Reconnecting Gävle's Delta

A post-industrial urban transformation project for Sweden's coastal landscape

Rachel Murray

Independent project • 30 credits
Swedish University of Agricultural Sciences, SLU
Faculty of Natural Resources and Agricultural Sciences
Department of Urban and Rural Development
Landscape Architecture for Sustainble Urbanisation - Master's Programme
Uppsala 2023

Reconnecting Gävle's Delta:
A post-industrial urban transformation project for Sweden's coastal landscape

Rachel Murray

Supervisor: Andrew Butler
SLU, Department of Urban and Rural Development

Examiner: Carola Wingren
SLU, Department of Urban and Rural Development

Credits: 30

Project Level: Second Cycle, A2E

Course Title: Independent Project in Landscape Architecture. A2E – Landscape Architecture for Sustainable Urbanisation – Master's Programme

Course Code: EX0945

Programme: Landscape Architecture for Sustainable Urbanisation - Master's Programme

Course Coordinating Dept: Department of Urban and Rural Development

Place of Publication: Uppsala, Sweden

Year of Publication: 2023

Online publication: https://stud.epsilon.slu.se

Publishing and Archiving :

☑ YES, I/we hereby give permission to publish the present thesis in accordance with the SLU agreement regarding the transfer of the right to publish a work.

Key Words:
Resilience, Blue-Green Infrastructure, Nature-based Solutions, Flooding, Brownfield Development, Post-industrial Urban Development, Landscape Architecture, Urban Planning, Climate Adaptation, Water-Sensitive Urban Design, Urban Ecology.

SLU, Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Urban and Rural Development
Division of Landscape Architecture

Abstract

This speculative design-led research project addresses the challenges of transforming dilapidated post-industrial brownfield sites into thriving, sustainable, resilient urban neighbourhoods. Tasked with allocating urban growth, municipality planning departments increasingly look towards underused but centrally located industrial sites for future development. Coastal brownfield sites, with the promise of prime waterfront views, are especially sought after, but can also pose many complex urban and environmental challenges.

This thesis confronts these challenges using the site-specific scenario at Näringen – an industrial 232-hectare site zoned for urban transformation – in Gävle, Sweden. Faced with urban growth, deindustrialisation, disconnectivity, flooding, and environmental disrepair, Reconnecting Gävle's Delta is a design proposal which draws on Nature-based Solutions, including Blue-Green Infrastructure (BGI) principles, and ideas of the 'productive city' to imagine a new climate-adapted mixed-use district at Näringen. First, a new water channel island is proposed to deal with future sea level rise by preventatively 'inviting the water', resulting in the creation of a new recreation island for the city. Second, a network of multifunctional blue-green corridors mitigates against cloudburst flooding while providing a focal point around which new mixed-use neighbourhoods – including housing, community, business, and industrial productive activities – can be designed.

Reconnecting the Delta critiques Gävle's anthropocentric and monofunctional planning approaches (which it argues led to Näringen's urban and environmental degradation in the first place), instead presenting a vision for reciprocity; firstly between ecological and urban systems – which in this project is initiated through a district-wide BGI framework; and secondly, between old and new – not just through preserving or recycling elements of the current physical urban environment, but through resolutely integrating and celebrating industrial productive activities (manufacturing, trade, logistics, repairs) that have historically and continue to take place at Näringen. The thesis concludes by encouraging the city of Gävle, and urbanism more broadly, to invest in further research that explores the integration of local production and industry as part of a truly mixed, sustainable, and flood-resilient city.

Acknowledgements

I would like to extend my gratitude towards those who have helped me complete this thesis:

My supervisor Andrew Butler for your useful insights and as a general 'go-to' person throughout the LASU programme; Burcu Yigit Turan for leading the course; Anna Lundvall for your interim feedback which helped steer the course of my design project; Carola Wingren for examining my thesis and for your valuable feedback; and my fellow LASU peers for your support as we navigated the last two years together.

Finally, thank you to my partner Willem, for your moral support, your proofreading and your 'in person' listening ear and advice when other ears were only available via zoom appointment.

< *Figure 1a: Winter sunset over Näringen. (Photo continues p. 9)*
Source: © Markus Boberg/Gefle Dagblad

Preface

This thesis represents the culmination of my studies and work in the Nordic countries, across the merging disciplines of architecture, landscape architecture, and urban planning and design. Over the last few years, it has becoming increasingly clear that I will forever be operating across all of these playing fields – despite having already set foot in the professional world as an architect, my passion for the natural environment, and my curiosity to engage further with nature and ecology's role in the rest of the city, and its peripheries, remained largely unsatisfied. Upon searching for a research topic for this thesis, the industrial site at Näringen in Gävle, with its planned future growth, adjacent delta nature reserve, and its increasing vulnerability to flooding, amongst many other challenges, leapt out as a complex but fascinating opportunity to confront head-on the complex interactions between urbanism and landscape. As such, this thesis sets out to explore the design possibilities for a certain reciprocity between urbanity and nature – research work that I endeavour to pursue far beyond this thesis.

>
Figure 1b: Winter sunset over the industrial area at Näringen, looking towards Gävle city.
Source: © Markus Boberg / Gefle Dagblad

Contents

Abstract		5
Acknowledgements		7
Preface		8
Contents		10
Introduction: Elucidating the potential for design research		**12**
	A site-specific scenario	15
	A wider (semi-) brownfield context	15
	A problem for Nature-based *Design* Solutions	17
	Research questions	18
	Scope and limitations	19
	Research by Design methods	20
	Thesis structure	21
PART 1: A coastal (semi-) brownfield site		**22**
Site Analysis and Background Context		
	Part 1: Introduction	24
1.1	Gävle is growing	26
1.2	Gävle is deindustrialising	32
1.3	Gävle's railways create barriers	40
1.4	Gävle is flooding	44
1.5	Gävle's delta is threatened	50
	Part 1 Discussion and Implications: Towards nature-based solutions	62

PART 2: Reconnecting Gävle's Delta 64

The Design

Part 2: Introduction 66

2.1 Reconnecting the Delta: Vision and Objectives 68

Objectives 1 +2 : An ecologically healthy, biodiverse delta/ A climate adapted delta 74

Objective 3: A connected delta 76

Objective 4: An innovative, productive delta 77

Objective 5: A dense, diverse delta 78

2.2 Three Key Spaces 80

I . Delta Island 82

II. Waterfront Näringen 90

III. Inland Näringen 102

2.3 **Part 2 Discussion: Reflections on the design process** 110

Connecting water and communities 110

Connecting new and old 112

Further research opportunities 113

Conclusion: Looking back; looking forwards **114**

References 120

List of Tables 124

Figures List 125

Figure 2: Aerial photo of a brownfield site in Näringen.
Source: Google Earth (Imagery 2022). 18-08-22

// introduction

^ *Figure 3: Näringen's coastal edge at Nyhamn abruptly meets the Testeboåns Delta Nature Reserve.*
Source: Regular Rick / Google Earth (CC) 18-08-22

v

Introduction

Elucidating the potential for design-research

A site-specific scenario

In Gävle, Sweden's 13th most populous city, the Gävle municipality is planning a radical urban transformation of the 232-hectare industrial site of Näringen (Gävle Kommun 2021). Strategically located close to the existing city centre, railway station and the shoreline, 6000 new homes and 450,000 square metres of business premises, public services, cultural and recreational spaces are envisaged in plans to create "one of Europe's most sustainable districts" (ibid: 5). The project, which is a collaboration between Gävle municipality, Gävleborg Region, and the Swedish government, seeks to strengthen the city's "role as a regional growth engine" and to "advance its position in the growing Stockholm region" (ibid). The project is also part of the Swedish government's wider strategy to address a nationwide housing shortage.

The proposed transformation, which is currently still in the preliminary planning stages, faces many challenges, however. From an environmental perspective, the soils of a former landfill on the banks of the Testeboåns Delta are contaminated from industrial land use. In August 2021, when record-breaking rain hit Gävle - the low-lying site of Näringen demonstrated its noticeable vulnerability to flooding – an event more likely to occur in the wake of increasing climate change (WSP 2020). From an economic development perspective, the future of the railway tracks across the site and the existing railyard – which represent significant physical urban barriers across Näringen – have also been the subject of back-and-forth negotiations between different stakeholders including the national government, Trafikverket (The Swedish Transport Authority), Gävle municipality and Gävleborg Region (See e.g.: Lundquist 2021).

A post-industrial 'semi-brownfield' context

The planned development of the industrial area at Näringen can be likened to the transformation of other similar post-industrial sites around the world. With mounting pressure to house growing urban populations, local governments are increasingly looking towards unused or – in the case at Gävle – under-used but centrally located industrial areas. While many such cities grew rapidly in the early industrial era, today, these manufacturing industries have significantly reduced in size due to global competition and society's transition to a service and knowledge-based economy, leaving behind vacant inner-city land suitable for urban densification. The development of these formerly occupied sites is referred to as 'brownfield' development (CARBENET 2006;

Rey et al. 2022). According to a CARBENET (Concerted Action on Brownfield and Economic Regeneration Network) report, the term brownfield has a great variety of definitions and can be interpreted in different ways. One definition follows:

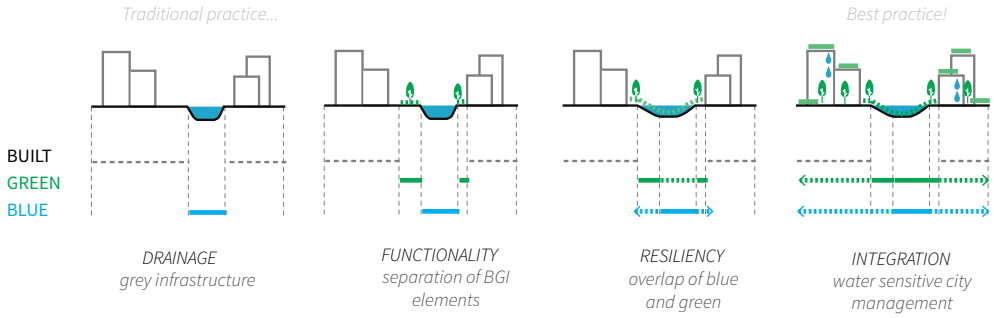
> *"Brownfields are sites that have been affected by the former uses of the site and surrounding land; are derelict and underused; may have real or perceived contamination problems; are mainly in developed urban areas; and require intervention to bring them back to beneficial use" (CABERNET 2006).*

This definition is referenced in another key text on European brownfield regeneration by Rey et al. (2022). The authors Rey et al. suggest that "beneficial use" implies the environmental, social, and economical improvement of a place, regarding the development of the sustainable city. Rey et al. also propose their own definition, using 3 principles that can be used to determine and describe a brownfield: Dimension, Type and Activity. First, brownfield sites are typically greater than half a hectare. Second, by considering the former use of the brownfield (e.g., industrial, railway, military, or commercial brownfields etc.). Third, they suggest that the vacancy time of a brownfield site is more than one year.

There are advantages and disadvantages to likening Näringen to other brownfield sites in such a way. On one hand, Näringen differentiates itself from this definition of brownfield since, even if many areas of Näringen are indeed worn down or underused, there are still over 300 companies active at Näringen. Also, although deindustrialising processes have affected Gävle's waterfront in similar ways to other brownfield sites, in Gävle this transition will be exacerbated by the local and national government-driven urban restructuring (which could see many of these existing businesses pushed to the periphery of the city, regardless of whether they want to be). In these circumstances, comparing Näringen to other brownfield sites which have been void of activity for years, risks side-lining the significance and opinions of existing industrial businesses at Näringen who would assumingly rather not be cast-off as 'derelict'.

At the same time, it is difficult to ignore facts: Much of Näringen land is contaminated from current and former uses and there are specific areas in Näringen that are clearly brownfield sites, such as Nyhamn (Fig. 3), the area closest to the bay, which is abandoned. Many other smaller sites within Näringen are either vacant or severely neglected and resonate with the definition of brownfield land. Situating this research alongside other brownfield projects is useful in this context, as it helps to tackle Näringen's challenges with reference to similar industrial transformation projects undertaken elsewhere which also suffer from similar problems: environmental challenges such as soil contamination and flooding; urban challenges, such as identity and connectivity; and economic and political challenges such as costly decontamination processes, multiple stakeholder involvement and mixed opinions about the future of the site. At the same time, it offers the opportunity to test ideas for brownfield regeneration which could have implications elsewhere.

In this thesis, the research opts to refer to Näringen as a post-industrial 'semi-brownfield' district, since the district deals with many of the same challenges as railway and industrial brownfield sites elsewhere and can benefit from comparisons. However, it is important not to downplay the significance of the existing industrial activity when referring to brownfield development – a topic which will be returned to later in this thesis.



^ *Figure 4: Diagram comparing typical grey infrastructure with blue-green infrastructure. Source: Author, concept adapted from Ramboll (2016)*

A problem for nature-based *design* solutions *?*

While post-industrial urban transformation is a broad topic and could be approached from many angles, the objective of this thesis is to interrogate the development potential of the semi-brownfield site at Näringen from a landscape architecture and urban design perspective, with special regard to Nature-based solutions and Blue-Green Infrastructure (Fig. 4). Nature-based solutions (NbS) which is an umbrella concept incorporating Blue-Green Infrastructure (BGI) amongst many other types of measures, has become increasingly prevalent with the heightened urgency to adapt our cities to climate change, and at the same time address parallel challenges related to social well-being and loss of biodiversity (Seddon 2020). The European Commission for example describes NbS as:

> *"Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience' (European Commission 2022).*

These solutions could include for example, the protection and management of natural and semi-natural ecosystems, the use of blue-green infrastructure in urban areas (retention and detention swales and lakes, cleansing biotopes/ raingardens and green roofs for example), and the application of ecosystem-based principles to agricultural systems (Seddon 2020). In this thesis, I am interested in the use of NbS, and especially BGI within urban areas. The goal for all nature-based solutions, as suggested in the European Commission's definition, is *resilience.* Resilience is defined by the UN Habitat as:

> *"The measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming toward sustainability."* (n.d.)

At Näringen, the goal is to investigate the potential of using NbS alongside other urban design principles to ensure social and ecological resilience. In the context of Näringen's low-lying flood-prone coastal environment, NbS measures such as BGI, offer ways to think about strengthening flood resilience, integrate the existing delta landscape and simultaneously address other urban issues such as connectivity, and the integration of outdoor social and recreation spaces.

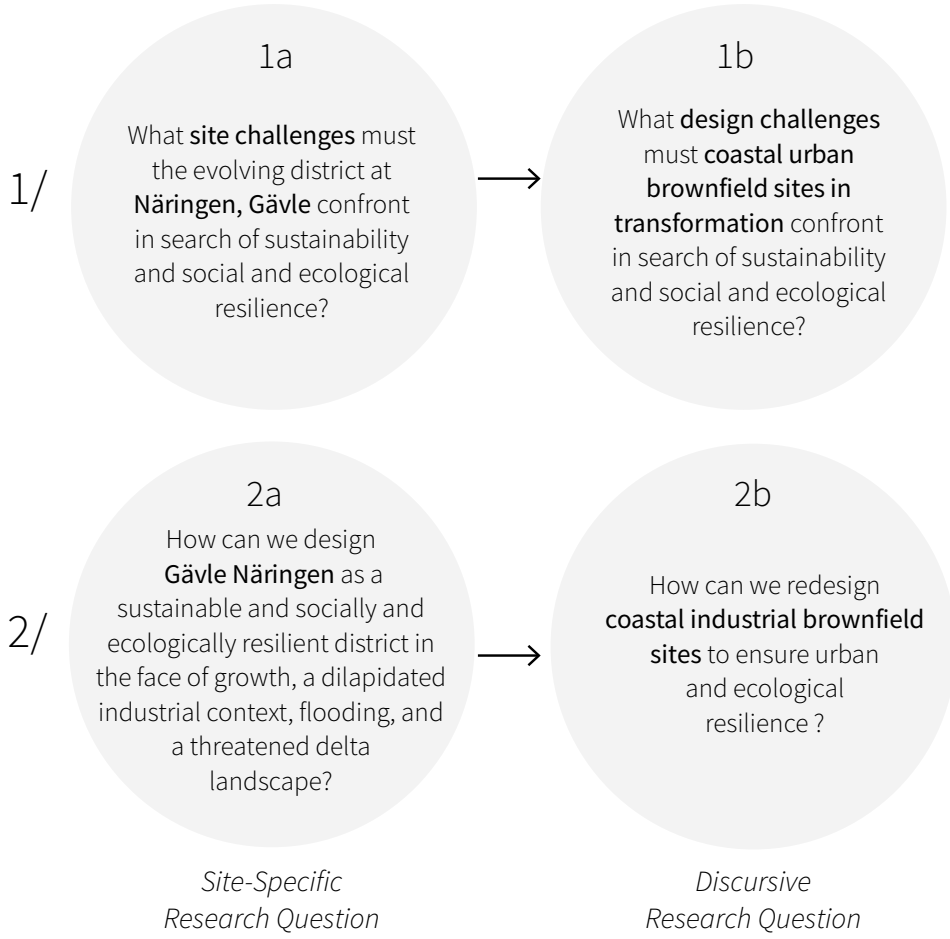
Research questions

This research uses the site-specific scenario at Näringen, Gävle in Sweden to investigate the potential for Blue-Green Infrastructure design to reimagine industrial brownfield sites, with the objective of promoting the sustainable and resilient growth of human and ecological communities.

Two main research questions direct this thesis work. The first question asks: 'What site challenges must the evolving district at Näringen, Gävle confront in search of sustainability and social and ecological resilience?' The second question which builds on this initial question, considers how to approach these challenges using a landscape architecture perspective, and is framed in a way which hypothesises nature-based solutions and blue-green infrastructure as a possible starting point. It asks: 'How can we use nature-based solutions to reimagine Gävle Näringen as a socially and ecologically resilient district in the face of growth, a dilapidated industrial context, flooding, and a threatened delta landscape?'

Initially, both research questions are framed specifically to address Gävle, since it was this particular site which inspired the research topic, (rather than the site being a case study example of a pre-determined research topic). However, in recognising that the problems encountered in Gävle and throughout the design process are likely to be encountered at other similar post-industrial transformation projects, the research question is also reframed in a way which becomes relevant for the wider architectural and planning discourse. Figure 6 outlines how the site-specific research has been reworded to encourage broader research implications beyond the Gävle Näringen site of investigation.

v *Figure 5: Sketch: the design process in action*



^ *Figure 6: Diagram of research questions*

Scope and limitations

The scope of research is limited by centring the study on Näringen and the adjacent Testeboån Delta. The thesis zooms in and out of this site as necessary however, to understand and tell the story of the complex interrelations regarding ecology, urbanity, politics, economics that tie this site to the rest of Gävle city and its wider region, and from which to inform the design. From the preliminary site discussion, it is evident that there are many avenues of departures.

Given the challenges and risks involved in building on Näringen, especially in regard to sea level rise and flooding, one direction for this thesis could have been to argue for Näringen's unsuitability as a location for new development. However, this project takes the stance that the benefits of building in Näringen (proximity to the city with sustainable connections for growth, opportunity to decontaminate the land, etc.) outweigh these possible risks. If anything, the risks are instead interpreted as a stronger incentive for design-led research, and as an opportunity to explore ways to mitigate and solve such challenges.

Research by Design methods

This thesis uses a *Research by Design* methodology, where the architectural design process serves as a way of revealing new insights, knowledge, and practices, generating critical inquiry not just specifically for Gävle but for the wider architectural and planning disciplines.

The methods used for this research are varied but not atypical from other design-led projects: an analysis of the site-specific conditions at Näringen, as presented in Part 1, informs initial concept sketching (Fig. 5) which is then developed into The Design (Part 2). To formulate the five chapters of Part 1, the thesis reinterprets and critiques material from existing planning documents, local newspapers, archives, historic and recent maps and orthophotos. This was supplemented by personal site observations and photography. To produce The Design, analogue and digital methods of sketching were used, alongside 3D modelling to produce visualisation material. The thesis structure presents this research in a linear format as a way of logically guiding the reader through the project. However, the order in which these design research methods occurred was much less linear, with the design resulting from a messy back-and-forth process where site studies were conducted at the same time as, and as a result of, the conceptual design process.

Thesis structure

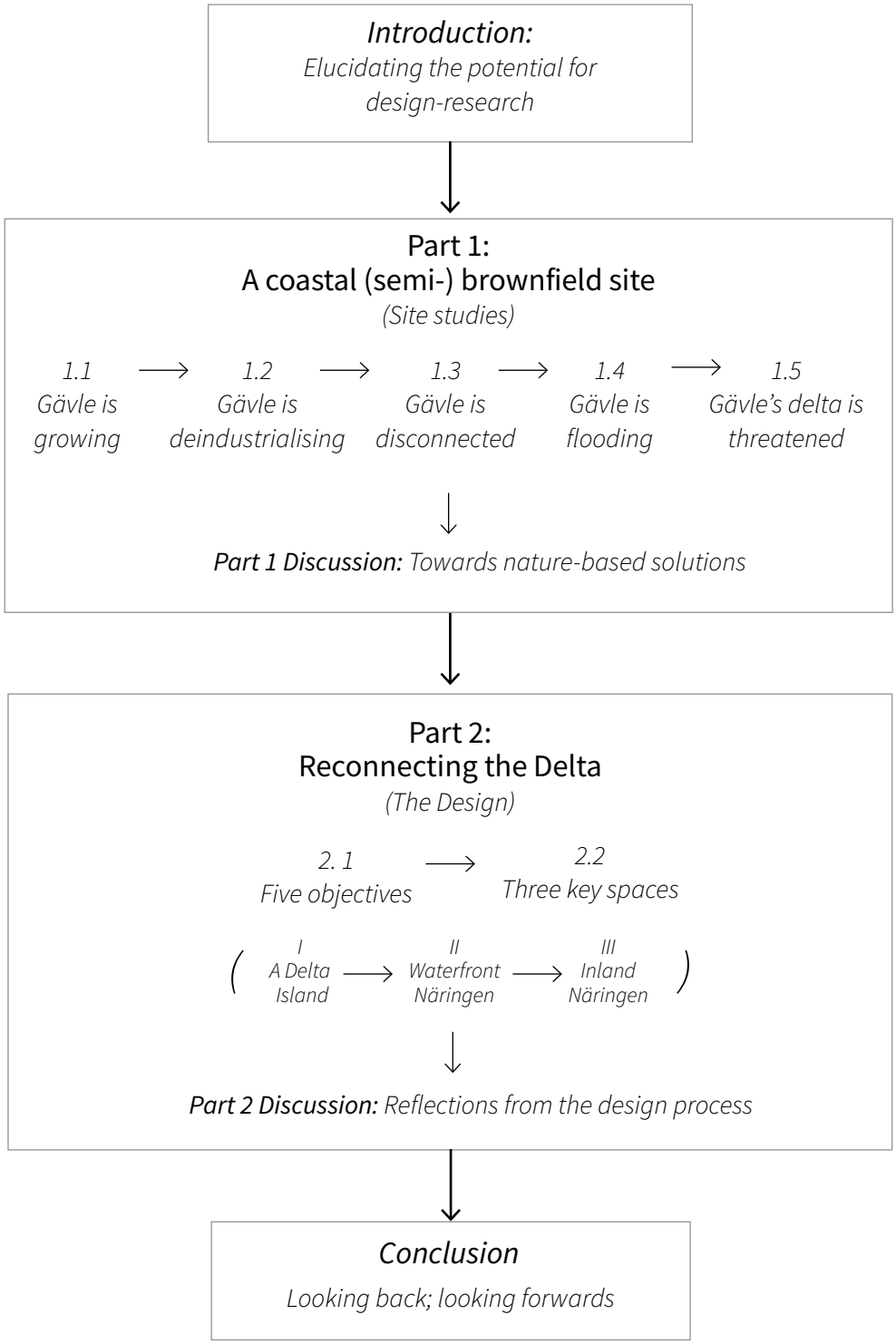
The thesis is divided into two parts (Fig. 7) which correspond with the two research questions:

Part 1: 'A coastal brownfield site' consists of five chapters and offers the findings from the site investigation at Näringen, Gävle. The topics chosen represent what I see as some of the biggest challenges which urban planners and designers must face when redesigning the future Näringen. Within each of these chapters, a description of the site problems is followed by a further discussion linking the issue identified at Näringen to a broader disciplinary context. As such, each chapter interweaves site analyses, theoretical concepts, and where necessary, case studies to answer the research question.

Part 2: 'Reconnecting the Delta' addresses the second research question, presenting a vision for Näringen which integrates BGI principles as part of a boarder urban design vision. This section is referred to throughout this document as The Design. The Design is supported by case study and reference projects to show from where inspiration has been derived. The presentation of the design project is followed by a reflection of the findings from the design process, where the successes and limitations of BGI principles, amongst other findings, are discussed.

>
Figure 7: Diagram of Thesis Structure

Reconnecting Gävle's Delta:
A post-industrial urban transformation project for Sweden's coastal landscape



0

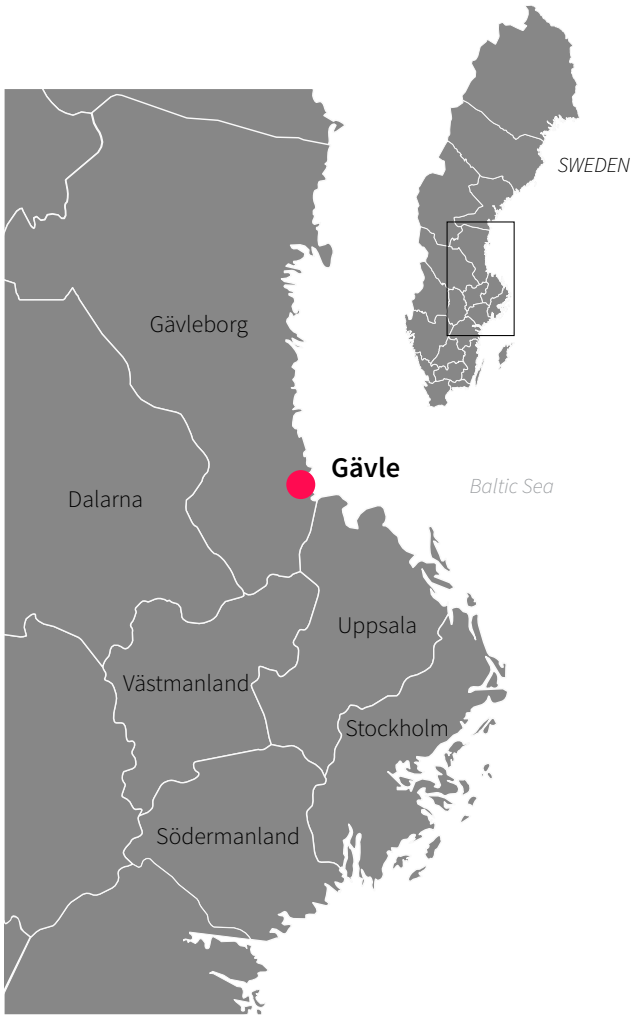
Figure 8 : Aerial photo of Näringen and Testeboåns River mouth. Source: Gävle Kommun

Part 1

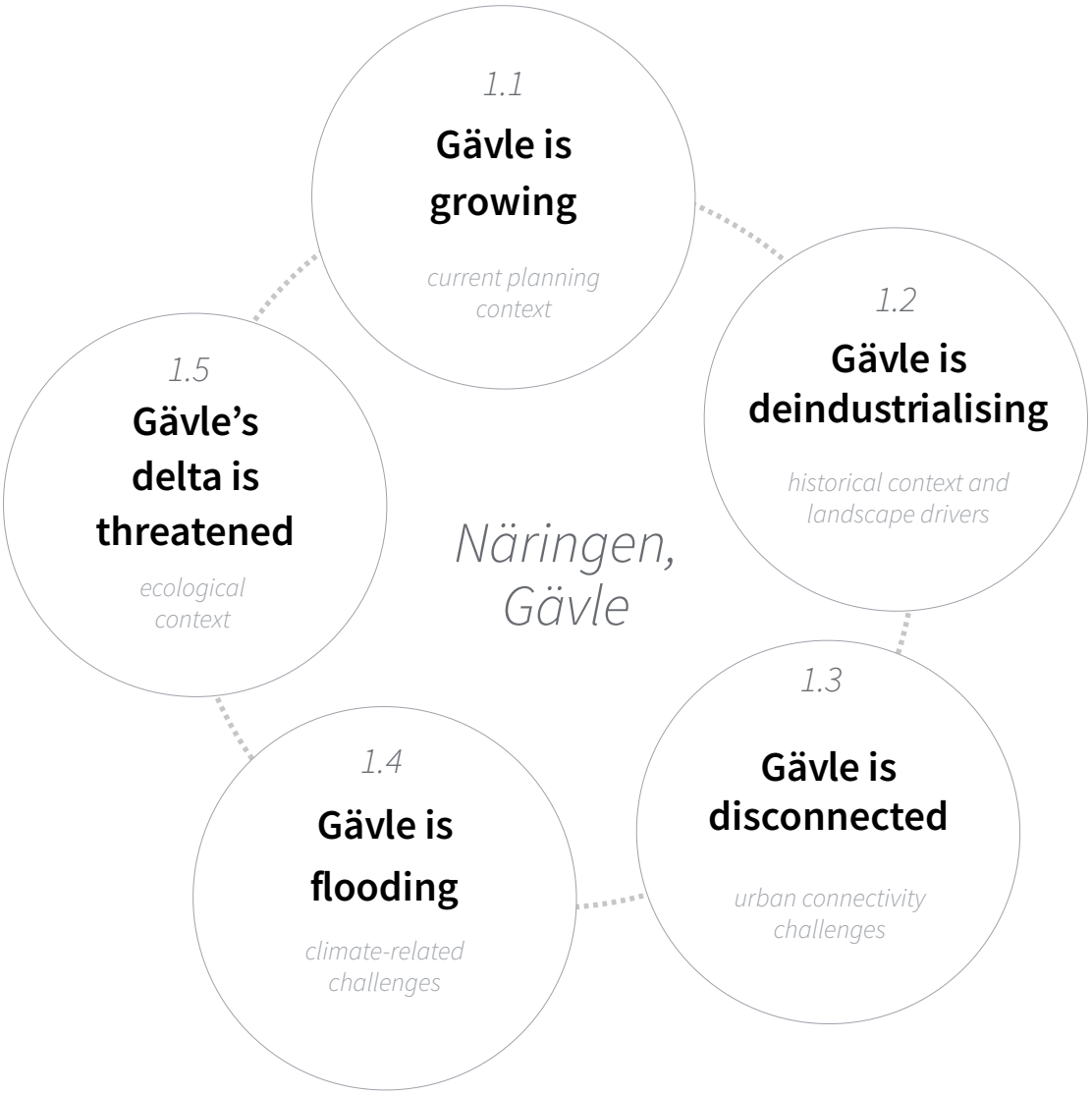
A coastal (semi-) brownfield site

Näringen, Gävle
Sweden

The site at Näringen in Gävle, Sweden (Fig. 9) offers an example of an industrial coastal area undergoing radical transformation and is the starting point for this research. The first chapter 'Gävle is growing' presents the current urban context, positioning the site of investigation, Näringen, within a wider narrative of national urbanisation and growth. The second chapter, 'Gävle is deindustrialising' recounts a brief land use history of the waterfront, identifying the underlying landscape drivers which have brought Näringen to this point of urban transformation. Chapter 3: 'Gävle is disconnected', investigates connectivity challenges in Gävle caused by the railways and industrial land uses. Chapter 4: 'Gävle is flooding', recalls the flooding event of summer 2021 in Gävle prompting an investigation of the risks of climate change-induced flooding risks. Finally, the fifth chapter 'Gävle's delta is threatened' highlights environmental challenges which threaten the ecological health of the wetland bay. Together, this section provides an overall picture of some of the biggest challenges deindustrialising cities like Gävle must confront in the coming future (Fig. 10).



