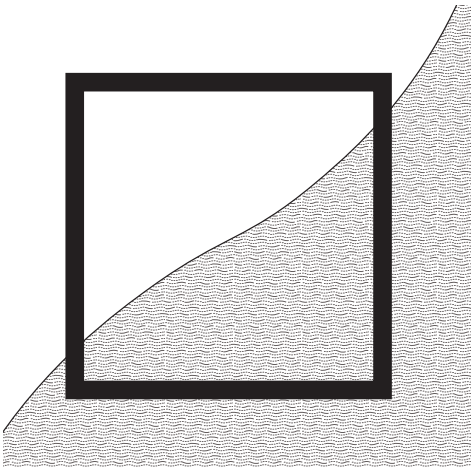
BRIDGING THE DIKE

an architectural intervention to unlock environmental engineering as a common ground



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" The landscape architect has to become an engineer again, making cautious interventions on the basis of knowledge of the systems and cycles of nature"

Adriaan Geuze, West 8

Geographical location of the Wadden Sea

© esa

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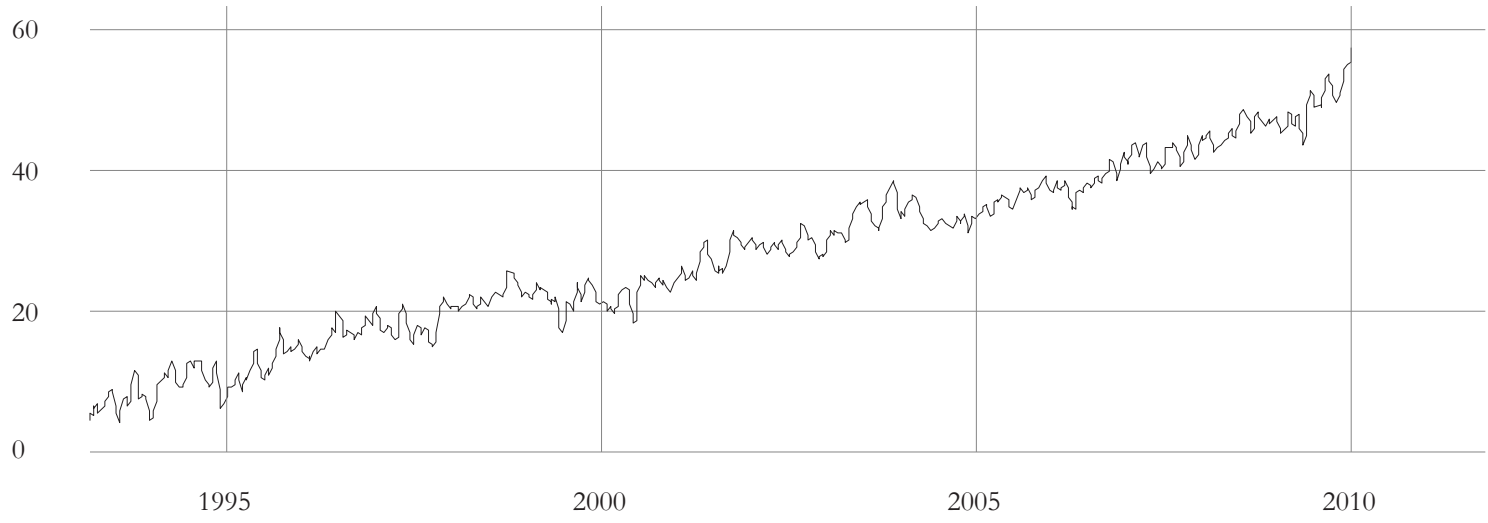
I. INTRODUCTION

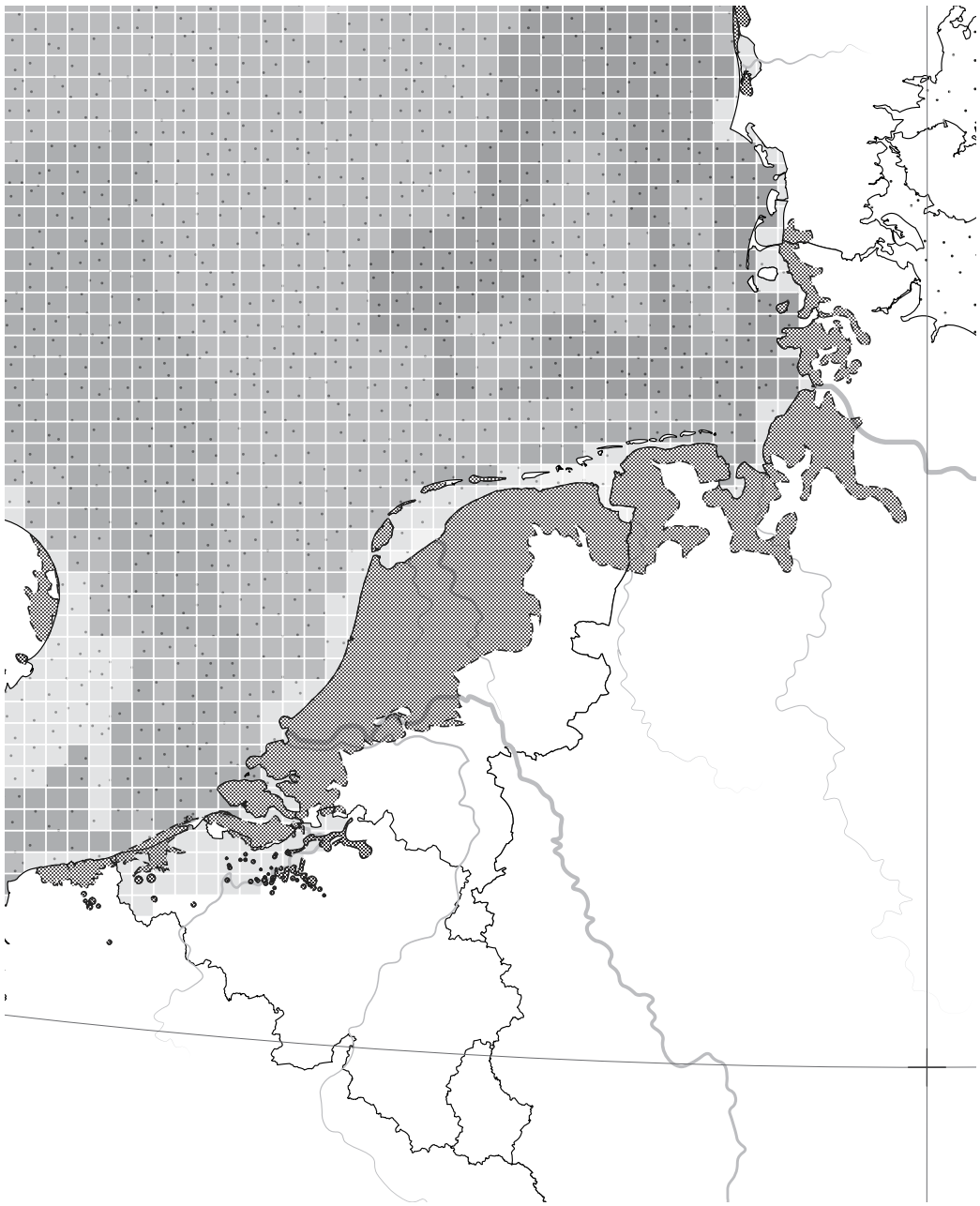
North Sea projections

The Dutch sea water level raised with 24cm over the last 128 years[1]. From a linear increase, we can see an increasing trend since the 1990s. According to recent scientific research, the sea level in the Netherlands will rise 1 to 2 meters by 2100 with a maximum global warming of 2 degrees Celsius[2]. With a temperature rise of 4 degrees, the North Sea water level will rise 3 meters. At the end of the next century, the rise can increase up to 8 meters[3].

[1] Compendium voor de Leefomgeving, *'Zeespiegelstijging langs de Nederlandse kust en mondiaal, 1890-2017'*, CLO news, 04 December 2018, https://www.clo.nl/indicatoren/nl0229-zeespiegelstand-nederland-en-mondiaal (accessed 12 April 2019).
[2] KNMI, *'Extreme zeespiegelstijging in de 21e eeuw'*, KNMI news, 06 April 2017, https://www.knmi.nl/over-het-knmi/nieuws/extreme-zeespiegelstijging-in-de-21e-eeuw (accessed 05 May 2019).
[3] C. Speksnijder, *'Bij snellere zeespiegelstijging dan verwacht, moet Nederland veel doen om het droog te houden'* De Volkskrant, 19 September 2018, https://www.volkskrant.nl/nieuws-achtergrond/bij-snellere-zeespiegelstijging-dan-verwacht-moet-nederland-veel-doen-om-het-droog-te-houden~b03ca425/ (accessed 12 April 2019).



Trend in sea level rise



Map of relative sea level rise until 2100

Future challenges

Physical geographer Kim Cohen from Utrecht University drew this map of the Netherlands in 2300 under extreme sea level rise

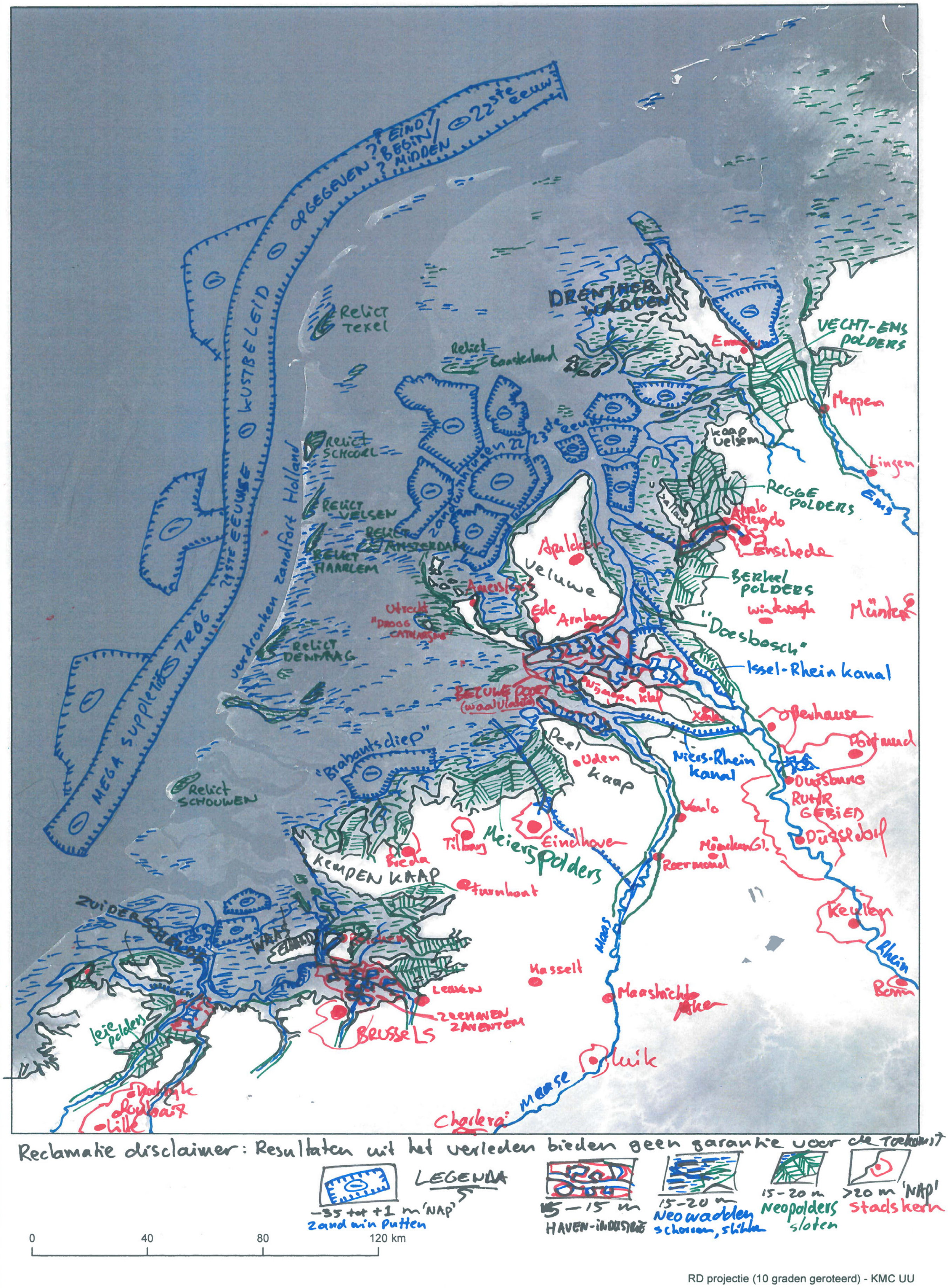
gradual developments from 2100 onwards without major disasters

the current Delta Program will be maintained until the middle of the 22nd century

First most of the West of the Netherlands will drown, with some islands remaining

"Neopolders" have been installed in the east of the country

The Wadden Sea has shifted to the Drenther Wadden



The Netherlands in 2300

The sea level rise is a bigger problem than we think

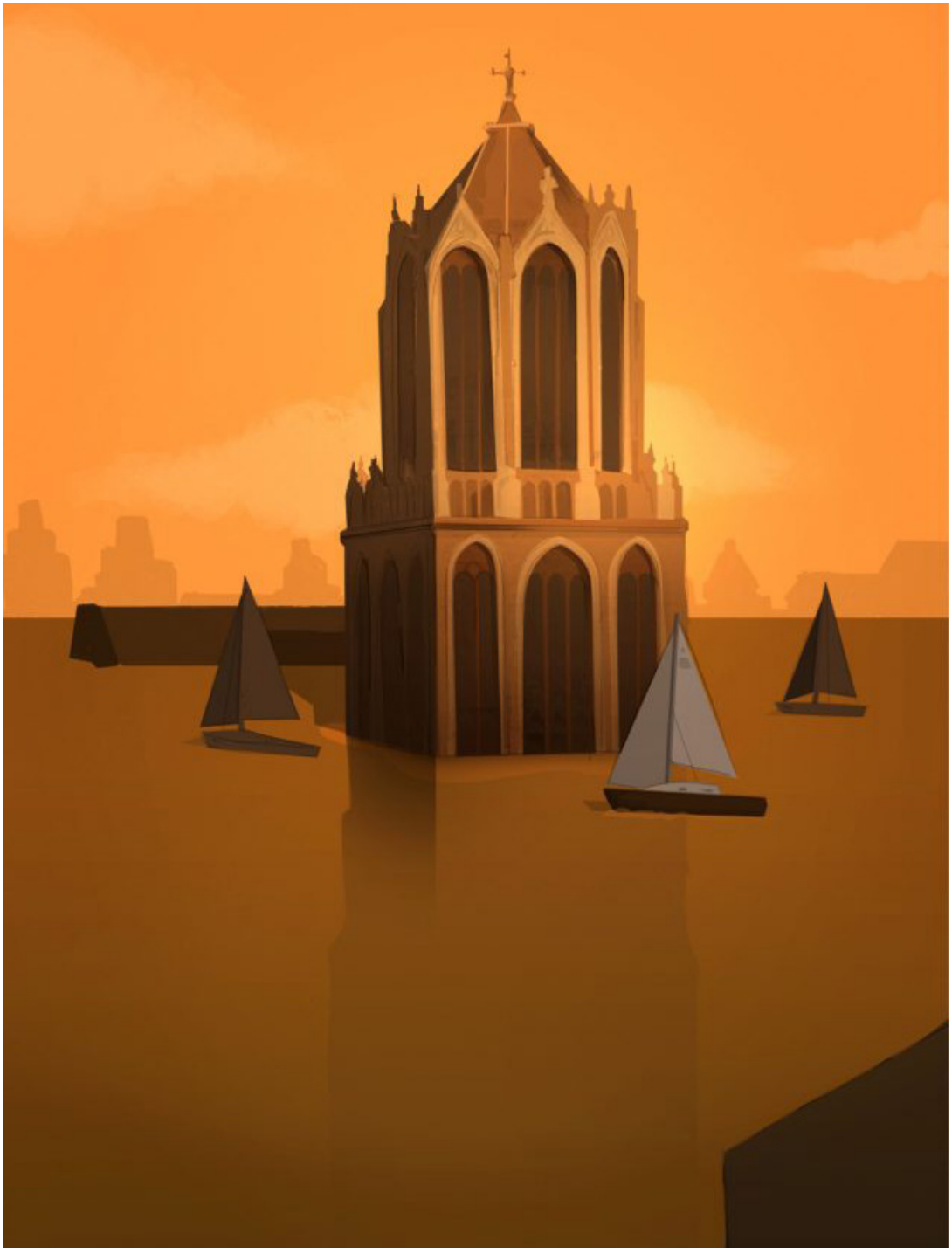
And the Netherlands has no Plan B

Most unfavorable scenario: a sea level rise of 292 centimeters in 2100

No alternative plan if the sea level rises faster than what we take into account in the Delta Program

How can we design the Netherlands if the sea level rise is much higher tha we previously thought? **3 meters in this century**, another **5 meters** in the next century

Main directions emerged by Deltares:
- we stay in our place and create our fortress, but the groundwater will be silt
- we stay in our place and built our cities on stilts
- we head towards the North Sea and build islands
- we grab our bags and head for higher ground



Dom tower, Utrecht

North Sea perspective

The image visualises the warm scencerio, asking the question what will our cities look like with a 5 metre water rise and little funding with a soft coastal defence line?The image depicts three types of housing scenarios; firstly acceptan-ce, the buildings are flooded floors which are not submerged by water will remain habitable, leaving the lower floors only accessible - if adapted prior - from the upper floors down (example scheme; Hamburg), these structures would be accessed via new galleries and external walkways. Secondly preparation, some residents may raise their houses before the sea level rise to ensure they do not have to relocate (example scheme; New Orleans). Thirdly retreat, some cities along the coastline are projected to be completely submerged, therefore they might relocate to somewhere higher and inland in the country or emigrate to countries not affected by the sea-level rise (Scotland and Norway or elsewhere in the world). Industries may move or adapt to the new environment, ports may find itself more inland, shipping and fishing boats now navigate around and through past inhabited structures remaining definitely above the sea. Whilst under the water ecological life forms now inhabit the spaces which were originally designed for man. The new coasts and coastal defences are now designed to work with nature, instead of blocking it. The image invites us to question our built environment; can we adapt it? Can we protect it? Or will we have to relocate in the future?

1. acceptance;
2. preparation;
3. retreat

Dutch coastal region: Wadden Sea

The Wadden Sea

The last of the authentic nature in the Netherlands

Stretches between Den Helder in the Netherlands and Esbjerg in Denmark

Declared a UNESCO World Heritage Site in 2009

One of the last remaining large tidal areas where the forces of nature are free to do as they please

Essential to millions of birds and fish

The Wadden area in danger of drowning

before the end of this centurybecause of:

1. rising sea level
2. dropping soil level due to gas drilling and mineral extraction in the area

The Wadden is a unique natural area, where sandbanks appear above the water twice a day

Important area for some 10 million migratory birds use the Wadden Sea as a stopover site every year

Area is an important link in coastal protection.

"Only by adding the most optimistic scenarios for sea level rise, sedimentation and soil decline can drowning be avoided and the Wadden Sea be retained in the long term" according to the researchers

Based on a 2017 study by TU Delft and Utrecht University on behalf or the Wadden Association

Waddengebied dreigt te 'verdrinken'

Wadlopen is mogelijk straks verleden tijd. Als de zeespiegel blijft stijgen en de bodemdaling doorzet, dreigen de Wadden nog deze eeuw te 'verdrinken'. Daarvoor waarschuwt de Waddenvereniging in een rapport dat vandaag is verschenen.

Redactie 10-05-17, 08:02 **Laatste update:** 10:10

Het waddengebied wordt ernstig bedreigd. © ANP

De Waddenvereniging wil de overheid en het bedrijfsleven oproepen te stoppen met gasboringen en de zoutwinning in het gebied. Eerst werd gedacht dat de zeespiegel met enkele tientallen centimeters zou stijgen, maar inmiddels wordt gerekend in meters. Volgens de Waddenvereniging zijn de modellen voor de zeespiegelstijging op basis van nieuwe inzichten naar boven bijgesteld. Aangezien in het Waddengebied ook sprake is van bodemdaling is de relatieve daling van de zeespiegel nog groter.

