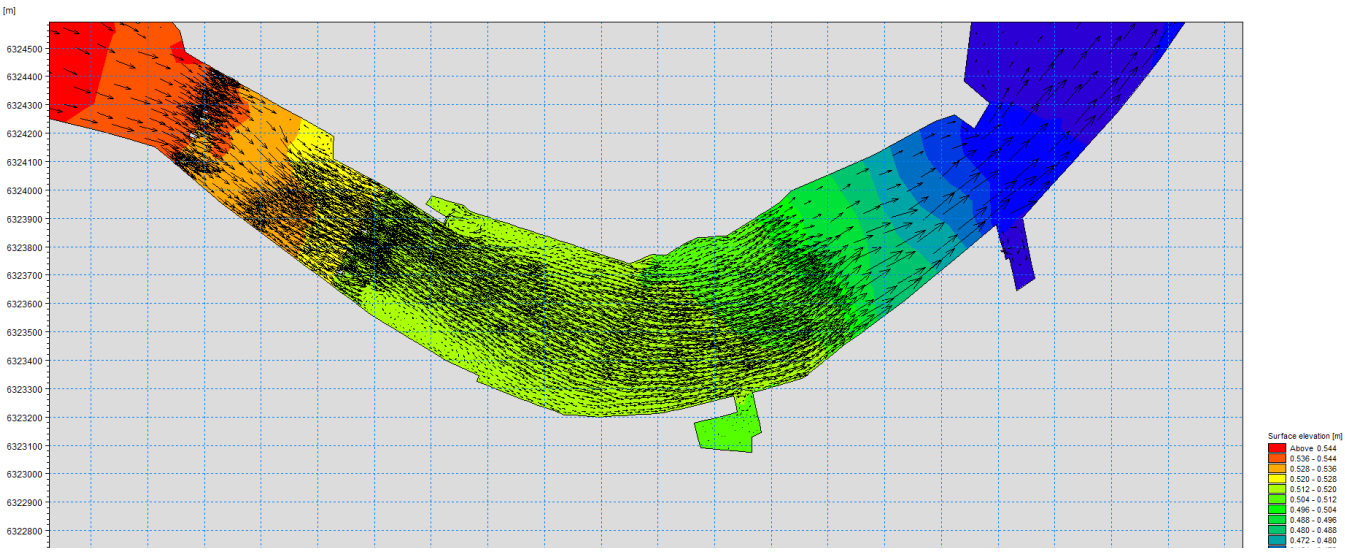
129. HABITAT, EASTERN SIMULATION WITH BRIDGE STRUCTURE



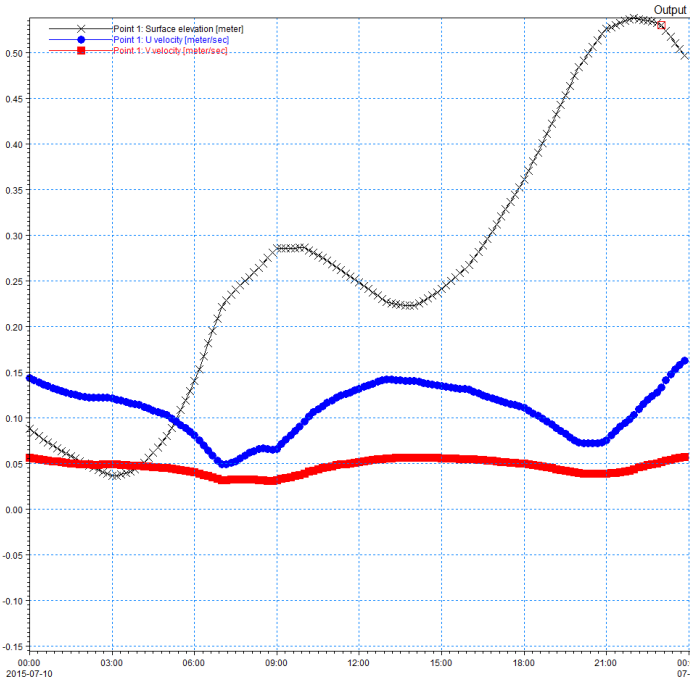
130 HABITAT, EASTERN SIMULATION WITHOUT BRIDGE STRUCTURE



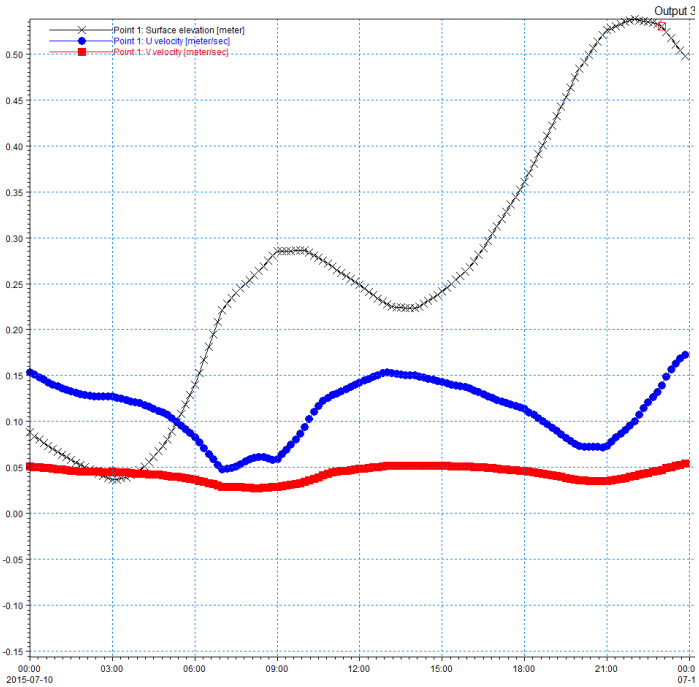
131.. WATER ELEVATION, RESULT AREA, WESTERN WITH BRIDGE STRUCTURE



132. WATER ELEVATION, RESULT AREA, WESTERN WITHOUT BRIDGE STRUCTURE



133.. HABITAT, WESTERN SIMULATION WITH BRIDGE STRUCTURE



134. HABITAT, WESTERN SIMULATION WITHOUT BRIDGE STRUCTURE

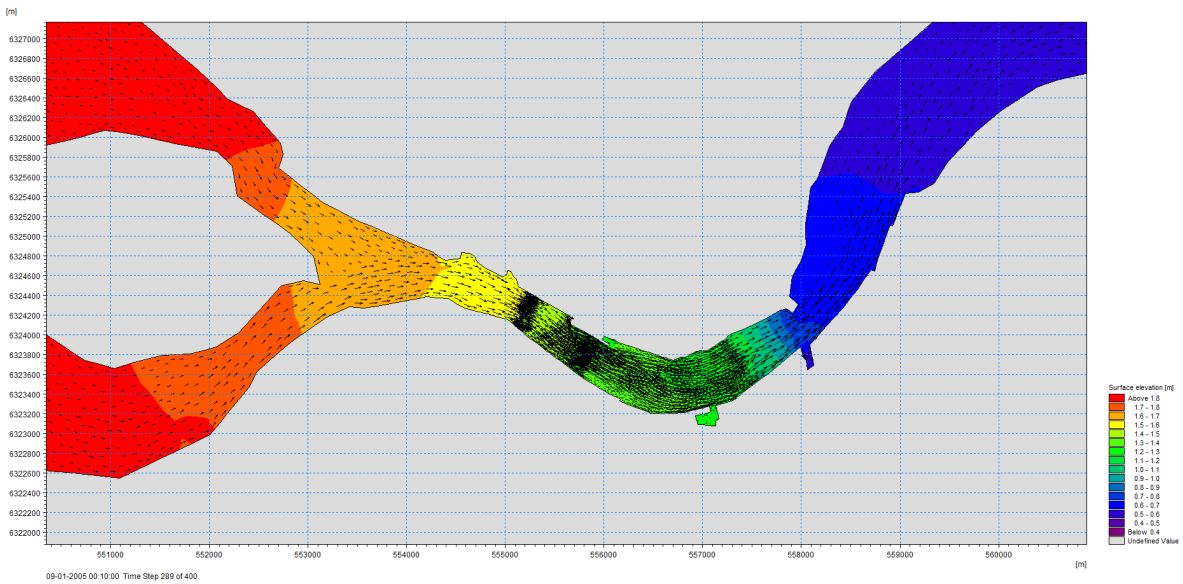
Western wind, 10th of July, 2015

The simulation made with western wind shows a significant lesser impact on the amount of discharge water, both around Østrehavn and Limfjord bridge. Around Østrehavn, east of the bridge is the discharge of water 105,8 percent higher than without the bridge structure, similar percent around the current bridge shows an increase of the amount of discharge water goes up with 103,5 percent. This amount is more acceptable, than the one indicated by the simulation made with the eastern wind.