^ *Figure 9: Location of Gävle in Gävleborg County, Sweden*



^ *Figure 10: The five site issues discussed in this chapter.*

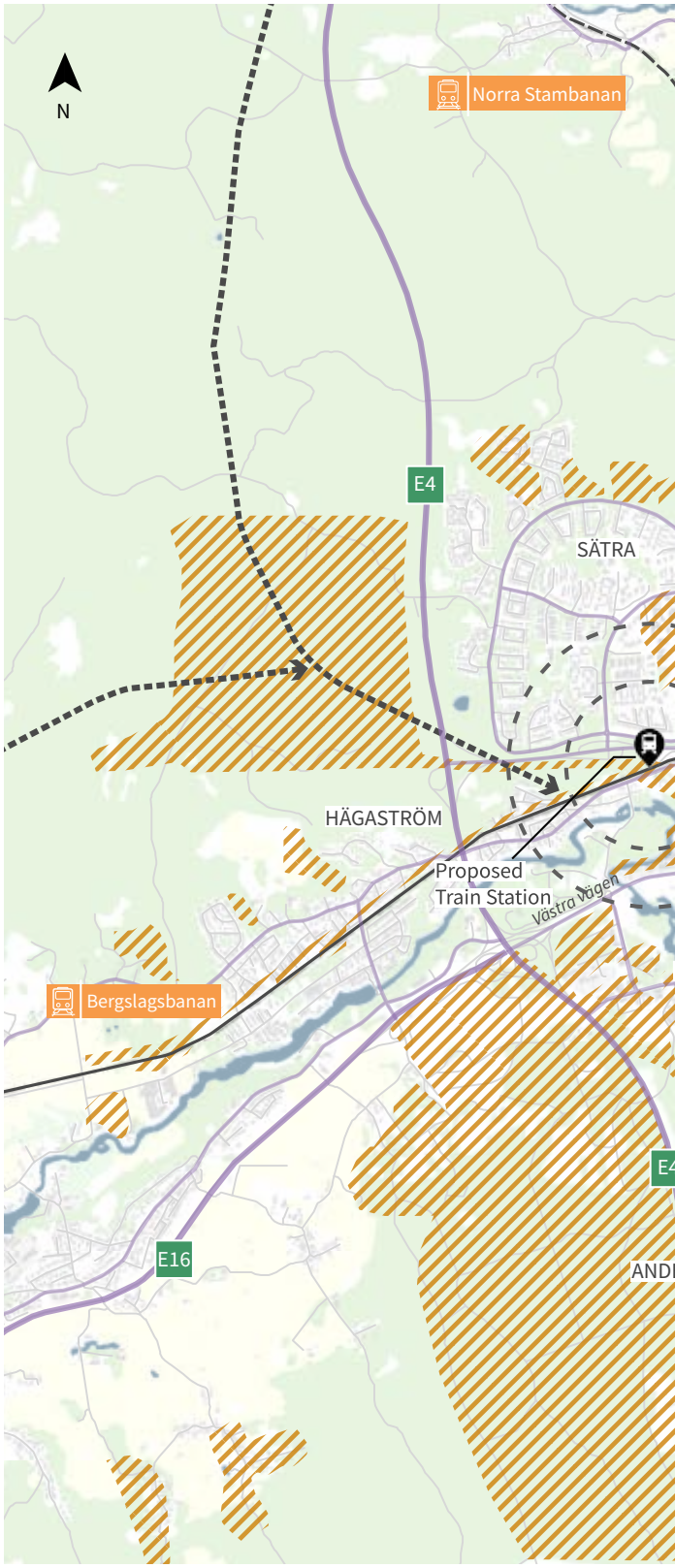
1.1

Gävle is growing

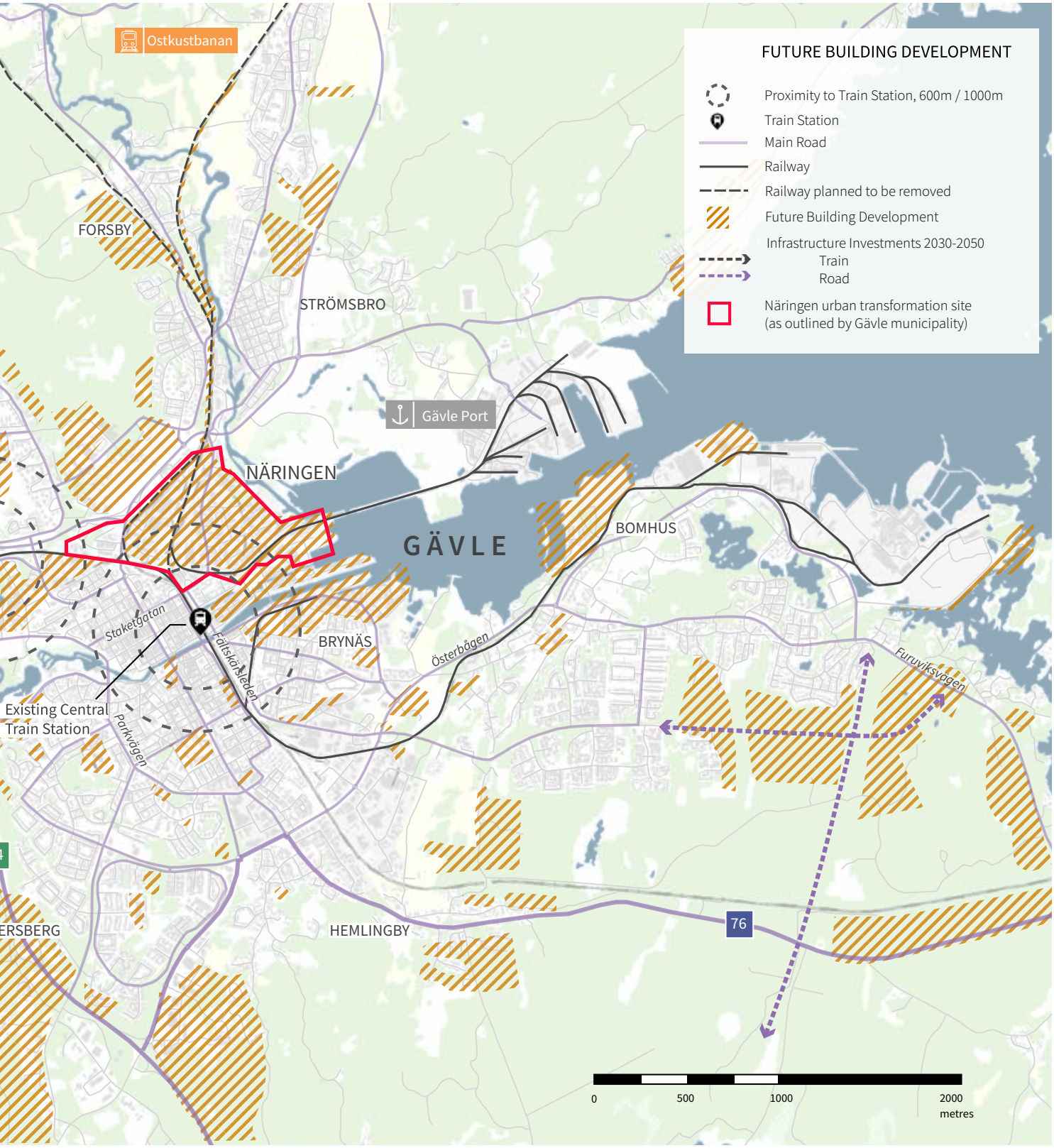
The current planning context

"Gavle is growing" is how the city of Gävle presents itself in the most recent Comprehensive Plan (Gävle Kommun 2017:6). With just 103,000 residents across the municipality and 78,000 in the city itself, Gävle is currently the 13th most populous city in Sweden but growing at a rate of 1000 people a year (Ekonomifakta 2020). Gävle municipality has ambitious goals to increase this, with the Comprehensive Plan outlining a target of 120,000 people by 2030 and 150,000 people by 2050, of which eighty percent are planned for in the Gävle urban area (Gävle Kommun 2017).

Gävle's growth agenda (Fig. 11) is part of a national strategy to construct more houses across Sweden amidst a housing shortage, concerning rental homes in particular, which has plagued the country for decades (Johnson 2019). In 2016, the government gathered a 22-point program for increased housing construction, with the point *Stor samlad exploatering – nya hållbara städer* [Large collective development – new sustainable cities] identifying areas in Sweden where the government can financially contribute to the long-term development of sustainable districts and cities with increased housing construction. An investigation of suitable locations for sustainable cities resulted in the designation of nine areas across six municipalities, including the 232-hectare Näringen industrial site in Gävle (Gävle Kommun 2020).



>
Figure 11: Future building development - Näringen is just one area in Gävle where new growth is planned. Note other coastal industrial areas also indicated as growth areas.
Map source: General Map © Lantmäteriet; edited by the author with information sourced from Gävle Kommun.


Ostkustbanan
FORSBY
STRÖMSBRO
Gävle Port
NÄRINGEN
GÄVLE
BOMHUS
BRYNÄS
Staketgatan
Fältskärsleden
Österbågen
Furuviksvägen
Existing Central
Train Station
Parkvägen
HEMLINGBY
76
0
500
1000
2000
metres
FUTURE BUILDING DEVELOPMENT
Proximity to Train Station, 600m / 1000m
Train Station
Main Road
Railway
Railway planned to be removed
Future Building Development
Infrastructure Investments 2030-2050
Train
Road
Näringen urban transformation site
(as outlined by Gävle municipality)

A connected region

In the municipality's recent business study, Gävle is described as a suitable location for directed growth and business opportunities because of its strategic location within the wider Stockholm region (Fig. 12), located just 1 hour by train from Stockholm-Arlanda Airport and 1.5 hours away from Stockholm Centre (Sweco 2018). Its connections promote good regional commuting, meaning individuals have better access to education and work opportunities, while the business community has a larger pool to locate needed skills, customers, and partners (ibid).

> *Figure 12: Regional context map showing Gävle in relation to the capital, Stockholm.*
Map source: General Map © Lantmäteriet; edited by the author with information sourced from Gävle Kommun.

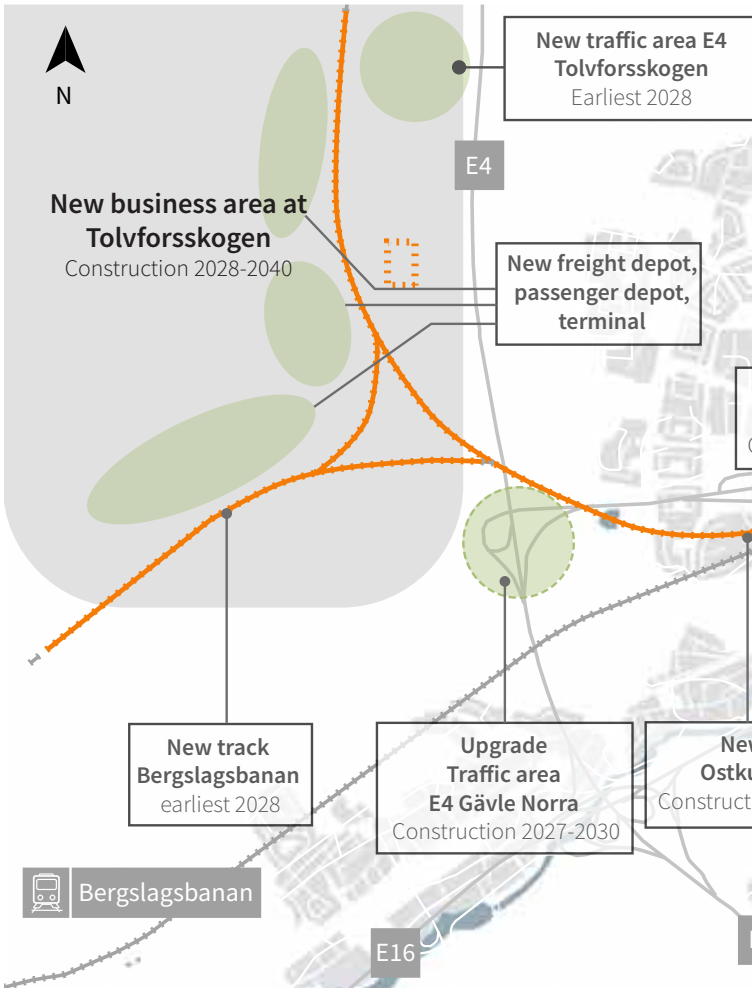
v *Figure 13: Diagrammatic map of planned transport upgrades involving local, regional and national governments.*
Map source: General Map © Lantmäteriet; edited by the author with information sourced from Gävle Kommun.

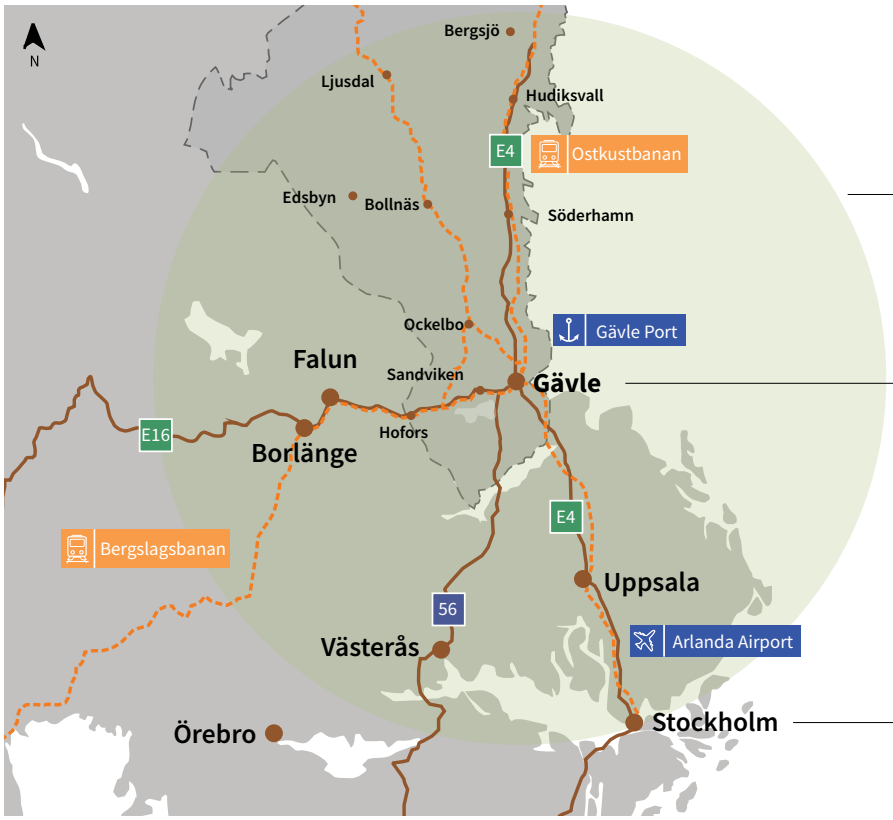
A new 'sustainable urban district' at Näringen

Following the identification of Näringen as a suitable location for growth, in 2017, the Gävle municipality, the region of Gävleborg and the Swedish government signed a collective agreement to develop the area into a new sustainable urban district with 6000 new homes by 2040 and 450,000 square meters of business premises, public services and recreational amenities (Gävle Kommun 'Förstudie' 2021). The transformation will require many existing industrial businesses still in operation at Näringen to move to the outer city greenfield site of Tolvforsskogen, where a new node for logistics and goods is planned. Some businesses, which support the municipality's sustainable version will be able to stay.

According to the 2017 agreement, Näringen will be subsidised by the national government in exchange for Gävle's commitment to growth and cooperation with renewed nationally-significant railway infrastructure including double tracks in a new section of the East Coast Line north, a new railway station at Gävle Västra, electrification of the existing track to the port and a relocation of the existing railway yard at Näringen (Fig. 13).

The findings from the municipality's preliminary studies have been collated in the key document *Förstudie Stadsomvandling Näringen* [Feasibility Study Näringen] (Gävle Kommun 2020).

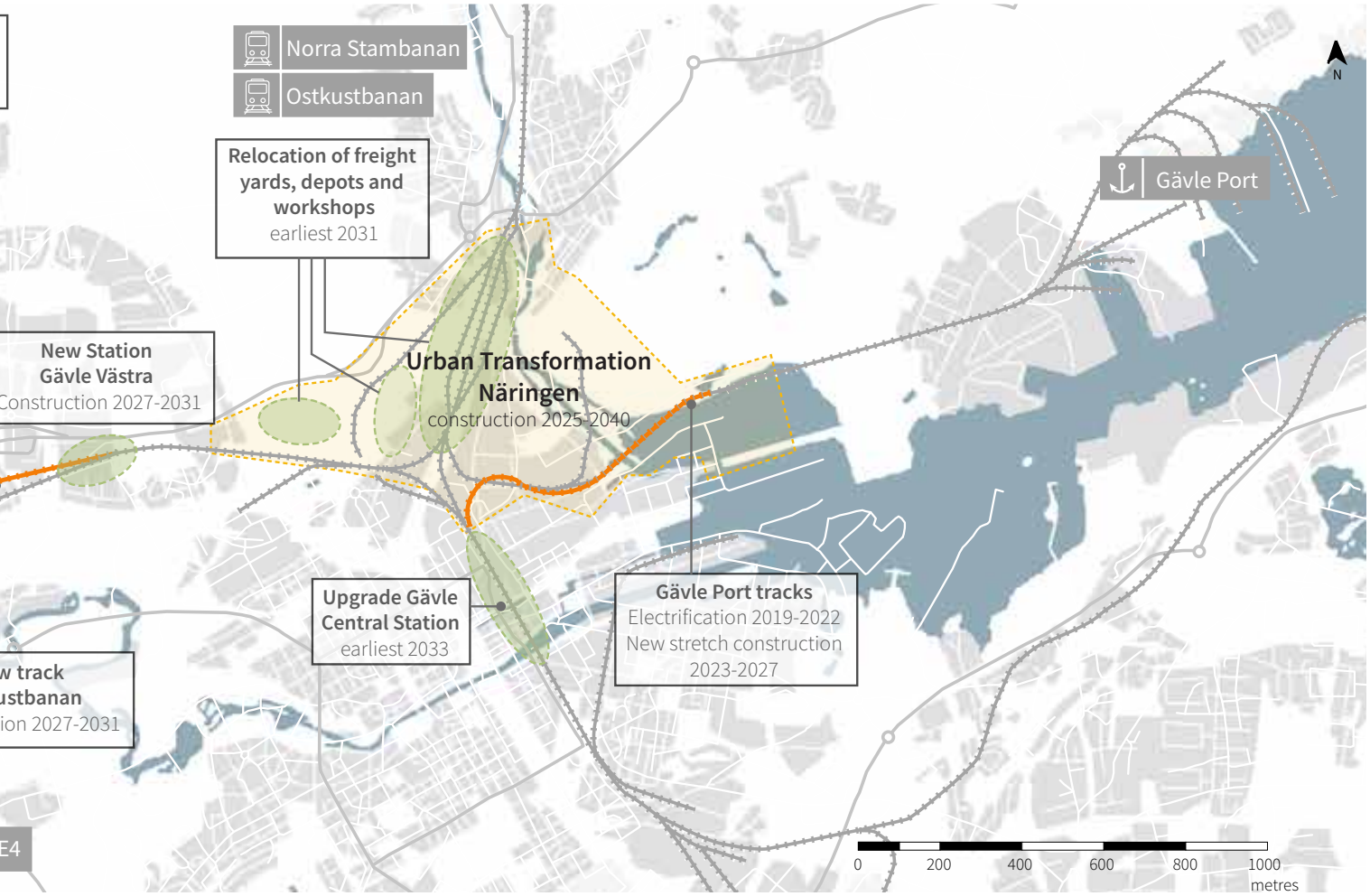




Areas within approx. 2 hours transport

Gävle boasts three railway trunk lines, three national arterial roads, the East Coast largest container port and proximity to an international airport.

The Stockholm- Märlarden region is one of Europe's strongest growth areas and Sweden's largest labour market.



^

Figure 14: Aerial photo of Näringen. The Gävle municipality's Näringen feasibility study area - outlined in yellow - is a total of 232 hectares, 212 hectares of land and 21 hectares of water. This thesis does limit itself to these boundaries, but uses this demarcation as a framework for commencing the research. Source: Photo by Gävle Kommun, annotations overlaid by author.

Designing for the *Compact City*

In the context of rapid growth and a housing shortage, the intensification of less dense areas is increasingly common. This strategy is commonly associated with the The Compact City concept. In the last 30 years or so, the Compact City has emerged as a leading paradigm in sustainable urban planning (Bibri 2020). Briefly explained, the compact city model is built on several key design strategies: density, compactness, diversity, mixed land use, sustainable transportation, green structure, and urban growth limits. Proponents of the compact city model argue that these strategies can contribute positively to economy, citizen health, social cohesion, and cultural dynamics, while reducing car dependency, lowering energy use, mitigating pollution, creating diversity, and limiting the loss of natural areas (e.g., UN Habitat 2014, 2015).

While recognising that the Compact City model is not without its flaws (critics argue that some of these benefits are not always true, and that the compact city can also lead to unfavourable living conditions for low-income groups if not well designed. See Bibri, Chapter 2.4, 2020), this thesis takes the position that, when used alongside other principles such as those relating to Nature-based solutions, Compact City ideas can be useful for two reasons: first, for understanding the motive behind brownfield development and framing the premise in which the design research takes place, and second, for helping establish a vision to guide sustainable urban design in the second part of this thesis.

1.2

Gävle is deindustrialising

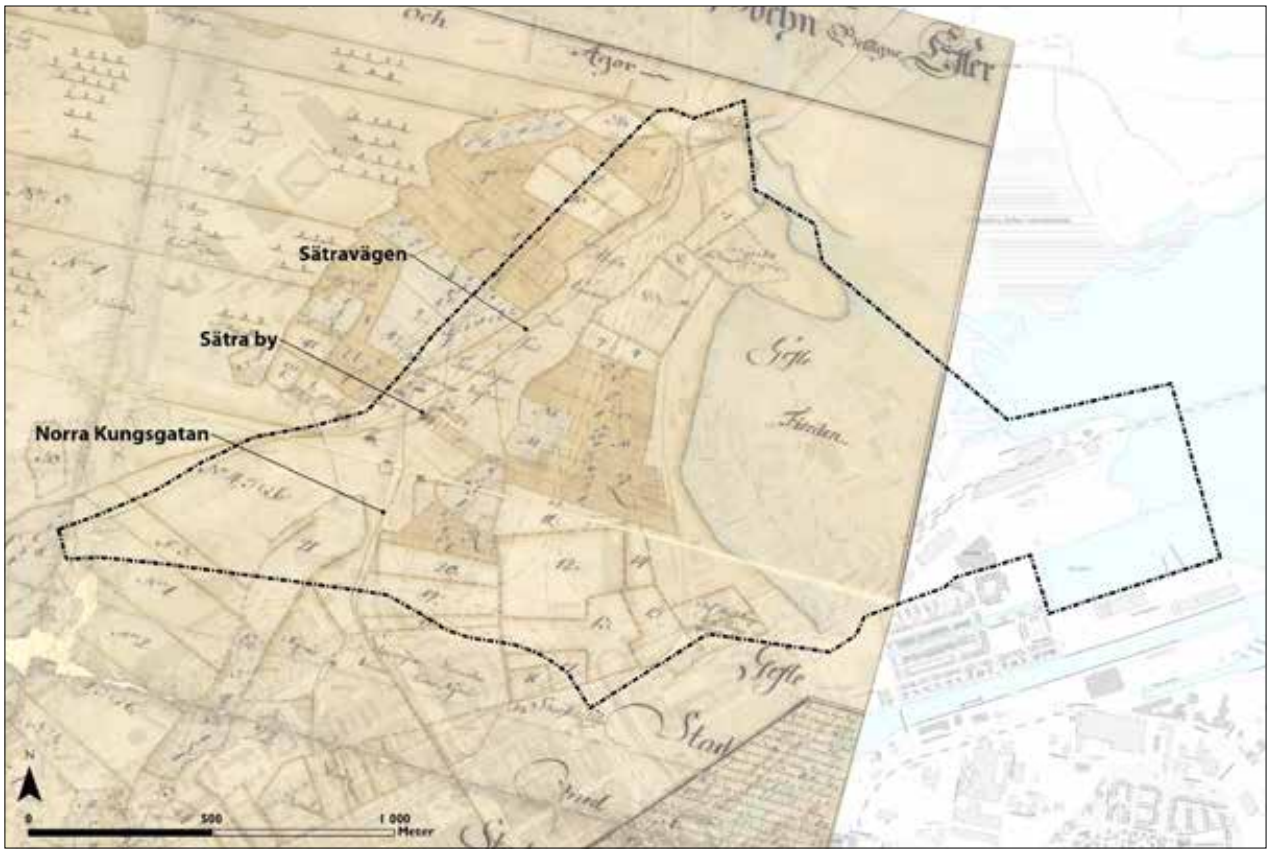
Gävle's plans to develop Näringen and relocate its remaining industrial businesses correspond with current interrelated global trends of post-industrial waterfront regeneration and compact city urban densification, although there are some nuances. This section considers the future identity of Näringen, identifying historic underlying drivers which have impacted the waterfront's transformation in the past, and continue to drive its future.

Early history at Gävle's waterfront

The changes at Gävle's waterfront have been largely defined by the city's maritime functions which have shaped the evolution of the city since the 15th century. What was once a tiny fishing village with small-scale farming nestled along a wetland bay, soon became the main port export city for the historical region of Norrland, and for the iron mining area of Bergslagen (Britannica 2012). Alongside iron, Gävle exported copper, wood, and tar and boasted successful fishing and shipbuilding industries (Port of Gävle). As a port town, only Stockholm and Lödöse (the precursor to modern-day Gothenburg) were larger.

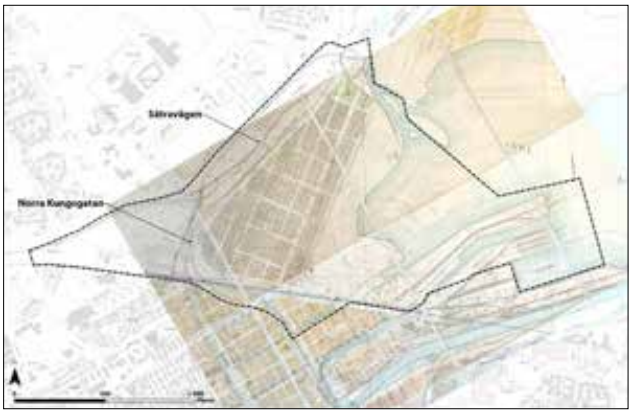
In the 18th century, like many cities all around Europe, Gävle's population growth and urban developments were largely accelerated by the Industrial Revolution which led to increased production and need for factory workers, and thus an increase in the process of urbanization (Arbetarbladet 2010). In 1800, 5410 people lived in Gävle, with this number increasing sixfold to 30,000 inhabitants by the end of the century. Gävle remained a strong industrial city until the 20th century, on par with the rapid growth of other major cities in Sweden. Over a hundred factories in Gävle produced everything from ships and textiles to candy, beer, and coffee (ibid).

In 1859, the first railway was introduced, connecting Gävle westward to the copper mines in Falun (GDJ Fonden n.d.). This was relatively early, given the first railways in Sweden only opened in 1856. A new connection to Uppsala, and onwards to Stockholm was opened in the 1870s, and later connections to Ockelbo and the Northern Mainline came in 1884. Historic maps show the railway lines continuing right through to the port, although many of these tracks have since been removed. Despite the historic breakthrough of the railway, Gävle's ships remained just as important (even until this day), transporting large quantities of goods over greater distances than was economical by train. As the number of ships increased, so too did their size, and in 1905 the port was relocated from Alderholmen to Frederiksskans Harbour (to the east of Gävle's inlet), with a railway link bridging Gävle with the new port across the bay (Port of Gävle n.d).



^ *Figure 15: Land survey map of Sätra's village estates in 1736.*
Coallated map source: Gävle Kommun. Historic map: Lantmäteriet

^ *Figure 16: Land survey map 1812.*
Changes to the shoreline evident at the south of the bay
Coallated map source: Gävle Kommun. Historic map: Lantmäteriet



^ *Figure 17: New City Plan (not realised) showing urban grid structure over Näringen. 1889-1890.*
Coallated map source: Gävle Kommun. Historic map source: Stadsingenjör C.L Almgren. Gävle Municipality Archive.

1960

A

Gävle's waterfront from the mid-20th century

At the neighbouring site of Näringen, the land consisted of undeveloped farm estates until the mid-20th century, when a General Plan was instigated in 1952, outlining a clear function-separation between residential and industrial uses in Gävle. Näringen was thus developed into the large-scale industrial-zoned area with the railway yard that remains today. Shipbuilding at Alderholmen (Fig. 19) ceased by the 1960s, and Gävle's former port and shipping yards remained largely abandoned until the 1980s, when a concept to transform the harbour into "an attractive lakeside district" was launched (Torget Arkitekter n.d.). By the 2000s, plans were in place to convert the area into a modern housing development. The first stages of what is now called Gävle Strand [*Gävle Beach*] were completed (Fig. 20), while the third and final stage is yet to commence.

^

Figure 18: Comparison between aerial photo of Gävle 1960 (A) and 2020 (B) shows the rapid transformation of Näringen over the last 50 years.
Photo Source: © Läntmateriet. Annotations overlaid by author.

>

Figure 19: Alderholmen during the 1920s. In the foreground is Holmkanalen and in the background Nyhamn. The area was primarily used as a storage place for timber and sawmill products.
Photo Source: Länsmuseet. Annotations overlaid by author.

>

Figure 20 (FAR RIGHT): Gävle Strand 2020. Modern housing developments lines the canal.
Photo Source: Balticman (CC) / Wikipedia

2020

B


golf course
N
Testeboåns Delta
Nature Reserve
infilled land
brownfield
Industrial
Näringen
Industrial
infilled land
brownfield
brownfield
Gävle Strand
housing

^

Figure 21: Photo series taken Februrary 2022 showing brownfield sites in Näringen.

A: The back face of an industrial plot which borders the nature reserve is home to adandoned waste and prone to flooding.
B: Large open space adjacent to the railway tracks is underused and littered with pallets.
C: Organic material mounds foreground the silo towers at Gävle Strand (adjacent to the Näringen site). The silos will be preserved in the Stage 3 development of the area.

On post-industrial brownfield transformation

Gävle's waterfront history resembles that of other historical port cities all around the world. Cities such as Melbourne (Docklands), London (Canary Wharf), New York (Hudson Park) or more locally, Norrköping (Inner Harbour) and Turku (Linnaniemi) in Finland, have all confronted waterfront landscape changes, where large-scale factory spaces and the shipping yards or timber mills which once occupied their shorelines are becoming increasingly redundant. Predominantly these spaces are replaced by housing and offices, in but in some cases, they are also reclaimed for large urban parks.