Met nieuw zand is de stijging van de zeespiegel nog wel te compenseren. Maar volgens het rapport is de zandafzetting in het Waddengebied onvoldoende om de stijging van de zeespiegel te compenseren. Daardoor 'verdrinkt' de Waddenzee en verdwijnen wadplaten, kwelders en de kwetsbare natuur in het gebied.

De Waddenvereniging vindt daarom dat er een einde moet komen aan de zout- en gaswinning die zorgen voor daling van de bodem. Alleen dan, in combinatie met het naleven van het klimaatakkoord van Parijs, kan het gebied mogelijk worden gered. ,,Hoe

Newspaper article in AD, 10-05-2017

Friesland and Groningen protected 165 km long dike

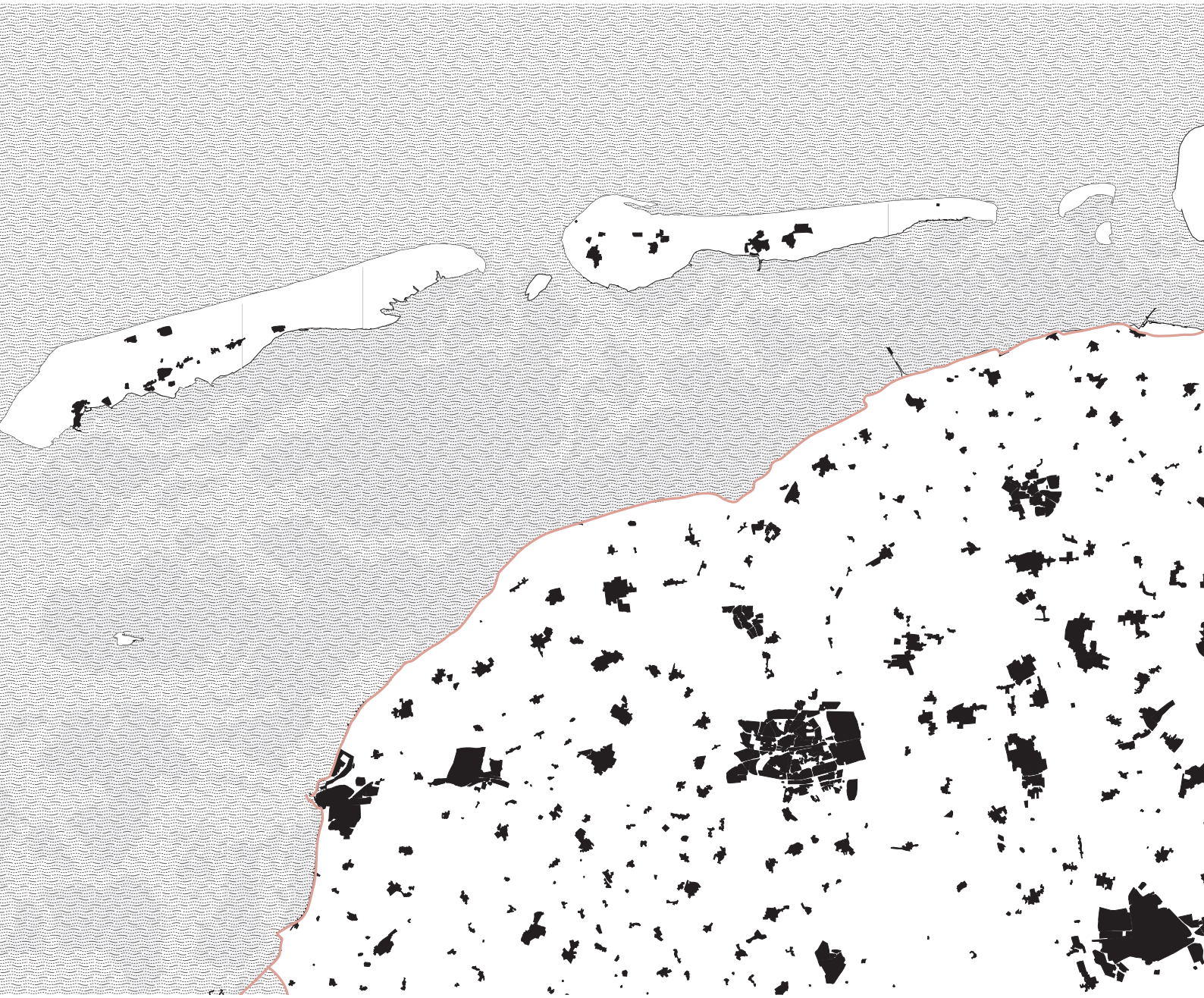
The longest dike in the country
The land is flat and limitless

Up to the dike

Here you have less of everything that makes an area crowded and full

No “randstad” but “randland”

Dutch defence plan for the coastal zone comes from the 1960s and are therefore very outdated: 24-56% of the dikes do not meet current standards



Behind the dike

Friesland; a typical North Netherlands coastal landscape

Mainly an agricultural province

Tourism as important source of income, with destinations at the lakes in the south-west and the Wadden Sea and islands to the north

About half the province below sea water level

Lowest population density in the Netherlands: 194 inhabitants per km² (compared to south Holland 1361 per km²)

Largest population shrinkage in the Netherlands, mainly because it's economically unattractive

The dike

a green bar, sharply contrasting with the sky. As if it also has to stop the land, not just the water

Hinterland

seems to underline the vastness of the land

On top of the dike

there is a strip of land that is one of the most empty parts of the Netherlands

Over the dike

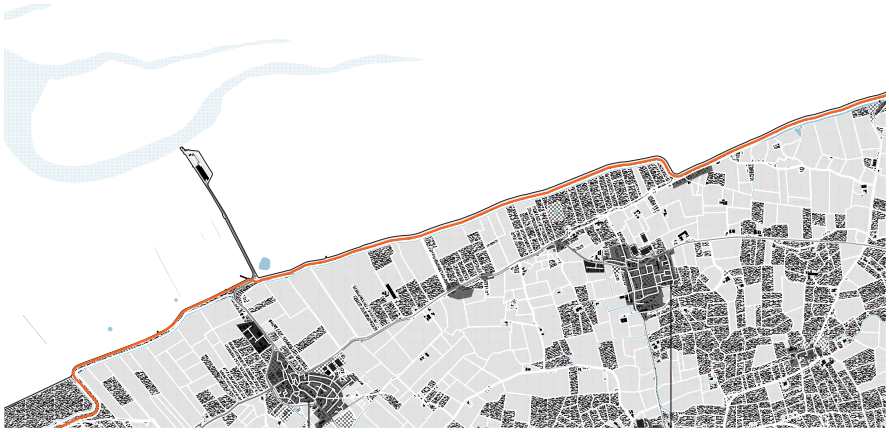
the Wadden mudflat area and with clear weather a glimpse of the Wadden Islands

Map of North Frisian coastline

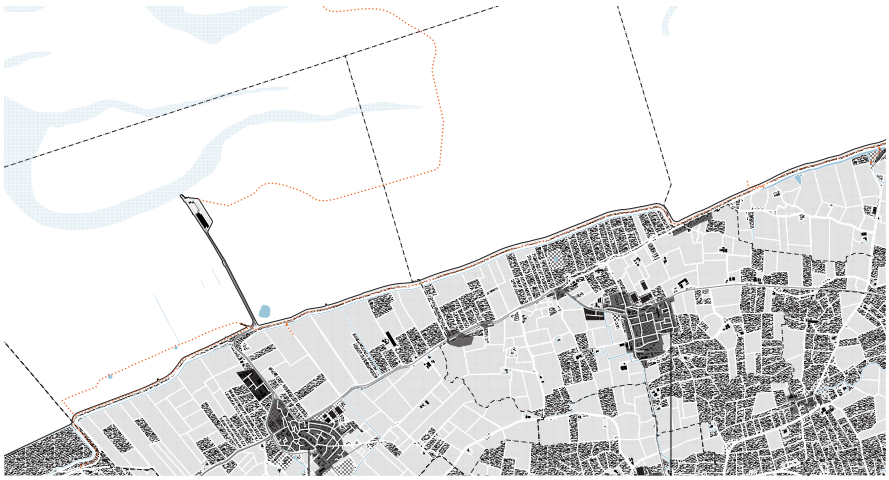
The tital flats and the hinterland of Friesland are separated by a 9.5 meter high dike. The pier leads to a deeper water body from where the ferry runs from the mainland to the Wadden island Ameland. From the end of the pier, mudflat walks starts which lead to Ameland. Also the dike is accessible for pedestrians with walking paths. The dike has some landmarks, of which most of the artwork is recently placed. Like the statues of "waiting for high water" and "the temple of Marrum" which indicates the rise of the dike in the past century

Land, tidal flats, sea

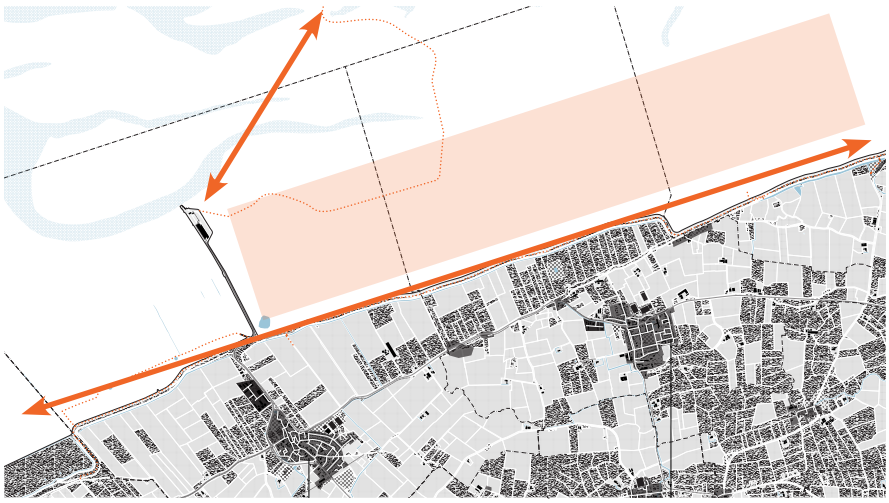
The dike



Pedestrian access



Disclosure of the area



The mudflat

During low tide a regular ditch pattern can bee seen in the salt marsh and on the mudflats. These are the remains of settling fields used for land reclamation.

From the 17th century, riparian owners began to polder in salt marshes for agricultural use The construction of settling field resulted in large-scale stimulation of sedimentation coming with the tide. Wood enclosures holds back sediments from the sea as the water as the water retreats after high tide.

The first to stick to the mudflats are salt tolerant species of vegetation. With their roots, the mudflat becomes more stable and brings oxygen into the soil. This results in regular plants being able to grow on the new land.

Settling fields

Salt marshes are grounds that were created outside the dikes through the deposition of sand and silt with a spontaneously established vegetation on them. The plants, such as sea lavender, samphire and sea aster, are resistant to the regular flooding by salt tidal water. Salt marshes are one of the few Dutch landscapes of very great international significance.

The Wadden Sea has salt marshes along large parts of the mainland coast and on the mudflats of the islands in the lee of drift dikes and sometimes as a green beach on the North Sea side. In the past the salt marshes were more or less maintained by nature, but after many embankments in the past centuries, many mainland salt marshes must be protected against turning.

From an early age, the coastal dwellers helped the natural slurrying process of salt marsh soils located outside the dikes. The first evidence can be found on a 1570 map of North Friesland (image below). Here brushwood dams were drawn perpendicular to the shore, which intended to stimulate the growth of the salt marsh. From the 17th century onwards, the salt marshes and the neighboring, still bare, mudflats were encircled by the coastal farmers. This farming method accelerated the growth of valuable land that was suitable for grazing with livestock and, after being reduced, as arable land. The coastal farmers acquired the ownership rights of this land reclamation[1].

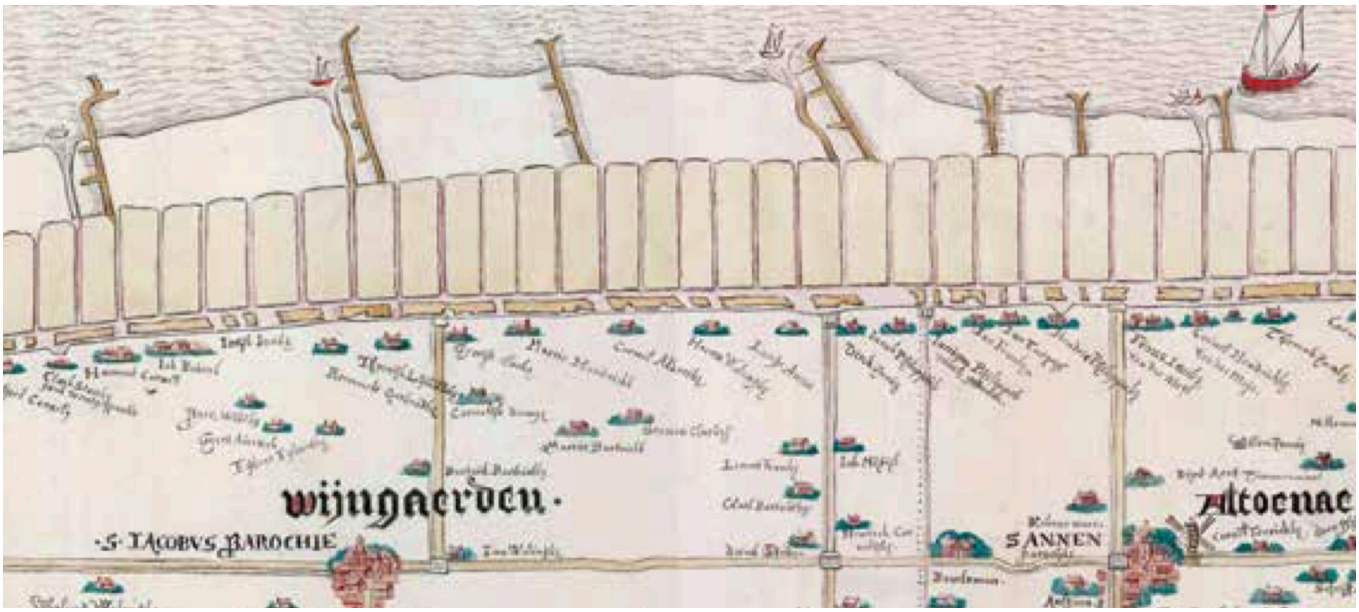
As a result of legal disputes about the ownership of the acquisitions and changing socio-economic conditions, the salt marshes were kept less and less serviced by the shoreline owners from about 1925 onwards. Instead of accretion, salt marshes were even eradicated, which eventually started to create a danger for the (still completely green) sea dikes. After an ownership regulation with the shoreline owners, land reclamation by the State was continued and intensified in 1935[2].

At the same time, the prevailing high unemployment rate could be fought against. The new method of land reclamation consisted of building row dams (double pile rows with brushwood inbetween them), with which sections of 400 x 400 m were laid. Approximately 25 m wide openings were left open to allow the flood and ebb water to pass through. The sludge carried by the flood remained in the settling fields thus formed. To optimize the sludge collection function, trenches and ground dams were also dug up in these settling fields, initially with manual force. After 1950, the annual excavation of the trenches was increasingly mechanized. In 1968, ditch maintenance was stopped in the most seaward settlement settlements for economic reasons. After 1982 the excavation of the trenches in the overgrown sedimentation fields was reduced to once every 2 to 6 years and almost completely ceased after 1998[2].

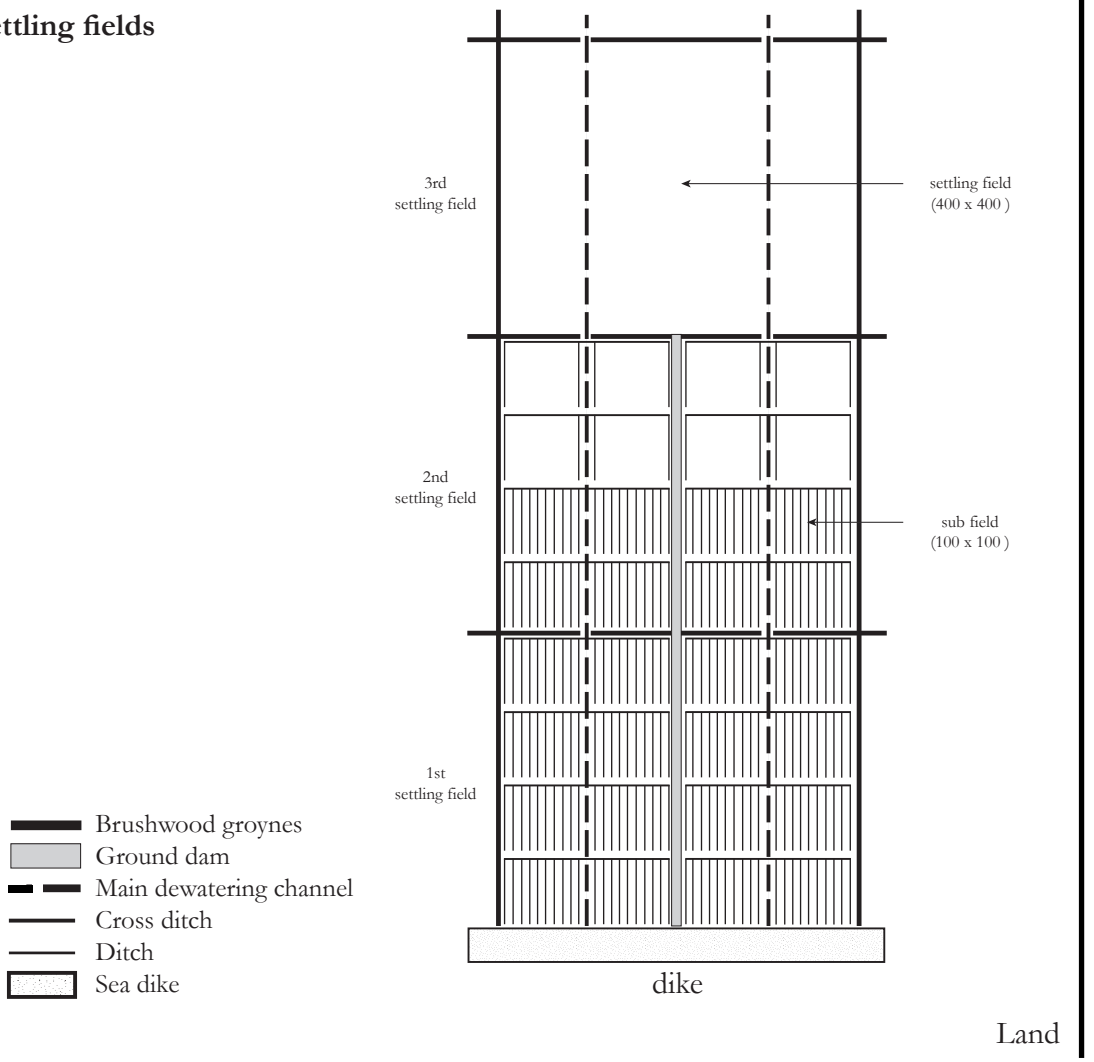
[1] A. Vierlingh, *'Tractaet van Dyckagie',* 's-Gravenhage, Rijks Geschiedkundige Publicatiën, 1920

[2] K.S. Dijkema, 'Changes of salt-marsh area in the Netherlands Wadden Sea after 1600', in A.H.L. Huiskes, C.W.P.M. Blom en J. Rozema (ed.), *Vegetation between land and sea*, Springer, Dordrecht, 1987, p. 42-49.

Map of Frisian coast in 1570



Schematic layout of settling fields



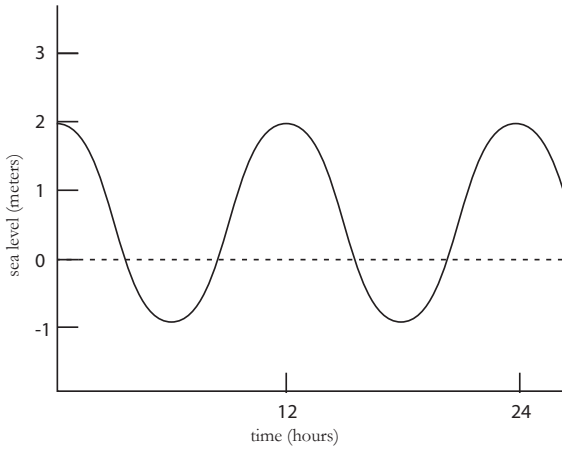
Man-made dams in settling fields

Reclaiming land in front of the dike along the Dutch north coast could help protect it for sea level rise and other effects of climate change. With the tide come sediments that are then held back by the wood enclosure as the water retreats. Salt tolerant species then stick to the mudflats making it more stable and bringing oxygen into the soil for regular plants to grow in these coastal ecosystems.