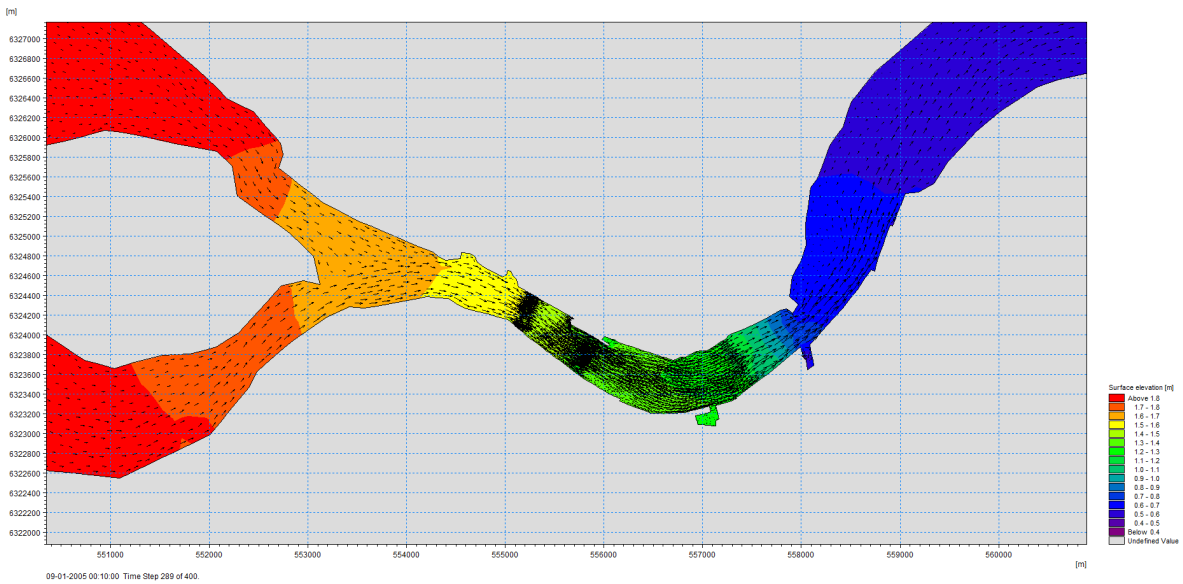
The habitat north-east of the site water levels and currents remains significant similar, and in terms of the western simulation is there no indications of impacts on the natural area.