According to a recent business study which examines these shifts in Gävle, processes such as globalisation, digitalisation, and emerging technologies are likely drivers of such transformation (Sweco 2018). Globalisation is responsible in part since many companies which once manufactured in Sweden's smaller towns and cities, are now outsourcing industries to emerging economies in Eastern Europe and Asia. Digitalisation and technological innovation have also changed the way in which work is performed; services and production become more streamlined, requiring less manual low-paid services and an increase in

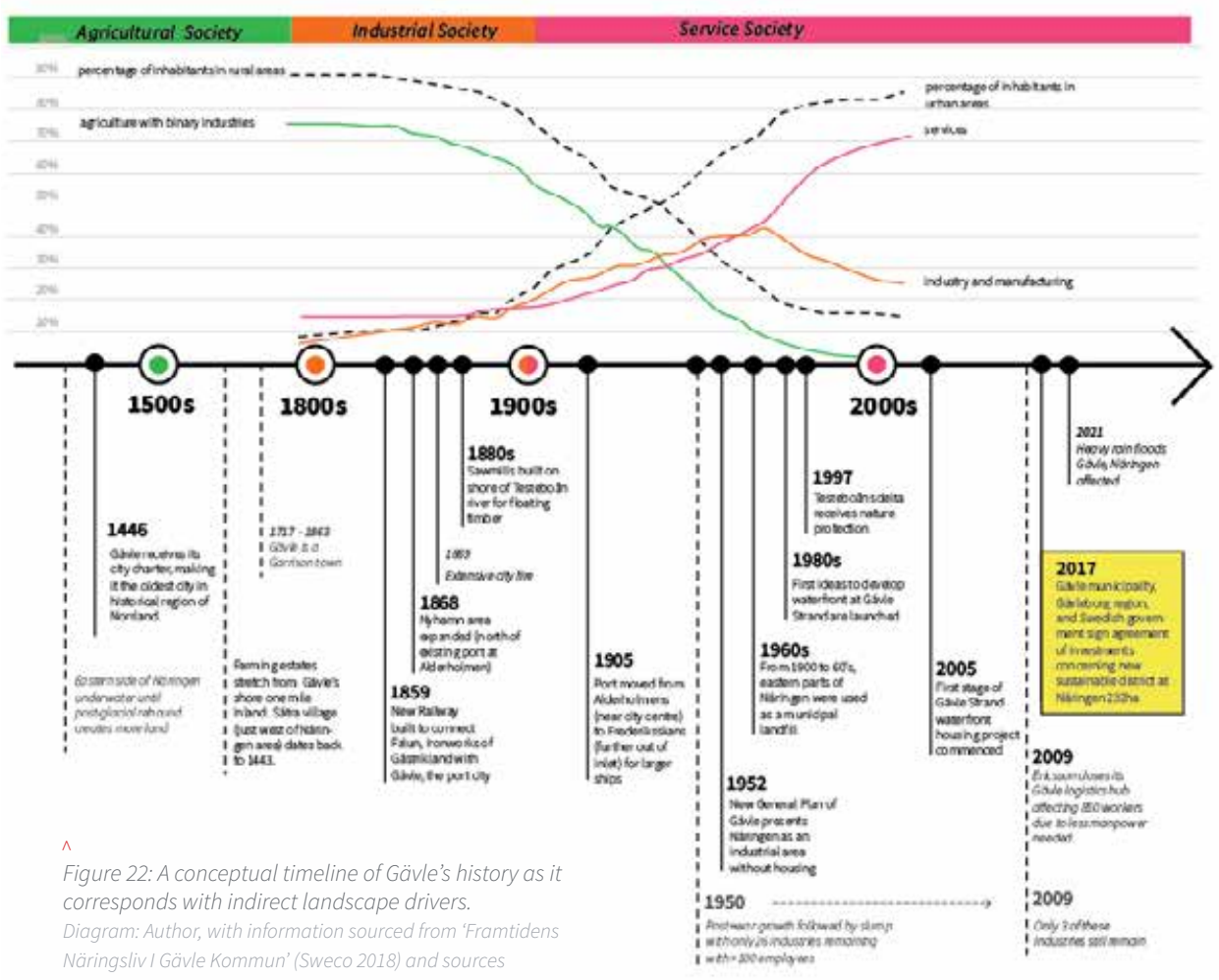
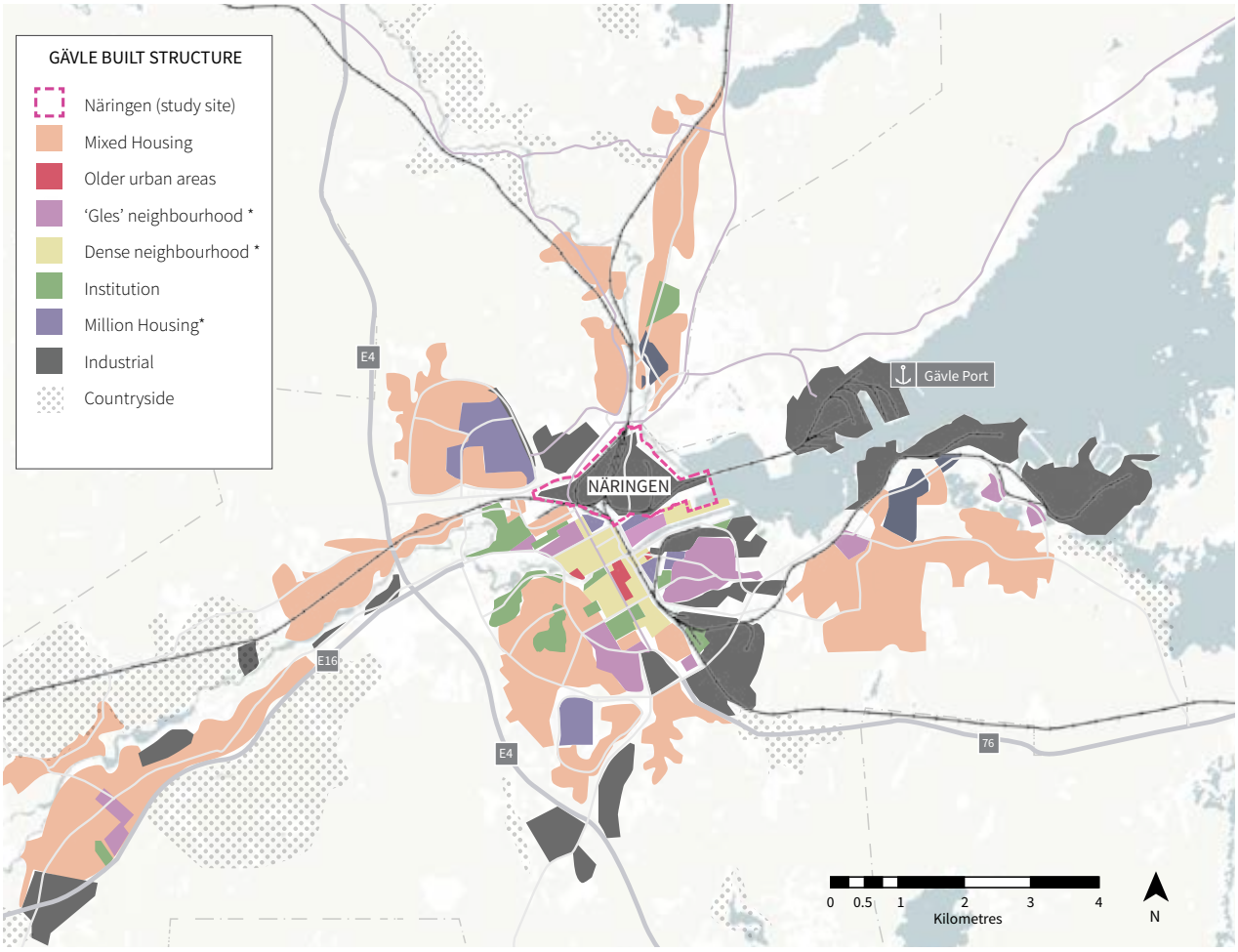


Figure 22: A conceptual timeline of Gävle's history as it corresponds with indirect landscape drivers.
Diagram: Author, with information sourced from 'Framtidens Näringsliv I Gävle Kommun' (Sweco 2018) and sources referenced in text.

higher-qualified occupations (ibid)(Fig. 22). At Näringen, service and knowledge-based companies are proposed in the redevelopment of Näringen, which risks pushing existing industrial and manufacturing businesses to the outskirts of the city. What does this mean for the future of Näringen (which incidentally translates to mean 'Industry') and its identity? What role do these existing businesses play in the future of Gävle? How can we ensure that the industrial cultural history of Gävle's waterfront is not lost forever?

v

Figure 23: General land use map of Gävle. Industrial areas (grey) occupy most of the coastal shoreline.
General Map: © Lantmäteriet; edited by the author with information sourced from Gävle Kommun



1.3

Gävle is disconnected

While Näringen's location close to the centre is well-suited for densification, the railway yard, railway tracks and large industrial plots act as barriers hindering pedestrian and cycling mobility. This section considers urban connectivity challenges for the project.

Railway barriers

The railway tracks and the railway yard at Näringen pose a major challenge for connectivity – especially pedestrian and cycling mobility – between Gävle's central city area and Näringen. The municipality has already identified these challenges and has proposed several changes. The first stage, which entails the electrification of the existing railway track to improve freight connections to Gävle's port, is currently underway and will eliminate a time-consuming transition to a diesel locomotive at the railway yard, reducing time to the port by 30 - 45 minutes (Trafikverket 2022). The next stage is to establish a triangular track junction which connects Fredriksskans Line (to the port) with the existing Bergslagen Line and the new Ostkust Line. Both stages intend to alleviate pressure and free space up from the railway yard. This will enable the relocation of the existing railway yard to Tolvforsskogen, freeing up valuable land close to the city centre. Still, the railway connection to the port, and the connection heading to the west will remain, posing a continued challenge for urban connectivity.

Impermeable Industrial Plots

Näringen's district's homogenous activity and large impermeable industrial plots, discourages pedestrian access in the area, and prevents easy access to the Testeboåns Delta nature reserve. In some cases, block sizes measure 500 by 300 metres, with no pedestrian thoroughfare. This is in comparison to the highly walkable street grid network of Gävle city centre which measures 60 by 90 metres. Pedestrian movement is further hindered by the lack of footpaths on most streets. In the old port area, fences and signs from private companies make it difficult to know if and where access to the water's edge is permitted.

>

Figure 24: Photos from the site (February 2020).

A: According to the sign, access to the shoreline near the railway port bridge is closed. No clear reason is provided.

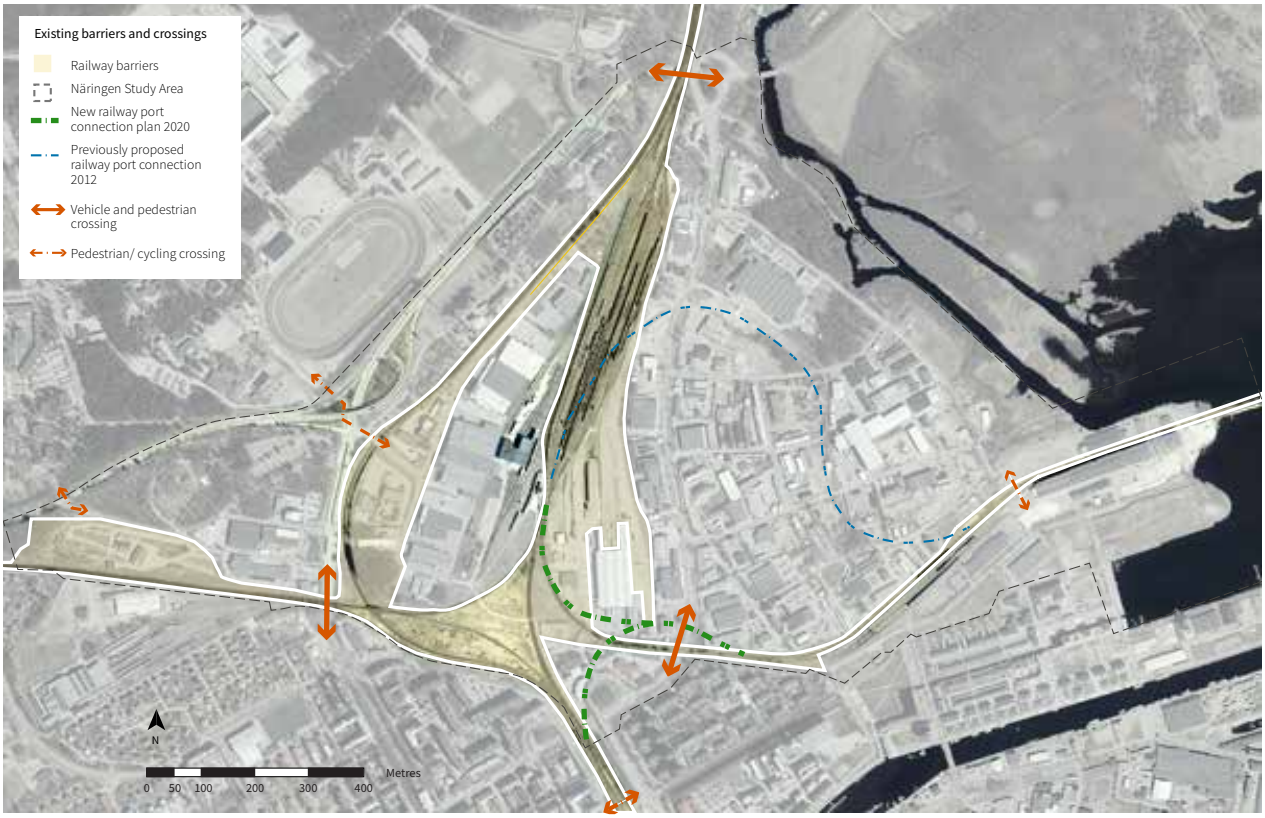
B: The railway fence at the site south of Näringen site prevents connectivity between different neighbourhoods.

C: A sign declares private access only, although cyclists and dog walkers can still be observed passing through to access the shoreline.

A

B

C


Existing barriers and crossings
Railway barriers
Näringen Study Area
New railway port connection plan 2020
Previously proposed railway port connection 2012
Vehicle and pedestrian crossing
Pedestrian/ cycling crossing
N
0 50 100 200 300 400
Metres

The Barrier Effect

From a regional planning perspective, the railways at Näringen are economically valuable, connecting Gävle Port with the rest of Sweden. However, from a local urban perspective, the tracks have a negative impact, reducing pedestrian and cycling connectivity between Näringen and the city centre. From an ecological perspective too, the railway's continuation across the bay interrupts both wildlife thoroughfare, and human accessibility to the nature reserve. These severances, in both urban and ecological theory, are examples of what is commonly referred to as the 'barrier effect' (van Eldijk et al. 2022; Rees et al. 2007).

In her book The Death and Life of Great American Cities (1961), Jane Jacobs refers to these barrier problems as 'border vacuums' - large single-use spaces such as transport infrastructure corridors with limited opportunities for crossing. Examples of borders might include railways, highways, main arterial routes, or edges of large impermeable blocks of land with a single use (e.g. large industrial plots or institutions such as hospitals). Borders such as the railway lines at Näringen, interrupt the continuity of the urban fabric, and even with bridges or passages beneath, they create dead-end streets, fragmented neighbourhoods, and psychological and social separation. Jacobs notes that railways in particular give rise to depilated urban environments on either immediate side of the tracks which are prone to graffiti, rubbish, and pollution (eg. Fig. 21, page 36).

From *Barrier* to *Seam*

Borders are an inherent part of the city, and Jane Jacobs herself highlights that we cannot simply eliminate all borders, since their functions as transportation corridors or institutions are imperative in the city. "Rather the point is to recognise that they are mixed blessings. If we can counter their destruction effects, these facilities will themselves be better served (1961:265)." She suggests that we must find strategies to create "seams" rather than barriers. She draws on the work of Kevin Lynch's Image of the City, quoting his definition of an edge: "An edge may be more than simply a dominant barrier, if some visual or motion penetration is allowed through – if it is, as it were, structure to some depth with the regions on either side. It then becomes a seam rather than a barrier, a line of exchange along which two areas are sewn together." (Lynch 1960: 100, See Jacobs 1961:267)

While the municipality and Swedish government have already taken measures to reduce the barrier effect at Näringen for the future, the railway will still always pose challenges for the project. Looking forwards, the thesis considers how the railways can be best optimised as an opportunity to also improve pedestrian and cycling connectivity, and as potential green corridor 'seams' for the future.

<

Figure 25 (ABOVE) : Aerial photo of large industrial plots at Näringen.
Source: Markus Boberg/Gefle Dagblad

<

Figure 26 (BELOW) : Existing barriers and crossings at Näringen. *Source: Orthophoto © Lantmäteriet, edited by author.*

1.4

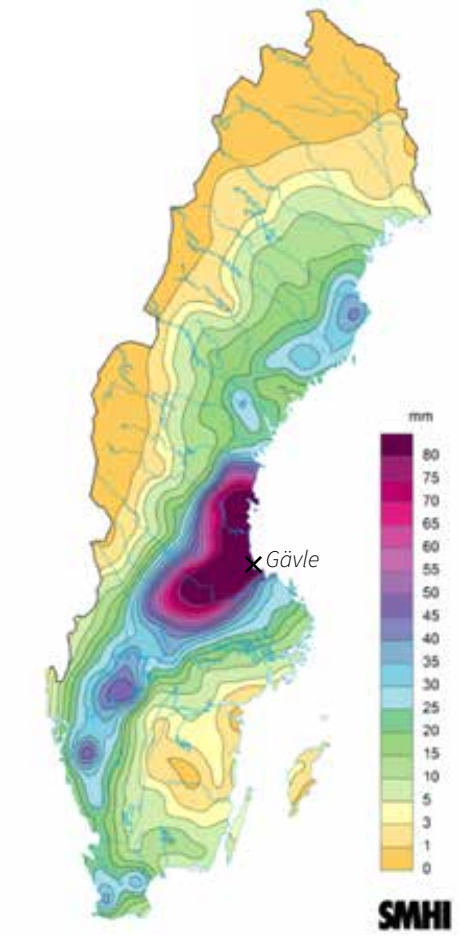
Gävle is flooding

Floods can typically be categorised in three main types: coastal floods caused by surges and high tides in the sea; fluvial floods resulting from Testeboån's river overflowing with high precipitation and melted snow/ice; and pluvial floods caused by precipitation cloudburst events in localized areas (WSP 2020). Of these types of flooding, Näringen has been identified as being most vulnerable to coastal and pluvial cloudburst flooding. This section elaborates on these risks and considers the problem in a wider context of urban climate change adaptation.

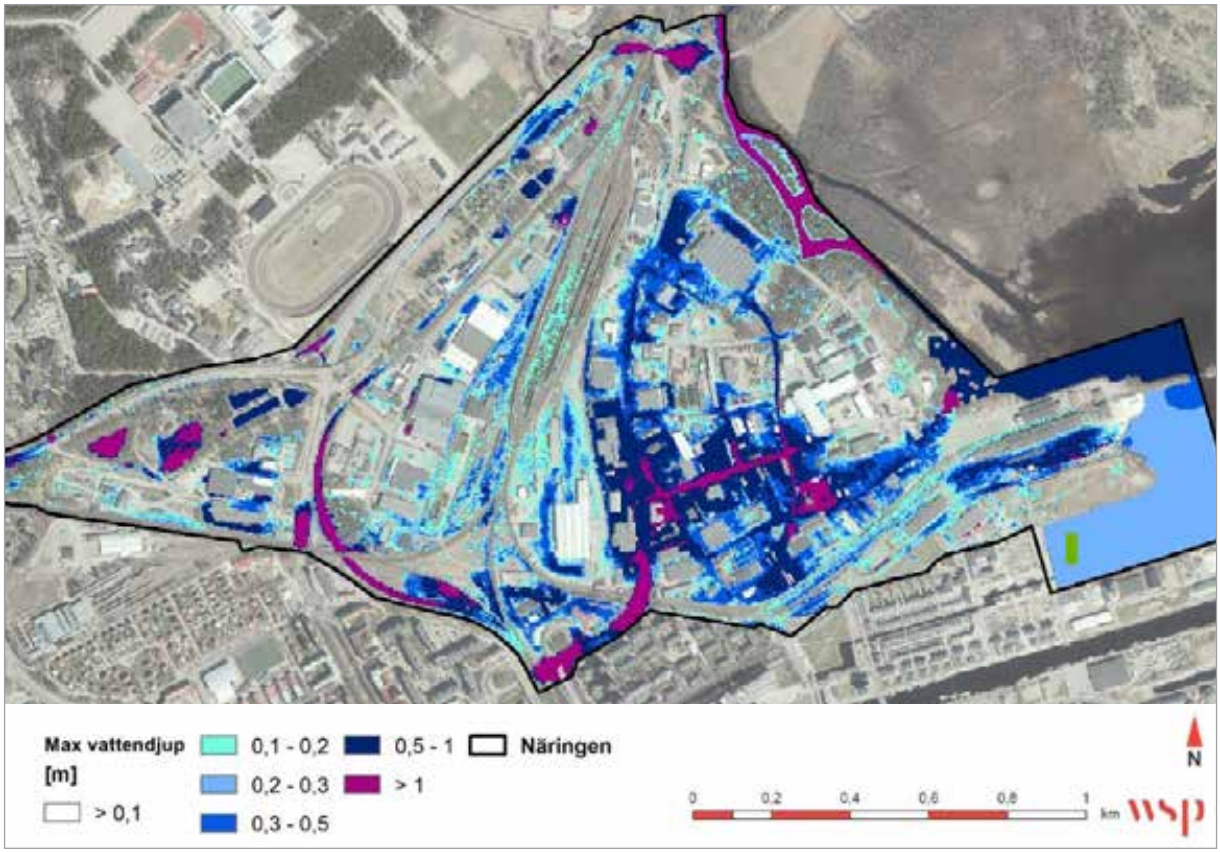
Cloudburst flooding 2021

In August 2021, the city of Gävle was hit with severe cloudburst flooding. In 24 hours, 162 millimetres of rain were recorded, over twice the amount that is expected to fall in an entire month.

At the Swedish Meteorological and Hydrological Institute (SMHI) a cloudburst event is defined as ≧ 50 mm precipitation per hour or ≧ 1 mm per minute (SMHI 2015). In Gävle, 100mm of rain fell in just 2 hours (Fig. 27). Näringen, with its distinctive lack of vegetated and permeable surfaces, and location at a low-point of a larger catchment, was one of the hardest-hit areas. With the existing stormwater pipe system overloaded, rain falling in higher areas of Gävle city drained towards low-lying areas such as Näringen, flooding streets and local businesses and incurring 2 billion Swedish Kroner in damage (SVT 2021; Byggindustrin 2022). According to SMHI, flooding because of cloudburst rain events is expected to occur more frequently across Sweden because of climate change (2015).

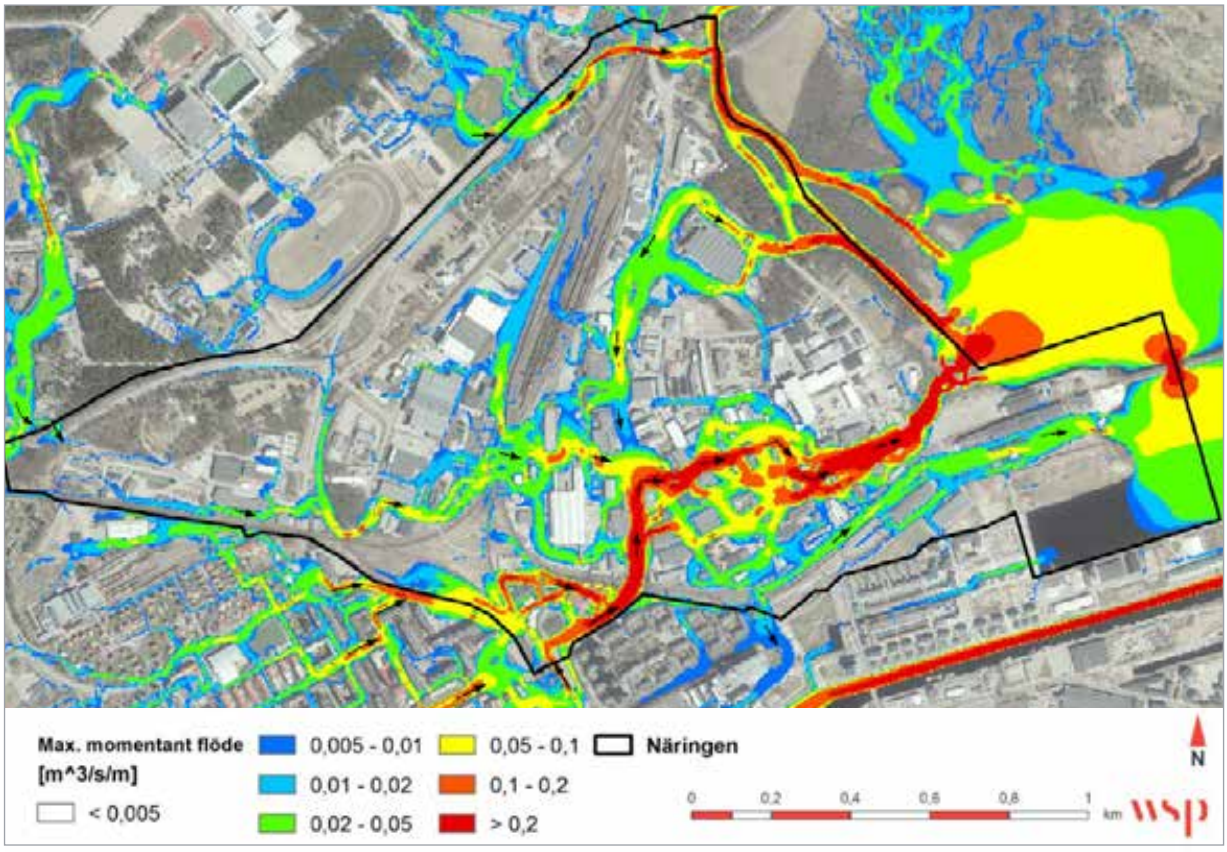


>
Figure 27: 2021-08-17, Daily precipitation Sweden, in mm. Based on preliminary data.
Source: SMHI. 'Gävle' annotation overlay by author



^ *Figure 28: Maximum water depth during a climate-adapted 100-year rainfall, Näringen, Gävle.*

Source: WSP/ Gävle Kommun



^ *Figure 29: Maximum momentary flow during a climate-adapted 100-year rain with run arrows, Näringen, Gävle*

Source: WSP/ Gävle Kommun

Coastal flooding

Coastal flooding also poses a risk to the low-lying coastal area of Näringen. According to the International Panel on Climate Change (IPCC), average sea levels have already risen by 3.6mm / year between the years 2006 and 2015 due to global warming (Oppenheimer 2019). In Gävle, the sea level is expected to rise from +0.07m (year 2019) to +0.40m (year 2100) and 100-year high tides from +1.37m RH2000 (year 2019) to +1.70m R2000 (year 2100). This takes into account the land uplift from isostatic forces.

Several factors need to be considered when estimating the rate of sea level rise, which is then used to determine suitable planning and construction levels. The Flooding Risks report for Näringen recommends that continued planning for Näringen should be based on a climate-adapted sea level at high tide with a statistical return time of 100 years, including wind accumulation and a safety margin depending on the type of structure (WSP 2020).

Table 1 outlines these proposed planning levels for the development of Näringen, which is used to inform the design for this thesis.

v

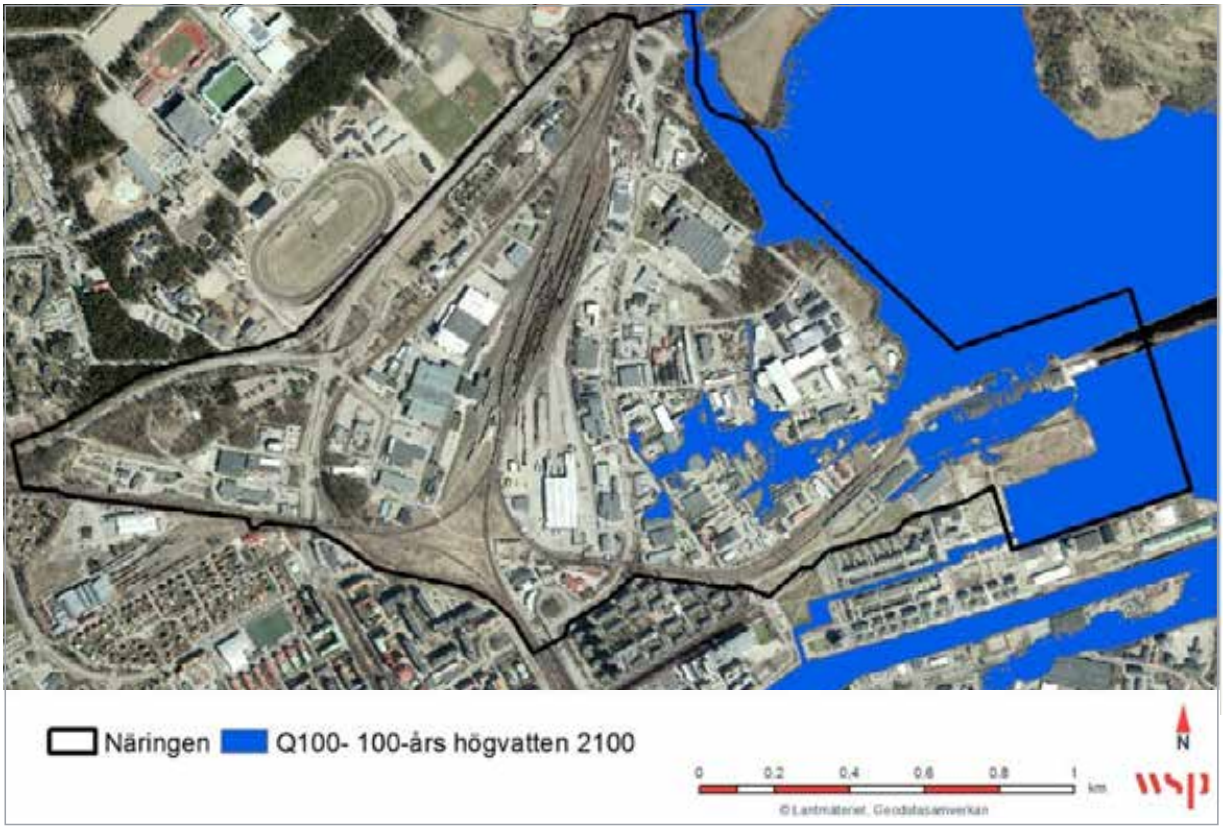
Table 1: Proposals for planning levels regarding floods from the sea in the event of new exploitation on the Industry

Information source: Gävle Kommun (2021) / WSP (2020)

Protected object	Dimensioning Level 100-year high tide 2100 inc. wind boost = +1.8m	
	Safety margin	Planning Level
Socially important new facility (eg. organisation with a long service life or very important function)	1.5m	+3.30m
Socially important activities	1.0m	+2.80m
Other buildings	0.5m	+2.30m
Access, road network, evacuation routes	max. 0.2m water depth	

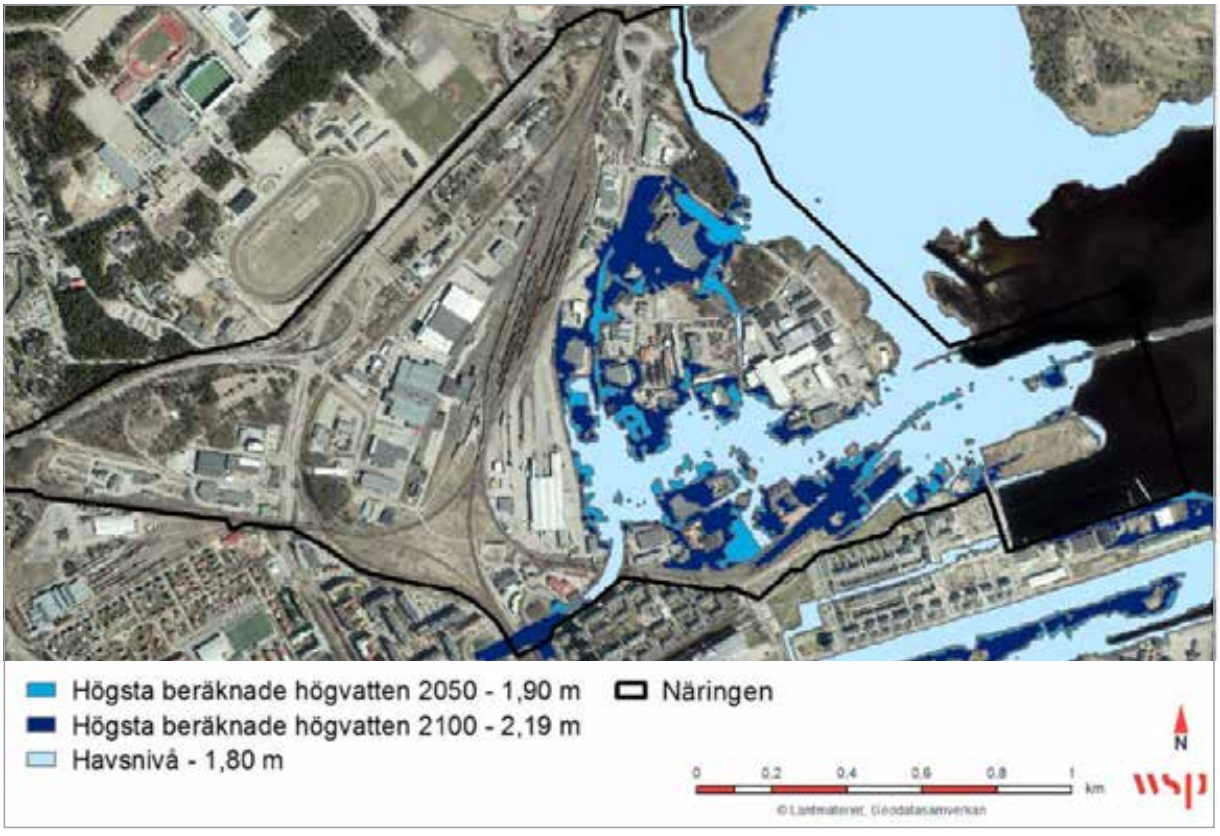
^ *Figure 30: Flooding in a residential area of Gävle after the rainstorms. August 18, 2021*

Source: Fredrik Sandberg / Getty Images



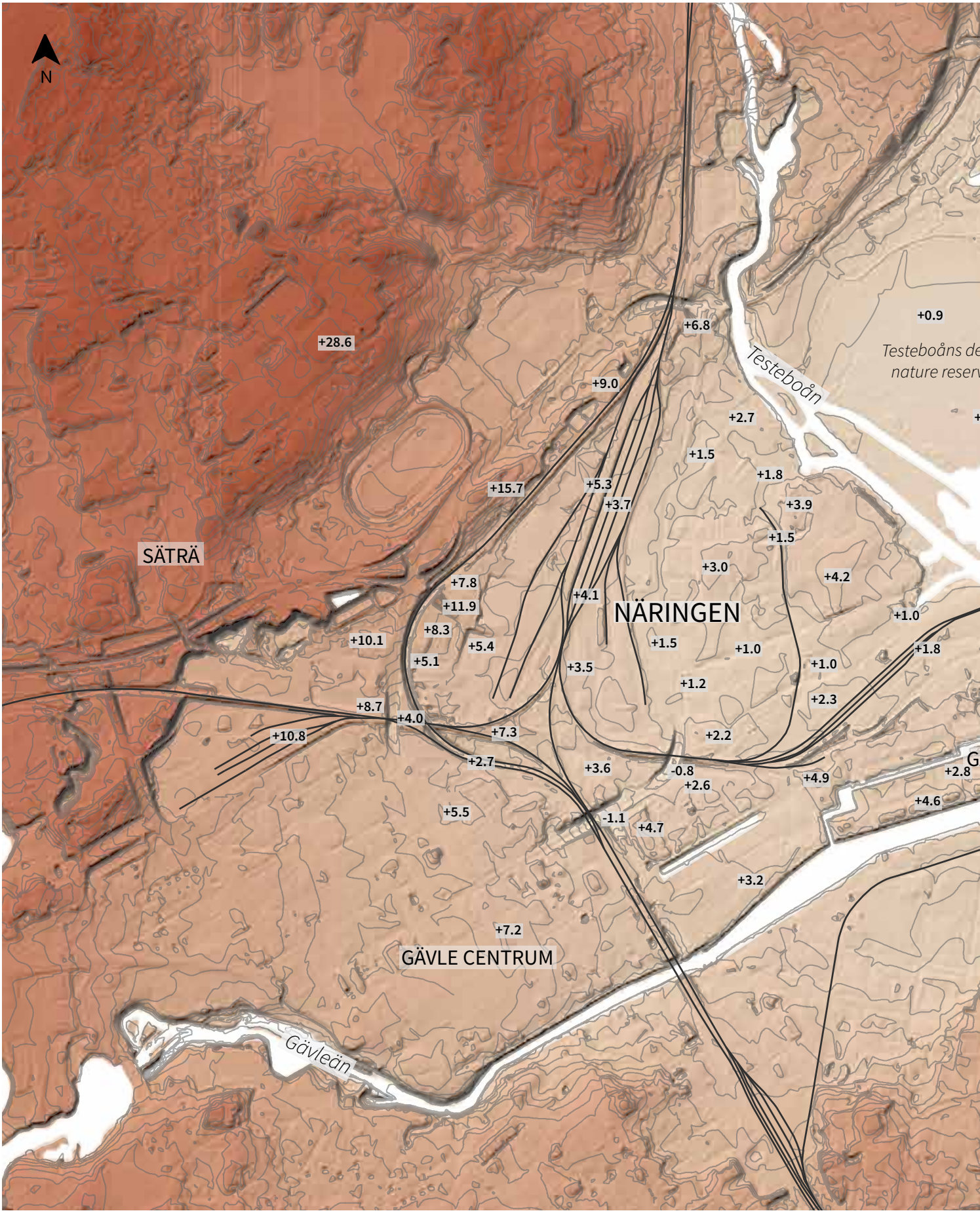
^ *Figure 31: Flood investigation for Q100 (160 m3/ s) in combination with 100-year high tide 2050 (1.41 m, RH2000).*