When the sea gets deeper, more sand will be supplied from other places. So when the sea level rises, sanding in the Wadden sea will increase. This sand comes from the North Sea cost, Texel and North-Holland. There is sufficient sand in the Wadden area to compensate sea level rise. This is also the case for salt marshes along the Wadden sea cost. The silting up of the mainland salt marshes is 130 to 180 centimeters per century. But in combination with more wind and higher waves, salt marshes will flood more often. Experts say that the Wadden sea soil will be able to keep up with a sea level rise of 20 to 60 centimeters. If sea level rise exceeds 85 centimeters, in combination with more frequent storms, the tidal flats will disappear completely[1].

[1] R. Schuttenhelm, *'Dreigt de Waddenzee te verdrinken?'* nrc handelsblad, 10 May 2017, https://www.nrc.nl/nieuws/2017/05/10/dreigt-de-waddenzee-te-verdrinken-a1557894 (accessed 13 April 2019).

Accretion of land



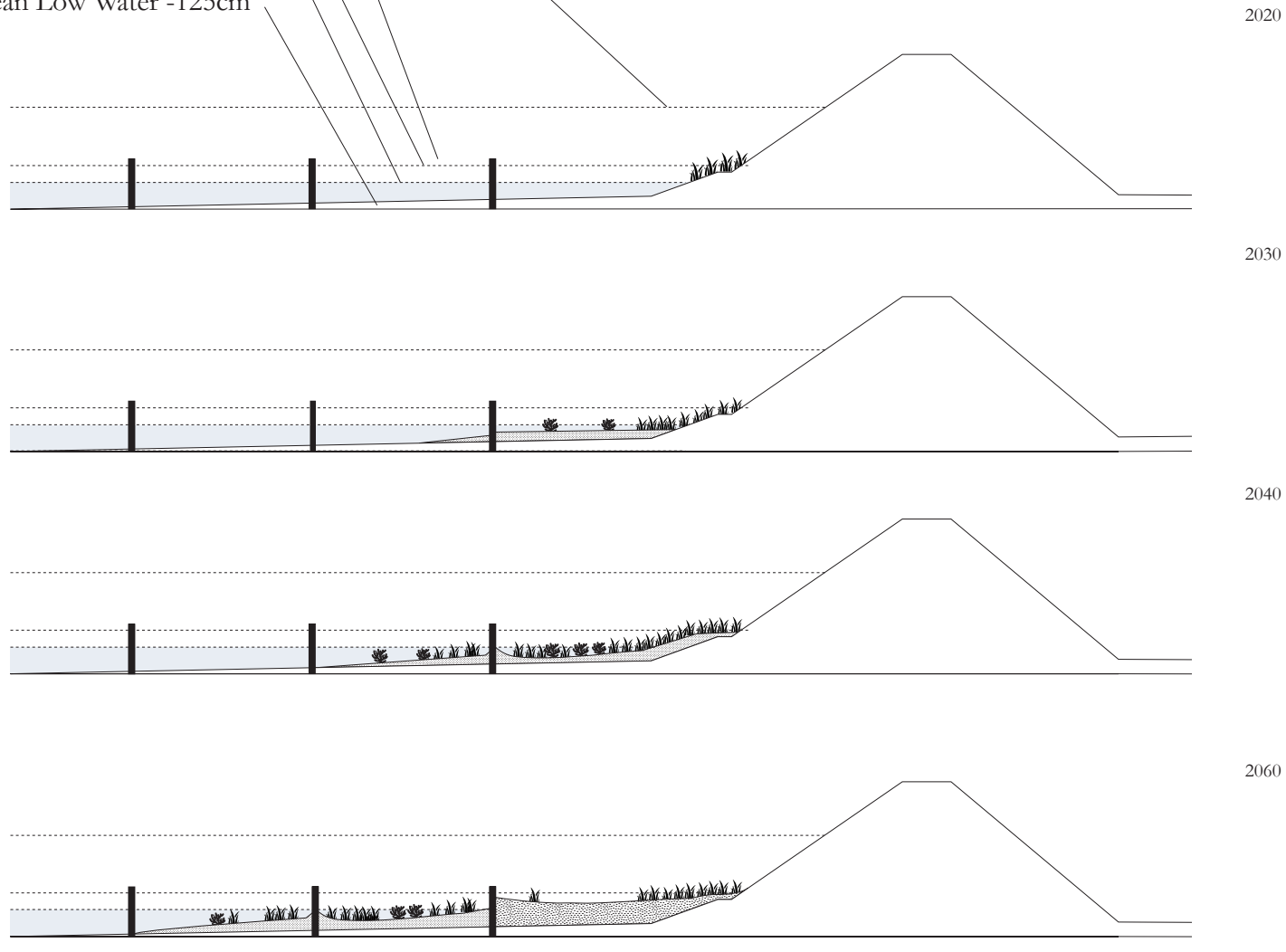
Spring Surge > +280cm

Dam +140 (30 cm above average high tide)

Mean Spring tide+120cm

Mean High Water +110cm

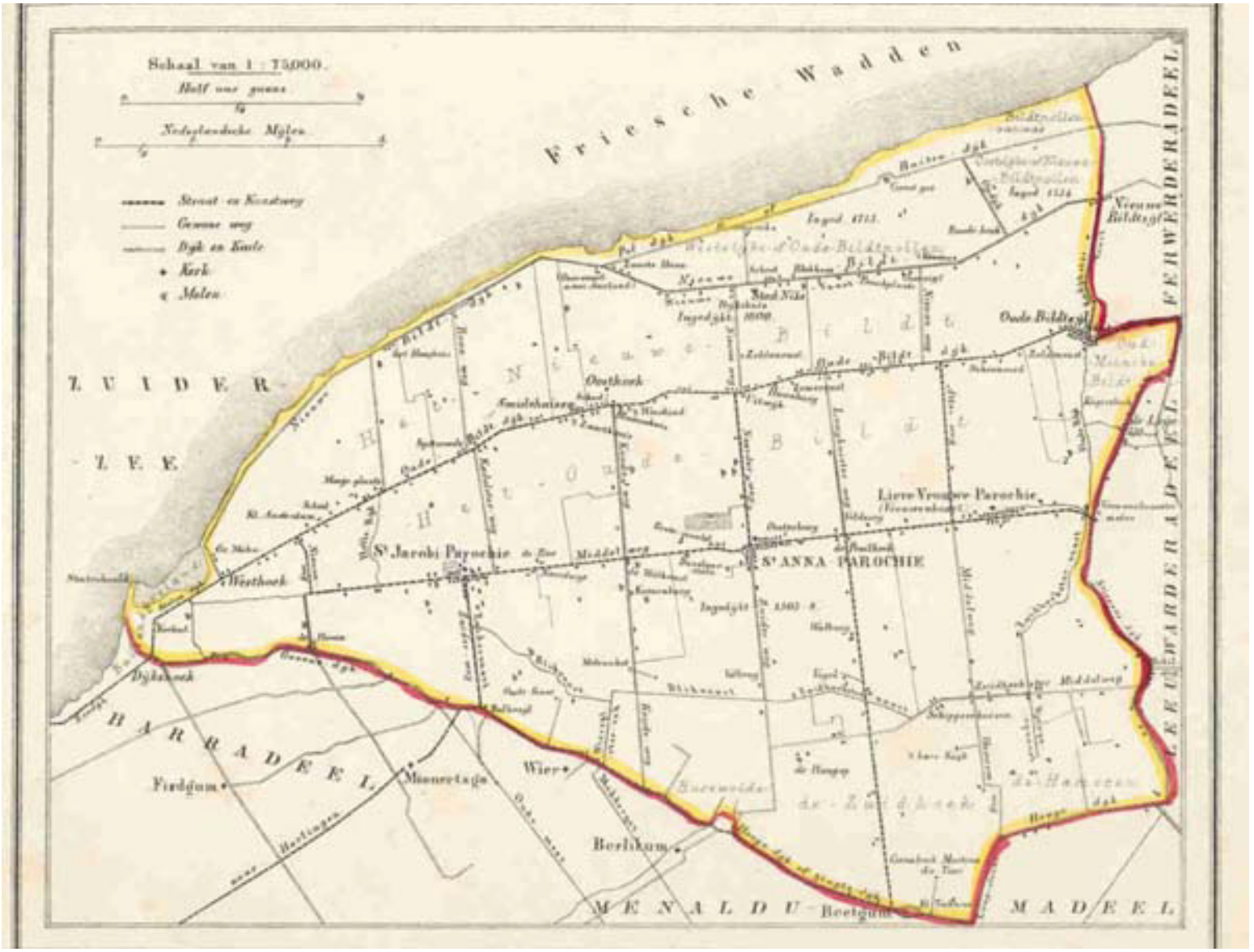
Mean Low Water -125cm



New land

Nothing has been more instrumental in the formation of the Dutch mentality than the sea and the threat of water. What the Alps are for the Swiss, and volcanoes, earthquakes, and tsunamis for the Japanese, the Dutch challenge their fate by building dikes and dams and institutionalizing their water management. The flood became the ground zero of Dutch culture.

The challenge of the sea came with living in the coastal marshes. The building of dikes was a first step to defend the unprotected lands. In the thirteenth century, the southern part of West Friesland was the first integrated polder area to get an enclosing, 126 kilometers long dike. Water management became a serious task for water boards, with voting rights and a mandate to levy their own taxes. But often the money available wasn't enough, or the memory for disasters was too short. Neglected dikes and overdue maintenance led to countless large- and small scale disasters. In the beginning of the fifteenth and the sixteenth century, however, another series of devastating storm floods made their appearance, whose names would be engraved in the collective memory.



Gemeente Het Bildt (Friesland), Jakob Kuyper, 1865

The representation of the New Land

The earliest representation of the new land was cartography, but the polder landscape with windmills, the horizon, and the clouds was so overwhelming and stimulating that it became a main theme of poets and painters.

The euphoria of the flat land was immortalized by Dutch masters in all its aspects. Albert Cuyp, Jan van Goyen, Johannes Vermeer, and Rembrandt van Rijn were impassioned about the everyday, and made use of the magical polder light. Ruisdael was fascinated by the monumentality of the New Land's infrastructure. Windmills, bridges or the waterwheels were subject to his dramatic landscape paintings.

De molens bij Wijk bij Duurstede, ca. 1778 - ca. 1670
Jacob Isaacksz. van Ruisdael

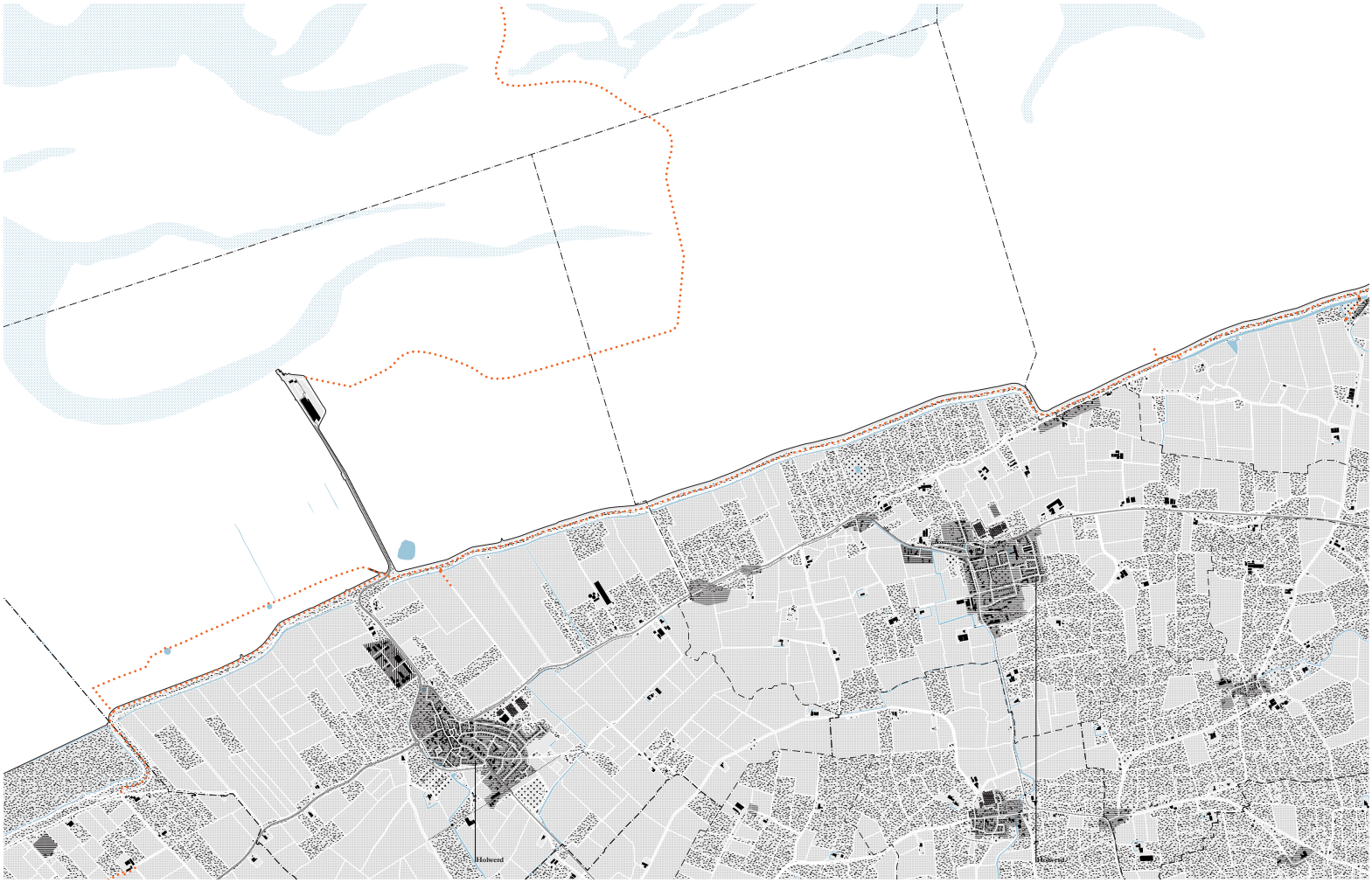
Inter-tidal zone

The Wadden Sea is the largest wadden region in the world. The shallow sea consists of bottom sand that is blown up by sea currents from the North Sea. Because a tidal flat is flooded twice a day by the tide, the current takes sludge along, which then settles in places that are quiet during a high water period.

The Wadden Sea is a UNESCO heritage site shared by The Netherlands, Germany and Denmark. A salt marsh, also known as a tidal marsh, is a coastal ecosystem in the upper coastal inter tidal zone between land and open saltwater that is regularly flooded and is therefore dominated by salt-tolerant plants such as herbs, grasses, or low shrubs. These plants are essential to the stability of the salt marsh in trapping and binding sediments. Salt marshes support terrestrial animals and provide coastal protection[1].

For demographic, economic and agricultural reasons, the Wadden Sea is one of the world's seas whose coastline has been most modified by humans. Over the last century, the sea water defense systems that have been installed were able to hold the raise in water levels of about 24cm. However, these levels are estimated to approximately reach another 85 to 200 cm by the end of the current century[2].

[1] C.D. Woodroffe, '*Coasts: form, process and evolution*', New York, Cambridge University Press, 2002
[2] KNMI, *'Extreme zeespiegelstijging in de 21e eeuw'*, KNMI nieuws, 06 April 2017, https://www.knmi.nl/over-het-knmi/nieuws/extreme-zeespiegelstijging-in-de-21e-eeuw (accessed 05 May 2019).



Water

Inter tidal zone (mudflat accessible on food at low tide)

Inter-tidal map of North - East Friesland

Tidal wetlands

Since maintenance was almost completely stopped after 1998, the wooden dams are currently in state of decay. With the dams almost perished, the plants that are essential to the stability of the salt marsh, are slowly washed away. With this comes the loss of their role in protection against coastal erosion, flood reduction, and the existence of an important ecosystem.

The degree of the wave reducing effect of the marshes depends on the height and width of the salt marsh, but also on the occurring water levels. It is still unclear to what extent salt marshes can contribute to water safety in a changing climate with higher water levels and more extreme weather. Studies have been developed by the Dutch Delta Program Subprogramme Wadden Sea Region. A literature study was done by Wageningen University and Research, Deltares, and Kennis voor Klimaat (Knowledge for Climate), to form a step in exploring suitable water safety strategies in the Wadden Sea Region that also focuses on objectives for nature and spatial quality[1].

The conclusions of the literature study by the research institutes in 2012 shows that the knowledge that is available is primarily focused on ecology and biodiversity in relation to abiotic aspects such as erosion, siltation and sediment composition. Although the capacity of salt marshes and foreland to grow along with the sea level has long been known, there is still a lack of sufficiently detailed knowledge about the behavior of salt marshes from the point of view of flood protection. The behavior of salt marshes under normative circumstances therefor requires more research. Their recommendations for future research are therefor to study wave run-up on dike sections with and without a salt marsh (as a foreland) under extreme conditions. Because the wave damping is highly location-specific, the wave reduction must be monitored at a number of characteristic and different locations so that the information obtained from the above recommendations can be used to calibrate models and then further develop the application of salt marshes for water safety[2].

For the use of salt marshes and / or bio-builders to contribute to safety, it is of great importance to invest in clear communication about knowledge and necessary knowledge development with direct stakeholders (owners/ managers, residents, water boards, provinces, municipalities and government). An existing salt marsh with many different widths (for example Noard-Fryslân) could serve as an example project. By constructing salt marshes cover a length of approximately 10-15 km of dike, a useful test case can be developed to research water safety objectives and nature policy objectives[3].

[1] J.M. van Loon-Steensma, et al., *'Een Dijk van een Kwelder. Een verkenning naar de golfreducerende werking van kwelders'*, Alterra-rapport 2267, 2012, p. 13
[2] J.M. van Loon-Steensma, et al., *'Een Dijk van een Kwelder. Een verkenning naar de golfreducerende werking van kwelders'*, Alterra-rapport 2267, 2012, p. 45
[3] J.M. van Loon-Steensma, et al., *'Een Dijk van een Kwelder. Een verkenning naar de golfreducerende werking van kwelders'*, Alterra-rapport 2267, 2012, p. 61

Position

This landscape shows, more than any Dutch landscape, the everlasting dialogue between humans and nature. The engineer is inextricable linked to the design and use of the landscape. Rehabilitating the landscape for the threat of sea level rise, should therefor also re-establish the dialogue between nature and humans.

II. ANALYSIS

Tidal change

The project consists of the restoration of the territory that almost entirely disappeared. It functions as a test case for the restoration of the system of salt marsh dams, a system dating from the 17th century. It is from the tidal dynamics that new relationships are established between, on the one hand, the engineering requirements and, on the other hand, the need to reconstitute extensive natural environments that boost the attractiveness of the area.

The territorial and landscape reactivation is established by an ephemeral light infrastructure of handmade wooden dams. Regarding the historical situation, the eroded salt marsh grows back over time, and will enriched with a route through the landscape, explaining the principles of the salt marsh through different tidal gardens. One walks from the land, as resulted from the construction of the dike, through the different stages the landscape takes in its transformation from sea to land, towards the sea.