Storm Surge, 2005

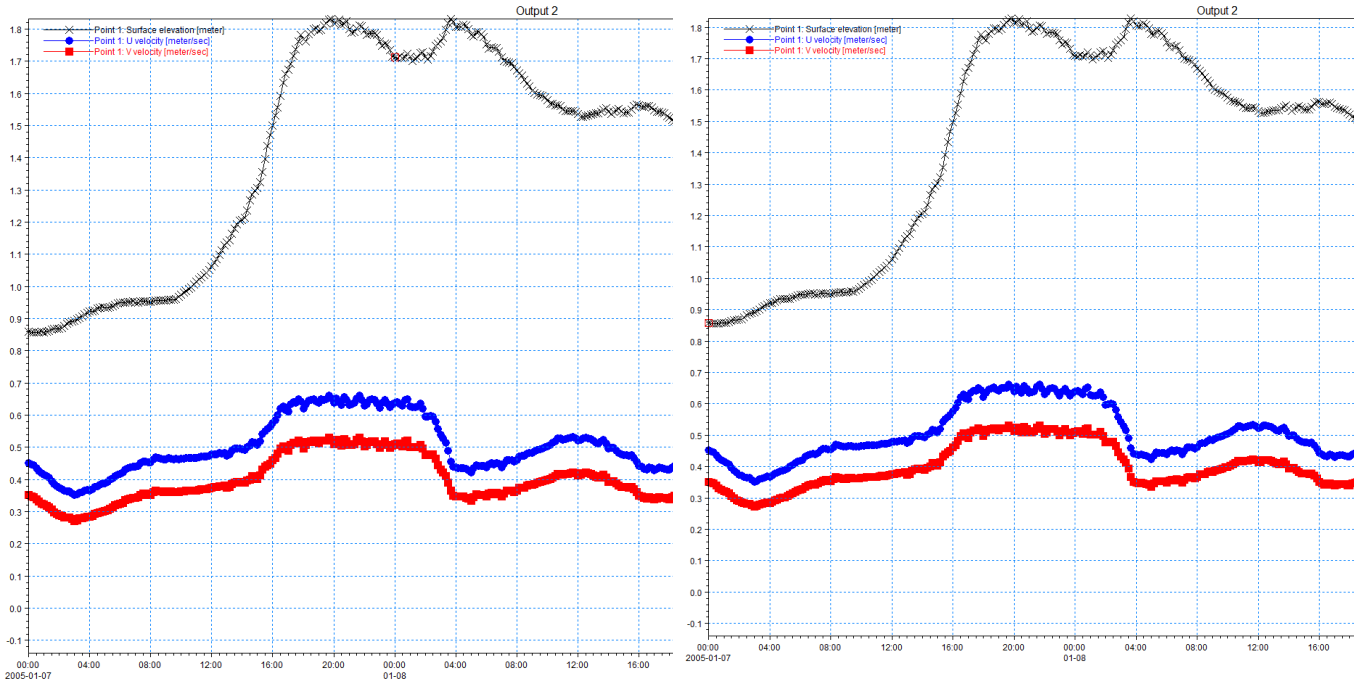
The third and last simulation is made with the data from the storm surge in 2005, which flooded severe parts of Aalborg and Egholm. The simulation shows that from the two simulations, with and without the bridge structure. For the analyze point around Egholm, does the results looks quite similar and it doesn't seems like the proposed bridge structure will worsen the flooding. The analyses point near the train bridge shows similar results, which could lead to the bridge structure being so far way, it doesn't have an influence during so intense storm surges.



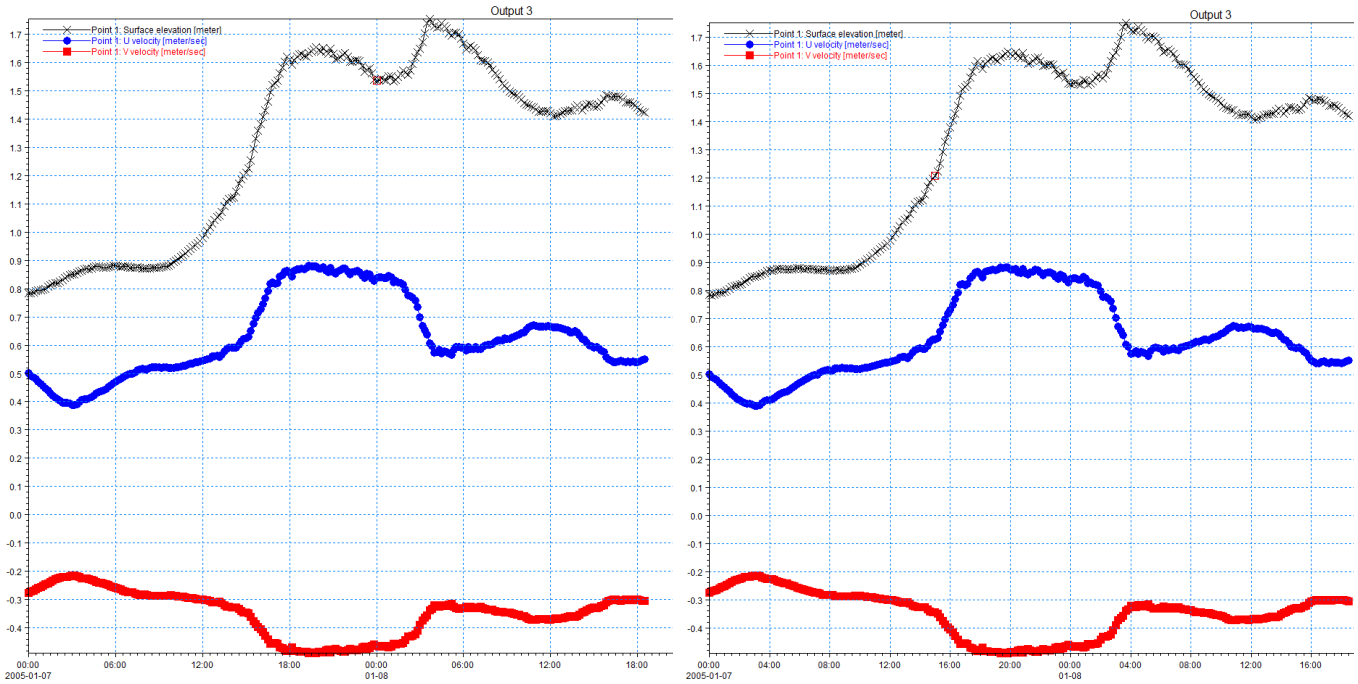
135. AREA WATER ELEVATION WITH BRIDGE STRUCTURE