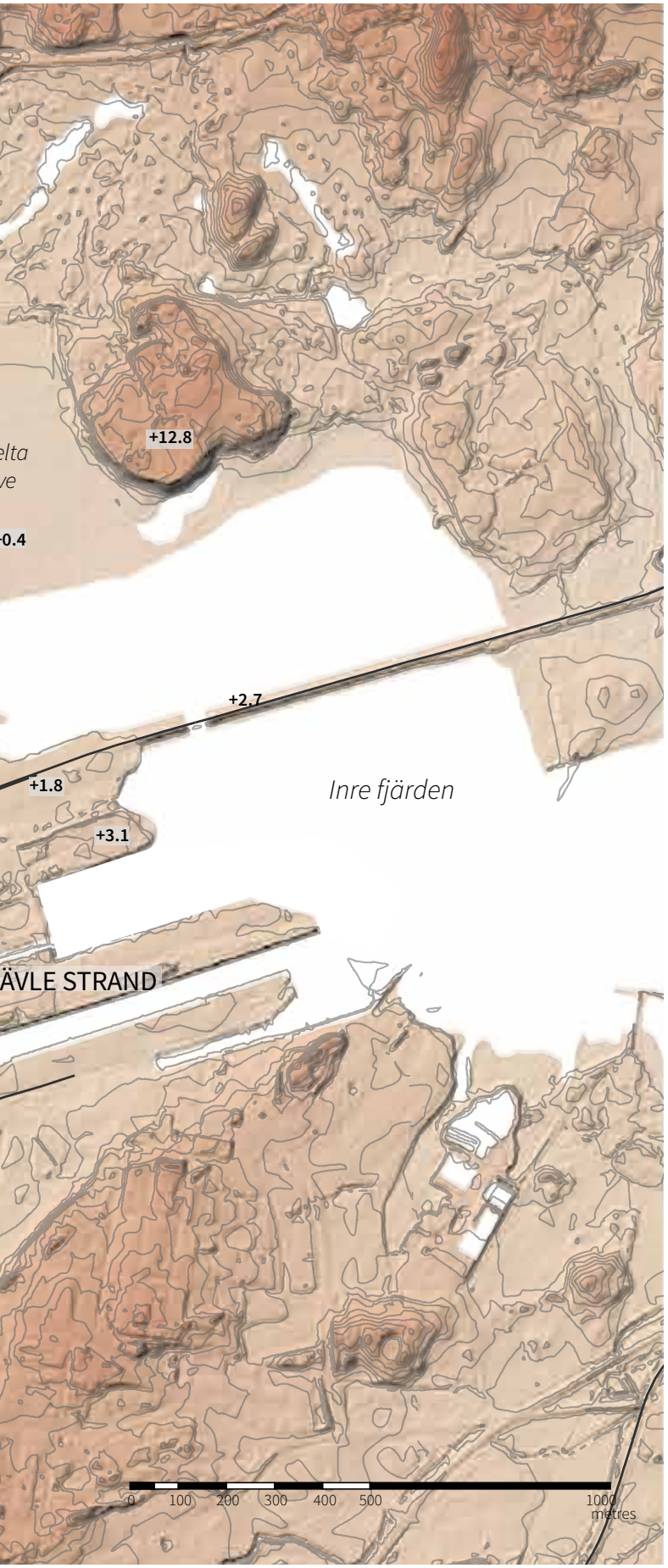
Source Gävle Kommun / WSP



^ *Figure 32: Flood distribution at 100-year high tide 2100 incl. wind storage (sea level 1.80 m RH2000), highest estimated sea level 2050 and 2100, corresponding to 1.90 m RH2000 and 2.19 m RH2000.*

Source Gävle Kommun / WSP


N
SÄTRÄ
NÄRINGEN
GÄVLE CENTRUM
Testeboån
Gävleån
+28.6
+6.8
+0.9
+9.0
+2.7
+1.5
+1.8
+15.7
+5.3
+3.7
+3.9
+1.5
+3.0
+4.2
+7.8
+4.1
+11.9
+1.0
+8.3
+10.1
+5.4
+1.5
+1.0
+1.8
+5.1
+3.5
+1.0
+1.2
+2.3
+8.7
+4.0
+10.8
+7.3
+2.2
+2.7
+3.6
-0.8
+2.8
+4.9
+2.6
+4.6
+5.5
-1.1
+4.7
+3.2
+7.2



Climate change: fight or flight?

In the face of flooding, and other climate related challenges such as heatwaves, droughts, water scarcity, windstorms, and wildfires there is an urgent need to change the way we plan and build our cities (EEA 2020). The term 'climate change adaptation' entails taking action to prepare our cities for the future (*'fight!'*). It can mean technical and physical changes to our existing urban environments, including rethinking the ways we construct buildings and infrastructure to integrate ecosystem services to strengthen resilience when climate-related events occur. Climate change adaptation is needed because, even if we significantly reduce greenhouse gas emissions, the lag in the climate system means that we will still be impacted by the emissions we have already put into the atmosphere (Shaw, R. 2022).

At Näringen, even with the use of Nature-based solutions to combat cloudburst flooding, some low-lying land will need to be raised in order to prevent coastal flooding as the sea level rises. These topographic changes will need to be performed in accordance with sea level rise predictions and planning level recommendations (i.e. as proposed in Table 1). However, given the uncertainty of these sea level rise predictions (which, incidently, do not take into account what happens beyond 2100) some might still question whether building a new city district at Näringen is worth the risk at all (*'flight?' - build elsewhere?*). As we progress towards the design phase, this thesis takes the stance that, regardless of the possible risks, the benefits to be gained from building at Näringen at least need to be explored. If anything, the flood risks provide an incentive for this exploration. (What can design do, if anything, to mitigate these risks?)

<

Figure 33: Topography of Gävle showing the lowest areas which are susceptible to both pluvial and coastal flooding.

Data Source: Elevation Data, Grid 1+ 2019 and Topographic Map © Lantmäteriet. Map compiled by author.

1.5

Gävle's delta is threatened

Näringen is located directly adjacent to a protected Natura 2000 site, the Testeboåns Delta nature reserve. This thesis positions the future planning processes of Näringen within this larger ecological context, outlining the delta's nature values, and the ecological challenges the area faces in the wake of expected growth.

Transformation of the delta

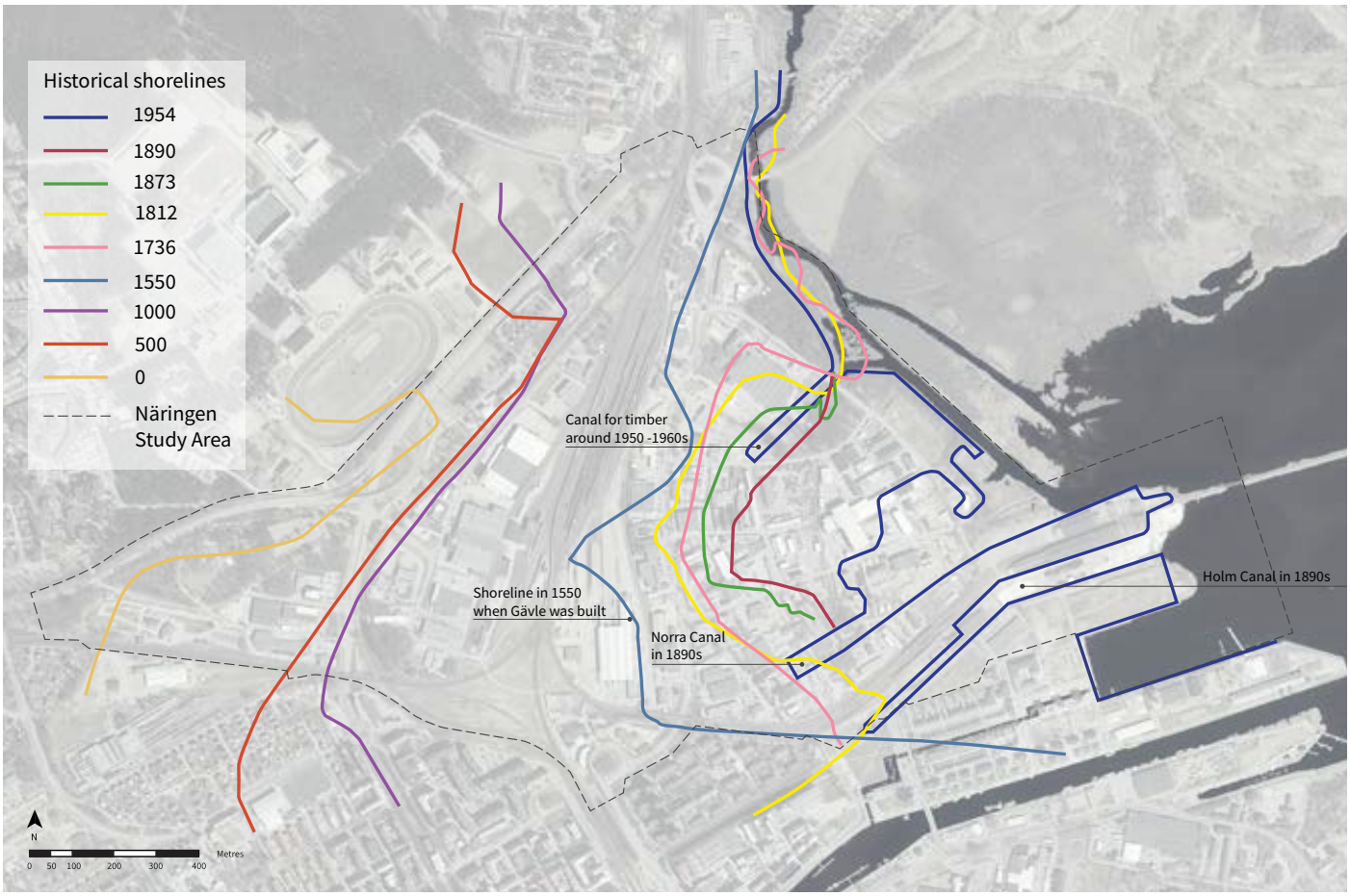
Over the last 100 years, the delta has seen radical changes, with the landscape we see today (Fig. 34) representing just a fraction of the once-extensive wetlands that formerly surrounded the bay. In part, this landscape transformation is linked to geomorphological processes, where isostatic forces have resulted in once-submerged areas where Näringen is now located, uplifted to form new land (this continues at approximately 6-7mm / year - WSP 2020). As the land to the west of Testeboåns river mouth rose however, so too did the opportunity to occupy it. Historic aerial photos and survey maps from the early 1900s (Fig. 35 & 36) show farming further from the shoreline, three humanmade inland water channels for ships and a municipality landfill on the riverbanks until the 1960s. In the 1950s, the development of Näringen resulted in the infill of the remaining water channels, the installation of an underground stormwater network, and large swaths of concrete laid out across the former farms of Sätra village, ultimately impacting the natural hydrological flows of the area. In 1997, Testeboåns Delta nature reserve was designated, preserving a portion of this former landscape. At the same time, its abrupt boundary with Näringen's disheveled edge at the Testeboåns river border (Figures 36-39) serves as a stark reminder of the delta's human-altered transformation.

^
Figure 34 (ABOVE): Photo of Testeboåns delta nature reserve. February 2022. This remaining undeveloped area of the delta now constitutes the Testeboåns delta nature reserve.

^
Figure 35 (BELOW): Aerial photo of Gävle taken in 1925 shows how the delta wetland landscape as pictured above, was once more widespread, constituting the area where Näringen is now located (left side of the image). Source: Länsmuseet

^ *Figure 36: Study area of Näringen overlaid on 1954 Economic map. The image shows the shoreline of Näringen and the canals that existed just before Näringen expanded.*

Source: Map compiled by KMV Forum / Gävle Kommun with maps from Lantmäteriet.



^ *Figure 37: Shorelines of Näringen from the Iron Age until today.*
Only a small area along the northwestern boundary was above water during the early Iron Age. Until approximately the early 1900s, the shoreline's slow shift eastwards can be attributed to land uplift. However, after the 1900s the shoreline's shift eastwards was also been sped up by human activity. Between the turn of the 20th century and the 1950s for example, the shallow harbour basin was filled with rubbish and/ or land infill.

Source: Map compiled by author using map and information sourced from Gävle Kommun/ KMV Forum. Orthophoto from Lantmäteriet. Caption text adapted from KMV Forum 2020

^ *Figure 38: Site photo (February 2022).*
A walking path on the border of the nature reserve runs alongside an industrial business fence.

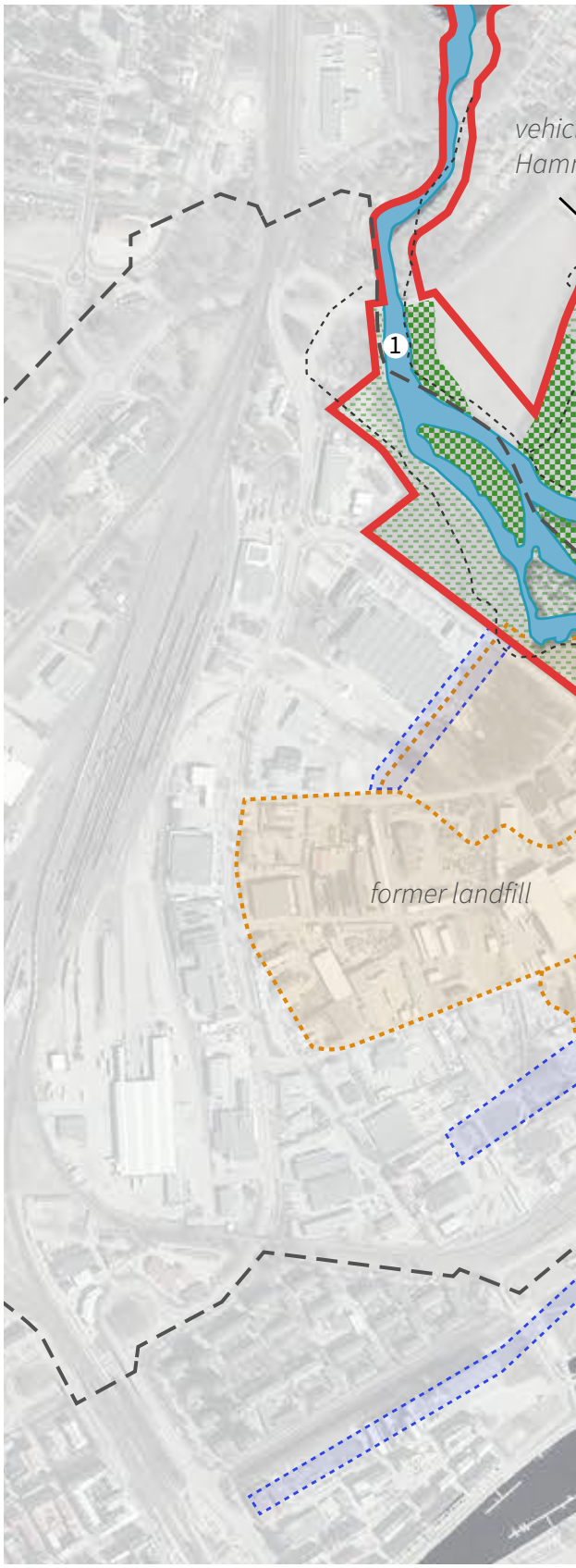
^ *Figure 39: Site photo (February 2022). The western edge of the nature reserve meets industrial buildings.*

^ *Figure 40: Site photo (February 2022). Abandoned tyres where Näringen meets the delta nature reserve.*

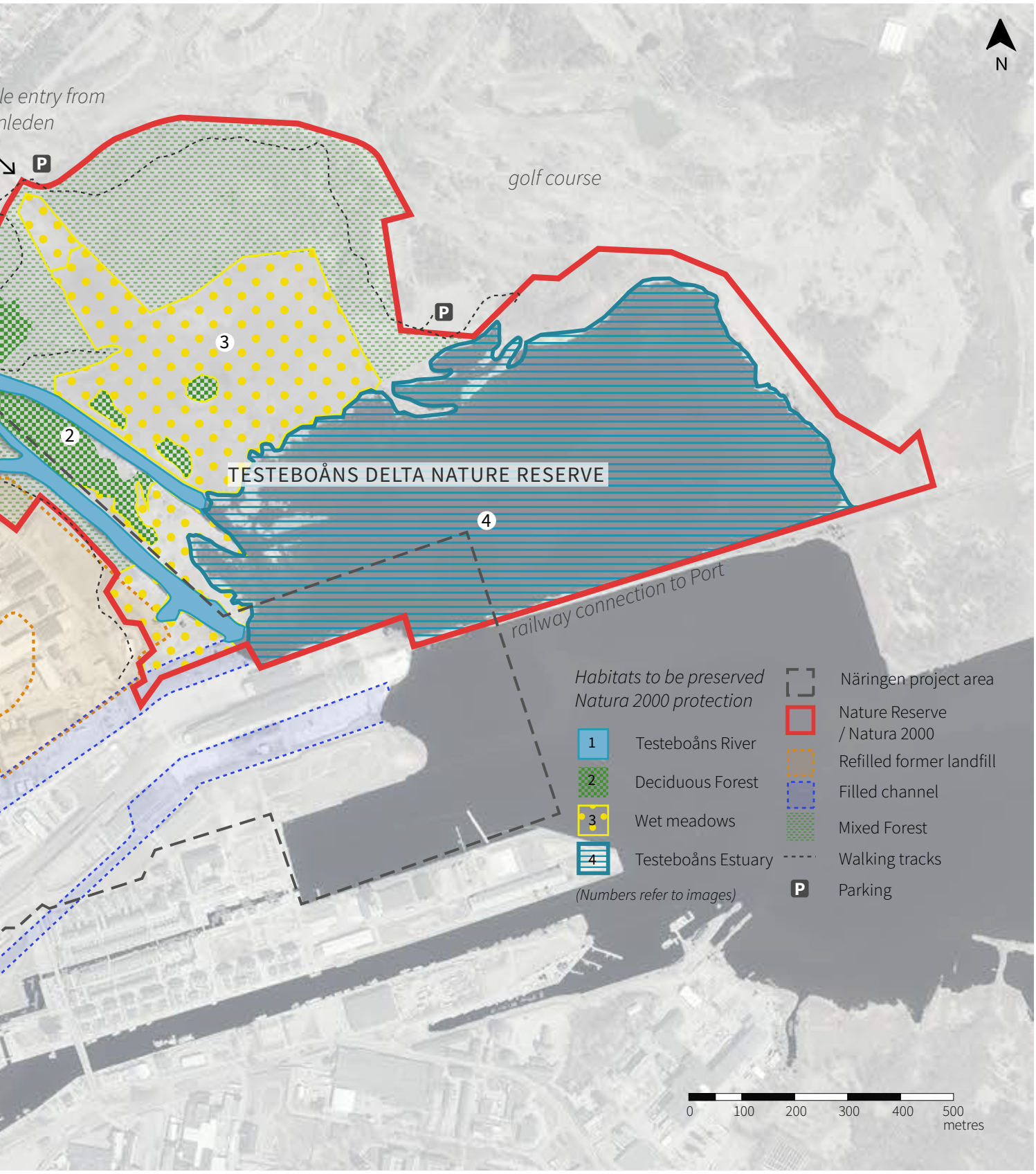
^ *Figure 41: Site photo (February 2022).*
Gravel desposits are stored at the edge of the nature reserve.

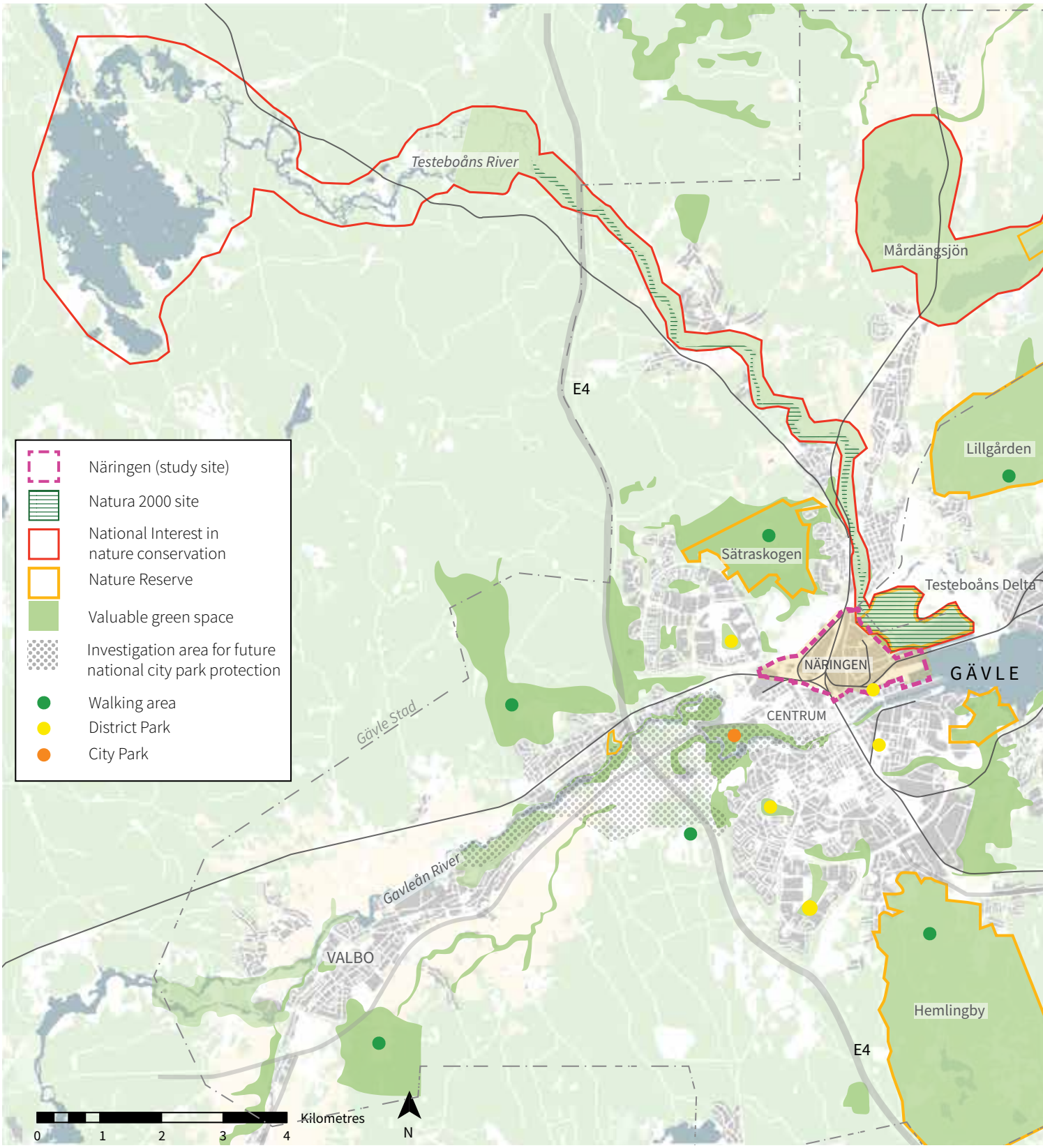
Ecological value of Testeboåns Delta

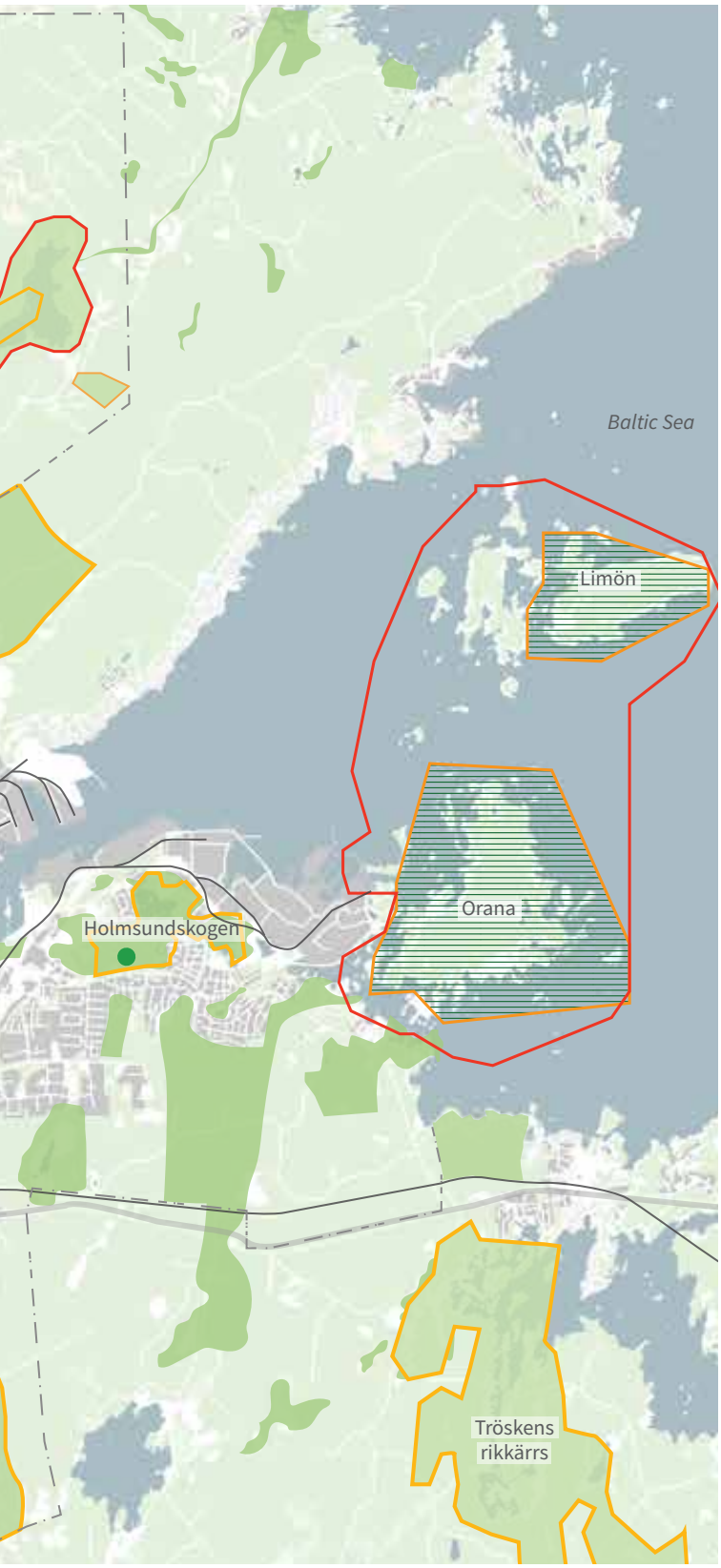
According to the Conservation Plan for the nature reserve area, today Testeboåns Delta is protected to preserve the open beach meadow wetlands, the rich beech forests with sticklebacks and the high bird values associated with these habitats (Fig. 42) – remnants of what existed more extensively in the bay prior to Gävle's coastal development (Lansstyrelsen Gävleborg 2016. See Fig. 35). While the ecological significance of the delta has diminished over the years, the estuary still constitutes an important resting place for waders and other wetland bound birds, while connecting migrating salmon with their spawning habitats located higher up the Testeboån's river (ibid). Other fish species such as trout and vimma are also found here and the area is a popular location for fishing. From a botanical perspective, the delta area is considered high value, harbouring at least 180 vascular plant species. According to the Conservation Plan, its flat wet ground vegetation type is unlike anywhere else in Sweden (ibid).



>
Figure 42: Map of habitat types at Testeboåns Delta to be preserved under Natura 2000 protection.
Data source: Testeboåns Delta Conservation Plan (Lansstyrelsen Gävleborg 2016). Map compiled by author.


N
le entry from
nleden
golf course
TESTEBOÅNS DELTA NATURE RESERVE
railway connection to Port
Habitats to be preserved
Natura 2000 protection
1 Testeboåns River
2 Deciduous Forest
3 Wet meadows
4 Testeboåns Estuary
(Numbers refer to images)
Näringen project area
Nature Reserve / Natura 2000
Refilled former landfill
Filled channel
Mixed Forest
Walking tracks
Parking
0 100 200 300 400 500 metres


Testeboåns River
Mårdängsjön
E4
Lillgården
Sätraskogen
Testeboåns Delta
NÄRINGEN
GÄVLE
CENTRUM
Gävle Stad
Gavleån River
VALBO
Hemlingby
E4
Näringen (study site)
Natura 2000 site
National Interest in nature conservation
Nature Reserve
Valuable green space
Investigation area for future national city park protection
Walking area
District Park
City Park
0
1
2
3
4
Kilometres
N



Social value of Testeboåns Delta

From an urban perspective, the Testesboåns Delta nature reserve's geographic proximity is a huge asset for the city, providing social benefits through increased access to nature and recreation opportunities which is widely known to have mental and physical health benefits. Activities in the reserve include walking, fishing, bird watching and trail biking. Small interventions such as a bird watching hut, and several fire pits can also be found along the walking trails, although these facilities are not always well maintained. The protected nature area also offers other ecosystem services such as carbon sequestration and urban heat island effect mitigation. Despite these recreation possibilities, access to the nature reserve is currently hindered by the large industrial area which reduces walkability to the nature reserve and diminishes the nature experience, especially at the west fringes of the nature reserve where piles of rubbish have been abandoned.

In Fig. 43, the nature reserve can be seen within a wider network of green structures around the city, one of the most proximate large areas of green space in the city .

<

Figure 43: Valuable Green Structure in Gävle.
Source: Topographic Map © Lantmäteriet. Edited by the author with information from Gävle Kommun.

Contamination challenges

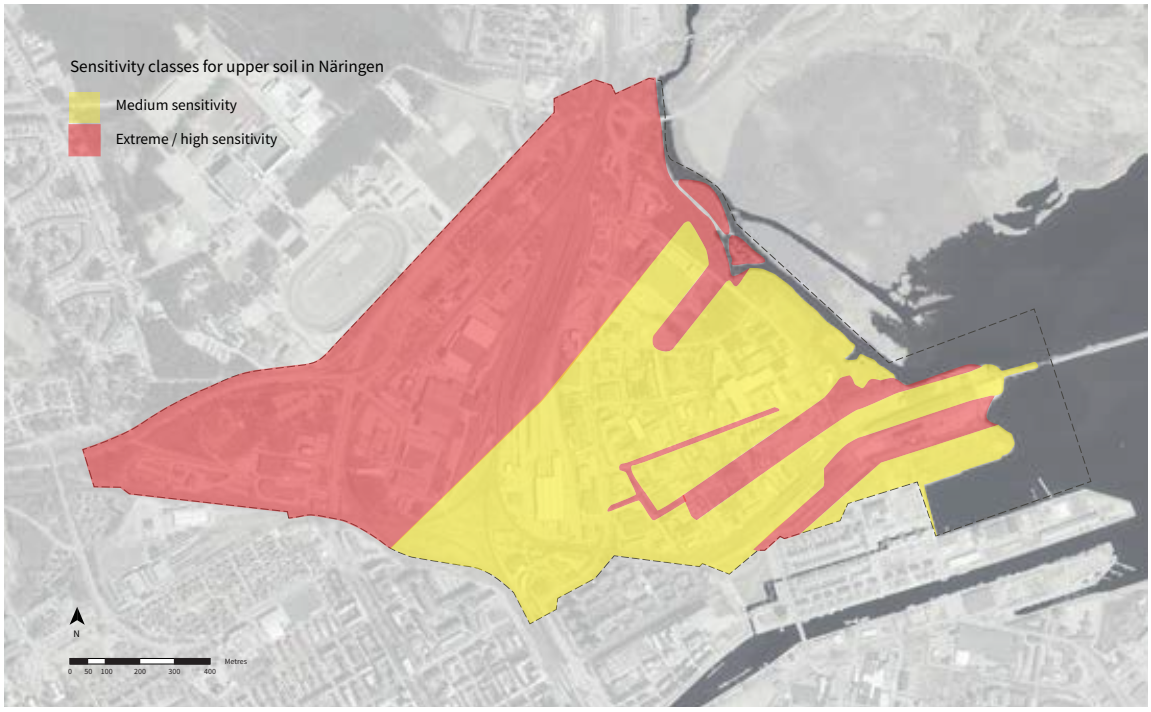
Although the proximity of the remaining delta nature reserve to Näringen is an asset, this proximity is also challenging since coastal development continues to threaten the ecological health of the delta. Today, while the conservation conditions of the remaining land parts of the reserve are considered favourable, the area's water biotopes are still exposed to negative impacts from previous and current industrial activities and developments which leak phosphorus and nitrogen pollution into the water and leads to eutrophication. (Lansstyrelsen Gävleborg 2016). Eutrophication results in reduced visibility depth, drifting algae mats, oxygen deficiency, and ultimately prevents fish from seeking food, and invertebrates with planktonic larval stages from settling. The railway connection between Näringen and Gävle Port also segregates the estuary from the rest of the bay, and it can be assumed that, as a result, the water has too low a salinity which also affects species composition (ibid).