(eroded) brushwood dams

Water level >180cm +NAP

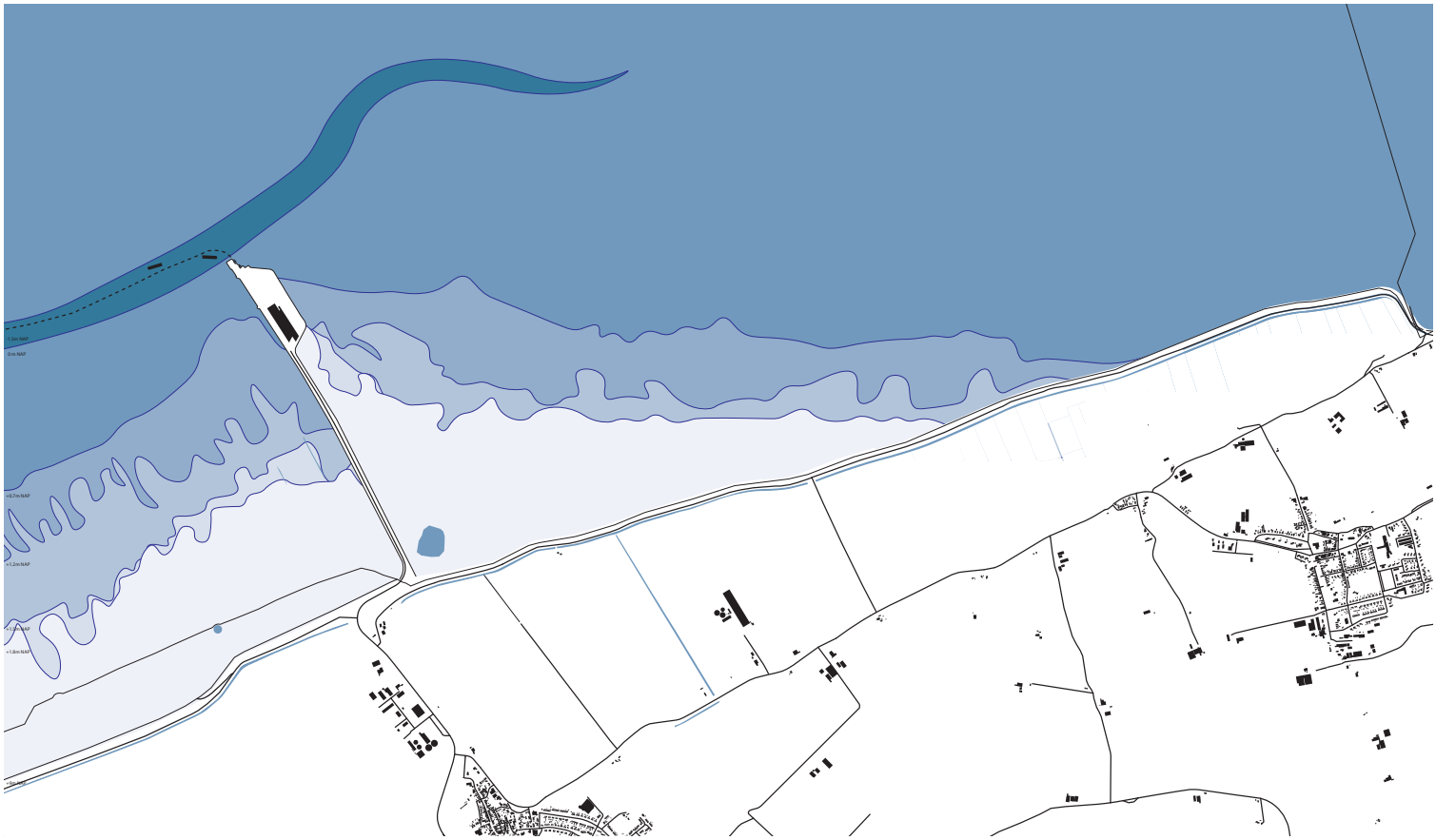
Water level 150-180cm +NAP

Water level 110 -150cm +NAP

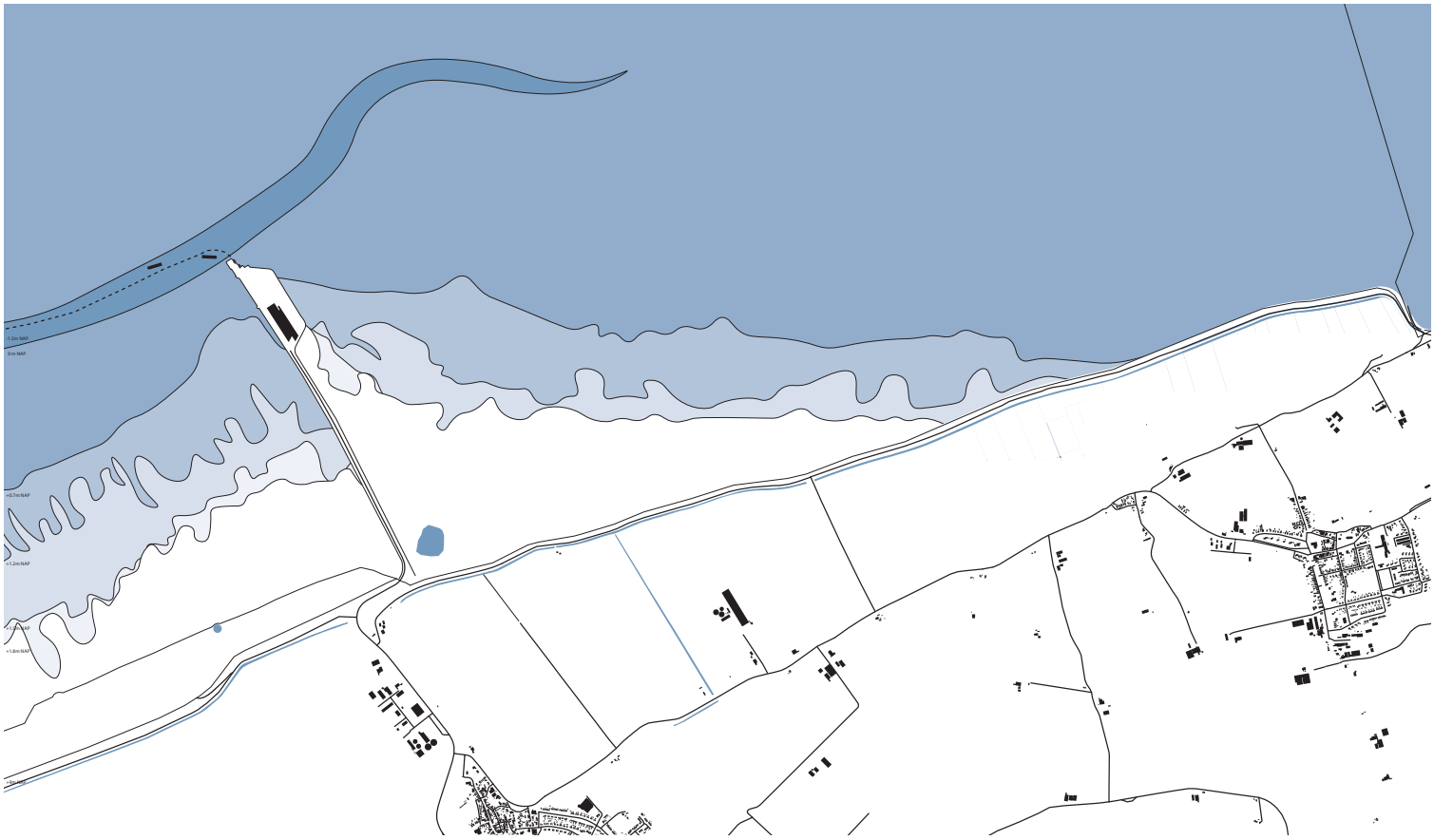
Water level 70 - 110cm +NAP

Water level <70cm +NAP

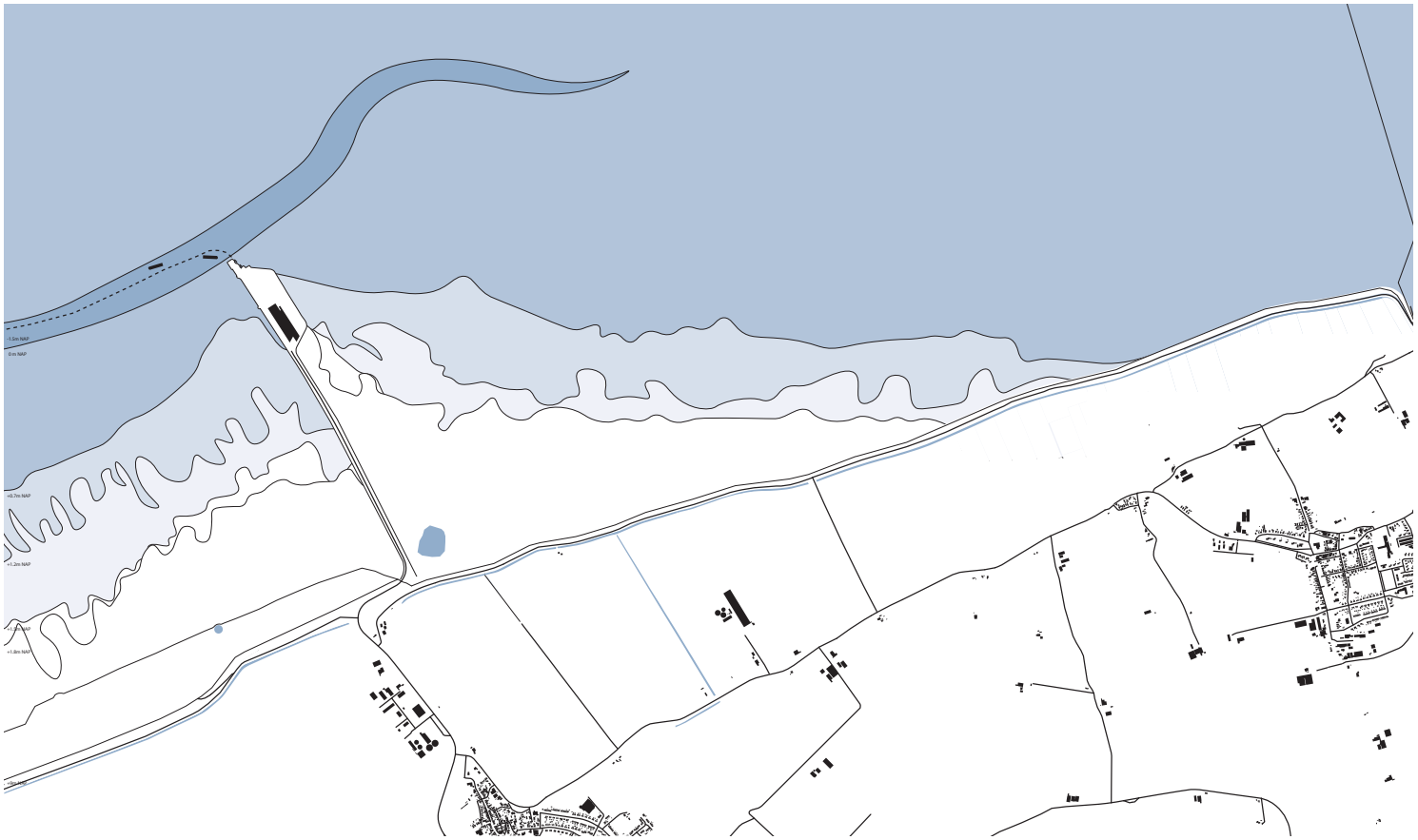
Water level <150cm -NAP



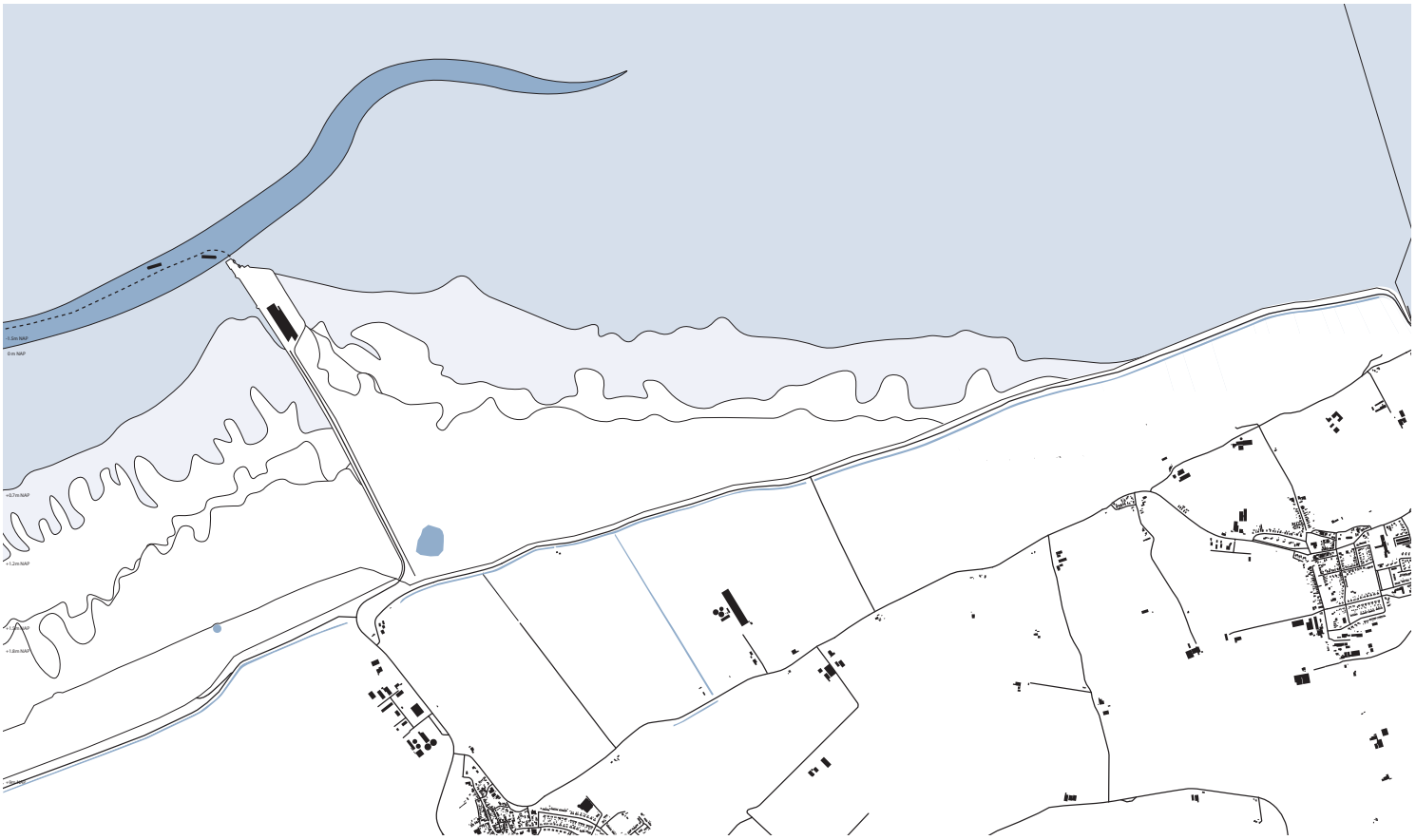
Spring surge: water levels > 250cm +NAP



Spring tide / HHW levels above 150cm +NAP



Spring tide: water levels above 120cm +NAP



Mean high tide: 110cm +NAP

Mean tide: 106cm +NAP

Low tide : < 100cm -NAP

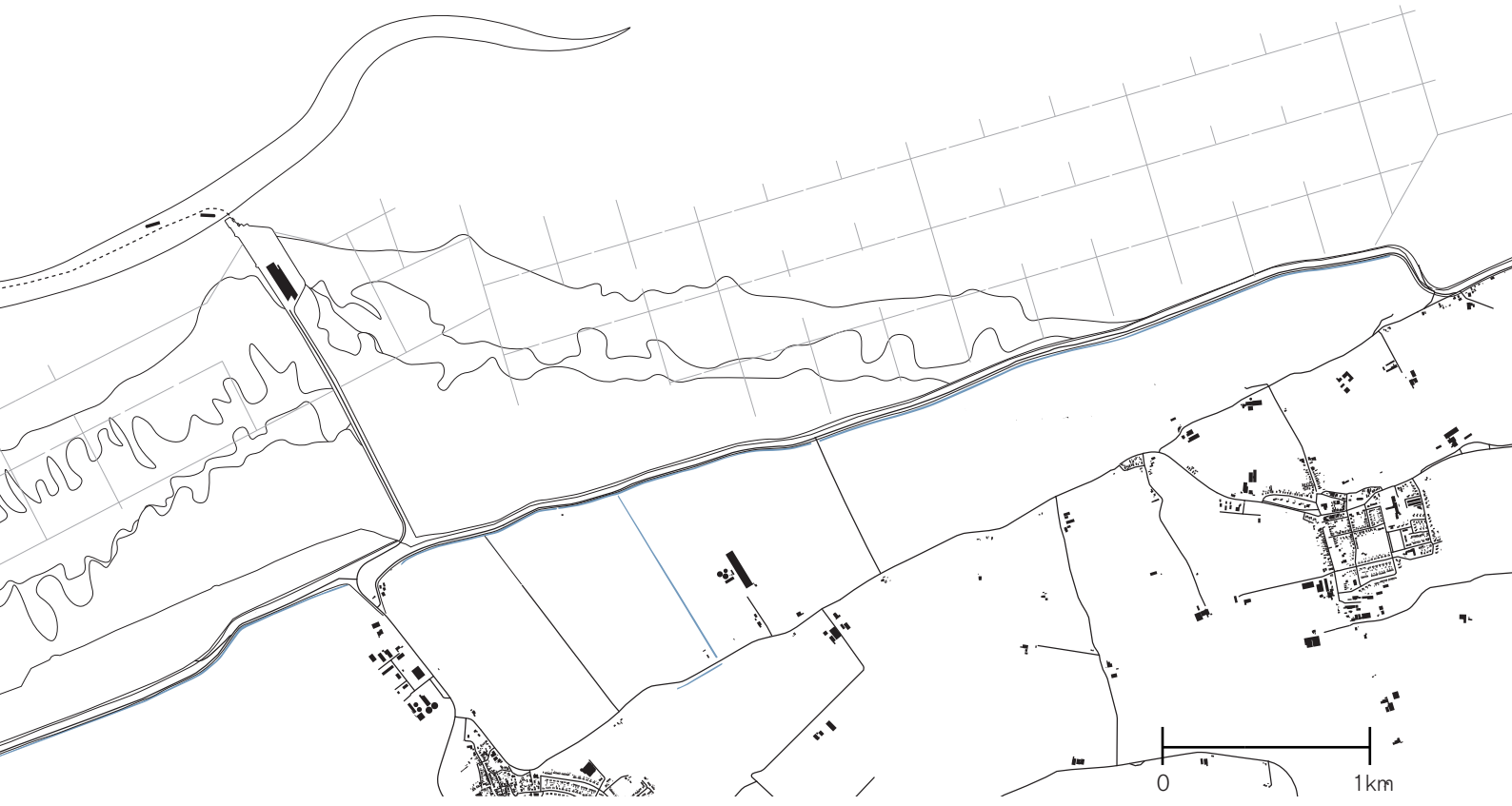
Eroded salt marsh pattern

Eroded brushwood dams


© It Fryske Gae


© Rijke Waddenzee


© FotoDeVoogd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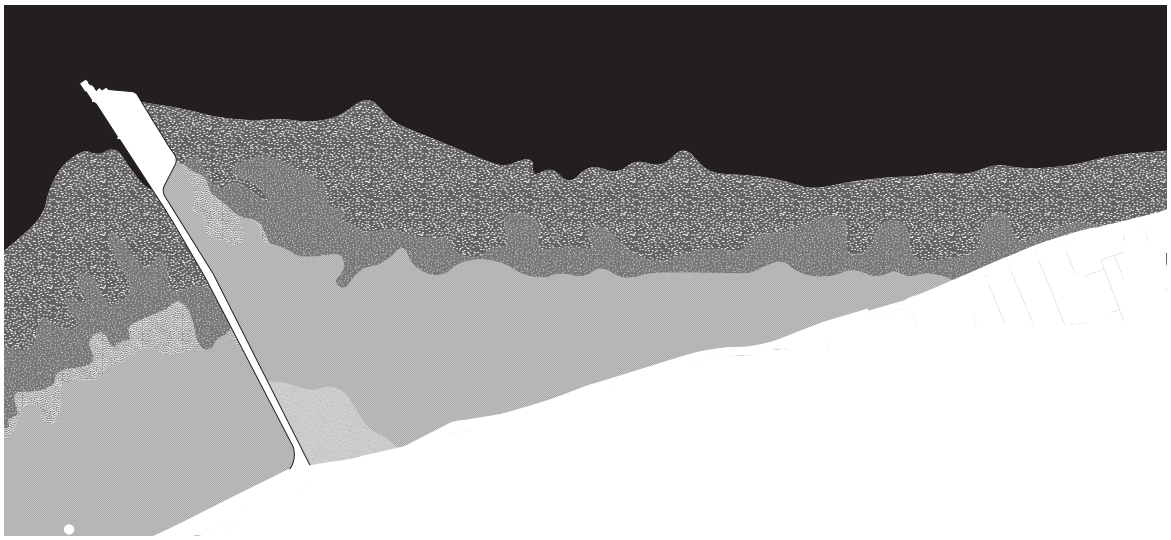
1km

Current seascape typologies



Tidal flat < 70cm +NAP

Pioneer vegetation 70 - 110cm +NAP

Low salt marsh 110 -150cm +NAP

High / medium salt marsh 150-180cm +NAP

Highland >180cm +NAP

Het Wad

Elevation: <70cm

Zone specific qualities:
- floods twice a day
- start of muflatwalks that lead to the island Ameland during low tide
- no vegetation

'Het wad', the tidal flat of the wad-densea, is a mud or sandbar that has been created in a shallow sea, with a height that is between the normal low water and high water levels.