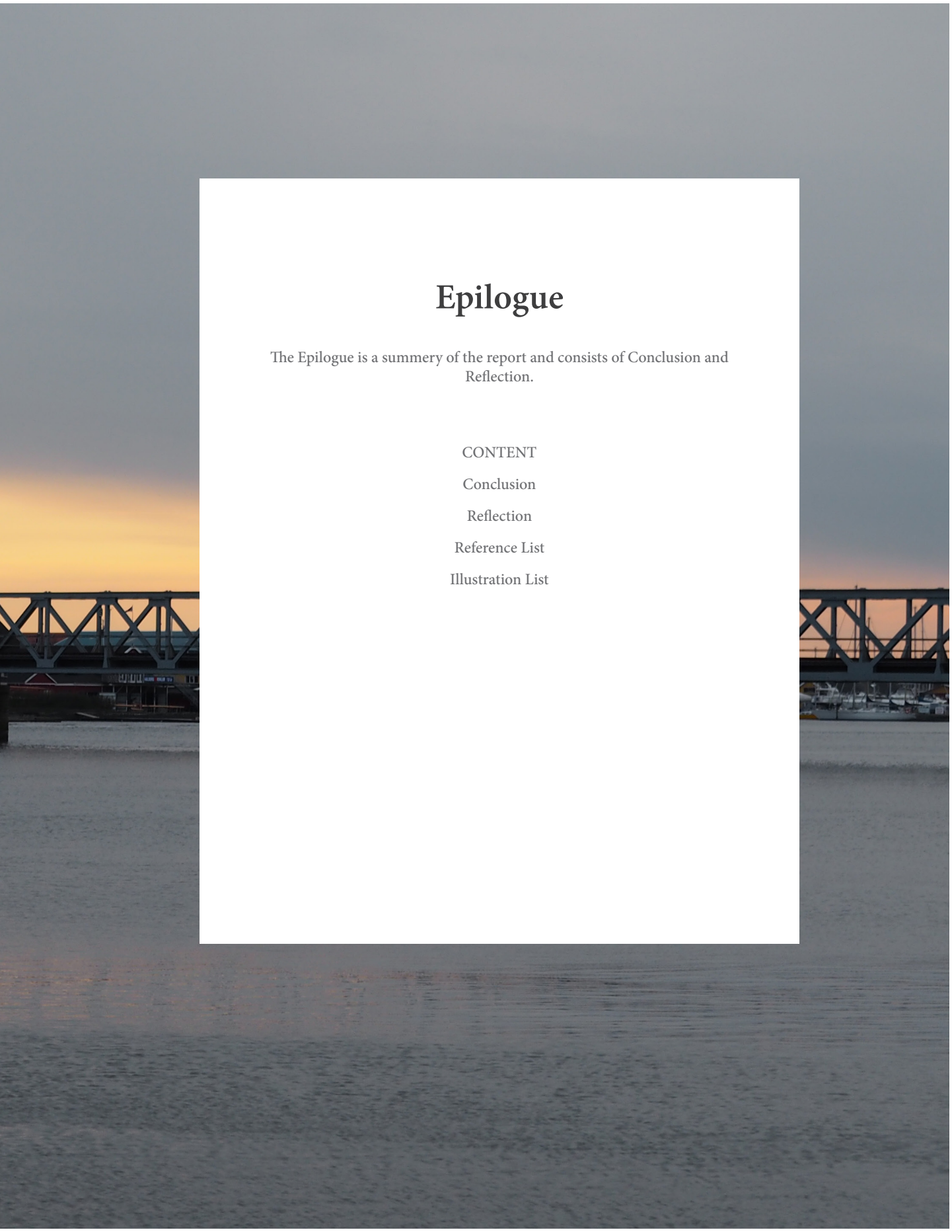
136. AREA WATER ELEVATION WITHOUT BRIDGE STRUCTURE



137. EGHOLM ANALYTICAL POINT : LEFT WITH BRIDGE, RIGHT WITHOUT



138. TRAIN BRIDGE ANALYTICAL POINT : LEFT WITH BRIDGE, RIGHT WITHOUT



Epilogue

The Epilogue is a summery of the report and consists of Conclusion and Reflection.

CONTENT

Conclusion

"HOW CAN WE RETHINK THE THIRD LIMFJORD ALIGNMENT AND CREATE A SPACE THAT INCREASE THE VALUE AND POTENTIAL OF TRADITIONAL INFRASTRUCTURE, BENEFITTING BOTH LOCAL AND REGIONAL DEMANDS, WHILE FACILITATING EVERY-DAY LIFE IN CLOSE RELATION TO THE BUILT- AND GROWN ENVIRONMENT?"

The third limfjords alignment, as thought and approved by the government and municipality of Aalborg, is very much a project that considers singular mobility modes in form of the motoring. A significant number of politicians have all agreed upon it being the "best" solution, for Aalborg and the northern region of Denmark, some even calling it "the best environmental solution" of the three proposed alignments. Even though that's an overly misinterpreted version of the EIA-report, the report does state that a western connection would be "the best socioeconomic" solution - a statement which referrers towards an economical aspect of the project, service and profits, but doesn't handle subjects such as livability, landscape, nature, wild-life and recreative areas as part of the calculation. It's a "cost" and "benefit" system where the sum, positive or negative, decides if a project is feasible or not. In this sense does noise from a future highway project, such as the third Limfjord alignment, in a residential area adds a negatively value to the overall sum of the project, while the same noise in a natural area or rural is without a value, negatively or positively. In this way do projects in rural or natural areas already have a beneficial edge in terms of the "cost" and "benefit" systems.