On land, the delta (which has been drained and now consitutes the land at Näringen) suffers from heavy metal contamination (Gävle Kommun 2021). The pollution is the result of former uses of the site – such as the former landfill in the eastern areas, but also the result of previous and current functions such as the port, the sawmill, the railyard, storage, and the warehouses. Soil contamination is a common problem dealt with in brownfield regeneration projects and in Europe, the European Environmental Agency (EEA) estimates a total of 250,000 contaminated sites across Europe, and approximately 3 million potentially contaminated sites (EEA 2017). The extent of the contamination at Näringen is not entirely known, and further investigations are still being undertaken. According to the municipality, the future development must also plan to ensure the underground drinking water supply is not contaminated, since the west areas of Näringen are located within the catchment area of Gävle-Valbåsen, Gävle's water source. The complex geotechnic and hydrogeological conditions in conjunction with this contamination (Fig. 44), could also potentially limit the types of construction and foundation types which are permitted in different areas of Näringen (ibid).

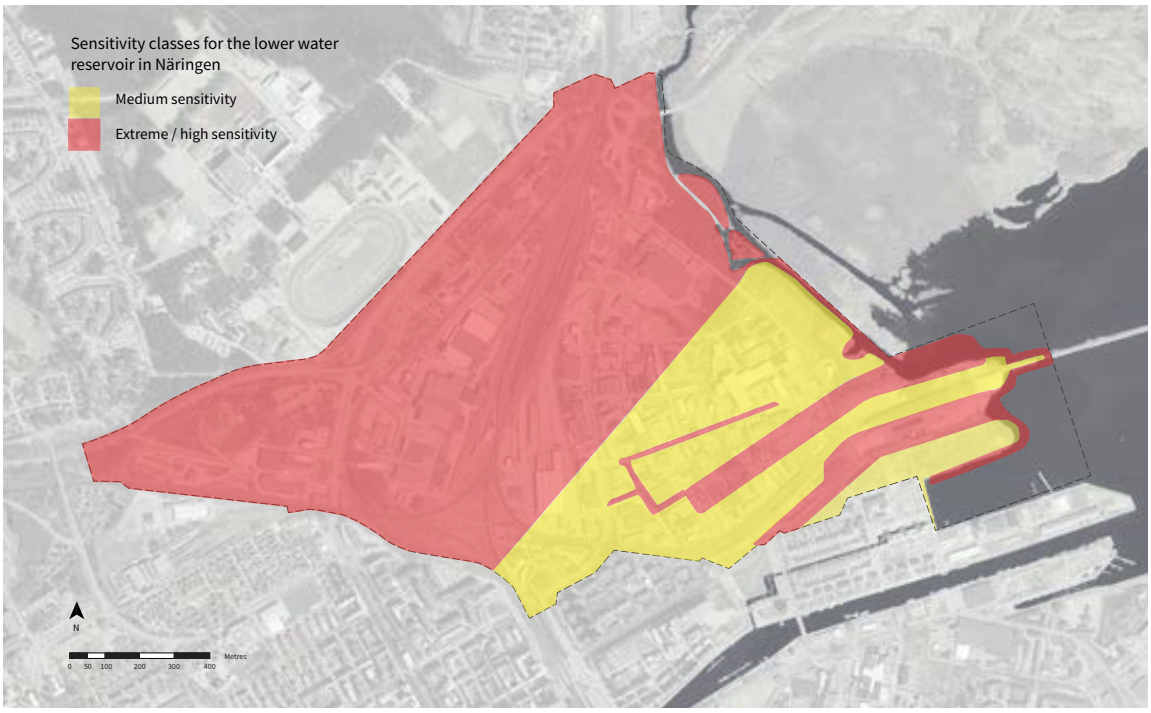
Wider context of habitat loss

The impact of human activity and the destruction of coastal wetlands at Testeboåns delta can be placed in a wider narrative of habitat modification, fragmentation, and loss. Throughout history, it has been estimated that over 70% of natural habitats in the habitable part of the planet have been either severely modified or exploited, and that we are still losing between 0.5% and 1.5% of wild nature each year (Balmford et al. 2003). Coastal marine ecosystems, where human activities are often concentrated, are particularly vulnerable - as human population in coastal areas has increased, so too has the pressure on coastal ecosystems through pollution, habitat conversion and the increasing need for coastal resources. In Europe, it is estimated that every day between 1960 and 1995, a kilometre of coastline was developed (Airoldi & Beck 2007). Since the beginning of the twentieth century, it is estimated that approximately two thirds of all European coastal wetlands have been destroyed (EEA 2006).

A



B



^ *Figure 44: Division of Näringen different sensitivity classes. A =Superficial soil layers. B = Lower water resevoir. Red area has extreme or high sensitivity, yellow area moderate sensitivity and green area low sensitivity (no areas).*
Source: Author, based off map by Geosigma in Näringen Feasibility study (Gävle Kommun 2021) with Orthofoto base map © Lantmäteriet.

Part 1: Discussion and Implications

Towards nature -based solutions

The site at Näringen has been shown to be multi-faceted and complex. How can we address these challenges and where to from here? In this section, I first summarise the issues discussed at Gävle with reference to other brownfield sites. Next, I explore the implications of these site findings for the design, and lay the groundwork for nature-based design solutions.

Coastal brownfield challenges: a summary

In this first section, the objective was to first address the site-specific research question: 'What site challenges must Gävle's growing district at Näringen confront in search of sustainability and social and ecological resilience? (Research question 1a) 'A low-lying coastal semi-brownfield site' responded by outlining 5 design-centred challenges for Gävle pertaining to urban growth; its industrial identity amidst deindustrialisation processes; urban barriers, in relation to railways which disrupt pedestrian connectivity; flooding, both from heavy rain and sea level rise; and a delta landscape threatened by historic and future human activity. These issues were identified as some of the major design questions relevant to Näringen's transformation into a sustainable district.

In answering research question 1b: 'What site challenges must *coastal urban brownfield sites in transformation* confront in search of sustainability and social and ecological resilience?', the findings from the site analysis continued into broader discussions, connecting the findings at Gävle with challenges from other sites, both brownfield and non-brownfield. The concept of the Concept City was discussed in relation to Gävle's quest for urban growth; waterfront transformation projects in general were presented as the result of deindustrialisation processes; Jane Jacobs' description of the barrier was identified as a problem for all urban areas; climate adaptation was highlighted as a likely goal for all flood prone areas; and finally, the issue of Testeboåns delta landscape degradation was framed within a global narrative of coastal wetland destruction and habitat loss. These discussions demonstrate that Näringen is not alone in facing these problems, in fact such issues are prevalent in many cities experiencing growth and looking to repurpose their once industry and port-focused coastlines.

Challenges of the Anthropocene

While each of these challenges is discussed separately within its own dedicated chapter, all these issues should in fact be considered interrelated. Urbanisation and new coastal

development in Gävle place pressure on natural systems and destroy habitats, while also increasing impermeable surfaces, which in turn contributes to cloudburst flooding. At the same time, greenhouse gas emissions from global manufacturing industries (as well as from power generation and other sources) contribute to global warming, leading to sea level rise which threatens coastal urban areas such as Näringen. This complex interplay between social and ecological systems, driven by urbanisation and the need to accommodate more people and more urban services, can be seen as typical challenges of the Anthropocene (Elmqvist 2021). As urban planners and designers tasked with distributing this urban growth in the face of such dilemmas, it becomes evident then, that no longer can our discipline be concerned with purely social objectives, but so too must it take into account wider ecological goals, for which we need a more holistic and integrated approach.

Nature-based solutions for resilient cities

Against this backdrop, the case for incorporating nature-based solutions (NbS) to redesign Näringen as a sustainable district, is presented. As briefly explained in the Introduction section, NbS involves working together with nature to tackle societal challenges such as those presented in Part 1: climate change adaptation and mitigation, protecting biodiversity, and ensuring human wellbeing in the face of growth (Seddon 2020). NbS invites synergies between these goals, seeking to tackle mulitple challenges at once.
While this might seem almost common sense, it is clear that such solutions were not previously used at Näringen - the abrupt border between industrial zoning and nature reserve serving as a stark reminder of former modernist monofunctional planning approaches that were typical of the 1950s era in which Näringen was conceived. In the Näringen of the future, there is a clear opportunity to redesign the district in conjunction with the surrounding delta landscape to promote multiple functions: eco-system services (fresh air, purifying functions, valuable recreation services for walking and fishing etc.), flooding mitigation, and increased habitats for birds, fish, insects and other species occupying the delta.

Blue-Green Infrastructure

Connecting to these ideas, and given Näringen's key location at the delta, Blue-green Infrastructure (BGI) offers a relevant concept for specifically approaching hydrological challenges (and opportunities) from a design perspective. The term BGI can be considered within the umbrella framework of NbS and builds upon the concept of "Green Infrastructure" – a landscape planning concept which was introduced to promote the integration of urban green bodies, and to highlight their multifunctional impact for both humans and non-humans in the city (Ghofrani et al. 2017). The integration of "Blue" to the existing "Green Infrastructure" landscape discourse emphasises the role of hydrology within these urban ecological systems, since vegetation depends on water and works reciprocally with local hydrology. Like "Green Infrastructure", BGI strengthens urban ecosystems, improves quality of life, but additionally places increasing importance on sustainable water and stormwater management. In a low-lying flood-prone coastal urban environment such as Näringen in Gävle, BGI measures (like retention and detention swales and lakes, cleansing biotopes/raingardens and green roofs for example) offer a way to strengthen flood resilience while simultaneously think about other urban issues such as connectivity, social and recreation spaces, and ecological remediation.


2.0

Part 2: The Design

Reconnecting Gävle's Delta

In search of resilience

In search of urban and ecological resilience, *Reconnecting Gävle's Delta* is an urban design proposal and vision to transform the industrial site at Näringen into a new mixed-use, water-centric district inspired by its delta landscape. At a macro-scale, the project proposes two key design moves: first, a new water channel and Delta Island restore part of the historic delta landscape at Näringen. Second, blue-green linear flood parks which connect both people and flood water to the sea and around which new neighbourhoods can be formed.

The Design is structured into two chapters (Fig. 45). First, 'A Reconnected Delta', presents the main masterplan image and overall guiding vision for the project. This is supported by 'Five Objectives for Näringen' (a 'flip' of the five challenges presented earlier in Part 1) which introduced the strategies used to inform scheme.

Next, the second chapter 'zooms in' and takes us through 'Three Key Spaces'. First, as a sort of prologue, 'The Delta Island' is presented as an initial key design move in the restoration of the delta landscape, and as a response to future sea level rise. Second, 'Shoreline Näringen' and 'Inland Näringen' showcase two examples of how the blue-green corridors which operate at macro scale could also inspire creative neighbourhood typologies at the meso scale. Reference projects are integrated into this section to support the design concepts and provide further inspiration.

Ultimately, The Design project argues that the ecological regeneration of the delta landscape, in conjunction with the environmental challenges posed by flooding, should be at the forefront of the proposal. This does not mean that urban needs are left behind; rather, the idea is to establish a reciprocal relationship where the urban regeneration project supports the ecological remediation of the delta and in turn, the healthy delta landscape supports a distinctive, high quality and inclusive urban structure.

How can we use design to reimagine Gävle Näringen as a socially and ecologically resilient district in the face of growth, a dilapidated and disconnected industrial context, flooding and a threatened delta landscape?

Research question 2 reposed, as a lead-in to the design section

>
Figure 45: Part 2: The Design Diagram Structure

PART 2: THE DESIGN

Reconnecting Gävle's Delta

2.1

A Reconnected Delta

A vision /

Five objectives for Näringen

2.2

Three key spaces

I.
The Delta Island
A park proposal

II.
Waterfront Näringen
BGI Neighbourhood Study 1

III.
Inland Näringen
BGI Neighbourhood Study 2

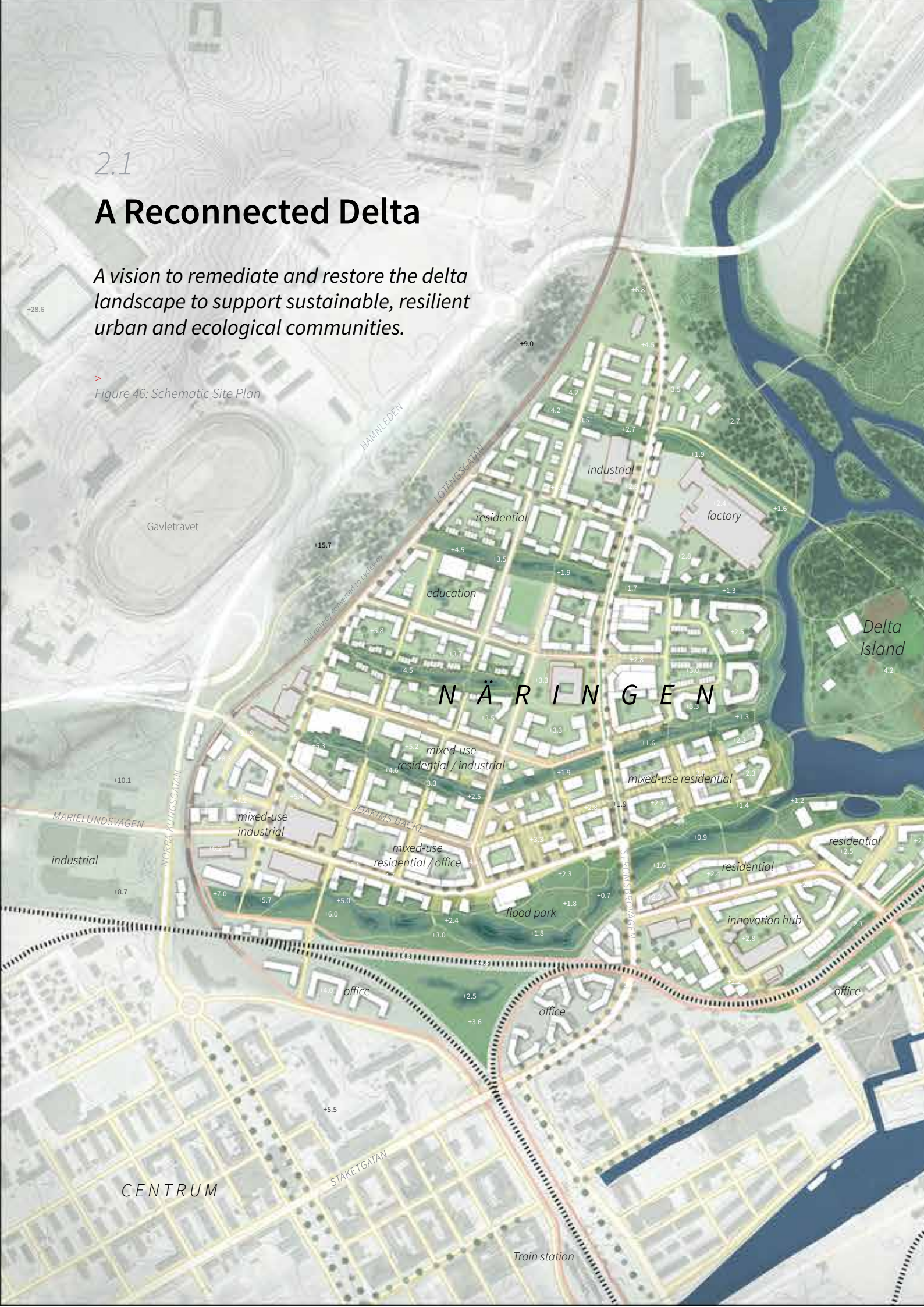
THE DISCUSSION

2.1

A Reconnected Delta

A vision to remediate and restore the delta landscape to support sustainable, resilient urban and ecological communities.

>
Figure 46: Schematic Site Plan

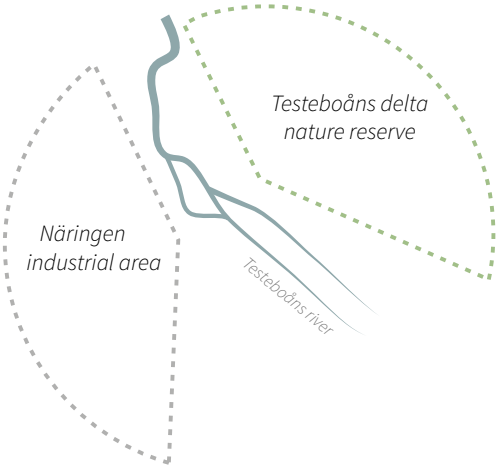



Testeboåns Delta
Nature Reserve
wetland
Inre Fjärden
Nyhamn
marina
Gävle Strand
ALDERHOLMSGATAN
N
0
50
100
200
300
400
500
metres

Existing: A Divided Delta

A delapidated urban condition disconnected from its delta landscape

Currently, the two sides of the Testeboåns river embody two very different conditions: on one side, the industrial development at Näringen, dominated by a vast swathe of impermeable concrete, contributes to the district's flooding problems. On the other side of the delta lies Testeboåns Delta nature reserve, a protected wetland area indicative of how Näringen would have also looked prior to its development. The site is a prime example of a divided landscape with where social and ecological systems have been planned for irrespective of one another.



^
Figure 47:
Diagram of existing site condition showing separated areas for 'nature' and 'city'.

^
Figure 48: Orthophoto with overlaid boundaries
Map Source: Orthophoto 2020 © Lantmäteriet. Text and boundaires overlaid by author

Vision: A Reconnected Delta

A reconnected delta landscape supports sustainable, resilient, interconnected urban and ecological communities.

The project identifies an opportunity for the redevelopment of Näringen to remediate and restore the historic Testeboåns delta landscape. By removing borders and reframing the Näringen project area alongside the nature reserve area, the design makes a clear statement: Näringen is part of a wider delta landscape ecosystem - all of which must be addressed together in the future transformation of Näringen.

Figure 49:
Diagram of proposed concept to integrate nature and the city.

Figure 50: Schematic Site Plan proposal: Testeboåns Delta

5 site challenges, 5 design objectives

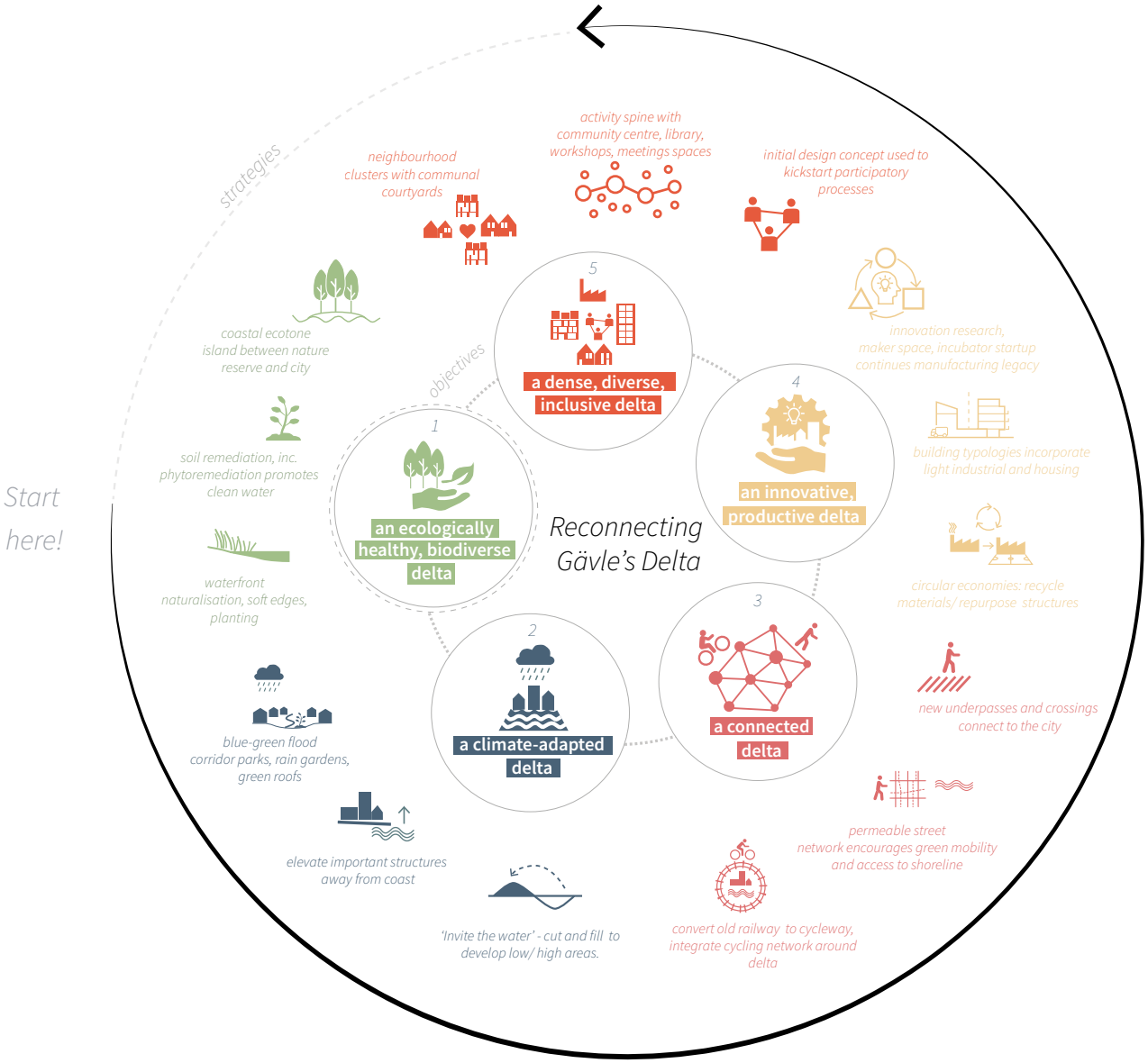
The design project argues that to develop a sustainable, resilient city for people, we must first restore the underlying ecological and - as is especially the case at Näringen - hydrological systems. Building off discussions from Part 1, a vision and objectives are developed by redefining the site challenges as objectives for The Design. Importantly, the order of these issues is 'flipped' with the ecological and environmental objectives taking priority (Fig. 52). On the following pages, these objectives are elaborated on in more detail, and supported by conceptual diagrams to explain the rationale behind different design elements at a macro scale.

^ *Figure 51: Context Diagram from Part 1*

Existing situation		*Proposed Design Objectives*
Site challenges identified in Part 1		*Challenges transformed into opportunities!*
1.5 Gävle's delta is threatened	→	*An ecologically healthy, biodiverse delta*
1.4 Gävle is flooding	→	*A climate-adapted delta*
1.3 Gävle is disconnected	→	*An accessible, connected delta*
1.2 Gävle is deindustrialising	→	*An innovative, productive delta*
1.1 Gävle is growing	→	*A dense, diverse, inclusive delta*

v *Figure 52:*

Five design objectives for Reconnecting Gävle's Delta

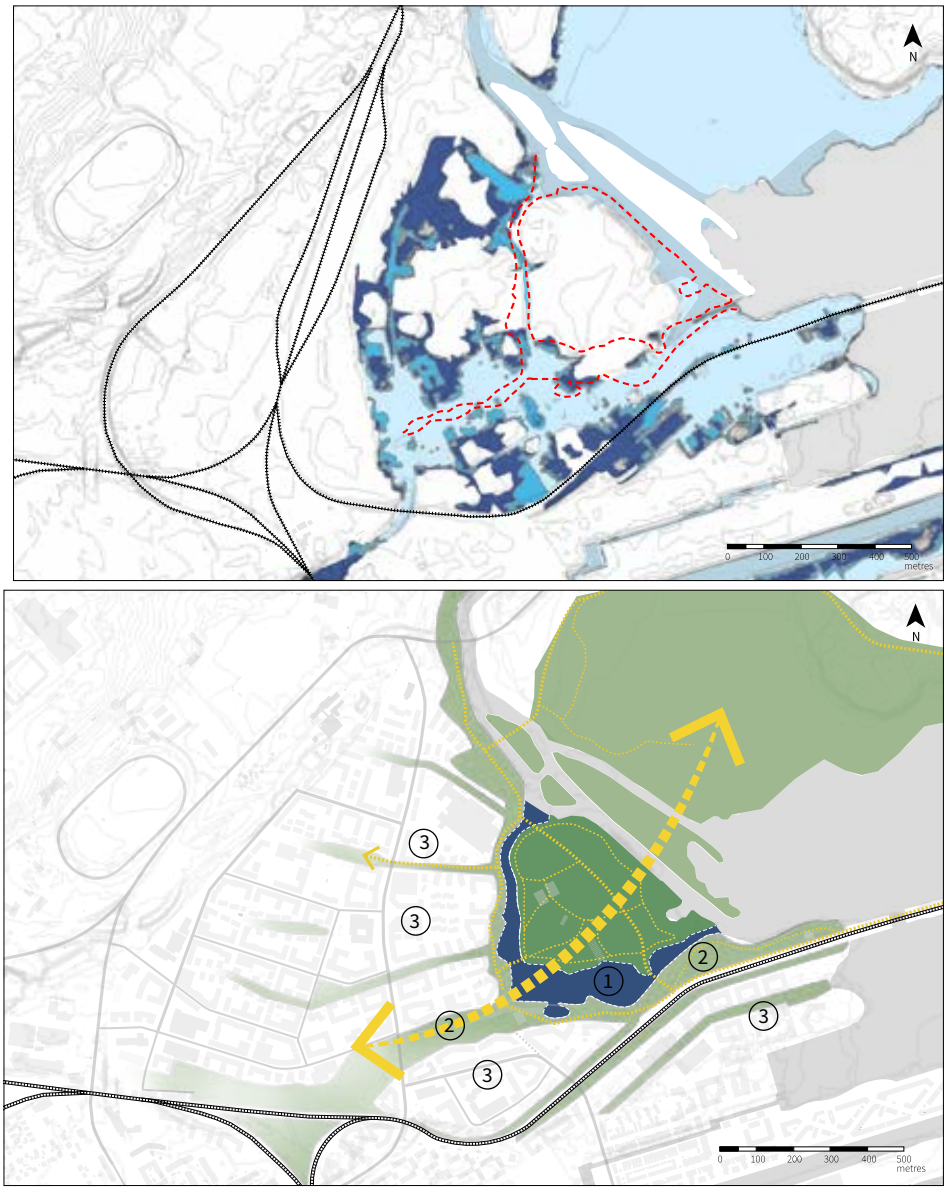


Objectives 1 & 2:

*An **ecologically healthy, biodiverse** delta/*
*A **climate-adapted** delta (to mitigate **coastal** flooding)*

Existing

Proposed



Existing: Future coastal flooding risk
Eastern Näringen is at risk of coastal flooding from sea level rise by 2100 if measures are not taken to protect the district.

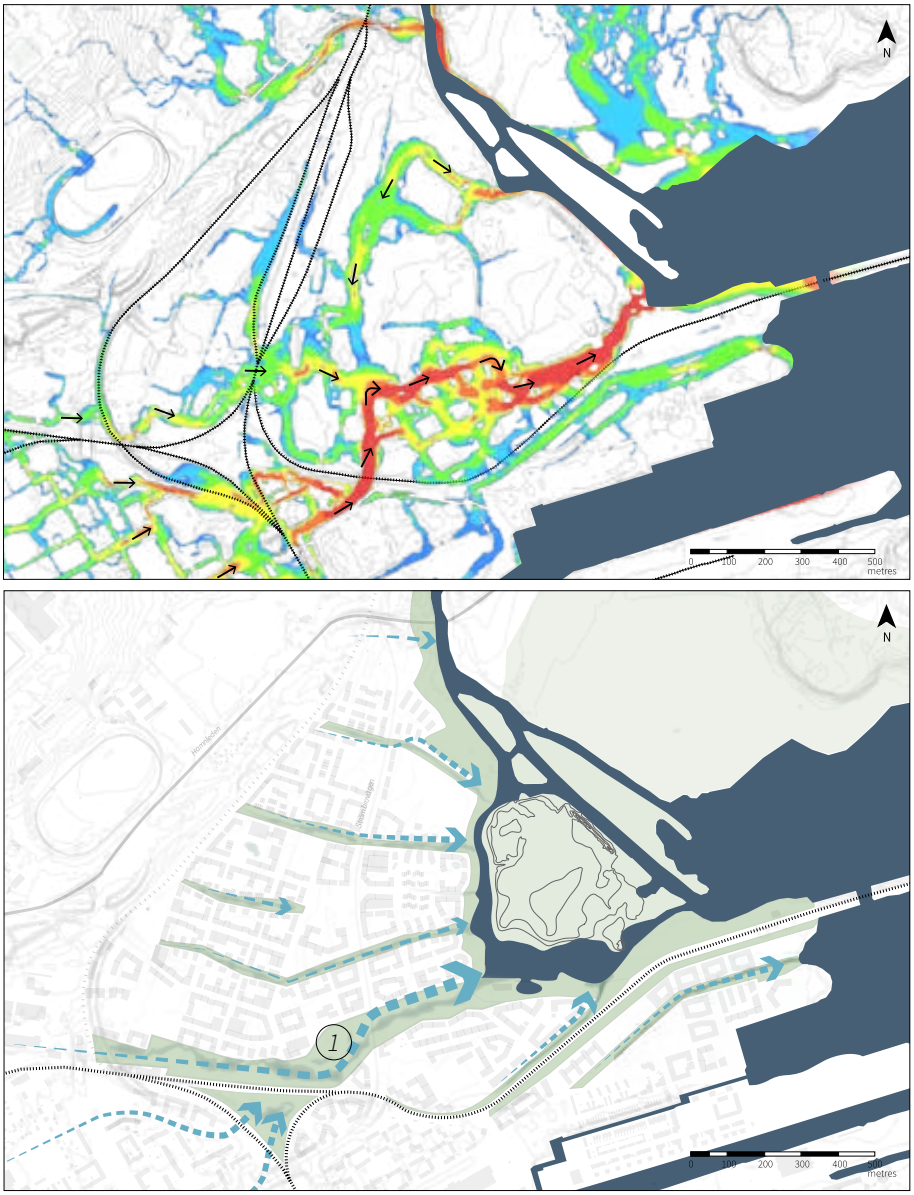
Proposed: 'Invite the water' -
A new island and water channel
Low-lying coastal areas are either: 1. Transformed into water channel; 2. Left the same elevation and "allowed to flood" or; 3. Elevated to minimum +2.8m. The new channel gives way to an island which acts as a 'stepping stone' between the city and the nature reserve, for people and ecological communities alike.

^ *Figure 53: Objectives 1 + 2 existing and proposed situations - coastal flooding.*
Base map source: See Figures List

Objectives 1 & 2:

*An **ecologically healthy, biodiverse** delta/*
*A **climate-adapted** delta (to mitigate **cloudburst** flooding)*

Existing



Proposed

Existing:
Increasing risk of cloudburst flooding
Recent heavy rain events (2021) demonstrated Näringen's susceptibility to flooding. Its low-lying geography results in rainwater from the upper catchment flowing down towards Näringen. Its existing grey infrastructure (underground pipes and sewers) are unable to deal with such high quantities.