Het 'wad' usually means the wadden region that runs along the coast from Den Helder in the Netherlands, and along the German coast to Esbjerg in Denmark.

Seals on a sandbank © climate gate

Sand banks appearing at low tide © Sijmen Hendriks

Mudflat walks to the islands © Friesland historie

Het wad with low tide

Pioneer salt marsh

Tidal dynamics:
Elevation: 70-110 cm
Floods: twice a day during mean high tide (avg. HT: +106cm NAP)

Zone specific qualities:
- furthest away from civilisation
- darkest point
- widest open

Samphire (zeekraal, salicornia) © Wilde planten

Common saltmarsh-grass (kweldergras, puccinellia fasciculata) © Wilde planten

Common cordgrass (engels slijkgras, spartina anglica) © Wilde planten

Pioneer vegetation with low tide

Low Salt marsh

Elevation: 110- 150cm

Zone specific qualities:
- floods twice a month spring tide (avg. HHT: > +120cm NAP
- first permanent vegetation
- silt nature is important bird breeding place
- some smaller mammals like hares can be found

Architectural intervention:
- bird shelter/ bird observatory which blends into the landscape. a horizontal structure to et closer to nature. Some openings provide a view over the land-scape at different heights.


oystercatcher (scholekster)


Sea lavender (lamsoor, limonium vulgare)


Spoonbill (lepelaar)


Sea purslane (zeemelde, artriplex halimus)


Redshanks (tureluur)


Zeeaster (sea aster, tripolium vulgare or aster tripolium)


Salt Sandspurry (zilte schijnspurrie, spergularia salina)

Silt nature at the mudflat

© *ecomare*

Terrestrial birds

For many migratory birds, the Wadden Sea is an important stopover or wintering site, forming an essential link in the East Atlantic Flyway. The distinctive habitats of the Wadden Sea region are also a breeding area for many bird species. Five species groups which share certain ecological and functional features and profit from comparable measures that can be distinguished in this region are: birds of prey, birds breeding in colonies, beach breeding birds, birds of meadows and salt marshes and birds breeding in the dunes. Friesland and the salt marshes are a great location to spot rare and less rare species of all groups, dependent of the season[1].

Due to various causes, many of these populations are decreasing. Birds of the meadows and salt marshes for example, are having a tough time breeding, since the nests of these birds in salt marshes have been swept away by high water. Birds also suffer a lot from drought, which makes food scarce[1].

[1] J. Blew, et al., *'Migratory Birds'*, in S. Kloepper, et al., Wadden Sea Quality Status Report 2017 https://qsr.waddensea-worldheritage.org/reports/migratory-birds, Wilhelmshaven Common Wadden Sea Secretariat, last updated 21.12.2017, qsr.waddensea-worldheritage.org/reports/migratory-birds (accessed 07 September 2019)

Birds of prey

Aalsgolver

Slechtvalk

Birds of meadows and saltmarshes

Lepelaar

Rosse grutto

Birds breeding in colonies

Grote stern

Kokmeeuw

Birds breeding in the dunes

Shelduck (bergeend)

Tapuit

High salt marsh

Elevation: 150- 180cm

Zone specific qualities:
- floods a few times a year during storm or extreme high tides (> +150cm NAP)
- suitable for silt agriculture. Almost one third of the Dutch agriculture area suffers from salinisation[1]. This requires knowledge of the cultivation of silt vegetables,
seaweed and fish. Salt marshes have historically been used for silt agriculture. They will again be used as a pilot and education field for silt potatoes, tomatoes, ice spice, sea cabbage, samphire, sea fennel, and sea beet.
- large mammals to maintain the salt marsh

Architectural intervention:
- focus on the story of the man-made landscape. A flat, cantilevered roof, underscores the horizontal character of the surroundings. With the roof almost floating, the space below fuses with the landscape which strengthens its relationship to the surrounding fields.

Silt nature

Red fescue (roodzenkgras, festuca rubra)

Sea thrift (engels gras, armeria maritima)

Sea couch (strandkweek, elytrigia atherica)

Silt agriculture

Silt potatoe

Sea cabbage (zeekool, crambe maritima)

Sea fennel (zeevenkel, sativam battim)

[1] R. Didde, *'Tegen het zout is spelt gewassen'*, de Volkskrant, 15 November 2003, https://www.volkskrant.nl/economie/tegen-het-zout-is-spelt-gewassen~b16e3205/ (accessed 8 September 2019)

Silt agriculture at the mudflat

Highland and seadike

Elevation: >180cm

Zone specific qualities:
- floods less than once a year during extreme storm surge in combination with spring tide (> +250 cm NAP)
- contains hiking and cycling paths
- mostly grasslands for sheep and other livestock

Architectural intervention:
- steps down from the dike into the man-made land and new silt nature. Seats extending the dike at all the different heights the dike has been elevated: to 4.4m in 1734, to 5.1m in 1883, to 6.2 in 1933, and to 9meters Delta height in 1960.

The sea dike along the Frisian north coast was raised in the period 1570-1970. In any case, that happened in the period 1570-1574.Then the dike was raised by a meter from 2.66 meters to 3.66 meters. Caspar De Robles took the initiative for this dike increase. After that, the dike was raised a number of times: around 1734 to 4.41 meters and around 1883 to 5.12 meters[1].

Between 1930 and 1933, hard work was still being done along the North Frisian Wadden coast to raise the dikes from Westhoek to Roptazijl to 6.21 meters. This in connection with the approaching closure of the Zuiderzee. A well was dug in the north of Firdgum (zoom village atlas AHN). The required soil was transported from this well by truck and brought to the dikes. Many unemployed have been put to work in this way. The well nowadays has a nature destination. Under the Delta Act, the entire coastline was raised again in the 1960s. The at that time sea-facing dike of Firdgum remained untouched, because a new dike was constructed just north of an existing summer dike. The mud that had grown in the lee of the Statenhoofd were polled by this intervention[1].

High water

Sheep on the dike

Fishsermen monument in Wierum

Dike temple in Marrum

[1] R. de Raad, *De dijk op Hoogte,* Harlingen, Waterschap Fryslan, 1993, p. 97-109

Sea dike Friesland

III. LANDSCAPE INTERVENTION

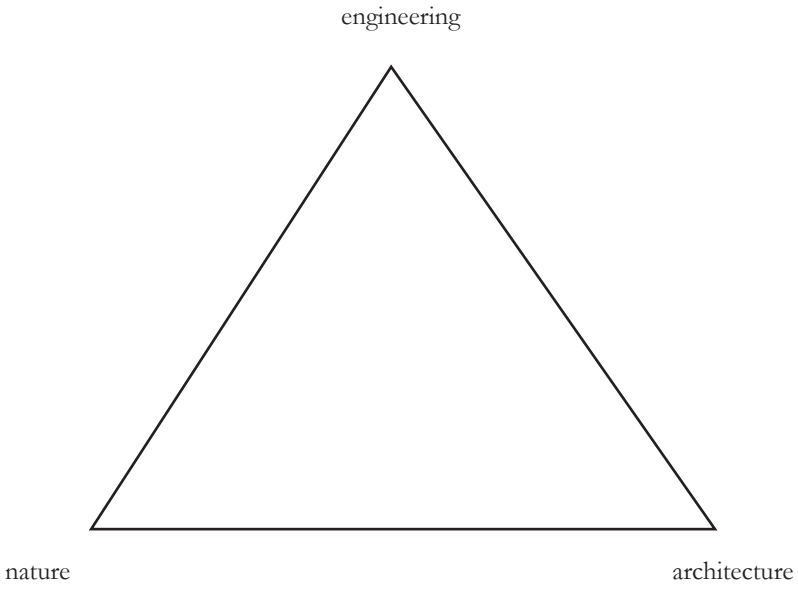
OMA / Rem Koolhaas: Haarlemmermeerpolder 1986
'A landscape grid towards the North sea'

Introduction

The grounds that were created outside the dikes through the deposition of sand and silt, resulted in one of few Dutch landscapes of very great international significance. But the valuable nature site is in decay. The termination of the maintenance of the salt marshes by local farmers, raised the problem of finding new, sustainable uses. This is a challenging task: any future solution needs to contribute flood reduction, against coast erosion and the existence of an important ecosystem.

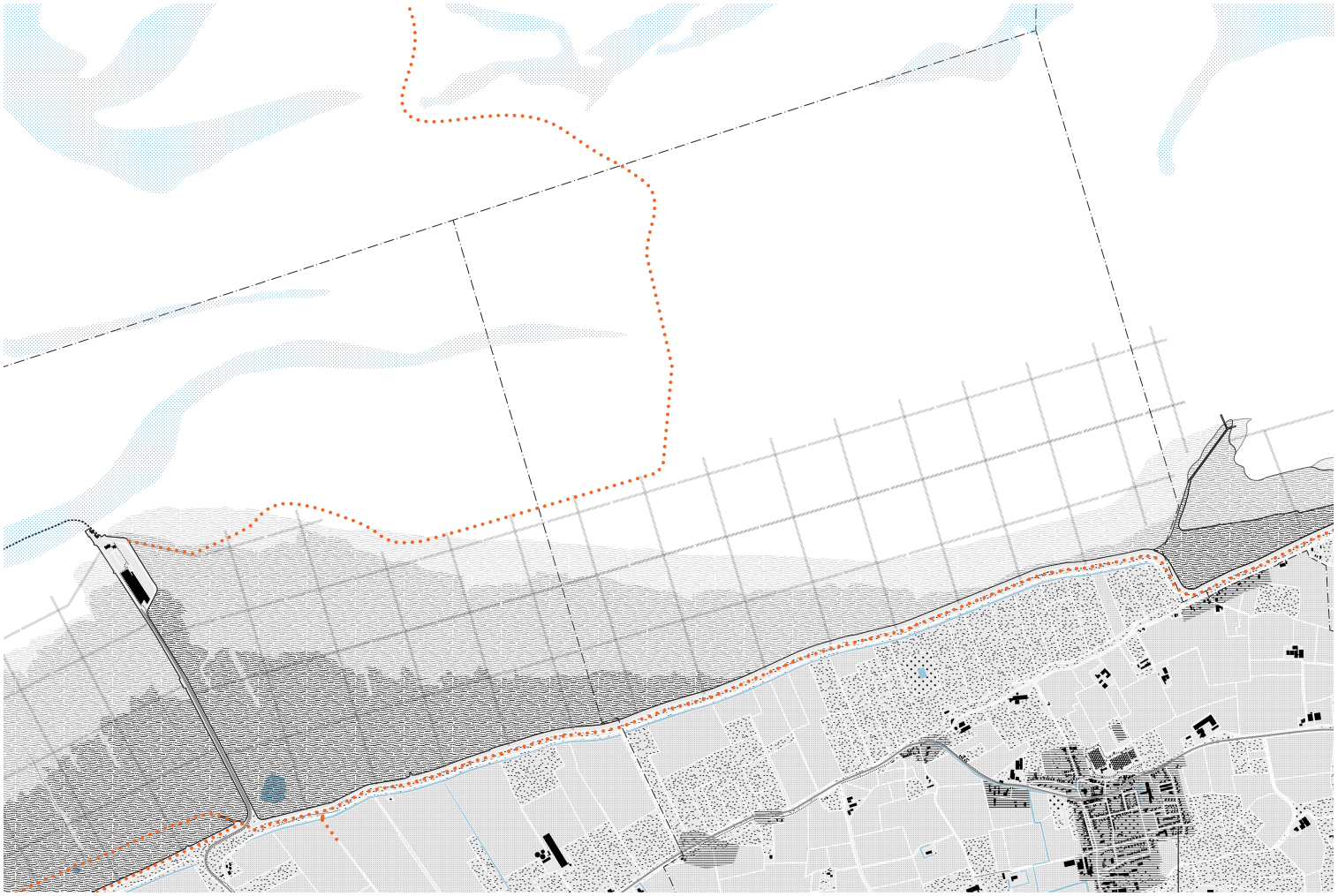
The design brings together the two concepts of landscape as a product of engineering and landscape as memory, based on a historic man-made landscape that was created in the seventeenth century. The same three parties that involved in the process and design will benefit from it. From the pragmatic point of view the hydraulic- and water management engineers and researchers, from the ecosystem point of view the ecologists and from the architectural point of view the designers and local community.

The engineers can use the test site for their research to the effects, development and maintenance of mudflats for (inter)national use. The ecologists and research bird migration and fauna in one of the most unique bird breeding places in the Netherlands. The architects can gain knowledge about technical opportunities and constraints when it comes to outer dike building and building in the sea. The local community will be employed to apply the craftsmanship that is deeply connected to the local history to the construction and maintenance of the structures.


engineering
nature
architecture

By field observations on several sites and flume measurements we will analyse fundamental ecological and physical processes for various types of wetland vegetations. The knowledge obtained will be applied in one implementation case study for a location in the Netherlands where dike reinforcement is needed in the future. This case study integrates fundamental knowledge from all the disciplines. It is used to design governance and implementation arrangements, and to demonstrate how vegetated foreshores can contribute to flood risk reduction.

The project will provide the knowledge, methods and tools (e.g. a maptable) required for the design and implementation of vegetated foreshores as a safe, ecologically desirable, and cost-effective alternative in flood management. Strong cooperation with end-users from the private sector, government and non-governmental organizations is embedded in the project to enhance the implementation of our findings in practice.

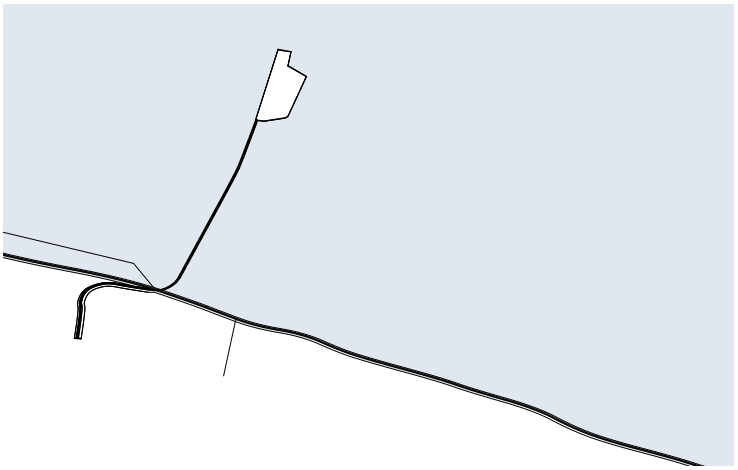


Proposal for the restoration of the pattern of dams

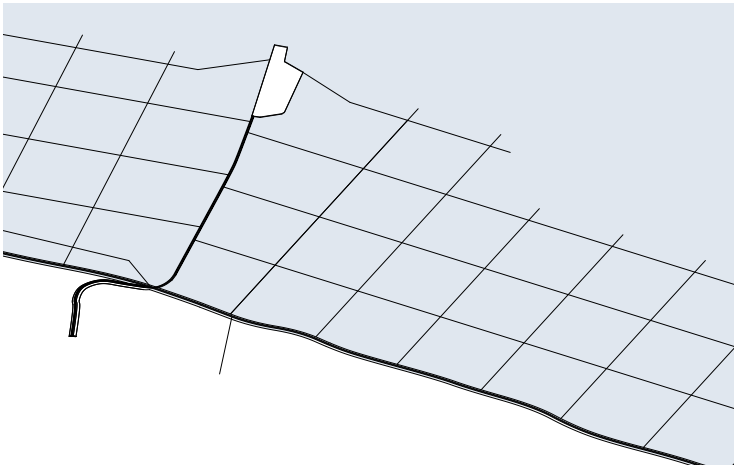
Sequence

The project consists of the restoration of the territory that almost entirely disappeared. It functions as a test case for the restoration of the system of salt marsh dams, a system dating from the 17th century. It is from the tidal dynamics that new relationships are established between, on the one hand, the engineering requirements and, on the other hand, the need to reconstitute extensive natural environments that boost the attractiveness of the area.

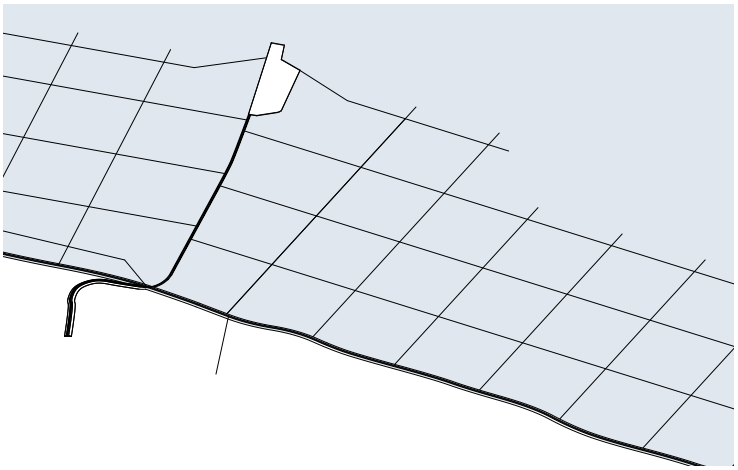
The territorial and landscape reactivation is established by an ephemeral light infrastructure of handmade wooden dams. Regarding the historical situation, the eroded salt marsh grows back over time, and will enriched with a route through the landscape, explaining the principles of the salt marsh through different tidal gardens. One walks from the land, as resulted from the construction of the dike, through the different stages the landscape takes in its transformation from sea to land, towards the sea.



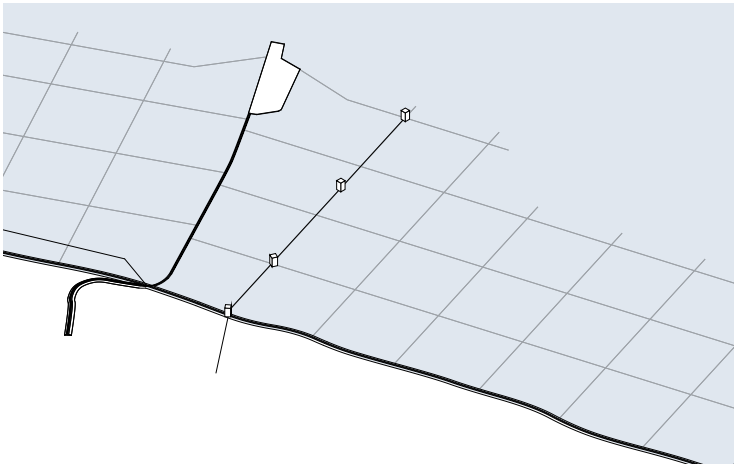
Original situation



Step 1: regeneration of the ephemeral infrastructure



Step 2: accessibility of the infrastructure: boardwalk route on top of the grid



Step 3: pavilions to explain and research the changing relation between seascape and landscape

Problem statement and research question

Problem statement

Regarding the Frisian coastal region

Nature

The Wadden area is at risk to get permanently under water before the end of this century

Engineering

Dike forms a barrier in the landscape. It has only one function: coastal protection. Many dike sections do not meet current standards for coastal defense

People

The Wadden area is not accessible from the Frisian mainland, just from the pier and the Wadden Islands. A social issue is that it has the largest population shrinkage in the Netherlands, economically unattractive

Potentials

For the Frisian coastal region

Nature

The tidal area can be saved by the same forces of nature that make it unique: sedimentation can potentially be increased at the same pace as sea level rise, with help of low impact and low cost brushwood dams.

Engineering

Salt marshes break waves, dampen the impact of incoming seawater, promote the wealth of species, and retain sediment. As a result, they can grow with rising sea levels. The eroded brushwood dams from earlier times can be rehabilitated to reclaim land in front of the dike.