An assessment of the strategically elements playing into the planning phase of such a significant infrastructural project, both analytical and theoretical showed another dimension of a project, showcased another model, which takes a more holistic approach towards sustainable infrastructural planning. By taking new technologies, climate changes, protection of valuable and sacred natural areas, and perhaps most importantly the strengthening of Aalborg municipalities strategically plans for the future development of Aalborg municipality – both rural and urban areas, can more informed decisions be made on larger mobility strategies and the placement of a bridge structure.

The mobility strategy takes it point of departure in the existing network of the city, and thereby builds on what is already there in a more urban context than the official proposal. By using the bridge structure to facilitate other mobility modes than private motoring, is not only the mobility of the city strengthen, but it also ties the two cities better together. By proposing a bridge structure, which offloads the existing structure, is it possible to create two new light rail corridors (or BRT corridors, for that matter), that can go across the fjord and strengthening the overall mobility of the city. The existing public transportation system is very much a series of various mobility modes that is poorly connected or requires multiple changes. However the two proposed corridors can become the backbone of the two cities public transportation system, by connection major nodes of the two cities; the new hospital, Aalborg Airport, Shopping area in city south, main train station and city center of both Nørresundby and Aalborg. Furthermore the two corridors facilitates several new "Park and Ride" areas, which can reduce the amount of people using private car and induce the public transportation systems instead which would lead to a decrease in the demand of new roads and infrastructures.