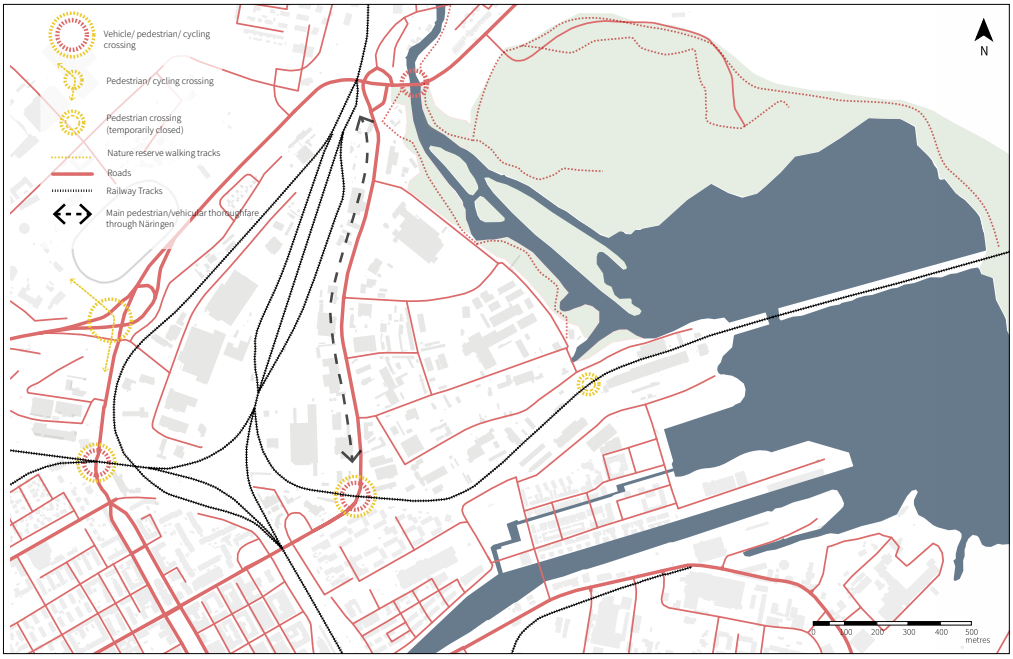
^ *Figure 54: Objectives 1 + 2 existing and proposed situations - cloudburst flooding.*
Base map source: See Figures List

Proposed: Blue-Green Network
Inspired by flood path modelling, Näringen employs a new blue-green network including linear stormwater parks which connect heavy rainwater and people to the sea. The largest stormwater park (1) deals with water from outside Näringen, while the other stormwater parks manage local water run-off. Other measures such as rain gardens in streets and courtyards manage water locally by delaying flows and / or infiltration. The parks act as ecological corridors for flora and fauna.

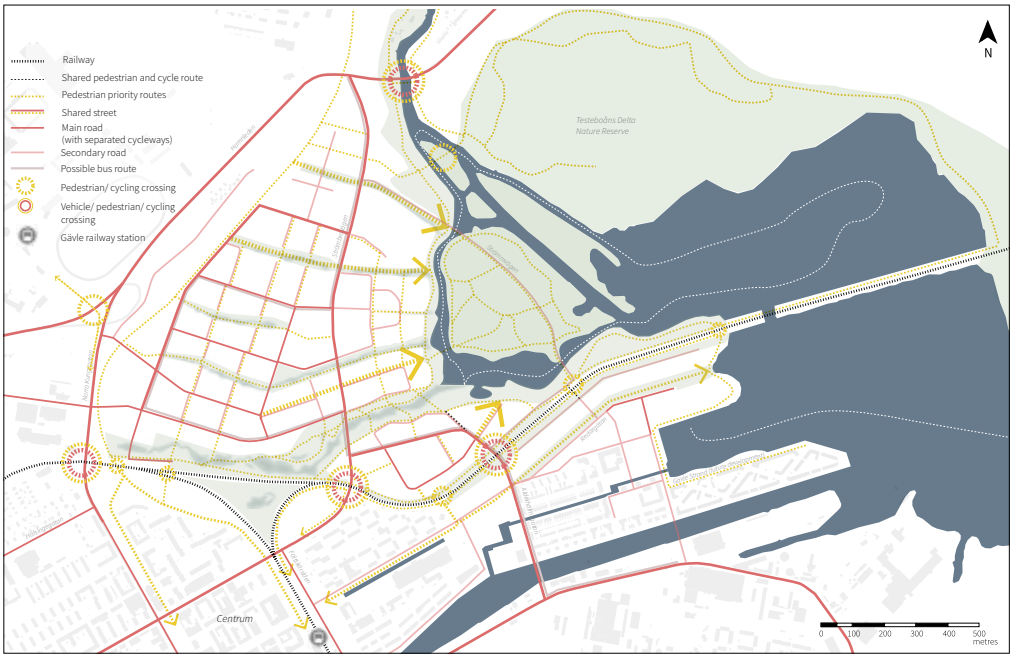
Objective 3:

*An **accessible, connected** delta*

Existing



Proposed



Existing: Lack of pedestrian connections

The railways and large industrial plot sizes restrict pedestrian access between the city and the nature reserve. The entire district is vehicle-orientated. Strömsbrovägen is the main vehicle, cycling and pedestrian thoroughfare through the district.

Proposed: Superblock grid street network

The new street structure is designed around the existing Strömsbrovägen street. The concept employs large block sizes to ensure future adaptability while striking a balance between vehicle movement and pedestrian/ cycling movement. Streets and blue-green corridors promote connections to the shoreline and nature reserve.

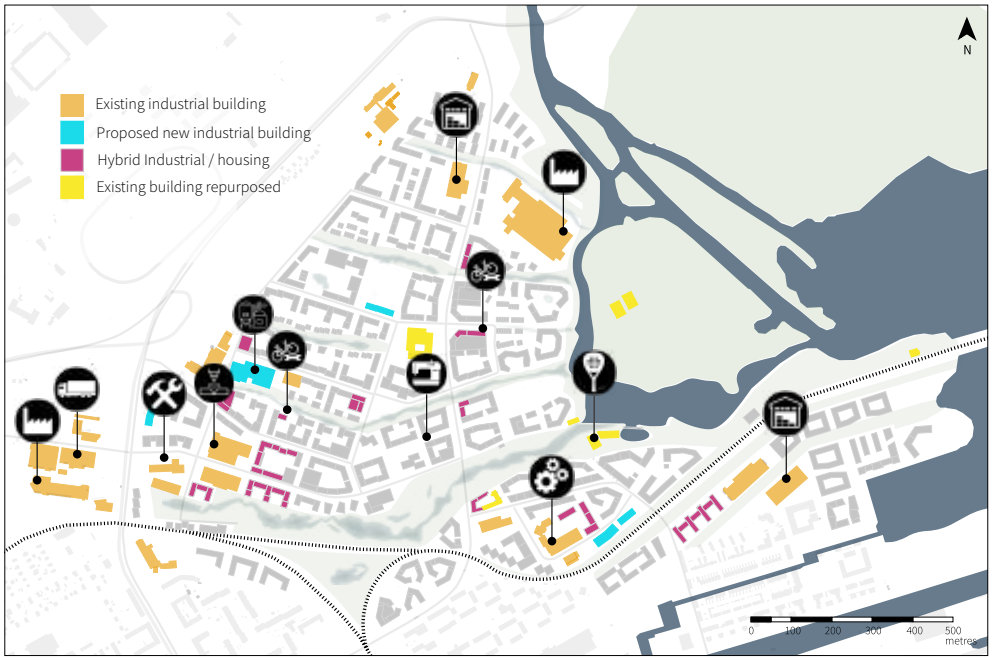
^ *Figure 55: Objective 3. Existing and proposed situations. Base map source: See Figures List*

Objective 4:

*An **innovative, productive** delta*

Existing

Proposed



Existing: Deindustrialisation / Inefficient use of central coastal land

The existing industrial area is still largely operational, however the district is monofunctional with many neglected spaces and low quality buildings and infrastructure. The removal of the railway yard and other railway changes will increase brownfield land in the area.

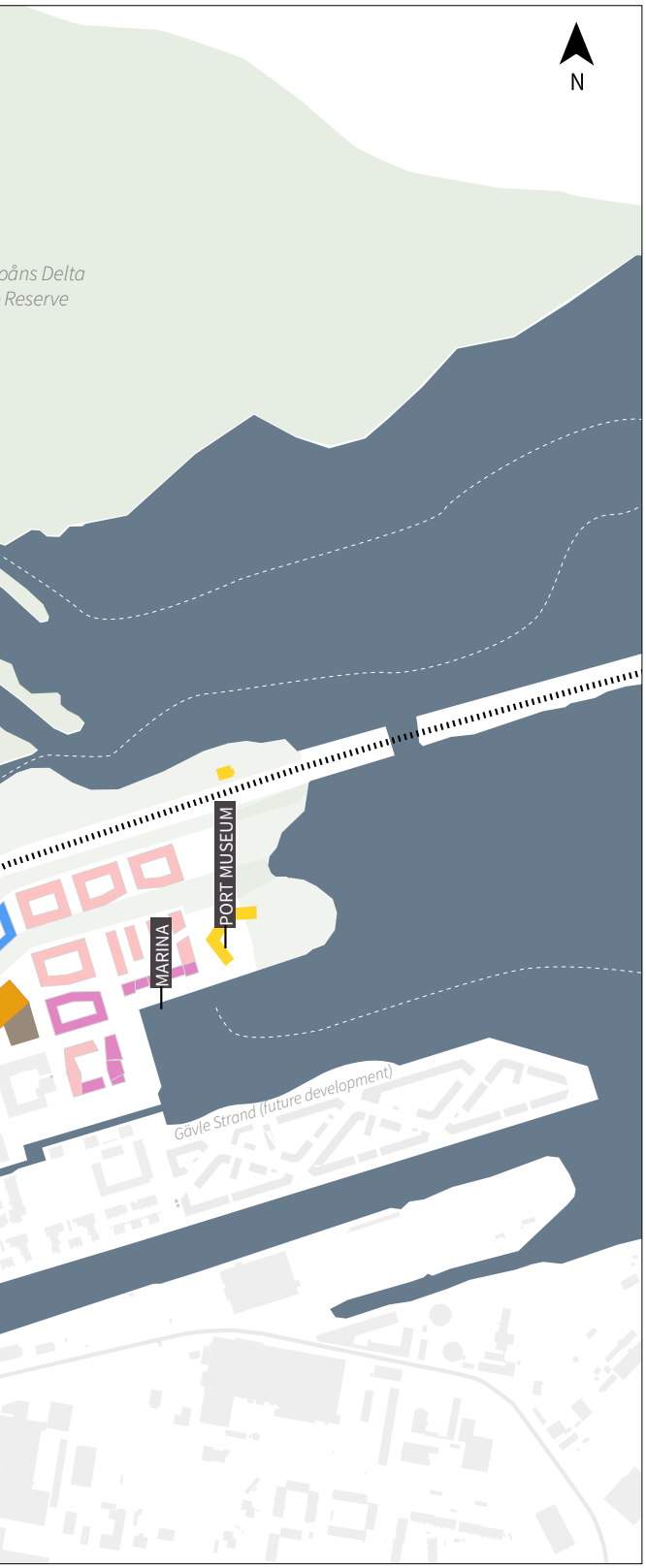
^ *Figure 56: Objective 4. Existing and proposed situations. Base map source: See Figures List*

Proposed: Industry retains a role in the centre

The new Näringen draws on Gävle's industrial and manufacturing heritage, integrating as many existing industrial businesses into the new central district - a test grounds for new hybrid industrial + housing neighbourhoods and building typologies. Buildings with character / longer life spans are kept and repurposed. New functions to support urban manufacturing are integrated such as a Makers' Space, a Fabrication Lab, Workshops etc.

Proposed


Hybrid 1: Light Industrial + housing
Hybrid 2: Commercial + housing
Housing
Industrial
Research / Innovation
Parking
Office
Community
Education
Strategic axes of activity
Hamnleden
Norra Kungsgatan
Strömmvägen
Hälsingegatan
Fältskärsliden
Redoxgatan
Centrum
INDUSTRIAL
INDUSTRIAL
FAB LAB
MAKERS SPACE
RECY-PARK
VERTICAL PRODUCTION
SUPERMARKET
START UP HUB
SWIMMING POOL
CAMPUS
LIBRARY
RETAIL
HOUSING
MECHANIC
KINDERGARTEN
HOUSING
DIY STORE
CARPARK
GALLERIES
BUSINESS CENTRE
KINDERGARTEN
RETAIL
INNOVATION HUB
MANUFACTURING
CAFE
SCOUTS
KAYAK / ROWING
RAILWAY SERVICE
0
100
200
300
400
500
metres



Objective 5:

*A **dense, diverse, growing** delta*

Existing: Population growth

Amidst continued growth, Sweden is experiencing a national housing shortage. Gävle is welcoming and planning for new residents in exchange for governmental investments in its railway infrastructure.

Proposal: A mixed-use district for new residents

The regenerated delta landscape supports the needs of new residents in Gävle in a mixed-use district (Fig. 57). Alongside existing and new industrial businesses (and other knowledge and service businesses), the delta supports 5000 new homes. Different housing types cater for different resident groups. Diverse urban activities, services and recreation amenities are concentrated along a pedestrian priority East-West spine running parallel to the main stormwater park and support the work, living and recreational needs of Gävle's new and existing residents (Fig. 58).

< *Figure 57: Objective 5. Proposed mixed-use concept*

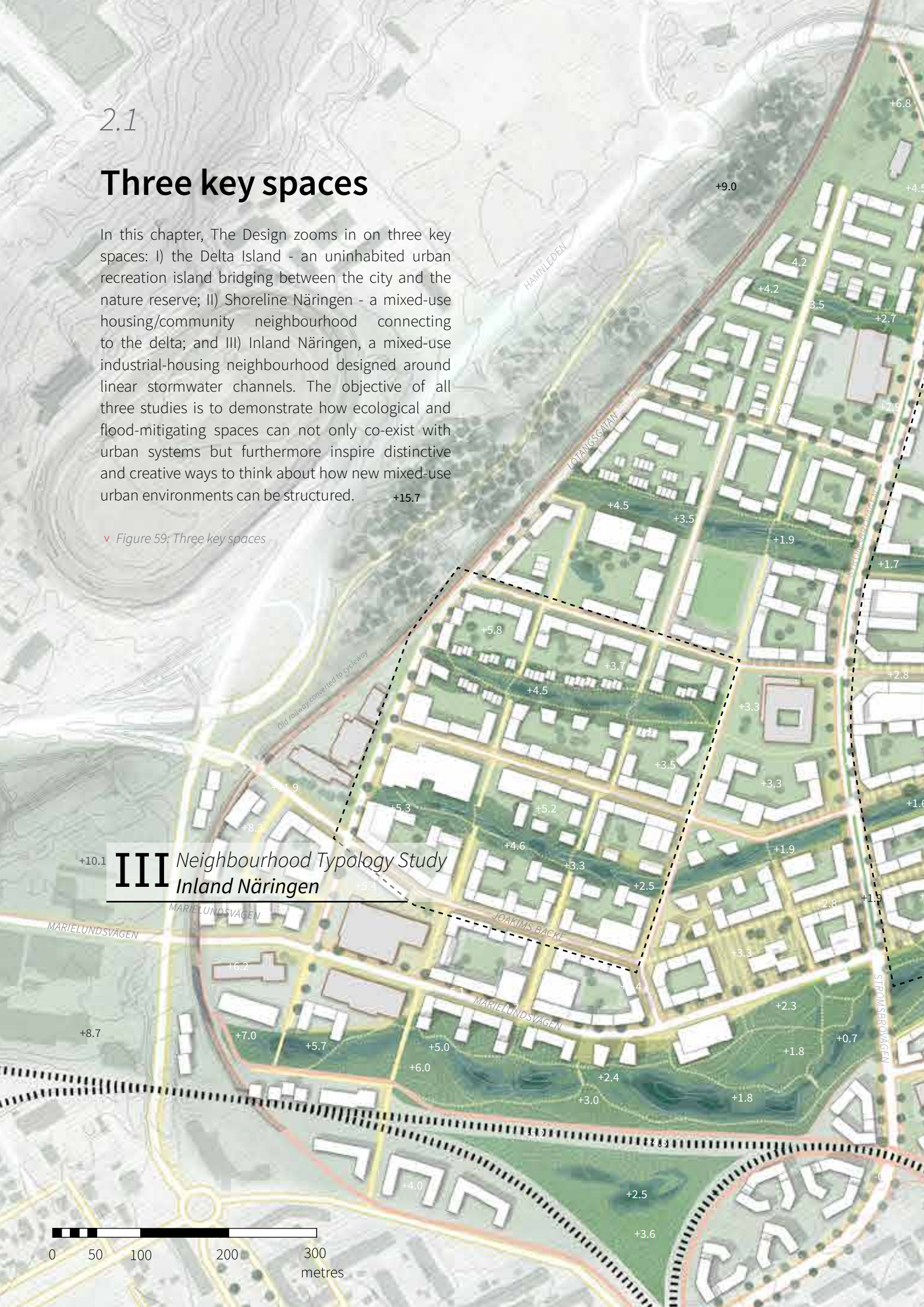
v *Figure 58: Objective 5. Proposed activity spines and 'hotspots'*

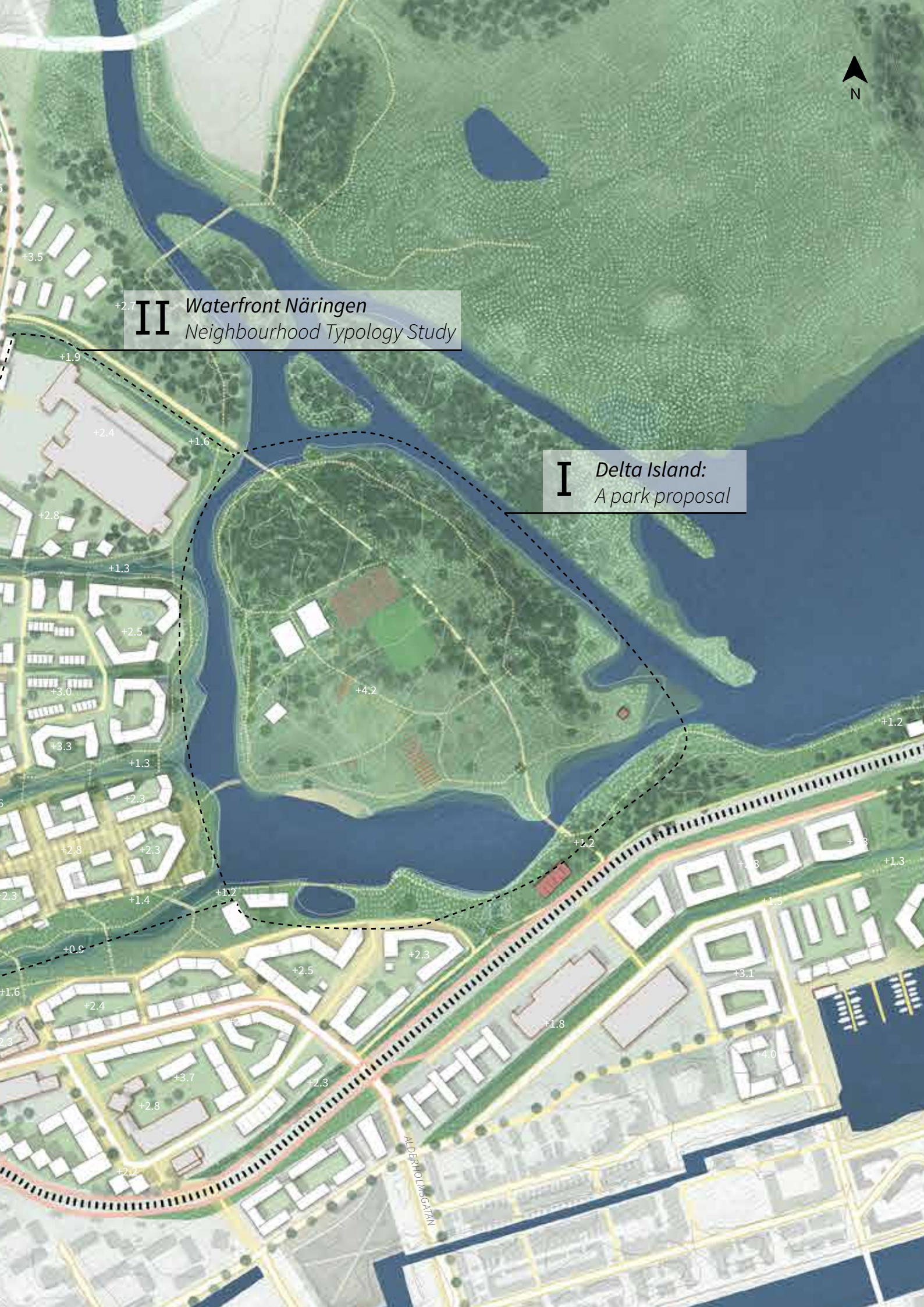
2.1

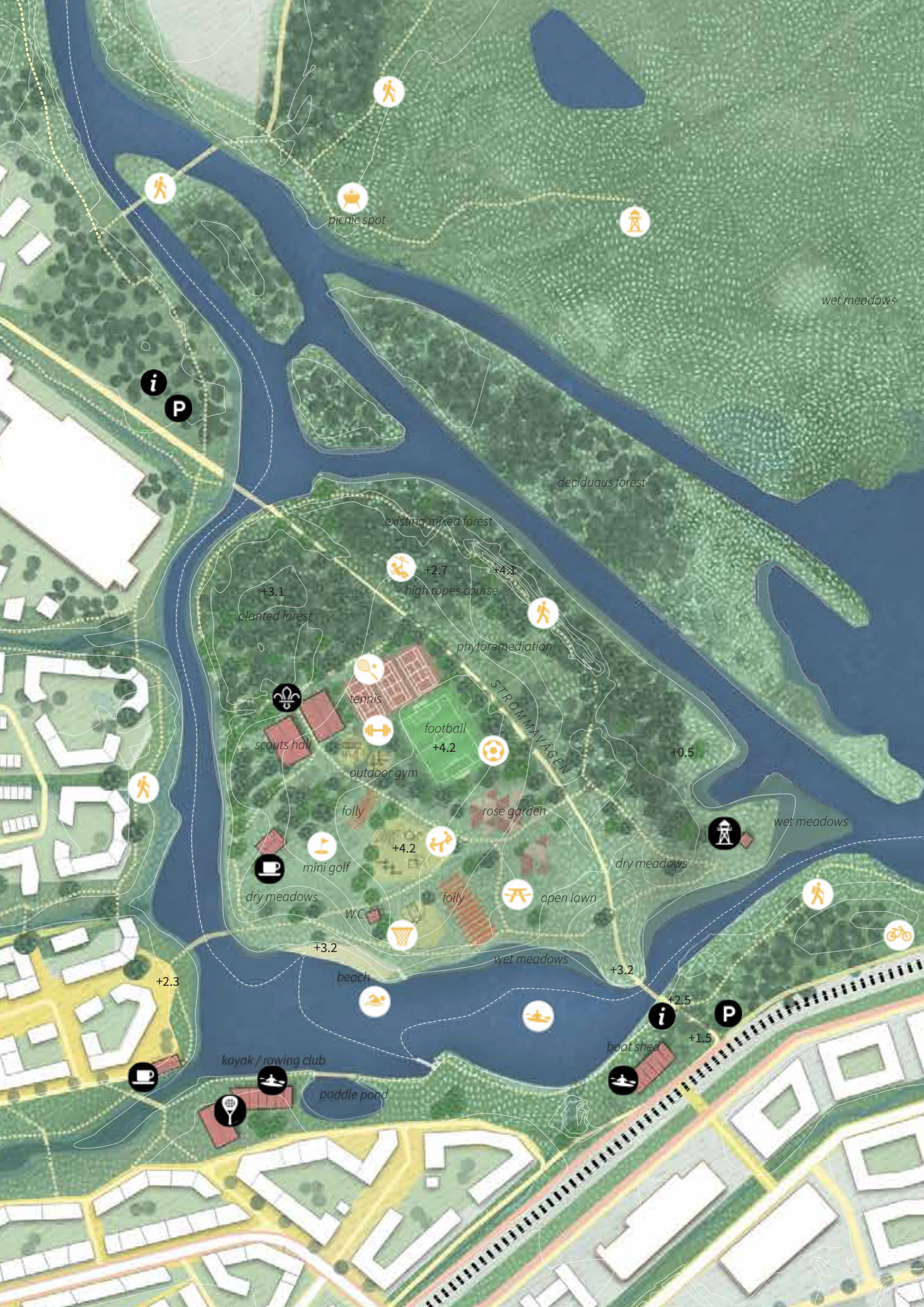
Three key spaces

In this chapter, The Design zooms in on three key spaces: I) the Delta Island - an uninhabited urban recreation island bridging between the city and the nature reserve; II) Shoreline Näringen - a mixed-use housing/community neighbourhood connecting to the delta; and III) Inland Näringen, a mixed-use industrial-housing neighbourhood designed around linear stormwater channels. The objective of all three studies is to demonstrate how ecological and flood-mitigating spaces can not only co-exist with urban systems but furthermore inspire distinctive and creative ways to think about how new mixed-use urban environments can be structured.

v *Figure 59: Three key spaces*




N
II Waterfront Näringen
Neighbourhood Typology Study
I Delta Island:
A park proposal
ALDERHOLMSGATAN


picnic spot
wet meadows
deciduous forest
existing mixed forest
+2.7
+4.1
high ropes course
+3.1
planted forest
phytoremediation
tennis
STRÖMMAVÄGEN
football
+4.2
scouts hall
+0.5
outdoor gym
folly
rose garden
wet meadows
+4.2
mini golf
dry meadows
dry meadows
folly
open lawn
W.C
+3.2
wet meadows
+3.2
beach
+2.3
+2.5
+1.5
boat shed
kayak / rowing club
paddle pond

I

Delta Island

A response to sea level rise flooding and a diminishing delta landscape

Figure 60: Delta Island schematic plan

Inviting the water

Rather than seeing sea level rise as a threat, the low-lying topography becomes a steering force for the design. The lowest lying land close to the shoreline is transformed into a new water channel, bringing the water closer to the city and forming a new nature recreation island. By 'inviting the water', the water channel and island cannot claim to 'solve' sea level rise, but they do demonstrate how flooding threats can instead be transformed into a positive feature of the new city. To deal with sea level rise, the project must also employ cut-and-fill techniques to move and infill land, designating high ground areas (at least +2.3m in accordance with recommended planning levels for Gävle).

Visions for the Delta Island

An opportunity for Ecological Remediation

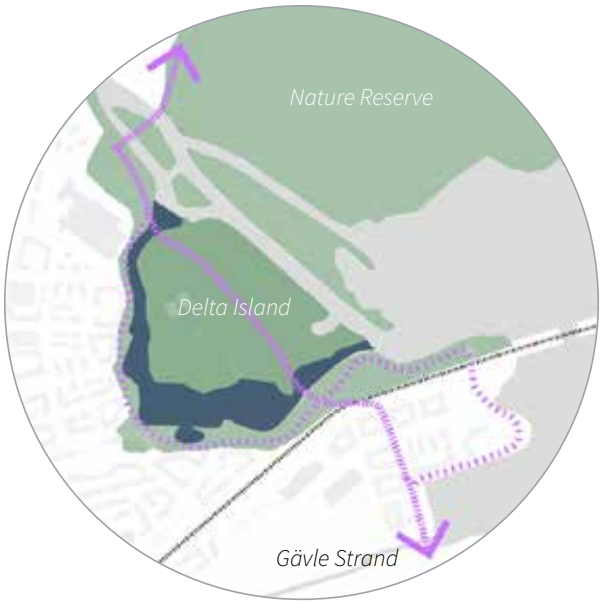
The island is positioned at the mouth of the delta, where the former landfill was once located. The island is an opportunity to clean the contaminated land, and bring the delta closer to its former state, lengthening the shoreline edge and restoring habitats for birds, fish and insects. The island includes existing forest areas, meadows, grasslands, a rose garden, a south-facing beach and coastal wetland areas. Depending on the exact degree and type of contamination, landfill material may need to be removed, or a traditional landfill capping with clean fill on top may be required. Biological phytoremediation methods could be explored, but it is highly likely they would need to be integrated into an engineered solution to manage the landfill leachate and risk of contamination to the water.

Retaining Näringen's cultural heritage

While most of the land is transformed from an industrial concrete district into a nature and recreation area, some elements of the former landscape are left as a reminder of the area's history. The forest on the north and eastern edge is kept and integrated into the planting concept. The street of Strömmavägen acts as a 'short-cut' thoroughfare for cycling and service vehicles across the island, but is redesigned without the asphalt to be visually less intrusive. Some of the buildings are left intact and repurposed. Other buildings are stripped of their facade materials, but their steel structures are left behind to provide memories of area's past light industrial functions.

Integrating Outdoor Recreation Functions

Compared to the nature reserve, the island is intended to have a more landscaped park feel with designed recreation spaces and activities. A playground, a cafe, a flexible venue hall, tennis courts, a sports field, mini golf, a high ropes course, and a basketball area are proposed but other activities and design suggestions for the island should be proposed by the public. The new edges of the channel host water-based activities: boat sheds and a kayak club, and a small south-facing beach on the south of the island directs views back to the city.



Connecting the waterfront with Testeboåns Delta Nature Reserve

The island acts as a gateway from the city to the nature reserve, with three bridges connecting the island directly with the urban fabric of Näringen. The open character of the island and the wider walking paths, compared to those of the nature reserve, make the delta island environment more accessible for those with prams, in wheelchairs or by bike. The delta island's trails are integrated with the existing pathways of the nature reserve and the port bridge to make a 4.5km walking/ running / cycling loop. The new channel and island safeguard public access to the waterfront area for future generations.

^ *Figure 61 (ALL): Delta Island vision diagrams*

Reference projects

These projects act as case studies to support the feasibility of the Delta Island concept.

Blaarmeersen / Karel Sabbeberg, Gent, Belgium

Relevance to project: Large-scale cut and fill excavation

Blaarmeersen is a 100-hectare recreation area which employed large scale cut-and-fill excavation techniques to raise a swamp area 2 metres in the 1960s and 1970s. The area today consists of a 2300 metre-long water course (which, incidentally, was historically a landfill) and in the 1980s, a lake was also dug, with the soil used to build an adjacent mound 34 metres high - today named the Karel Sabbeberg (The Karel Sabbe mountain). While the initial conversion of the swamp might today be considered controversial, the project nonetheless demonstrates how the cut and fill strategy can be employed on a large scale to achieve topographical changes.

^ *Figure 62: Aerial image of Blaarmeersen park area.*
Source: Google Earth. 10.10.2022

Lakeside Garden, Singapore

Relevance to project: Landscape heritage restoration
Landscape Architecture: Ramboll Studio Dreiseitl

Lakeside Garden is a project to restore a 53-hectare lakeside swamp that was eradicated with the development of an industrial area in 1961. Rather than attempting to return the site to its former mangrove forest landscape, the project proposes a series of different swamp, woodlands and grassland habitats with various plant types suited to different fauna. Newly excavated streams as deep as 6m are engineered to replace a straight concrete drain that once led from the road to the lake. The project forms part of a much larger Water Sensitive Urban Design project in which many such concrete drains were replaced with swales and naturalised streams to cleanse the water before its eventual release in the lake.

^ *Figure 63: Lakeside Garden heritage project.*
Source: Ramboll Studio Dreiseitl

Freshkills Park, Staten Island, New York

Relevance to project: Park constructed on landfill

Landscape Architecture:
James Corner Field Operations

Freshkills Park is a 890-hectare public park constructed on top of a former landfill. Construction began in 2008 and is expected to continue in phases for another 30 years. The park design is defined by four landfill mounds covered in open grasslands,with tidal creeks running through the landscape. The park hosts a variety of public spaces and facilities for social, cultural and physical activitiy, play and education. Although the park has many natural features, it is highly engineered. The park is achieved by sealing the landfill mounds with a cap which comprises different layers of soil, geotextiles and a geomembrane to prevent the release of landfill gas to the atmosphere. The park demonstrates the possibilities for landscape engineering to convert large-scale landfill sites into open park space for public use (Freshkills Park Alliance n.d.).

^ *Figure 64: View towards Manhattan from Freshkills Park*
Source: James Corner Field Operations

Mustikkamaa Island, Helsinki, Finland

Relevance to project: Nature Recreation Island

The Mustikkamaa ("blueberry land") Recreation Park was established in 1921 and covers about 36 hectares (City of Helsinki 2020). The park is located south of the inhabited Kulosaari island about 5km from the city centre, and adjacent to the brownfield regeneration area of Kalasatama (Fig. 65). The island integrates existing nature areas (rocky shorelines, pine tree forests, meadows) with recreation activities such as hiking and skiing tracks, a beach and changing rooms, a marina, a restaurant, a summer theatre, tennis courts and a volleyball court. The southernmost bridge connects the island to another island which hosts the city zoo. It is not human-made, as the island at Gävle would be, but it does provide an example of concentrated outdoor recreation activities on an island and successful early planning efforts to safeguard centrally-located nature areas for future generations.

Figure 65: Aerial view of Kulosaari Island (right), Mustikkamaa Island (left) and Kalasatama (back).
Source: 'Migro'/ Wikipedia. (CC) 6.2.2010

> *Figure 66:*

Open space for future generations

By setting aside a portion of Näringen's development for open space, the Delta Island park acts as a model for sustainable land reclamation and a source of pride for Gävle. Its landscape and amentities welcome Gävle's current residents and generations to come.

Old structures are stripped of their materials and turned into landscape follies.

Existing mixed forest is integrated into the park

The south side of the island is less planted compared to the north, opening up to the city and the sun.