People

Make the salt marsh dams into a multi purpose structure so that the engineered intervention becomes transparent and unlocks common ground. This increases attractiveness of the land in front-, on- and behind the dike and make it better accessible from the Frisian hinterland

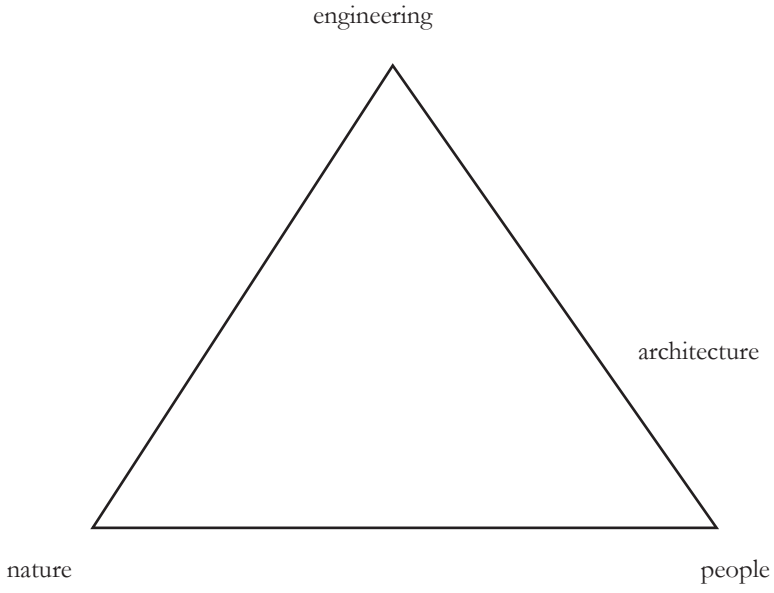
How can an architectural addition to an engineered structure unlock common ground that will last despite future sea level rise?

Sub-questions

- What is the role of the dike in the landscape and for the people of the Northern Netherlands?
- What threats will the future bring to this coastal region behind- and in front of the dike?
- How can the abandoned salt marsh area be regenerated into an attractive, accessible area?
- What type of building intervention can cope with the unsure future (sea level rise, sedimentation accumulation), and changing dynamics of this off shore region?

Strategy

Research through design: new ways of environmental engineering



Territorial intervention: environmental engineering

Current situation

© Werken aan de Muur

Environmental engineering

Proposal for the restoration of the brushwood dams; Holwerd as a “test site”

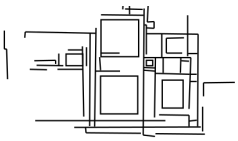
The dams

The dams are made of griend wood
from the local pollard willow
(knotwilg)

Grid structure

The ancient Romans were about the first to employ regular orthogonal structures on which they molded their colonies. These structures can still be considered a laboratory for the production landscape. The territory is considered as a palimpsest, as the product of a slow and incessant process of accumulation of traces, elements, attempts, which have been overlapping over centuries.

The grid plan method of land measurement has played a role in the continuous modification of the landscape since centuries. Within this frame, the 'architecture of logistics' is presented as one of the elements that have imposed a pervasive economic-political control of the territory, to the point of producing specific forms of living. It is therefor that the grid is used to bridge the apparent limits between architecture, landscape architecture, and engineering. An urbanity overlap with the idealized landscape of the countryside.



Palace

0 500m

N

45 m

125 m

Agora

Roman grid city

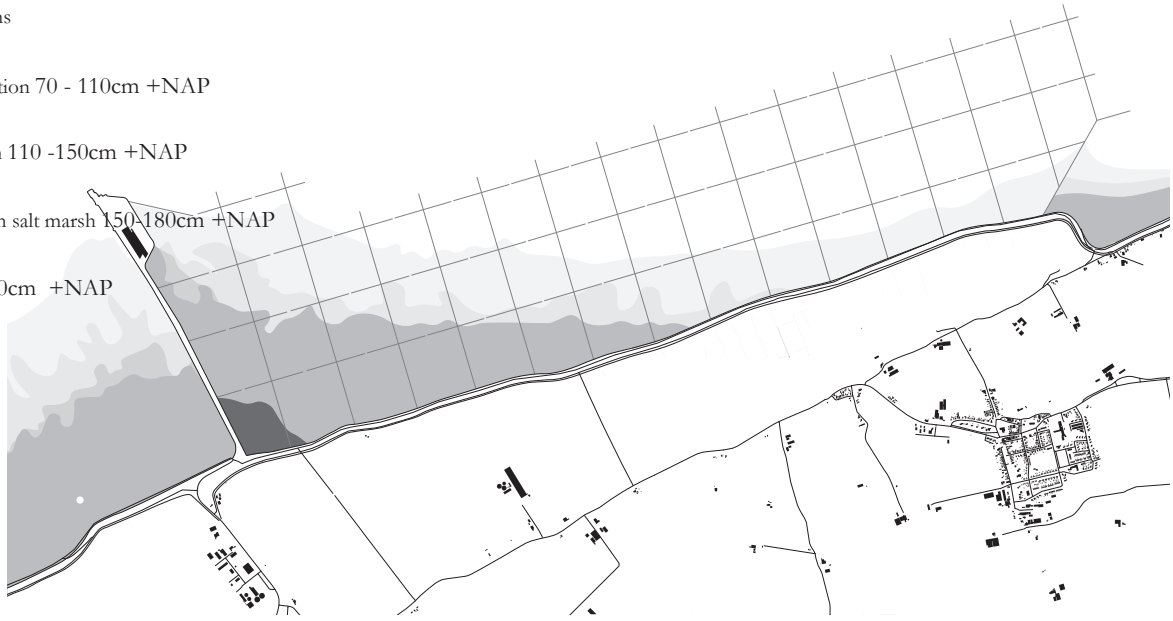
Salt marsh dams

Pioneer vegetation 70 - 110cm +NAP

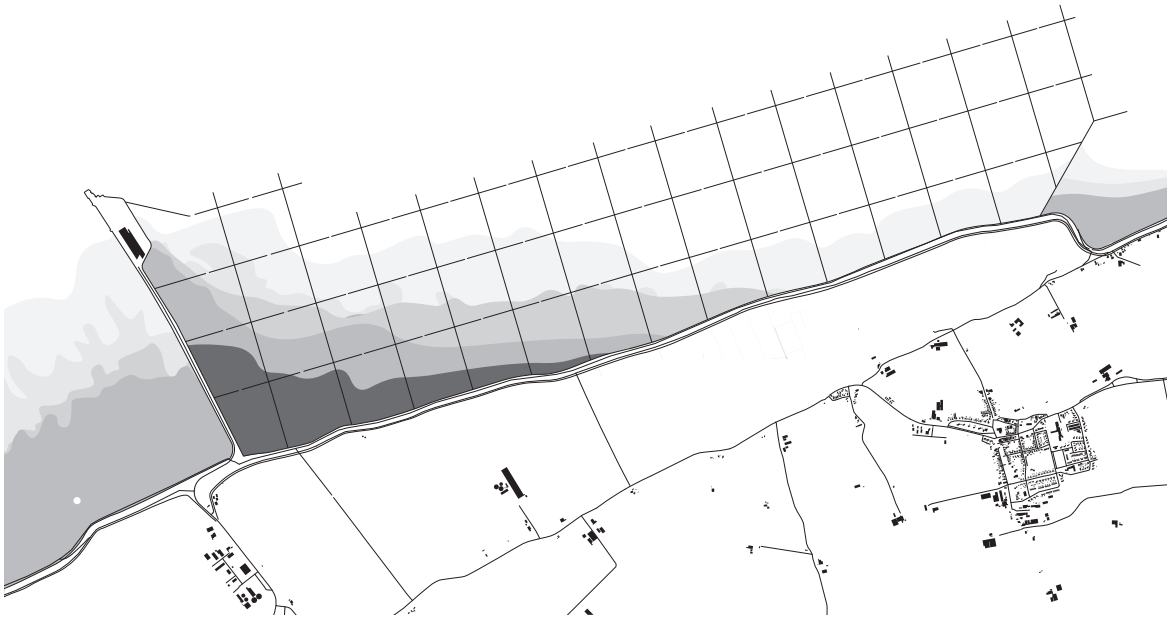
Low salt marsh 110 -150cm +NAP

High / medium salt marsh 150-180cm +NAP

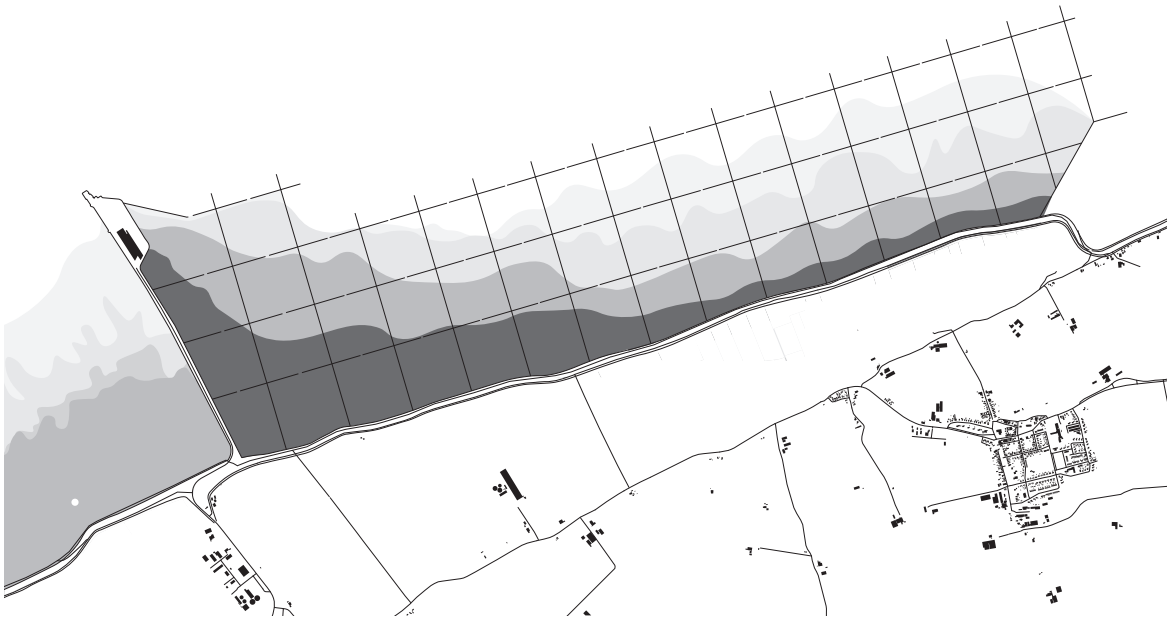
Highland >180cm +NAP



2020



2040



2060

Engineering, landscape architecture, and architecture

Recent developments in landscape architecture have been strongly influenced by the fierce debates about the planet's limitations when it comes to housing and feeding an exploding world population, the exhausting of primary sources like water and fossil fuels, and the visible facts of climate change.

In the early days of the profession, landscape architecture was conceived as a synthetic discipline operating in the range of agriculture, forestry, hydrological engineering, bridges and roads. Following this promising start for the profession, there were almost two centuries of landscapes designed by landscape chief builders whose tendencies were to achieve equilibrium and the fixed state of sites.

The current trends in landscape systems, have moved away from an equilibrium-based model which supported stability, certainty and order, to a continuously adaptive model which favors more contemporary understandings of dynamic systemic change and the related phenomena of adaptability, resilience and flexibility. The landscape architect is becoming an engineer and an ecologist again, making cautious interventions on the basis of knowledge of the ecology of landscape systems and use the intelligence embedded in the landscape to make its won environment more resilient.

Additionally, the landscape is always the expression of collective memory. In fact, landscape architecture must operate on the basis of a tradition in which meaning, memory, and our mythic desires are fostered.

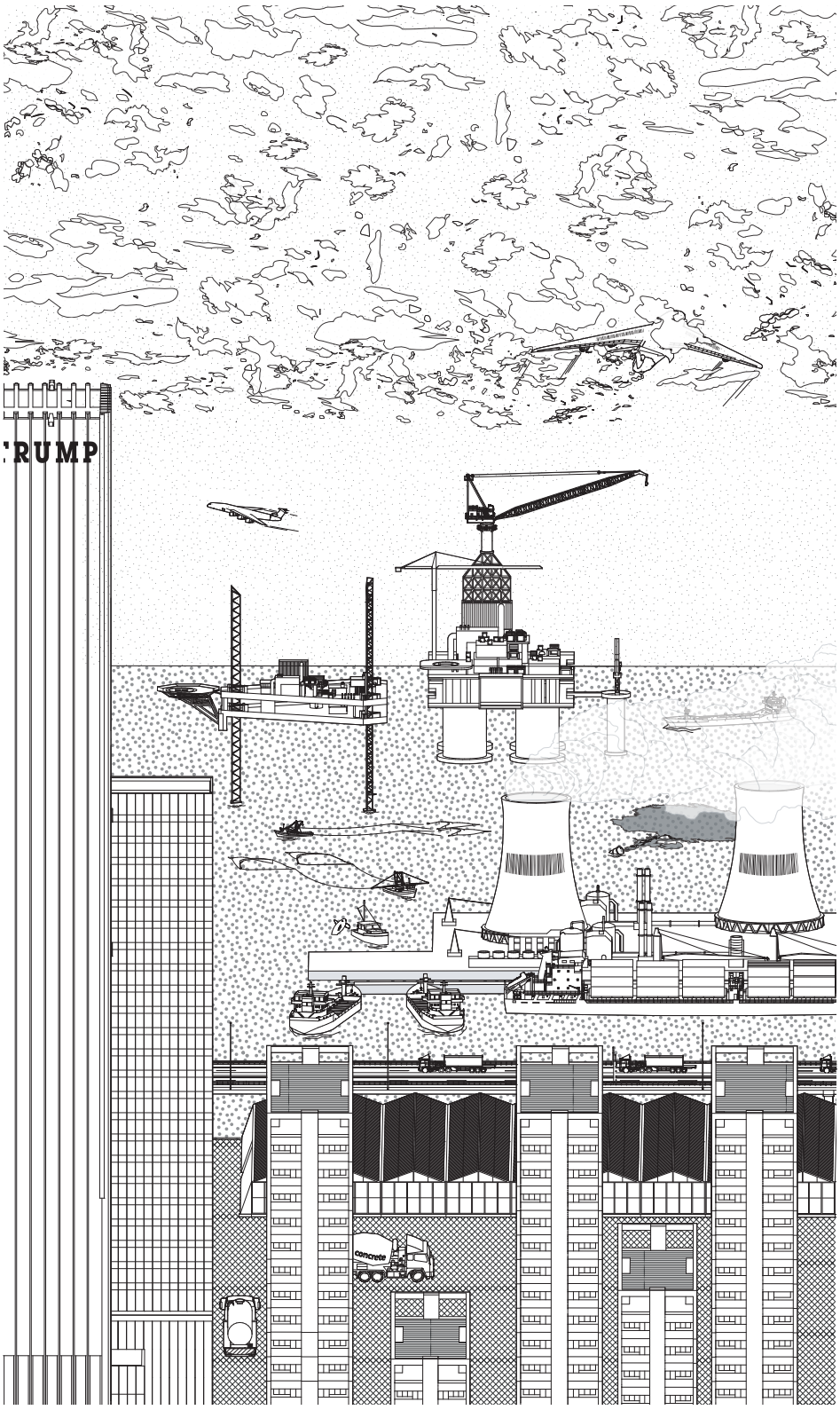
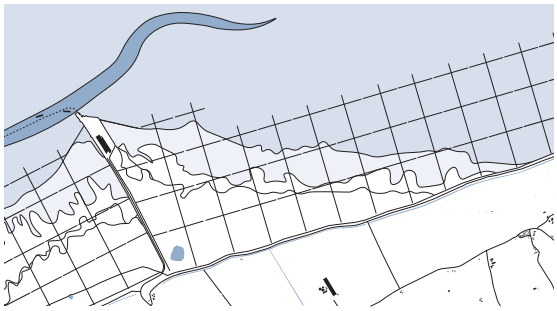
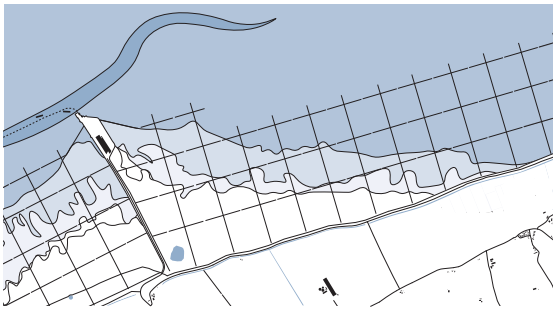


Illustration of future coastline and urban area, strongly affected by a political climate of cooperation and extractivism