The placement of the bridge, between two larger development areas; Stigborgsbrygge and Østrehavn, strengthens the development and connects these areas with rest of the city and each other. This will not only increase the value of both development areas, but also strengthen the recreational possibilities along the fjord, as the bridge will connect the Aalborg side, with the natural areas towards the east of the project site, as proposed in Aalborg municipalities "Blue and Green" strategies.

The concept of the bridge, which arrived from the natural phenomenon of a river delta, ensures a green infrastructure, which both facilitates mobility and natural experiences along a dense and largely paved harbor front. The greenery and vegetation implemented on the bridge are experienced along the harbor front which creates a certain linearity and coherence. Despite of that the bridge can be understood and seen as a landscape element in itself because of its size and function. The bridge structure adds a significant amount of green areas in and around the harbor front, while staging the landscape and experience of it. A significant aspect of the design was to facilitate a natural experience for the everyday users of the urban spaces and the daily commuters. This is achieved by implementing a

series of landscape elements along the structure, which varies in density, composition and experience among each other, changing weather and during the yearly seasons.

A series of branches arises out of the main structures and creates islands. The branches are extensions of the landscape principles and create a series of varying spaces. Some branches go down towards the water and create wetlands with saltmarshes and eelgrass, while others creates lush, green forests on the edge of the structure, capable of handling the harsh winds of the fjord. This adds to the experience of the spaces and introduces a natural experience into the urban environment.

A variety of programs will help extent the urban fabric and connect the two sides, while activating both the bridge structure, but also the fjord itself. With the implementation of a water activity center, which will house both facilities for kayaks or other sailing clubs, and a harbor bath, will the users be able to swim from the bridge in the middle of the fjord, while having the scenery from both the Nørresundby and Aalborg harbor fronts. The implementation of housing units onto the bridge will help activate the spaces along the bridge structure and stage the fjord in a new way. The houses in and around the forest landscapes, will have a view out towards the fjord and the natural surroundings, from the amenity of their homes and the built environment, while residential units in Wetlands will have a more active relationship with the riverbed. Here will it be possible to create blue gardens, enjoying wildlife, fishing, kayaking and other activities which reconnects the residents with the natural landscape surrounding them and the activate the blue layer of the city.
The implementation of natural areas, will not only add towards the natural experience of the bridge, but also provide the city with a series of new ecosystems; food, local climate and air quality regulation, carbon sequestration and storage, waste-water treatment, pollination, habitat for species (minor species), Recreational, mental and physical health, Tourism, Aesthetic appreciation and inspiration for culture, art and design and a spiritual experience and sense of place service.

The bridge challenges the conception of traditional infrastructures, by combining several mobility modes, reconnecting the city with the fjord, creating natural experiences, while facilitating everyday life in close relation to the built- and grown environment.

Reflection:

Our motivation for the choice of project and subject was in many ways the many contrary opinions and demurs surrounding the projects and the choice of an alignment crossing Egholm, which in our sense is a significant and unique landscape element in Aalborg. We wanted to understand the agreed alignment and see what would happen if we brought in more parameters than what the current project were based on. So what happens when you start thinking of the "hidden value" of nature? Changing technologies and their impact of our physical worlds? The impact climate changes and rising sea levels will have on future infrastructural projects, such as the third Limfjord alignment. What happens when you start addressing these issues?

The "cost" and "benefit" system is very much a tool of the past. It doesn't take real issues into consideration and the so-called "hidden-value" of natural areas. The area west of Aalborg has, besides of Egholm a significant amount of natural areas, which is greatly used by its citizens as recreational areas, while several red-listed animals has habitats in the areas. The typography of Aalborg and the rising water levels will submerge, temporary or permanently larger part of the western area of Aalborg, however this subject were not addressed in the EIA-report? The natural areas were very thoroughly addressed and documented in the EIA-report, both in terms of various fauna's, ecosystem services (such as habitats, tourism, recreation and fresh water), landscape characteristic and the fragility of these. However it never really seemed like these elements played any significant in terms of decision making. A good example of this was the description of Lindholm alignment, where the Lindholm stream is being moved to make room for the tunnel. However this was a sub sentence in the overall description, like it wasn't a major intervention, in an area they described earlier in the report, as a valuable habitat and recreational area. There is a necessity of taking the "Natural capital" more serious in the way we plan larger infrastructural project, such as the third Limfjord alignment. If the natural capital were part of the "cost" and "benefit" system, would Egholm then be considered more valuable, both in terms of habitats and recreational use? And what would the best socioeconomic solution then be? The best thing for the natural world and our environment, or?