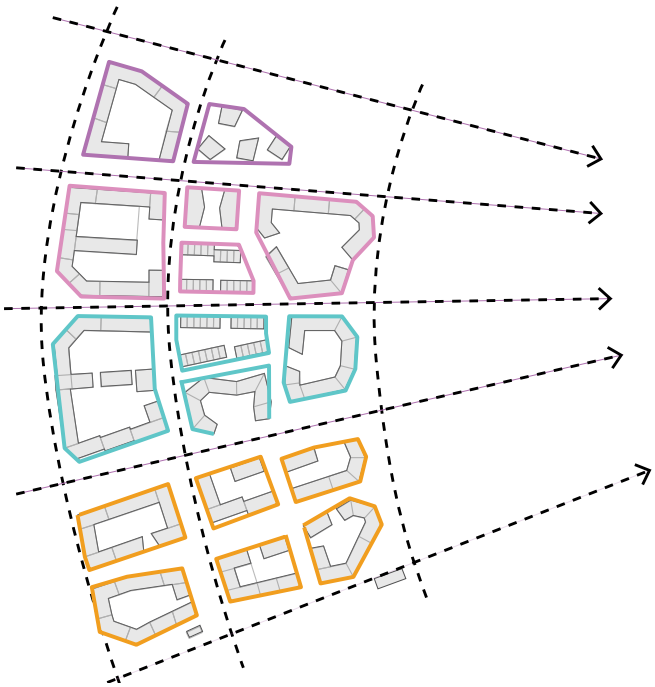
Pedestrian and cycling bridge connects to 'mainland' and on towards the city

II

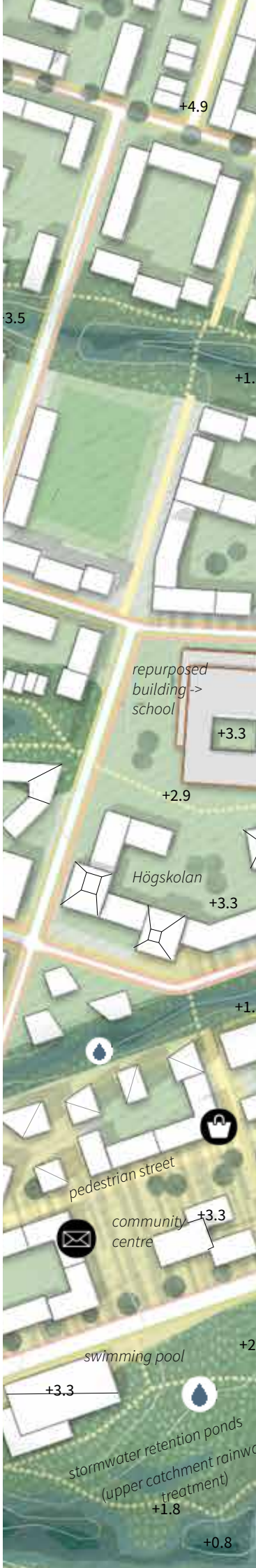
BGI Neighbourhood study: Waterfront Näringen

In eastern Näringen, the urban environment is shaped around the multiple stormwater corridors meeting the delta water channel. From the bustling Strömsbrovägen (which is transformed into a livable boulebard with 6-8 storey mixed-use buildings), pedestrians are able to follow the paths of the stormwater parks to reach the shoreline. Alternatively, the new pedestrian street, named after the existing Beckasinvägen, takes pedestrians directly to the Delta Island. Without through traffic, the neighbourhood becomes an open pedestrian environment suitable for housing and other compatible amenities and functions.

> *Figure 67: Shoreline Näringen Plan*

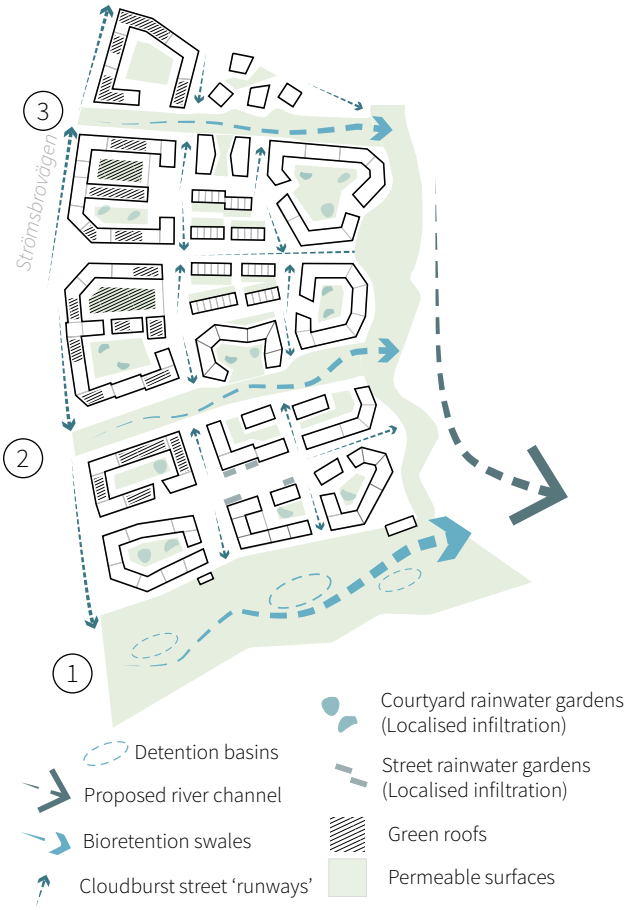


^ *Figure 68: Shoreline Näringen Urban Block concept diagram*




N
+1.9
+2.9
+2.4
Existing manufacturing business hub
+1.6
+2.3
+2.8
+1.7
+1.3
housing
+2.3
row houses
+2.3
+2.7
+2.7
+2.1
+3.0
housing
+2.5
+4.2
DELTA ISLAND
kindergarten
+3.3
+2.5
mixed -use
+1.3
+1.6
housing
+2.3
connection to island
+2.8
mixed -use
+2.3
Beckasinvägen (pedestrian street)
+2.3
+1.2
kayak/ row club
+1.8
+2.3
+1.4
existing padel
+1.9
+1.8
+0.9
future coastal flood zone
outdoor gym
+1.8
+2.1
apartments
+2.5
+1.6
mixed -use
+2.4
+2.2
+2.4
mixed -use
+2.3
+1.8
+0.7
+2.3
business
+2.8
+2.3
+2.5
+3.7
innovation hub
+2.8
+2.5

Stormwater Concept

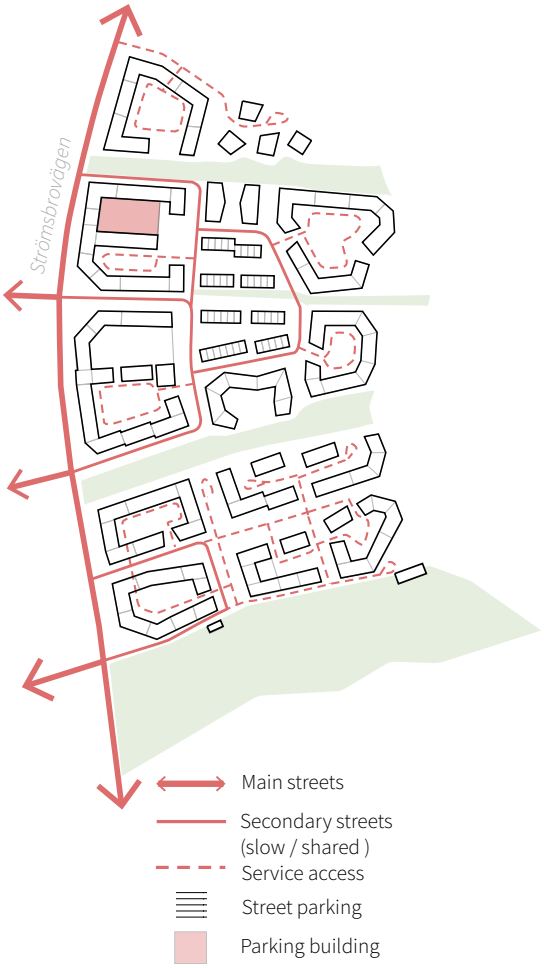


Connecting flood water to the sea is the driving force behind the neighbourhood design. In the south, a major stormwater park (1) deals with water flowing towards Näringen from other districts. Other stormwater swale channels are established (2,3 & others not pictured) to deal with Näringen's own local rainfall.

Outdoor Space Concept

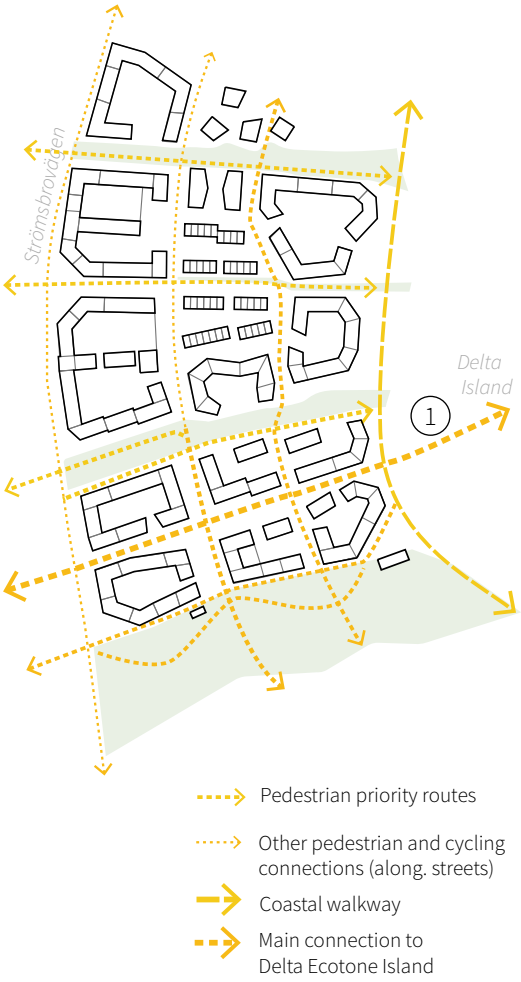
The outdoor spaces can be categorised into public spaces (streets and parks), semi-public spaces (apartment courtyards) and private spaces (gardens / balconies). The focus is on creating good quality public and semi-public spaces which everyone can enjoy.

Traffic Concept



Traffic is minimised by restricting through vehicles to the existing main street Strömsbrovägen. Large parking decks are integrated into the building blocks to the west of the site to reduce traffic flow in the neighbourhood. Neighbourhoods are still designed to allow drop off/ service vehicles and some street carparking.

Pedestrian Permeability Concept



The building blocks encourge pedestrian (and cycling) permeability across the entire neighbourhood. In the East-West direction, the blue-green corridors connect to the shoreline, and a pedestrian street leads directly to the new island. In the North-South direction, the coastal walkway (1) maintains public access to the water.

^ *Figure 69: Shoreline Näringen Diagrams*

Connecting communities around water

Rainwater management provides the storyline to create an atmospheric neighbourhood park with multifunctional social and ecological goals. The linear stormwater parks frame views towards the Delta Island and retain a sense of public openness and permeability, encouraging access for everyone and preventing the creation of a gated community. Additional functions are inserted along the ground level to activate the spaces for the public - in Figures 70 and 71, a kindergarten and local shops, cafes and community workshops overlook a dynamic and lush landscape.

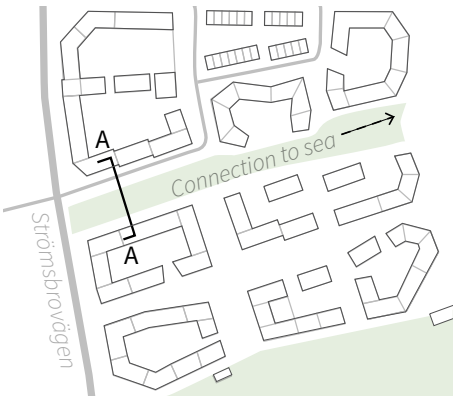
v *Figure 70: Conceptual section through stormwater park*

> *Figure 71: Stormwater park visualisation in dry summer conditions.*

Landscape concept

While each park can, and should be designed differently, in this park, large concrete stepping stones are ‘cut-out’ from the former brownfield concrete landscape, providing a distinctive character and offering a reminder of the past. The dynamic nature of the naturalistic wet meadow planting and fluctuating water level, contrasts with the hardness of the park’s concrete edge and seating platform. On the opposite side, a mowed lawn gradually descends down to the swale, offering a flexible place to play or rest.

Figure 72: Reference Plan



Flood parks: how they work

The parks use bioretention swales to collectively manage a 100-year flood. In the transverse section, the parks are located at a lower elevation than the built areas to receive stormwater run-off. In normal rain events, these swales provide small pools (Fig. 69) to collect and infiltrate water. However, during heavy cloudburst rain events (Fig. 71), these pools are designed to overflow and the swales transform into small streams, taking advantage of the natural but slight gradient in the east-west direction to transport water to the sea.

< *Figure 73: Stormwater park during heavy cloudburst event*

Cloudburst Flood Resilience Reference Projects

The following three projects act as case studies to support the feasibility of a district-wide flood-resilience scheme.

1. Copenhagen Cloudburst Masterplan

The Copenhagen Cloudburst Management Plan stands out as an example of a city-wide use of integrated planning and implementation of blue-green infrastructure. While Näringen's 232-hectare site dwindles in comparison to the Copenhagen site at 3400 hectares, the plan demonstrates the potential for blue-green infrastructure in the planning of large-scale sites.

In 2011, Copenhagen was hit with a heavy cloudburst rain event which caused at least 6 billion Danish kroner (US$863 million) worth of damage. According to the Copenhagen Climate Adaptation Plan, Copenhagen is expected to experience heavier downpours because of climate change (Copenhagen City 2011). As a response, the city released a Cloudburst Management Plan which incorporated both traditional grey infrastructure measures (including an expansion of the underground sewer network) alongside 300 above ground BGI solutions which the city planned to implement at a rate of 15 per year (Copenhagen City 2012). This response was based on an overall cost assessment, where it was found that this 'combined' solution would result in a higher net saving when compared to a grey infrastructure-only upgrade, or no upgrades at all (ibid).

The BGI solutions were conceived as a 'Cloudburst Toolbox' (Fig. 73), consisting of a variety of strategies adaptable to each local site: stormwater 'runway' streets which transport water to lakes and the harbour; detention streets with areas which store water; green streets with planting which retain and filter water locally. The measures are designed to be multifunctional, proving additional urban functions to improve mobility, recreation, health and biodiversity to ensure long-term resilience (Ramboll Studio Dreiseitl n.d.)

The Copenhagen Cloudburst Master Plan is relevant to this project as it demonstrates how Blue-Green Infrastructure measures must, and can be, integrated across a large catchment scale with consideration of extensive stakeholder involvEment. At the same time, this project demonstrates the necessary planning that must occur if catchment-wide stormwater measures are not adapted from the onset of the project - extensive retrofitting measures such as those now needed in Copenhagen would be necessary. Although the masterplan has not been fully implemented and the success of the flood mitigation measures cannot yet be verified, the project's endorsement by the City Council already represents a huge achievement, signifying a leap towards growing acceptance of BGI strategies in urban planning.

>

Figure 74: (ABOVE)'Before and After' illustrations showing how a park (A) and a boulevard (B) are transformed into flooding retention basins in heavy rain. Source: Ramboll Studio Dreiseit

>>

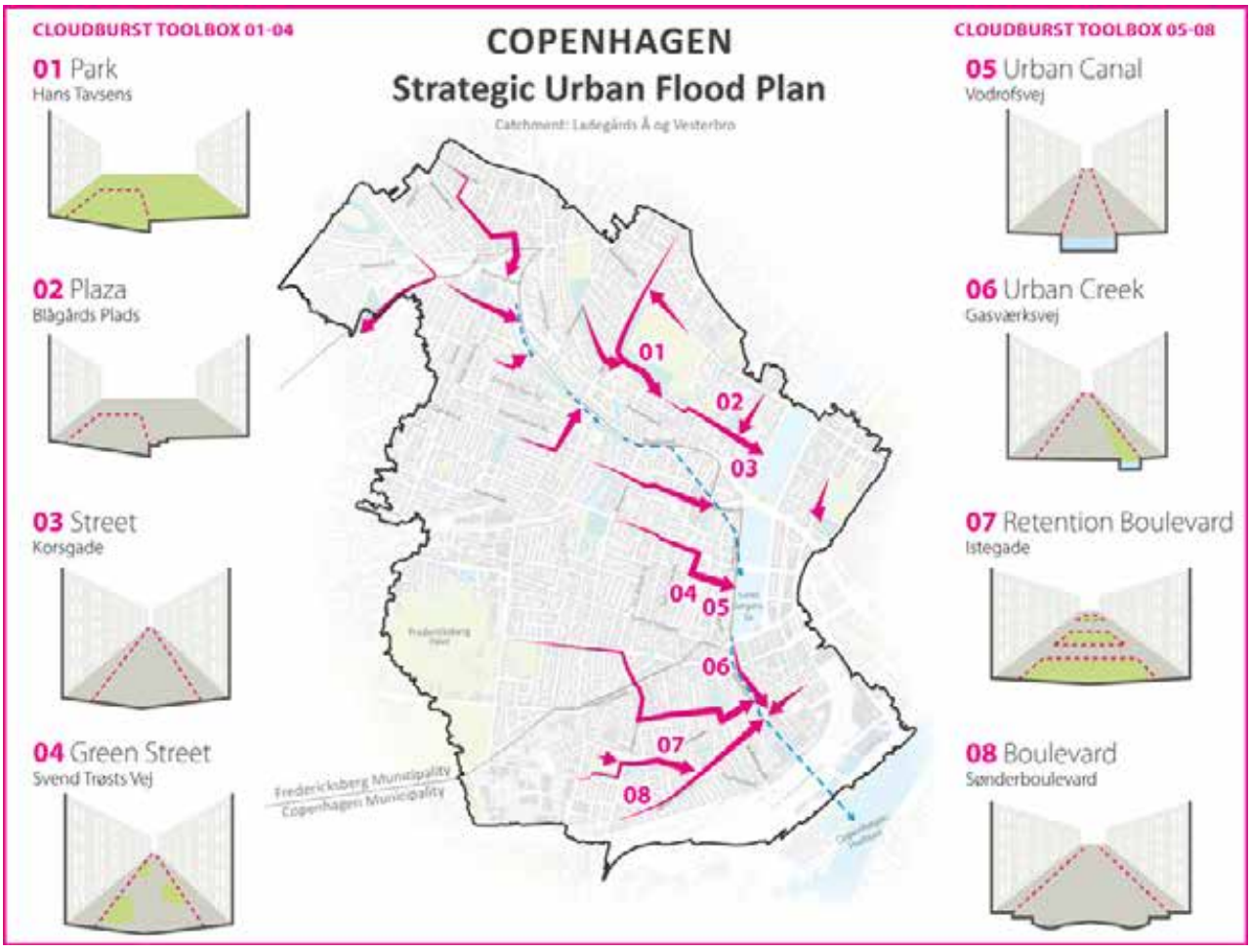
Figure 75: (BELOW) Copenhagen Cloudburst Masterplan showcasing different BGI strategies across the city to mitigate flooding and improve the social/ urban life in the city. Source: Ramboll Studio Dreiseit

A


SANKT JØRGENS SØ
Dry
Existing Lake Edge
Flood Outflow
Safety Zone
Flood Zone
40,000m³ retention capacity
Safety Zone
Flood Zone
7,000m³ retention capacity
Flood Event

B


SØNDERBOULEVARD
Dry
Existing Street Profile
Safety Zone
Flood Pathway
3,300 l/s flow capacity
Flood Event


CLOUDBURST TOOLBOX 01-04
COPENHAGEN
Strategic Urban Flood Plan
Catchment: Ladegårds Å og Vesterbro
01 Park
Hans Tavsens
02 Plaza
Blågårds Plads
03 Street
Korsgade
04 Green Street
Svend Trøsts Vej
01
02
03
04
05
06
07
08
Frederiksberg Municipality
Copenhagen Municipality
CLOUDBURST TOOLBOX 05-08
05 Urban Canal
Vodrofsvej
06 Urban Creek
Gasværksvej
07 Retention Boulevard
Istegade
08 Boulevard
Sønderboulevard

2. Amagerfaelled Masterplan

Masterplan: Urban Agency, C.F. Møller A/S, Niras, Jens Kvorning

The Amagerfaelled Masterplan provided inspiration for developing a new built area designed to prevent flooding and prioritise pedestrians at the same time. The 19-hectare site comprises 2000 houses in a dynamic 'island' layout and is supported by public amenities, schools and stand-alone vertical carpark buildings. Since Näringen is much larger, and not a 'dead-end' community like this one, the same idea could not be replicated across the whole Näringen site without severely limiting traffic flow and creating isolated communities. Still, this project inspired the neighbourhood typologies used in the Näringen project, especially around the waterfront area.

v

Figure 76 (ALL): Amagerfaelled Masterplan Image Series
A: Concept Diagram. B: Conceptual axonometric. C: Flooding concept. D: Masterplan Concept.
Source: Urban Agency. / C.F. Møller A/S

3. Pihlajaniemi Stormwater Park

Landscape Architecture: Masu Planning.
Masterplanning: Gehl Architects / AJAK Architects

Rainwater management is the primary goal of this stormwater park design for a new urban development on former military land in Turku, Finland. The park is centred around a calm, meandering stream on a rocky streambed and features flexible lawn areas, sports and play areas on either side. In flood events, the stream grows, filling up the park and forming three temporary lakes.

The project is a useful example of a stormwater park situated in a relatively dense environment - the park measures approximately 15-20m at its narrowest, and 50-60m at its widest. This creates variety in the park's edges - some edges are 'hard' with stepped areas leading to the water (Fig. 77A), while others are more gradual and accommodate wet meadow zones supporting biodiversity (Fig. 77- D.). The project provides inspiration for how the blue-green corridors in the Näringen masterplan could be developed further as multi-functional flood and stormwater cleansing parks in later stages.

v *Figure 77: (ALL) Pihlajaniemi Stormwater Park design. A: Section of water channel. B: Plan. C: Activities Diagram. D: Section of stream and wet meadow.* Source: Masu Planning


N
HAMNLEDEN
LÖTÄNGSGATAN
mechanic
school
+5.8
housing
+4.9
housing
+5.2
+4.7
old railway cycling path
+4.3
playground
mixed-use
housing
+5.8
mixed-use
housing
+4.8
+6.3
Recy-Park
brewery
+11.9
+5.7
+5.7
+4.9
outdoor gym
+5.2
+5.1
+5.2
+4.2
+4.5
+6.2
offices
+5.4
+3.3
LÖTÄNGSGATAN
+5.1
+3.8
JOAKIMS BACKE
+4.0
Makers' Space
mixed-use
housing
+5.1
+5.4
+4.7
Fabrication Lab
mixed-use
housing
mixed-use
business

III

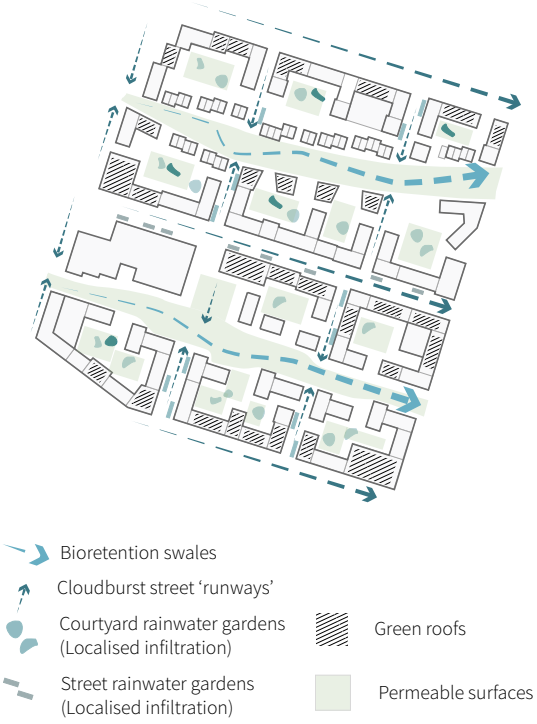
BGI Neighbourhood study: Inland Näringen

This western neighbourhood of Näringen is structured around the concept of linear stormwater parks connected to the sea. Unlike the eastern neighbourhood though, this area is differentiated by its superblock grid street structure which supports more diverse forms of transport - including the cars, buses, taxis, and trucks necessary to support thriving businesses and activities in the city. At the same, the superblock concept, as opposed to a regular grid network, restricts through-traffic to main outer streets only, preserving the centre of the block for stormwater, ecological and community recreation purposes. In this way, the stormwater parks can be thought of as extended neighbourhood courtyards.

< *Figure 78: Inland Näringen Schematic Plan*

^ *Figure 79: Superblock concept*

Stormwater Concept



Neighbourhoods are formed around east-west orientated stormwater corridors which take advantage of the natural gradient to channel excess stormwater towards the delta. Smaller BGI measures include rain gardens in courtyards and streets, the use of permeable surfaces and green roofs.

Outdoor Space Concept

The urban block courtyards are designed to 'open' towards the stormwater parks. In non-rain events, these spaces act as regular parks providing recreation and meeting spaces for residents of Näringen.

Pedestrian permeability Concept

Traffic Concept

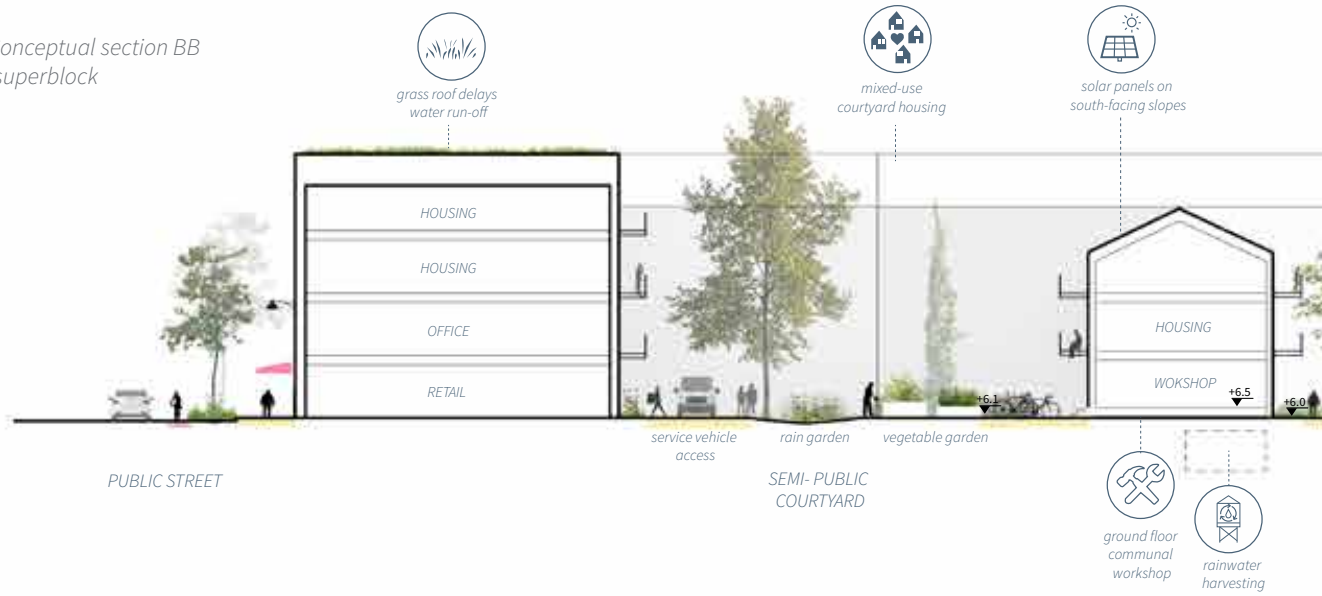
The parks are (mostly) car-free, optimising the pedestrian experience, and providing connections to the delta in the east, and the walkway/cycleway in the west.

Main traffic is restricted to the outside of the superblocks. Vehicles are still allowed within these areas at slow speeds to ensure accessibility and service requirements. Vertical parking structures and parking decks keep courtyards free of cars.

^ *Figure 80 (ALL): Superblock concept diagrams*

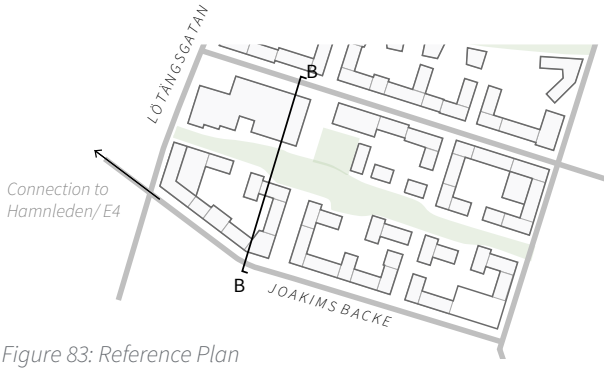
^ *Figure 81: The stormwater park and brewery interface on a dry summer's day*

> *Figure 82: Conceptual section BB through a superblock*



Connecting production and living

At the upper end of the blue-green corridor, new and existing productive functions come together with housing around the stormwater parks. The western edge of Näringen (along Lötängsgatan, Fig. 83) is an ideal location to incorporate industrial functions since it backs on to Hamnleden (which connects to the E4 Highway), preventing large trucks entering Näringen central. Figures 81 and 82 for example demonstrate how a brewery can be incorporated into the stormwater neighbourhood. Its western side opens towards Lötängsgatan for service access while its southern side fronts on to the stormwater park. In the summer afternoons and evenings, a restaurant/bar activitates the terrace and brings people to the park. The large windows reveal the brewery's impressive boiling kettles, establishing transparency between the public and Näringen's productive activities.



^ *Figure 83: Reference Plan*

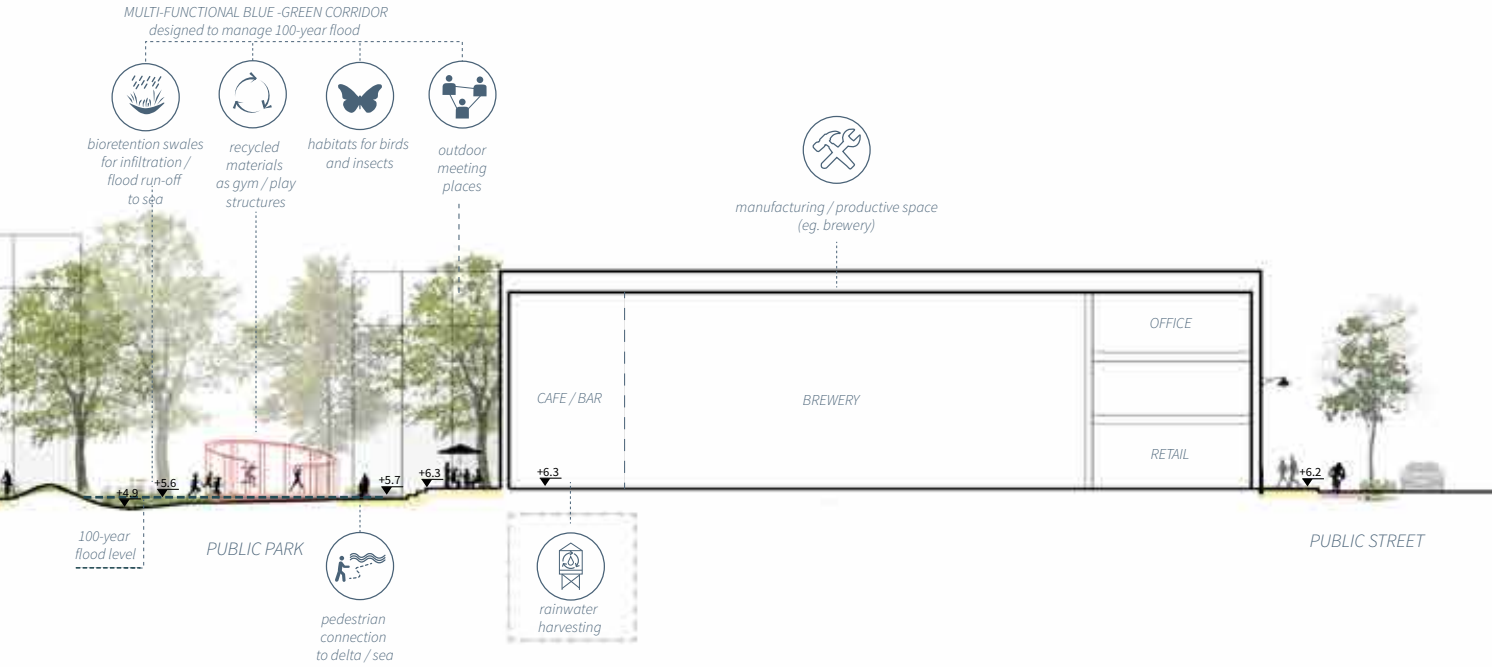


Figure 84 :

Spring Melt

The blue-green stormwater parks serve functions in all seasons. In the winter months, they provide local areas for the city to pile snow from the streets. In the spring, the stormwater parks help to manage excess water from the snow melt.

Part 2: Reflections from the design process

Discussion

This section reflects on two key findings that were discovered during the design process and culminated in The Design. First, I discuss the emphasis of BGI in creating a sustainable and resilient framework, before discussing some of its shortcomings and how these were reworked. Next, I discuss how the dilemma of attempting to weave existing elements of the site into the new district resulted in unexpected findings for the research. These findings are then discussed with reference to possible future research directions.