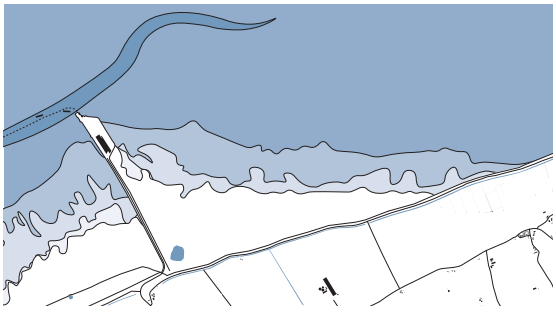
Low tide
< -100cm
2x p/day



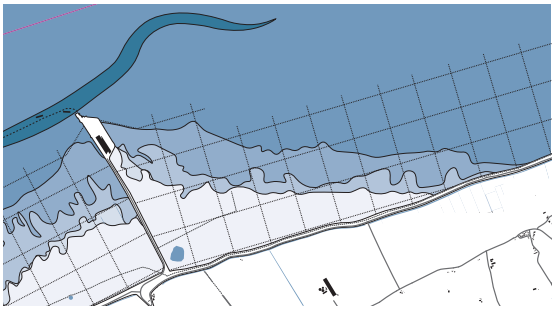
High tide
100-120 cm
2x p/day



Spring tide
120-180cm
24x p/year

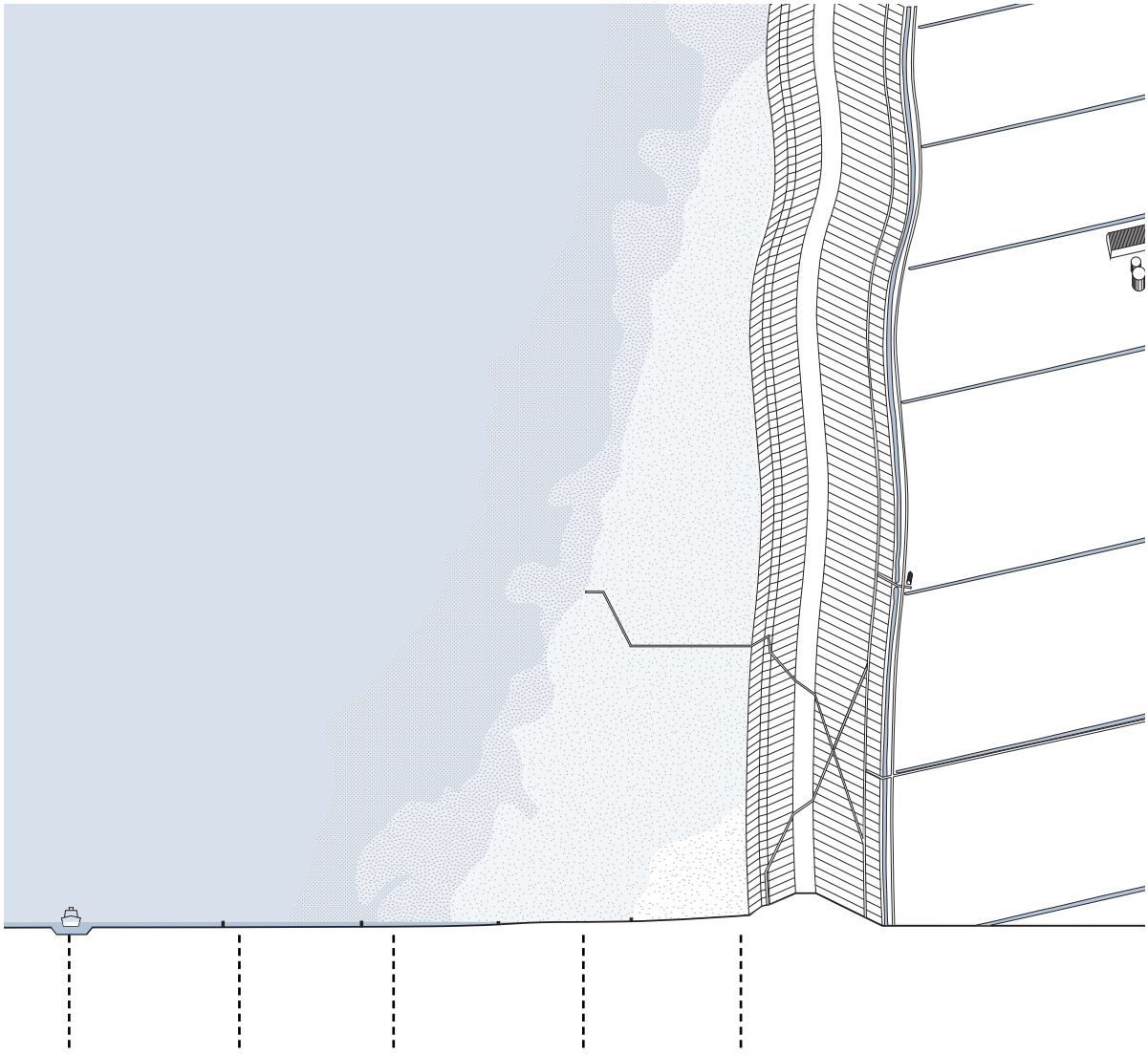


Storm surge
180-280cm
1-5x p/year



Extreme spring surge
> 280cm
<1x p/2 years

Development of the tidal landscape - current situation



Mud flat
< 70cm +NAP

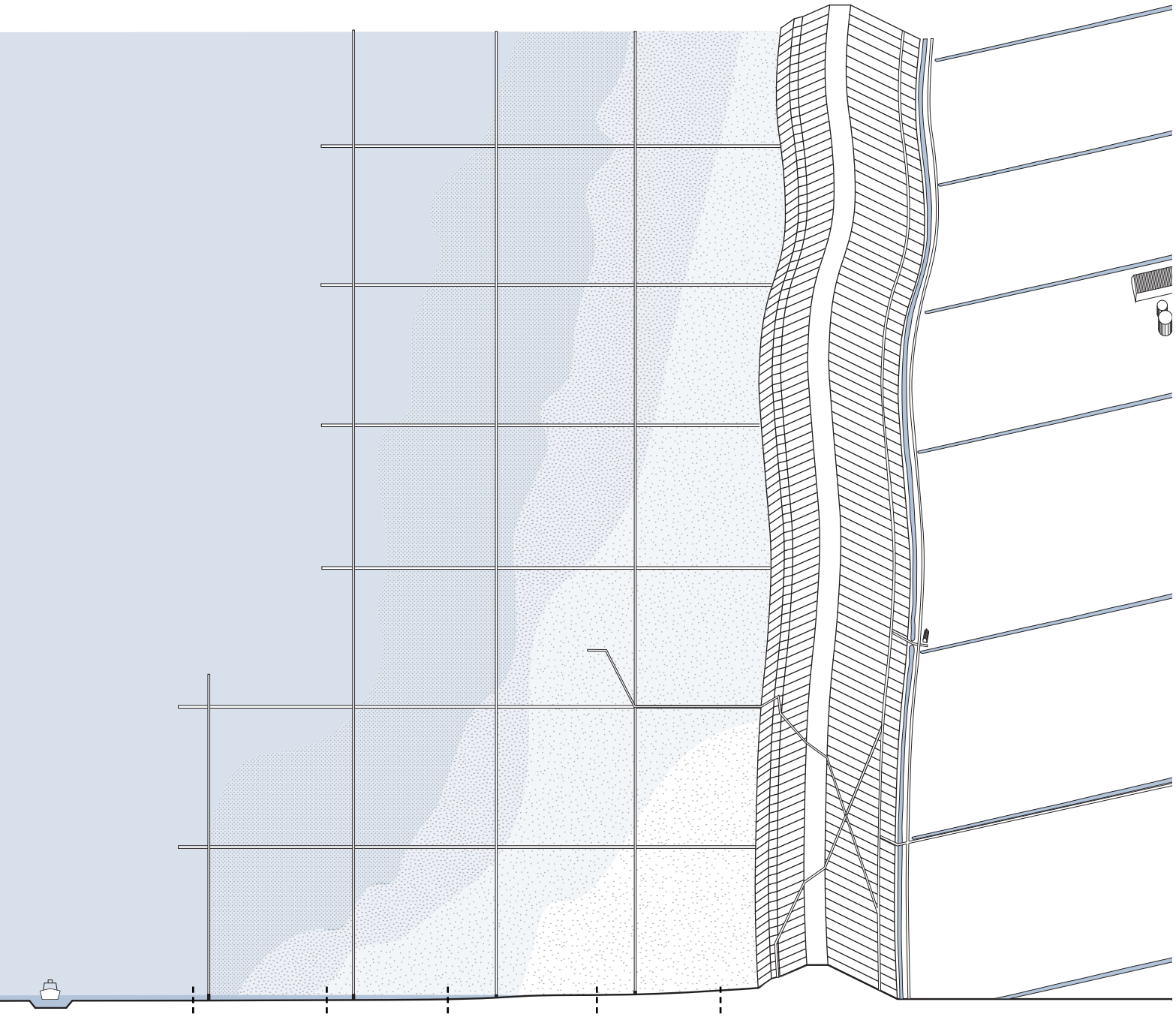
Pioneer vegetation
70 - 110cm +NAP

Low salt marsh
110 -150cm +NAP

Medium /high salt marsh:
grasses, silt agriculture and livestock farming
150 - 180cm +NAP

Permanent habitation:
outer dike building
> 180cm +NAP

Development of tidal landscape - 2040



Mud flat
< 70cm +NAP

Low salt marsh
110 -150cm +NAP

Medium /high salt marsh:
grasses, silt agriculture and livestock farming
150 - 180cm +NAP

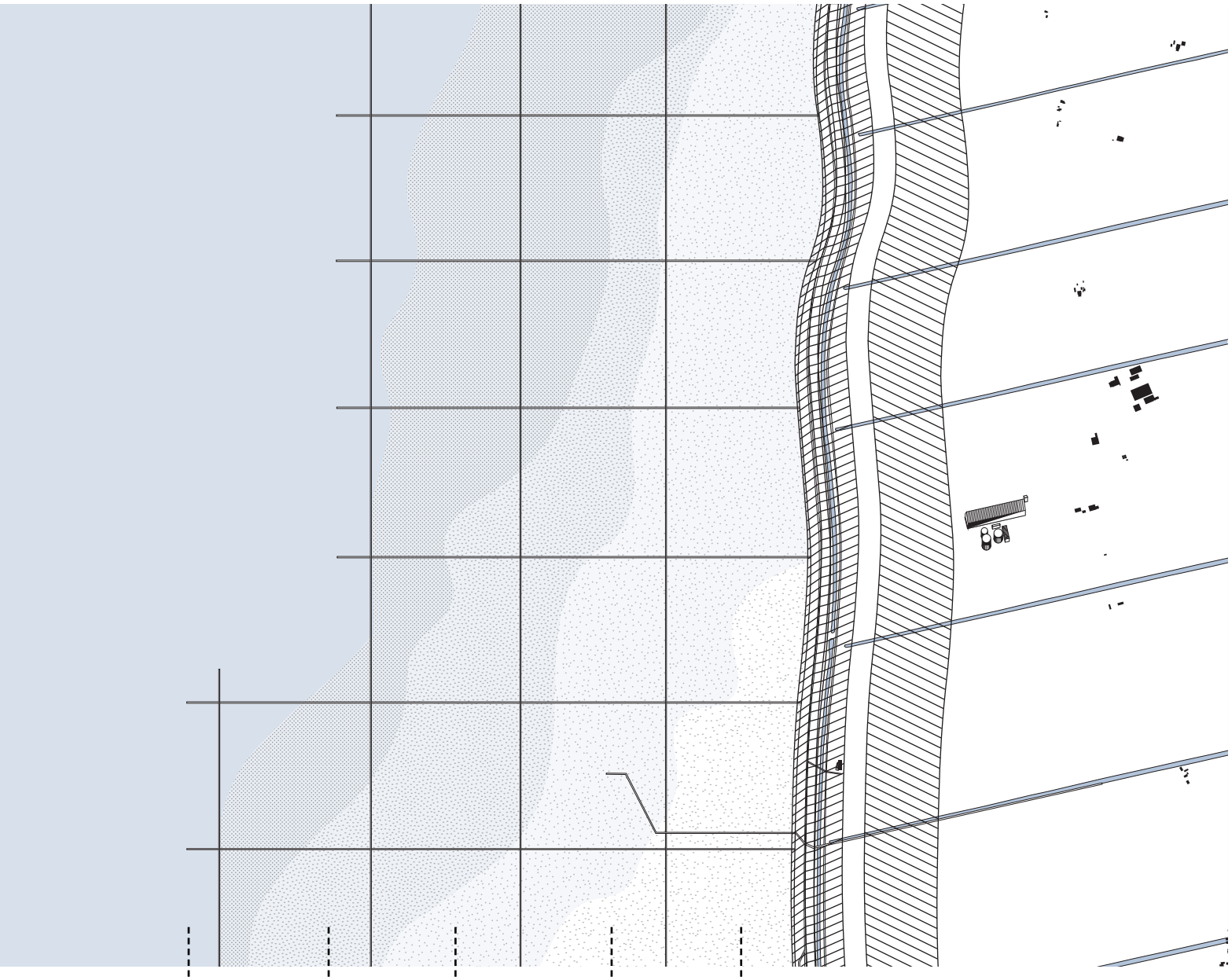
Permanent habitation: outer dike building
> 180cm +NAP

Permanent habitation: outer dike building
> 180cm +NAP

Development of tidal gardens - 2040

Development of tidal gardens - 2060

Grows with economy and sea level rise



Mud flat
< 70cm +NAP

Low salt marsh
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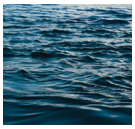
Medium /high salt marsh:
grasses, silt agriculture and livestock farming
150 - 180cm +NAP

Permanent habitation: outer dike building
> 180cm +NAP

Permanent habitation: outer dike building
> 180cm +NAP

Unlocking a new landscape

Schematic section of typical salt marsh landscapes



Water

Wad

Mudflat

Zeekraal

Kweldergras

Pioneer Vegetation

Zeeaster

Lamsoor

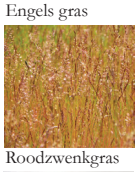
Zilte Schijnspurrie

Zoutmelde

Zeealant

Low Salt Marsh

Engels gras



Roodzwenkgras

Strandkweek

Silt agriculture

Highland

Livestock at dike

Dike

Hinterland

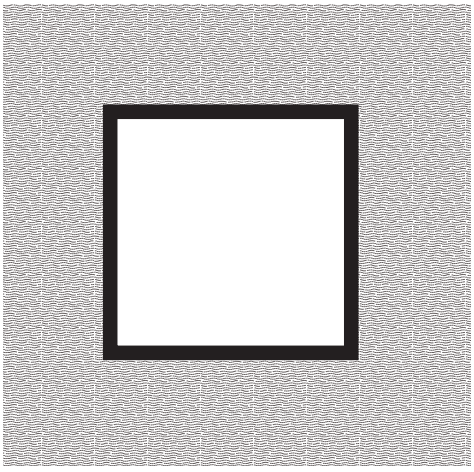
Building intervention

The Wall

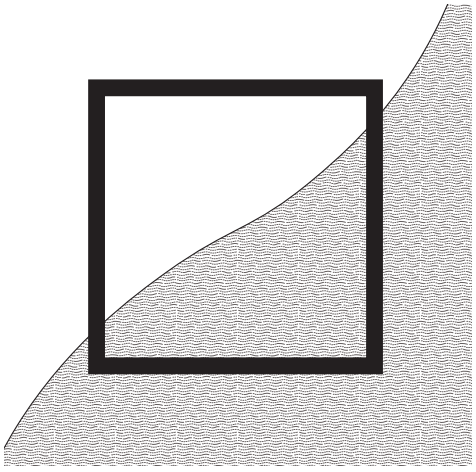
Dutch defence system

Protective dike ring system

The bounded entity
Dutch defence system

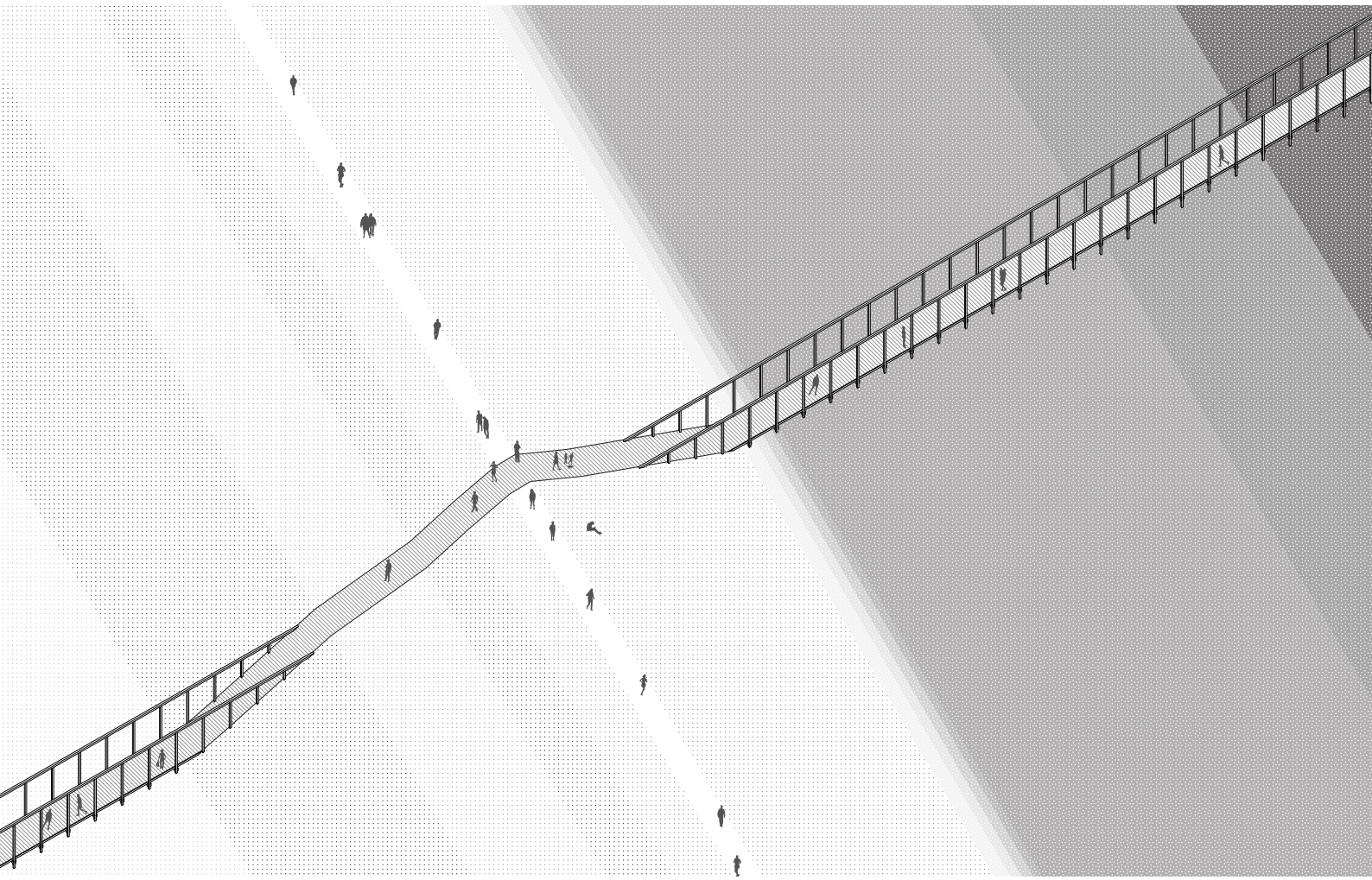


The uniting entity
Dutch defence system



A wall which unites, rather than divides

Proposal: architecture as connector



Two types of building interventions

Floating boardwalk

Goal:
improve accessibility of the site

Requirements
- accessible during both low tide and high tide
- accessible in the future (sea level rise and seabed rise)
- minimal carbon footprint
- minimal building footprint to minimize impact on ecosystem

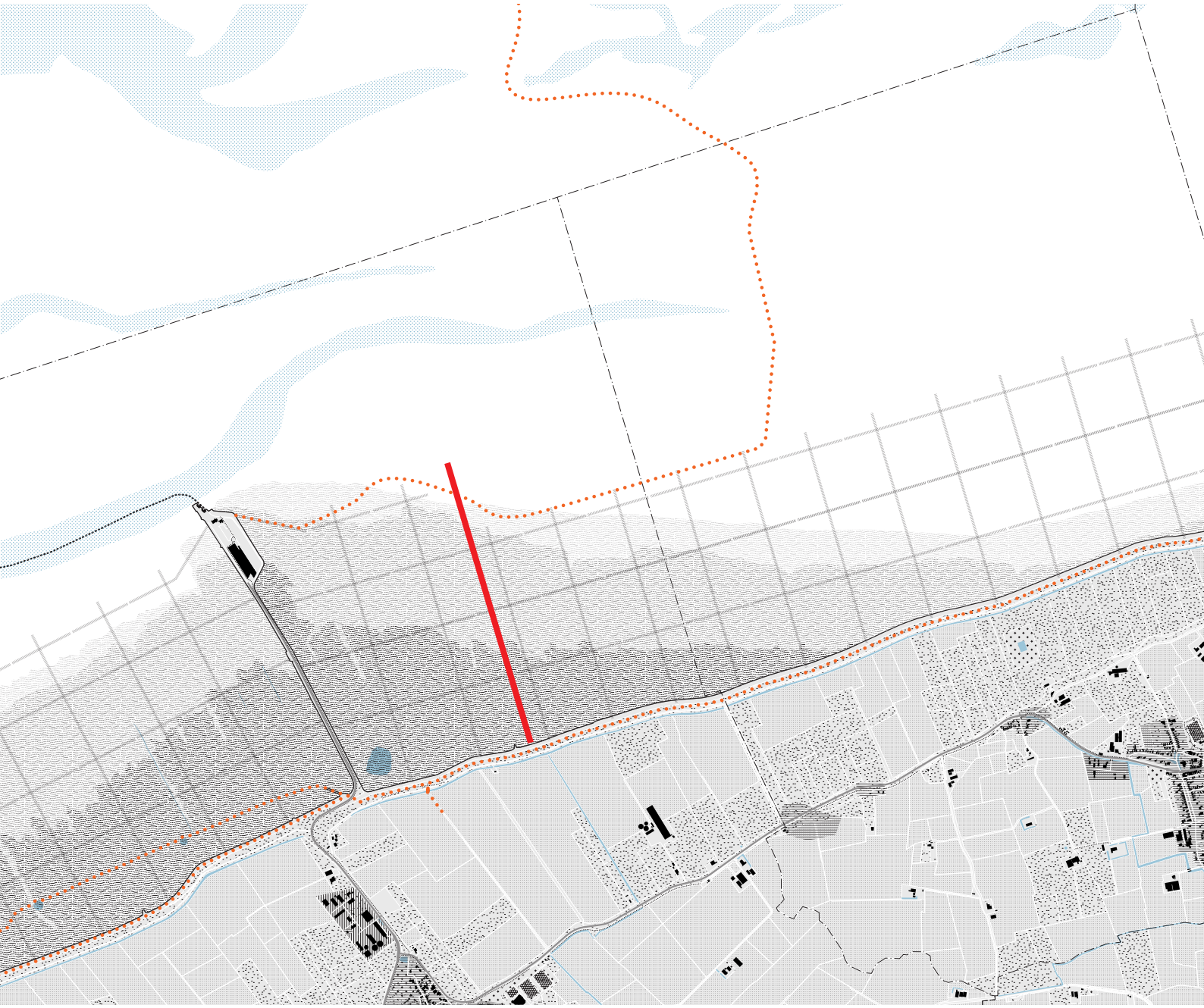
(Off-shore) cabins

Goal:
experience staying in this dynamic, engineered landscape

Requirements
- removable due to the insecurity of the site
- light weight to assemble on site
- modular elements must fit on truck
- ability to close up against the elements
- off grid

Placement of the boardwalk in the landscape

Connected to the existing trails



Floating boardwalk

Floating boardwalk

Characteristics

Changing sea level, poor soil conditions for foundations and restrictions in working on the protected site are challenges for both design and construction