The foundation of our project and the decisions made on both a strategically and design level depend on an ideology of nature having a value, but also on new technologies and the impact they will have on the future design of our cities. But what do new technologies mean for our cities? And how can we address them both strategically and on design related issues? In our assignment we have assumed that driverless cars, would be part of the reality in which are project would be part of, when it would be "finished" in 10-15-20 years. We have done that because a significant amount of research suggests that this is on the verge of happening, with several pilot projects already on the way – one of which is concerning driverless busses in the eastern part of Aalborg in 2018. But how will the driverless car change our perception of public transportation and the future of motoring? Will the driverless car become the new public transportation through sharing schemes? And what will happen with our urban environment, when we no longer need parking spaces, but only turning points and temporary stopping areas? That's some quite essential questions, which is difficult to foresee because there are some many parameters, which can decide the direction it will take. However we still incorporated it into our design, which removed the necessity for an alignment based solely on regional demands, as the current proposal does. But can municipalities and other planners take the same freedom as we've done? Or do they need to address the current demands and in ten or fifteen years transform the spaces, which perhaps are no longer needed in our cities?

In the same way you can also look at our proposal and ask if it's a necessity, both on a strategically plan and a design level. With the significant amount of houses incorporated on the bridge structure, could it be argued that the bridge wouldn't be necessary in the next 50 or 60 year, if it ever will be? However the connection in itself could be a good forerunner for the future development of Stigborgsbrygge, as it would make the area more attractive for investors and citizens, due to the lower proximity towards larger cultural areas, such as Nordkraft and House of Music, as

well as the city center. Stigborgsbrygge in itself is a rather large developing area, on approximately 55ha, which in itself demands new, if not improved infrastructures. Already now is there discussion of a temporary test with water busses, which would connect the two sides further. However a fixed connection capable of transporting not only cars, but also pedestrians, bikes and public transportation would add a certain value to such a large extension of the existing urban fabric of Aalborg and Nørresundby.

The bridge structure in itself is a significant element, and could be seen as a landscape element in itself. The question then begs, can the context of Aalborg cope with such a large element? And what is the branding value of such a project? When talking about urban transformation and prestige protect, projects such as the turning torso in Malmø and the Guggenhiem museum in Bilbao comes to mind. Can our bridge do the same for Stigborgsbrygge? Or is it so large that it's not necessary before 50-70 years? The projects in Bilbao and Malmø, has a like other urban transformation and "branding" project been placed in the periphery of the city, where new lands are being transformed. However our proposed bridge structure placed in-between to areas, which could provide a framework for the next 30-40 years development of Aalborg, where it would be the backbone of a strong network of public transportation. However it would still be a significant landscape element, and positively or negatively affect the Limfjord, as an open landscape element. However we are building in a highly cultivated area, which are more likely to "accept" such a structure, than if it would have been around Egholm or further out towards the east.
The concept of the bridge is in many ways inspired by a river delta, which is a natural phenomenon, that's both dynamic and in a constant process of change. The development of the concept lead to a fixed form, as a bridge structure in many ways is and should be, however the implementation of various landscape elements and more importantly wetlands gave the bridge some of the dynamic of a river delta – however in a firm and fixed shape.

The design adds a natural experience and layer towards the city, and thinks multiple mobility modes and services into one structure. It provides a series of ecosystem services to the city and recreational areas. It's a result of a holistic approach, a consideration of multiple elements rather than mono-functional "hit and run" projects, which creates barriers towards, and fragmentize valuable natural areas. It's a design which adds to the natural experiences and towards the relationship with nature, rather than creating barriers towards them. This should be a significant part of urban planning and not least in the planning of larger infrastructural elements, such as the third Limfjord alignment.

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