Connecting Communities around Water

Prompted by the Gävle's 2021 summer flood and the harsh border between Näringen and the delta nature reserve, this research project considered first how to tackle the delta's flooding issues and urban and environmental degradation challenges using BGI to inspire a sustainable and resilient framework that could support new housing and business development. Large-scale BGI projects such as the Copenhagen Cloudburst Masterplan along with ecological brownfield development transformation projects such as Freshkills Park, inspired an early focus on hydrology and ecological systems: Which areas were most vulnerable to coastal and cloudburst flooding? Where can we implement new large-scale blue-green spaces to collect and/or drain stormwater and likewise create habitats and in the city? And how can water become a resource in the creation of a sustainable and resilient new district?

1. The initial BGI 'hunch'

The design process responded by proposing two large-scale BGI measures to structure the new urban district: first, the water channel and delta island at the coast as a response to future sea level rise, and second, the inland blue-green corridors as a response to cloudburst flooding. These ideas were born in the very early stages of the design project – initial design 'hunches' inspired by other BGI projects and developed by sketching on top of flooding maps and orthophotos of the site. While the first coastal water channel/ delta island concept changed very little throughout the design process, the second BGI concept of blue-green corridors underwent a series of adaptions as it attempted to merge with the redesign of Näringen's urban infrastructure systems.

2. A problem with the hunch

Despite the obvious benefits the blue-green corridors provided in terms of flood resiliency and the provision of outdoor recreation

space, the blue-green corridors were difficult to implement because they unintentionally created barriers which initially separated the new district into fragmented neighbourhood, exacerbating the already existing 'barrier' issue of the railway tracks identified in Chapter 1.3. For example, in an earlier design iteration (Fig. 85), the stormwater park begins further north and performs a complicated curve towards the railway before reaching the delta outlet. The resultant trajectory however, in conjunction with the existing railway tracks, resulted in two neighbourhoods to the south becoming divided both from Gävle's city centre, and from Näringen's geographical centre.

3. *Developing the hunch: From barrier to seam!*

To resolve this, the largest stormwater park in the south ('A' - Fig. 85) dealing with upper catchment water was 'straightened out' to follow a simpler trajectory, running alongside the railway and thus integrating the previously isolated southwestern neighbourhood back into the main urban fabric of Näringen. Additional smaller blue-green corridors were then introduced to separate Näringen's local stormwater from the external stormwater entering the site. These smaller blue-green corridors became easier to integrate within the new street and building network, and ultimately inspired the 'superblock' structure presented in The Design – a neighbourhood typology featuring stormwater parks and outdoor meeting spaces at their centre and framed by mixed-use functions at the edges (activities such as kindergartens, restaurants and productive activities like the brewery and workshop which were proposed). In this way, rather than creating barriers, the stormwater parks developed into 'seams' stitching together neighbourhoods and strengthening flood, ecological and community resilience.

v *Figure 85 : Earlier iteration of the site plan showing the divided neighbourhoods in the south.*

Connecting New and Old:
From industrial 'heritage' to industrial continuity

When considering the locations of the new stormwater parks and the new street network, it was necessary to 'ignore' some of the existing buildings and streets to prioritise optimal locations for the stormwater flow. In some instances, it was possible to redirect the blue-green corridors or to imagine that water could potentially be diverted underground if a certain building was considered worth preserving. This presented a dilemma that was impossible to ignore – how much of the existing urban environment should be preserved? And what was the criteria for deciding what should be protected when so much needed to be demolished and redeveloped? The project went through three stages of thinking:

1. A blank canvas

In the earliest phase, the thesis sided with Gävle municipality, agreeing that the land at Näringen was a suitable location for urban densification, including 6000 new homes alongside new business premises, given Näringen's proximity to the city centre. Although the municipality's proposal would require the relocation of many existing industrial businesses to the outer city greenfield site at Tolvforsskogen, it was reasoned that this could be justified if the more central Näringen site were to be highly intensified. At the same time, the urban transformation project would offer the opportunity to address the site's flooding and contamination challenges and reverse Näringen's historic environmental debt.

2. Celebrating cultural industrial heritage

During a review, a critic questioned if everything needed to be demolished, and it was suggested to consider how small elements of the existing cultural landscape could be retained – a street, a building, or demolition materials perhaps. The objective 'celebrate cultural industrial heritage' was formed alongside four other delta regeneration goals. The idea here was to demonstrate that despite the large-scale urban transformation, the new design could still retain clues to hint at Näringen's cultural past. This strategy is common in many post-industrial transformation projects. At the neighbouring site of Gävle Strand for example, the silos (Fig. 21) and the old cranes will be retained with the construction of new housing, serving as reminders of the pier's past life. At other post-industrial sites around the world, factories and warehouses structures have been repurposed into office and residential spaces.

At Näringen however, the difficulty was that there were few obvious structures to preserve. Most buildings lack any distinctive historical character and are already very worn down. Some interesting structures which once existed at the old port had already been destroyed. In these circumstances, I did my best to identify 'better-maintained' buildings and reroute the blue-green corridors and street network around them. I also came up with other ideas: a to-be-discontinued railway was repurposed as a cycle and walkway; structures were stripped of their materials and integrated into the landscape of the delta island park, some timber structures near the waterfront were kept and repurposed as cafes

and galleries, concrete foundations could be reused as steppingstones in the parks etc. While many of these ideas were, on a small scale, valid suggestions and thus still presented in The Design, it was questionable whether such gestures were overly romanticised and perhaps tokenistic. Was celebrating industrial cultural 'heritage' really the right ambition when so many businesses were in fact still operating in Näringen? What could these industries still contribute to Näringen?

3. Celebrating industrial activity

In the last phase of the design process, the project highlights the value of Näringen's industrial activity, rather than simply the buildings in which these activities are housed, through suggesting ways in which compatible productive industrial activities could be accommodated in the new district. Suggestions for productive community spaces such as a 'Maker's space', a 'Fabrication Laboratory' and a 'Recy-Park' were made. The western area (around Norra Kungsgatan) was suggested as a suitable location for industrial activity because of its location close to the main exit roads. A brewery on the western edge of the stormwater park, and a ground floor bike workshop were loosely suggested as ideas for productive activities which could co-exist with housing around the stormwater parks. Importantly, the fourth objective was also readjusted to emphasise these ideas: 'Celebrate industrial heritage' was transformed into 'An innovative, productive delta', providing a vision for an urban district that, although affected by wider deindustrialisation processes, still makes a decided effort to encourage and celebrate local production and manufacturing within the city.

Future Research Directions: *Industry in the post-industrial city?*

Further design-research and wider knowledge gathering is needed to execute the parallel blue-green and productive visions presented in this thesis. Communicating the vision – why manufacturing and productive activity should be part of the sustainable water-centric city – needs further developing too, and certainly in conjunction with those who operate these existing industrial businesses, and those that could potentially live in future Näringen too.

Investigating the drawbacks are also critical – potential noise, smell, space required, and other disturbances such as the movement of heavy freight all need to be factored in and some industrial activities will not be compatible alongside housing and office. For a small city like Gävle the added cost of 'stacking' mixed-use functions together might not be economically feasible compared to other denser cities which employ such strategies, for example in Brussels (See: 'Borret n.d.' - an inspirational compilation of mixed-use productive projects in Brussels).

Regardless of such potential obstacles, the thesis highlights a vision to develop this project beyond initial BGI measures, in way that is more inclusive of existing industrial businesses, and compatible new ones. While this thesis focuses on an overarching landscape planning vision for Näringen, the project reveals great opportunities to further explore interesting mixed-use architectural typologies which bring together housing, industry and water-centric outdoor public spaces.

^ *Figure 86: Testeboåns Delta.*
View looking east towards the port.

// conclusion

Conclusion

Looking back; looking forwards

***Reconnecting the Delta** ultimately argues for a nature-based approach to urbanism's engagement in the regeneration of our dilapidated coastal brownfield landscapes.*

In Part 1, five challenges were presented – growth, deindustrialisation, disconnectivity, flooding and ecological disrepair – providing the context in which to begin design-research. The topics were discussed in relation to Näringen but were considered likely issues for many cities experiencing growth and looking to repurpose their once industry-dominated coastlines. These challenges, particularly Näringen's flooding and ecological problems, were argued to be the result of anthropocentric and monofunctional land use planning approaches which prioritised Gävle's urban goals over the health and protection of the delta landscape.

In Part 2, the intention was to counter this approach, by 'reconnecting the delta'; a vision to establish a reciprocal relationship between the urban and ecological systems of Testeboåns Delta and Näringen, in order to collectively address the five challenges addressed in Part 1. The design section thus began by transforming the five challenges from Part 1, into five design objectives: A biodiverse, healthy delta; a climate-adapted delta; a connected delta; an innovative, productive delta; and a dense, diverse, growing delta. In a slight twist, the design objectives are ordered in reverse from the site challenges; in doing so, arguing for the ecological remediation of the delta as the pillar upon which a sustainable and resilient urban framework could be developed.

To achieve these objectives, The Design first turned towards Blue-Green Infrastructure principles, reconnecting Näringen's hydrological and ecological systems with the delta landscape to promote biodiversity and mitigate both cloudburst and coastal flooding. First, the design addressed the risks of coastal flooding by 'inviting the water'; an engineered approach entailing the construction of a new water channel and island. The channel gives rise to a new urban wetland interface while creating a new delta recreation island to act as an ecotone bridging between the nature reserve and the city. The water channel and the island remediate the former landfill, support biodiversity, and serve as a valuable outdoor recreation space preserved for the future.

Inland, the design proposed dense, mixed-use neighbourhoods comprising housing, business, community, and industrial functions, structured around several multifunctional blue-green corridors. The positioning of these corridors was based on the modelling of heavy rainfall flow paths. During normal rainfall, the parks are designed to collect and infiltrate stormwater using

planted swales. During extreme rain events, the swales transport overflow water to the sea, mitigating against urban flooding and protecting vital infrastructure. The blue-green corridors integrate regular park functions like playgrounds, rest areas, and walking tracks, providing central common spaces for pedestrian-centred neighbourhoods, separated from through-traffic disturbance.

Following a presentation of The Design, the discussion reflected on further challenges that became apparent during the design process, and the learnings that could be taken from these. Two main challenges and their corresponding developments were discussed: firstly, blue-green corridors as spatial barriers, and how these barriers were overcome by establishing new neighbourhood typologies centred around blue-green spaces; and secondly, the dilemma encountered when trying to decide what to preserve from the site regarding the necessity to uphold Näringen's existing cultural identity amidst urban renewal. What became increasingly apparent, was that it was more important to preserve the industrial activities – and particularly those related to manufacturing – rather than any specific physical element of the site. This additional finding, which could not have been anticipated at the beginning of the research project, highlighted the significant role that industry still plays in the post-industrial city and highlighted a gap for further research regarding ways to consider how industrial functions can still be integrated into the mixed, compact and water-centric city.

In considering how the project at Gävle could move forwards, this thesis argues for reciprocity; firstly, between ecological and urban systems – which in this project is initiated through a district-wide BGI framework and neighbourhoods designed around water; and secondly, between old and new – not just through preserving or recycling elements of the current physical urban environment, but through resolutely integrating and celebrating industrial productive activities (manufacturing, trade, logistics, repairs) that have historically and continue to take place at Näringen.


Krickvägen
Krickvägen
Arvid Svenssons i Gävle AB
Truckvägen
Truckvägen
Truckvägen
Truckvägen

Figure 88: Aerial view of industrial sites at Näringen.
Source: Google Earth (Imagery 202

References

Airoldi, L. and Beck, M.W. (2007). Loss, Status and Trends for Coastal Marine Habitats of Europe. *Oceanography and Marine Biology*: *An Annual Review*. 45, 345-405.

Ameli, N. (2021). Skador för 160 miljoner efter skyfallen och husbranden I Gävle. *SVT Nyhter.* November 24.https://www.svt.se/nyheter/lokalt/gavleborg/skador-for-160-miljoner-efter-skyfallen-och-husbranden-i-gavle [05.02.2022]

Balmford, A., Green, R.E. & Jenkins, M. 2003. Measuring the changing state of nature. *Trends in Ecology and Evolution.* 18, 326–330.

Bibri. S., Krogstie, J., Kärrholm, M. (2020). Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability. *Developments in the Built Environment* 4.

Borret, K. (n.d). *Brussels Productive City*. Bouwmeester Maître Architecte. https://bma.brussels/something-productive-2/ [05.10.2022]

Britannica, The Editors of Encyclopaedia. (2012) 'Gävle'. *Encyclopedia Britannica*. www.britannica.com/place/Gavle [05.04.2022]

Brown, K., Mijic, A. (2019). Integrating green and blue spaces into our cities: Making it happen. Grantham Institute Briefing Paper No 30. Imperial College London.

Byggindustrin (2022). Ett år skyfallen I Gävle – kostnaderna spräcker tvåmiljardersvallen. August 17. https://www.byggindustrin.se/affarer-och-samhalle/hallbarhet/ett-ar-efter-skyfallen-i-gavle-kostnaderna-spracker-tvamiljardersvallen/ [18.08.2022]

CARBENET (2006). Sustainable Brownfield Regeneration: CABERNET Network Report. Ferber U, Grimski D, Millar K, Nathanail P. University of Nottingham.

City of Helsinki (2020). *Mustikkamaa*. November 25. https://www.hel.fi/helsinki/en/culture/recreation/in-helsinki/mustikkamaa [19.08.2022]

Copenhagen City (2011). *Copenhagen Climate Adaptation Plan*. https://en.klimatilpasning.dk/media/568851/copenhagen_adaption_plan.pdf [18.05.2022]

Ekonomifakta (n.d), *Population growth, Gävle.* www.ekonomifakta.se [05.02.2022]

Elmqvist, T., Andersson, E., McPhearson, T. et al. (2021) Urbanization in and for the Anthropocene. *npj Urban Sustain* 1, 6. https://doi.org/10.1038/s42949-021-00018-w

European Commission, Directorate-General for Research and Innovation (2022). *The vital role of nature-based solutions in a nature positive economy*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/307761

European Environmental Agency (EEA). 2006. *The Changing Faces of Europe's Coastal Areas.* EEA Report 6/2006. Luxembourg: OPOCE. https://www.eea.europa.eu/publications/eea_report_2006_6 [14.06.2022]

European Environmental Agency (EEA) (2007) P*rogress in management of contaminated sites.* https://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites-3/assessment [30.07.2022]

European Environmental Agency (EEA). 2016. *Rivers and lakes in European cities.* EEA Report 26/2016. Luxembourg: OPOCE. https://www.eea.europa.eu/publications/rivers-and-lakes-in-cities/file [26.07.2022]

Gävle Kommun (2009). *Översiktsplan Gävle stad 2025*. Gävle: Gävle Kommun. https://www.gavle.se/kommunens-service/bygga-trafik-och-miljo/planer-och-samhallsbyggnadsprojekt-i-gavle/oversiktsplanering/las-oversiktsplaner-och-strategiska-dokument/gavle-stad-2025/ [03.01.2022]

Gävle Kommun (2017). *Översiktsplan för Gävle kommun år 2030 med utblick mot år 2050* (Dnr 17K340). Gävle: Gävle Kommun. https://www.gavle.se/kommunens-service/bygga-trafik-och-miljo/planer-och-samhallsbyggnadsprojekt-i-gavle/oversiktsplanering/las-oversiktsplaner-och-strategiska-dokument/oversiktsplan-gavle-kommun-ar-2030/ [03.01.2022]

Gävle Kommun (2021). *Förstudie stadsomvandling Näringen*. (Report: Dnr 17KS102) Gävle: Gävle Kommun.

Gävle Kommun (n.d) *Näringen – one of Europe's most sustainable districts*. https://www.gavle.se/kommunens-service/bygga-trafik-och-miljo/planer-och-samhallsbyggnadsprojekt-i-gavle/pagaende-byggprojekt-i-gavle/naringen/ [05.02.2022]

GDJ Fonden (n.d). *Historisk tidslinje.* http://gdj-fonden.se/historisk-tidslinje [05.04.2022]

Ghofrani, Z., Faggian, R. (2017). A Comprehensive Review of Blue-Green Infrastructure Concepts. *International Journal of Environment and Sustainability*. 6(1), 15-36

Havlik V., Pliska, Z., Noake, B. (2018). *From Threat to Opportunity – Reevalutation Stormwater management in Urban Areas*. Urban Move Report. Sweco.

Hill, Adrian V (ed.). (2020) Foundries of the Future: a Guide to 21st Century Cities of Making. With contributions by: Ben Croxford, Teresa Domenech, Birgit Hausleitner, Adrian Vickery Hill, Han Meyer, Alexandre Orban, Victor Munoz Sanz, Fabio Vanin and Josie Warden. Delft. TU Delft Open, 2020. www.citiesofmaking.com [19.10.2022]

IPCC (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.

Jacobs, Jane. (1961). *Death and Life of Great American Cities.* Reprint. NY: Vintage Books, 1992.

Johnson, Simon. (2019). Sweden grapples with housing market reform as risks mount. Reuters. December 18. https://www.reuters.com/article/sweden-economy-housing-idUSL8N28L43A [19.03.2022]

KMV Forum (2020). Näringen, Gävle Stad: Arkeologiskt planeringsunderlag. [Fenno, H].

Lansstyrelsen Gävleborg (2016) *Bevarandeplan för Natura 2000-området: SE0630165 Testeboåns delta.* Lansstyrelsen Gävleborg. https://www.lansstyrelsen.se/ [25.4.2022]

Lundquist, Magnus (2021). Stadsdelen Näringen hotad – tio miljarder från staten kan utebli. February 10. Gefle Dagblad. https://www.gd.se/2021-02-10/stadsdelen-naringen-hotad--tio-miljarder-fran-staten-kan-utebli [14.04.2022]

Lynch, Kevin (1960) *Image of the City.* Reprint. Cambridge: MIT, 1990.

Nilsson, U. (2010). Storstaden som försvann. *Arbetarbladet*. https://www.arbetarbladet.se/2010-03-07/storstaden-som-forsvann [05.04.2022]

Oppenheimer, M., B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R.M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari, (2019): *Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities*. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. Cambridge University Press, Cambridge, UK and New York, NY, USA. 321–445. https://doi.org/10.1017/9781009157964.006.

Pinto, M.P. (2020) Environmental ethics in the perception of urban planners: A case study of four city councils. *Urban Studies,* Vol. 57 (14) 2850-2867.

Port of Gavle (n.d) 'History of Gävle'. https://gavlehamn.se/en/about-port-of-gavle/history/ [05.04.2022]

Ramboll (2016). *Strengthening Blue-Green Infrastructure in our Cities.* https://ramboll.com/-media/38fc23d12a5d47dcb7b3821716d69270.pdf [14.03.2022]

Ree, R. V, Gulle, N., Holland, K., Grift, E. V, Mata, C., & Suarez, F. (2007). Overcoming the Barrier Effect of Roads - How Effective Are Mitigation Strategies? UC Davis: Road Ecology Center. https://escholarship.org/uc/item/66j8095x [26.05.2022]

Rey, E. Laprise, M., Lufkin, S. (2022). *Neighbourhoods in Transition: Brownfield Regeneration in European Metropolitan Areas.* Switzerland: Springer. https://doi.org/10.1007/978-3-030-82208-8

Seddon N., Chausson A., Berry P., Girardin C. A. J., Smith A., and Turner B., (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges . *Philisophic Transactions of the Royal Society*. 375: 20190120

Shaw, R., Colley, M., and Connell, R. (2007) *Climate change adaptation by design: a guide for sustainable communities.* TCPA, London.

Smit, B., O. Pilisofa, I. Burton, B. Challenger, S. Huq, R. Klein, G. Yohe (2001) *"Adaptation to Climate Change in the Context of Sustainable Development and Equity",* Chapter 18 in McCarthy , JJ, OF Canziani, NA Leary, DJ Dokken, KS White (Eds.) Climate Change 2001: Impacts, Adaptation and Vulnerability, Contribution of the Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

SMHI, (2015). S*kyfallsuppdraget – ett regeringsuppdrag till SMHI*. Klimatologi nr. 37. https://www.smhi.se/polopoly_fs/1.165071!/Klimatologi_37%20Skyfallsuppdraget%20ett%20regeringsuppdrag%20till%20SMHI.pdf [2021-12-03]

Sweco (2018) *Framtidens Näringsliv I Gävle Kommun*. Gävle Kommun. https://meetingsplus.gavle.se/welcome-sv/namnder-styrelser/kommunstyrelsen/mote-2019-04-09/agenda/slutrapport-2018-11-08-fran-sweco-framtidens-naringsliv-i-gavle-kommun-en-analys-av-naringslivsstruktur-och-utvecklingsforutsattningarpdf?downloadMode=open [29.03.2022]

Stojic, N., Pucrevic, M., Stojic, G. (2017) Railway Transportation as a source of soil pollution. *Transportation Research Part D: Transport and Environment*. 57. 124-129

Storbjörk, S., Hjerpe, M. (2014) "Sometimes Climate Adaptation is Politically Correct": A Case Study of Planners and Politicians Negotiating Climate Adaptation in Waterfront Spatial Planning. *European Planning Studies*. 22:11, 2268-2286, DOI: 10.1080/09654313.2013.830697

Taha, H. (2004). Heat Islands and Energy. *Encyclopedia of Energy,* Ed: Cutler J. Cleveland, Elsevier.133-143. https://doi.org/10.1016/B0-12-176480-X/00394-6

Torget Arkitekter (n.d). A*lderholmen – Gävle Strand*. https://torgetark.se/referenser/alderholmen-gavle-strand/ [05.04.2022]

Trafikverket (2022). *Gävle hamn, ny spåranslutning över Näringen.* https://www.trafikverket.se/vara-projekt/projekt-i-gavleborgs-lan/gavle-hamn-ny-sparanslutning-over-naringen/ [25.05.2022]

UN Habitat (2014). *A New Strategy of Sustainable Neighbourhood Planning: Five Principles.* United Nations Human Settlements Programme, Nairobi, Kenya

UN Habitat (2015). I*ssue Paper on Urban and Spatial Planning and Design.* United Nations Human Settlements Programme, Nairobi, Kenya

UN Habitat (n.d.) *What is Urban Resilience*. https://urbanresiliencehub.org/what-is-urban-resilience/ [30.08.2022]

United States Environmental Protection Agency (EPA) (2022). *Guidance for Cleaning up Groundwater, Soil and Air.* https://www.epa.gov/hw/guidance-cleaning-groundwater-soil-and-air-corrective-action-facilities#:~:text=The%20main%20methods%20used%20include,and%20other%20physical%2Fchemical%20treatments. [30.07.2022]

Van Eldijk, J., Gil, J. & Marcus, L. (2022). Disentangling barrier effects of transport infrastructure: synthesising research for the practice of impact assessment. *European Transport Research Review*. 14, 1. https://doi.org/10.1186/s12544-021-00517-y

WSP (2020). *Översvämningsrisker Näringen*. (Report: 10297111) Kaiser, G., Åkesson., Thurin, S. Gävle: WSP.

List of Tables

Table 1: Proposals for planning levels regarding floods from the seaPage 46.
Information source: Gävle Kommun (2021) / WSP (2020).

Figures List

Figure 1: Winter sunset over Näringen. Page 9
Photo: © Markus Boberg/Gefle Dagblad

Figure 2: Aerial photo of a brownfield site. Page 12
Source: Google Earth (Imagery 2022). 20-08-22

Figure 3: Näringen's coastal edge at Nyhamn. Page 14
Source: 'Regular Rick' / Google Earth (CC). 18-08-22

Figure 4: Diagram of BGI. Page 17
. Source: Author, concept adapted from Ramboll (2016). See references.

Figure 5: Sketch: the design process in action. Page 18
Source: Author

Figure 6: Diagram of research questions. Page 19
Source: Author

Figure 7: (Right) Diagram of Thesis Structure. Page 21
Source: Author

Figure 8: Aerial photo of Näringen. Page 22
Source: Gävle Kommun

Figure 9: Location of Gävle. Page 24
Source: Author

Figure 10: The five site issues. Page 25
Source: Author

Figure 11: Future building development . Page 26
Source: General Map © Lantmäteriet; edited by author with information sourced from Gävle Kommun.

Figure 12: Regional context map.. Page 28
Source: General Map © Lantmäteriet; edited by the author with information sourced from Gävle Kommun.

Figure 13: Diagrammatic map of planned transport upgrades. Page 29
Source: General Map © Lantmäteriet; edited by the author with information sourced from Gävle Kommun.

Figure 14: Aerial photo of Näringen. Page 30
Source: Gävle Kommun. Annotations by author.

Figure 15: Land survey map of Sätra's village estates in 1736. Page 33. *Coallated map source: Gävle Kommun (Historic map: Lantmäteriet)*

Figure 16: Land survey map 1812. Page 33.
Coallated map source: Gävle Kommun. Historic map © Lantmäteriet

Figure 17: New City Plan (not realised) showing urban grid structure over Näringen. Page 33.
Coallated map source: Gävle Municipality. Historic map source: Stadsingenjör C.L Almgren. Gävle Municipality Archive.

Figure 18: Comparison between aerial photo of Gävle 1960 (A) and 2020 (B). Page 34-35
Photo Source: © Läntmateriet. Annotations overlaid by author.

Figure 19: Alderholmen during the 1920s. Page 35
Photo Source: Länsmuseet. Annotations overlaid by author.

Figure 20: Gävle Strand 2020. Page 35
Photo Source: 'Balticman' / Wikipedia. (CC)

Figure 21: Photo series taken Februrary 2022 showing brownfield sites in Näringen. Page 36
Source: Author

Figure 22: A conceptual timeline of Gävle's history . Page 38. *Diagram: Author, with information sourced from 'Framtidens Näringsliv I Gävle Kommun' (Sweco 2018) and sources referenced in text. See references.*

Figure 23: General land use map of Gävle. Page 39
General Map: © Lantmäteriet; edited by the author with information sourced from Gävle Kommun

Figure 24: Photos from the site (February 2020). Page 41
Source: Author

*Figure 25: Aerial photo of large industrial plots at Näringen.*Page 42. *Source: © Markus Boberg/Gefle Dagblad*

Figure 26: Map of existing barriers and crossings at Näringen. Page 42. *Source: Orthophoto © Lantmäteriet, edited by author.*

Figure 27: 2021-08-17, Daily precipitation Sweden, in mm. Based on preliminary data. Page 44.
Source: © SMHI. 'Gävle' annotation overlay by author

Figure 28: Maximum water depth during a climate-adapted 100-year rainfall, Näringen, Gävle. Page 45. *Source: WSP/ Gävle Kommun*

Figure 29: Maximum momentary flow during a climate-adapted 100-year rain with run arrows, Näringen, Gävle. Page 45
Source: WSP/ Gävle Kommun

Figure 30: Flooding in a residential area of Gävle after the rainstorms. August 18, 2021. Page 46
Source: Fredrik Sandberg / Getty Images

Figure 31: Flood investigation for Q100 (160 m3/ s) in combination with 100-year high tide 2050 (1.41 m, RH2000). Page 47
Source: Gävle Kommun/ WSP

Figure 32: Flood distribution at 100-year high tide 2100 incl. wind storage (sea level 1.80 m RH2000), highest estimated sea level 2050 and 2100, corresponding to 1.90 m RH2000 and 2.19 m RH2000. Page 47
Source: Gävle Kommun / WSP

Figure 33: Topography of Gävle. Page 48
Data Source: Elevation Data, Grid 1+ 2019 and Topographic Map © Lantmäteriet. Map compiled by author.

Figure 34: Photo of Testeboåns Delta nature reserve. Page 50-51. *Source: Author*

Fig 35: Aerial photo of Gävle taken in 1925 . Page 50-51
Source: Länsmuseet

Figure 36: Study Area of Näringen overlaid on 1954 Economic map. Source: Map compiled by KMV Forum / Gävle Kommun

Figure 37: Shorelines of Näringen from the Iron Age until today. Page 53. *Source: Map compiled by author using map and information sourced from Gävle Kommun/ KMV Forum. Orthophoto from Lantmäteriet. Caption text adapted from KMV Forum 2020*

Figure 38: Site photo (February 2022). Page 54
Source: Author

Figure 39: Site photo (February 2022). The western edge of the nature reserve. Page 54
Source: Author

Figure 40: Site photo (February 2022). Abandoned tyres. Page 55. *Source: Author*

Figure 41: Site photo (February 2022). Gravel desposits. Page 55. *Source: Author*

Figure 42: Map of habitat types at Testeboåns Delta. Page 56-57. *Data source: Testeboåns Delta Conservation Plan (Lansstyrelsen Gävleborg 2016). Map compiled by author.*

Figure 43: Valuable Green Structure in Gävle. Page 58
Source: Topographic Map © Lantmäteriet. Edited by the author with information from Gävle Kommun.

Figure 44: Division of Näringen's different soil sensitivity classes. Page 61. *Author, based off map by Geosigma in Näringen Feasibility study (Gävle Kommun 2021)*

Figure 45: Part 2: The Design Diagram Structure. Page 67. *Source: Author*

Figure 46: Schematic Site Plan. Page 68. *Source: Author*

Figure 47: Diagram of existing site condition. Page 70
Source: Author

Figure 48: Orthophoto with overlaid boundaries. Page 70. *Map Source: Orthophoto 2020 © Lantmäteriet. Text and boundaires overlaid by author*

Figure 49: Diagram of proposed concept to integrate social and ecological systems. Page 71. *Source: Author*

Figure 50: Schematic Site Plan proposal: Testeboåns Delta. Page 71. *Source: Author*

Figure 51: Context Diagram from Part 1. Page 72. *Source: Author*

Figure 52: Five design objectives for Reconnecting Gävle's Delta. Page 73. *Source: Author*

Figure 53: Objectives 1 + 2 existing and proposed situations - coastal flooding. Page 74.
Base map source: Flooding data from Gävle Kommun / WSP. Elevation Data, Grid 1+ 2019 and Topographic map © Lantmäteriet. Map complied by author with overlaid elements.

Figure 54: Objectives 1 + 2 existing and proposed situations - cloudburst flooding. Page 75.
Base map source: Flooding data from Gävle Kommun / WSP. Elevation Data, Grid 1+ 2019 and Topographic map © Lantmäteriet. Map complied by author with overlaid elements.

Figure 55: Objective 3. Existing and proposed situations. Page 76. *Base map source: Topographic map © Lantmäteriet. Map complied by author with overlaid and edited elements.*

Figure 56: Objective 4. Existing and proposed situations. Page 77. *Base map source: Topographic map © Lantmäteriet. Map complied by author with overlaid and edited elements.*

Figure 57: Objective 5. Proposed mixed-use concept. Page 78. *Base map source: Topographic map © Lantmäteriet. Map complied by author with overlaid and edited elements.*

Figure 58: Objective 5. Proposed activity spines and 'hotspots'. Page 79. *Base map source: Topographic map © Lantmäteriet. Map complied by author with overlaid and edited elements.*

Figure 59: Three key spaces. Page 80. *Base map source: Elevation Data, Grid 1+ 2019 and Topographic map © Lantmäteriet. Map complied by author with overlaid elements.*

Figure 60: Delta Island schematic plan. Page 82. *Source: Author*

Figure 61: Delta Island vision diagrams. Page 84. *Source: Author*

Figure 62: Aerial image of Blaarmeersen park area. Page 86. *Source: Google Earth. CC. 10.10.2022.*

Figure 63: Lakeside Garden heritage project. Page 86. *Source: Ramboll Studio Dreiseitl*

Figure 64: Freshkills Park. Page 87. *Source: James Corner Field Operations*

Figure 65: Aerial view of Kulosaari Island). Page 87. *Source: 'Migro'/ Wikipedia. 6.2.2010*

Figure 66: Open space for future generations. Page 88. *Source: Author*

Figure 67: Shoreline Näringen Plan. Page 90. *Source: Author*

Figure 68: Shoreline Näringen Urban Block concept diagram. Page 90. *Source: Author*

Figure 69: Shoreline Näringen Diagrams. Page 93. *Source: Author Source: Author*

Figure 70: Conceptual section through stormwater park and street. Page 94. *Source: Author Source: Author*

Figure 71: Stormwater park visualisation in dry summer conditions. Page 94. *Source: Author Source: Author*

Figure 72: Reference Plan. Page 95. *Source: Author Source: Author*

Figure 73: Stormwater park during heavy cloudburst. Page 96. *Source: Author*

*Figure 74: 'Before and After' illustrations. Copenhagen Cloudburst Masterplan.*Page 99. *Source: Ramboll Studio Dreiseit*

Figure 75: Amagerfaelled Masterplan Image Series Page 100. *Source: Urban Agency. / C.F. Møller A/S*

Figure 77: (ALL) Pihlajaniemi Stormwater Park design. Page 101. *Source: Masu Planning*

Figure 78: Inland Näringen Schematic Plan. Page 102 *Source: Author*

Figure 79: Superblock concept. Page 103 *Source: Author*

Figure 80: Superblock concept diagrams. Page 105. *Source: Author*

Figure 81: The stormwater park and brewery interface on a dry summer's day. Page 106. *Source: Author*

Figure 82: Conceptual section BB through a superblock. Page 106. *Source: Author*

Figure 83: Reference Plan. Page 107. *Source: Author*

Figure 84: Spring Melt. Page 108. *Source: Author*

Figure 85 : Earlier iteration of the site plan. Page 111. *Source: Author*

Figure 86: Testeboåns Delta. Page 115. *Source: Author*

Figure 87: Aerial view of industrial sites at Näringen. Page 118. *Source: Google Earth 20-08-22*