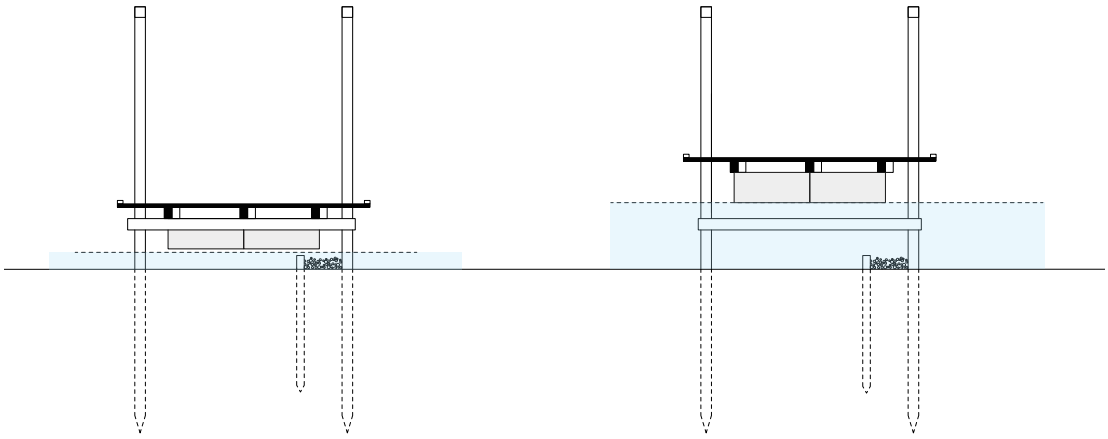
Wooden poles framing both the path and the dam, keep the elements in place in varying water level conditions

Occasional flooding can lift the floating elements up to 2 meters

The pathway is 2.5 meters wide

The complete length of the boardwalk is 1200 meters

To minimise waste and the use of new material, the base structure of the boardwalk is primarily made of recycled mooring poles a



low tide
boardwalk resting on wooden beams

high tide
boardwalk floating on pontoons

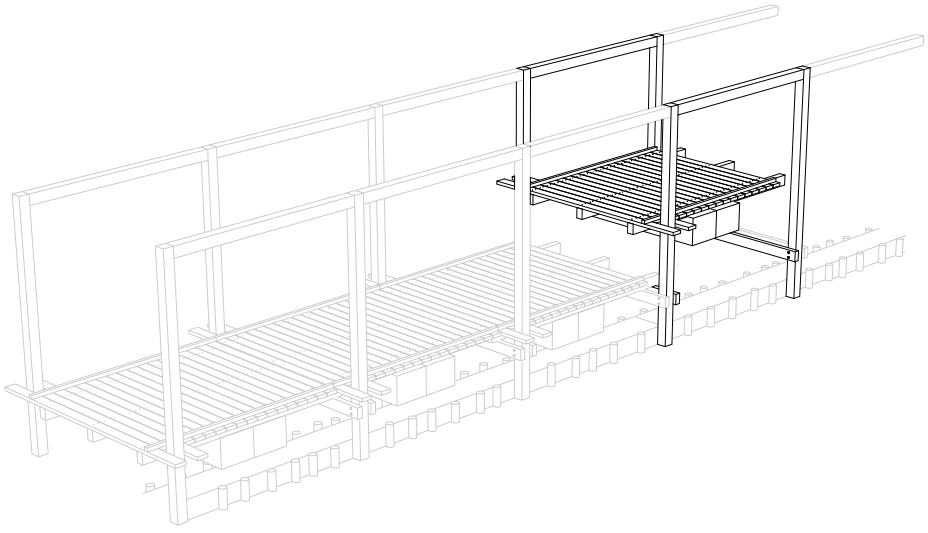
Floating boardwalk

Materialization

recycled mooring poles
- Surinam Basralocus hardwood
- size 140 * 140 * 4500
- specific weight 720-750 kg/m3
- total weight of the structure between 2 posts (one element) is 320kg
- additional weight visitors max 480 kg per element

pontoons
- recycled plastic
- size 100*50*40cm
- buoyancy 350 kg/m2
- total buoyancy of 4 pontoons is 700kg

Production and assembly
Prefabricated on dry land
Brought to the site for installation with light or floating vehicles



Materials and structure

sustainability forces us to minimize our ecological footprint

The structure and cabins are build from recycled mooring poles

This durable material has a life expectancy of 15-25 years without harmful treatments that would eventually leach into the sea.

Alone in the province of Friesland, a few hundred mooring poles are replaced every year

The poles are currently only sporadically reused, even though there are plenty of possibilities for reuse (as described in the table)

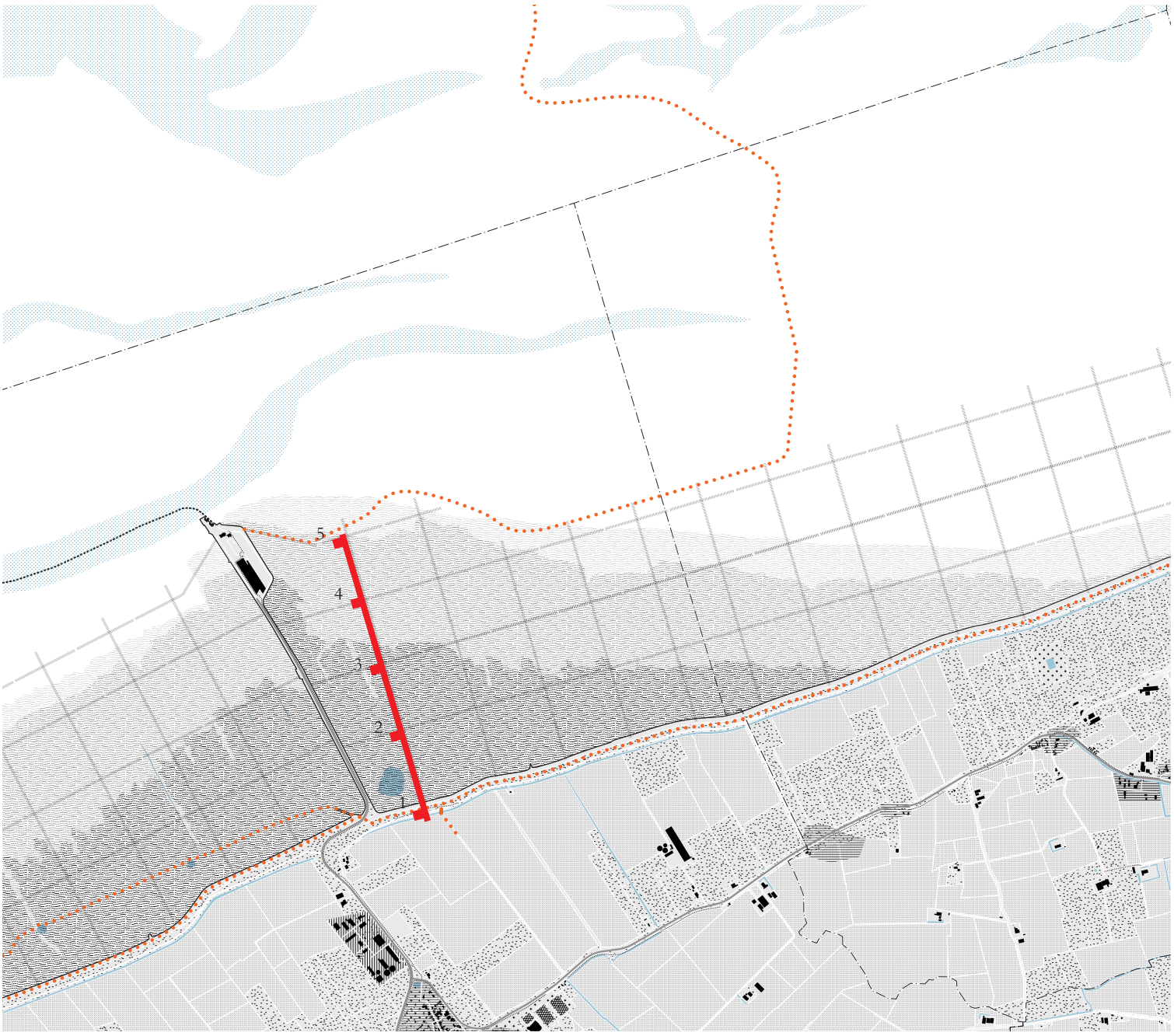
Used mooring poles: normally 400 x 400 mm with a length of 15 meters

Wijzen van hergebruik meerpalen

Bewerking	Toepassing
De bovenste verrotte 1 à 2 meter afzagen	In hetzelfde water maar omgekeerd
Oplengen van palen met stalen opzetter	In hetzelfde water
De bovenste verrotte meters afzagen	In water met lagere vaarklasse, in jachthavens, in Engeland / Duitsland
De paal verzagen tot dunnere palen	In jachthavens voor steigers en remmingwerken
De paal verzagen tot planken	In (jachthavens) als steigers, remmingwerken
De paal verzagen tot shingles	Als gevelbekleding
De paal in stukken zagen	Als stophout bij waterbouwkundige werken

Insert the pavilions

In the boardwalk structure



Vernacular architecture

local references: drenkelingen huisjes (rescue cabins)

Off-shore cabins inserted in the structure

Exploded axo

The cabins follow the rigid grid shape of the dams

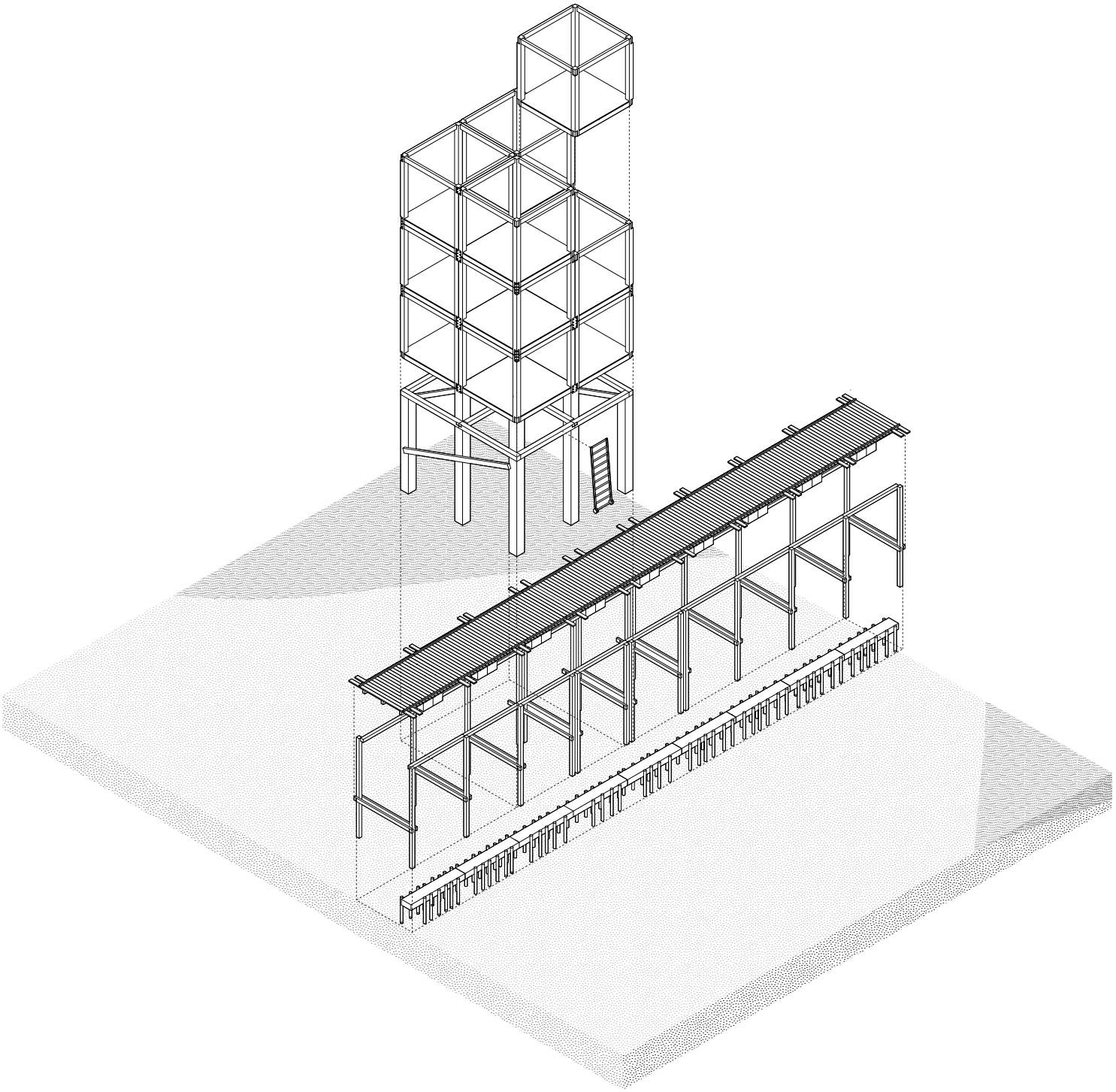
Their design is modular

The modules are build by the local community

Off-site construction in vacant barns

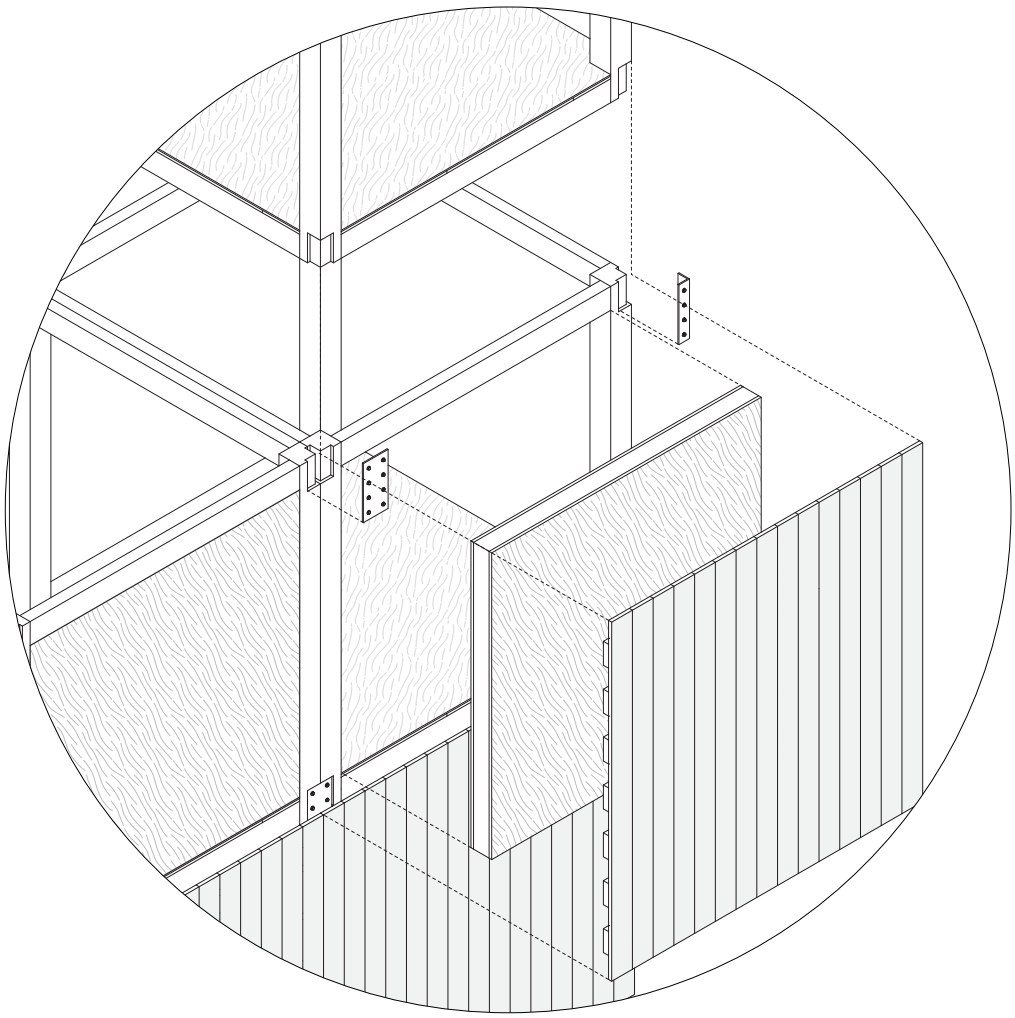
Small seize, are relatively light, easier to assemble at the muddy site

The pavilions can be easily de-mounted and moved



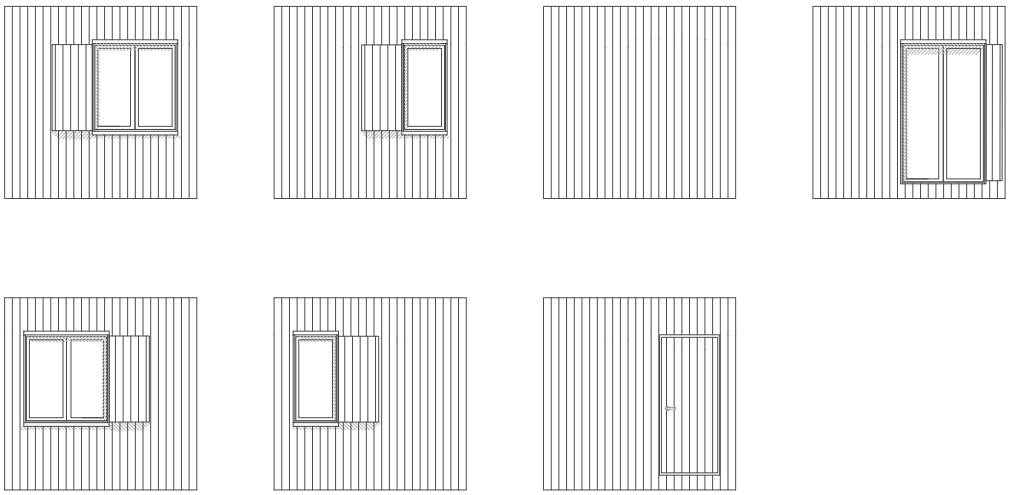
Off-shore cabins inserted in the structure

Module

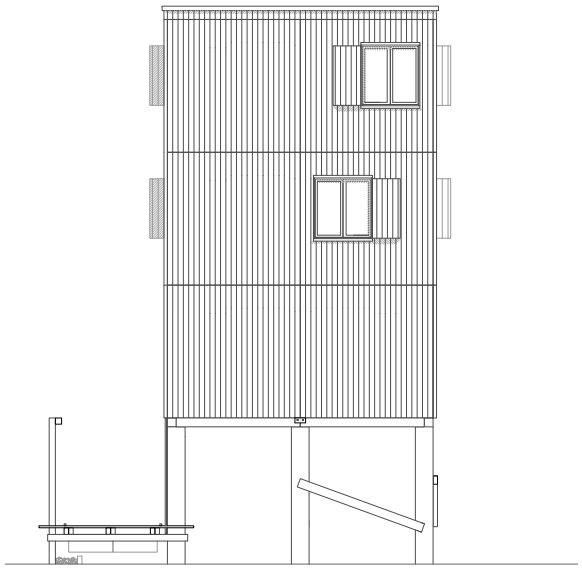


Off-shore cabins inserted in the structure

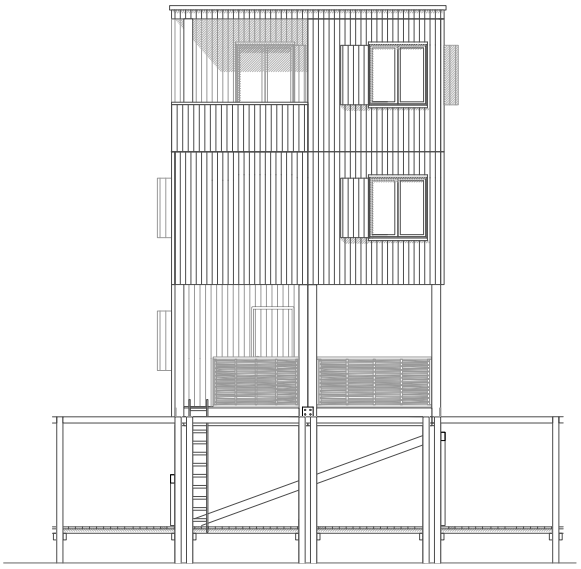
Facade elements



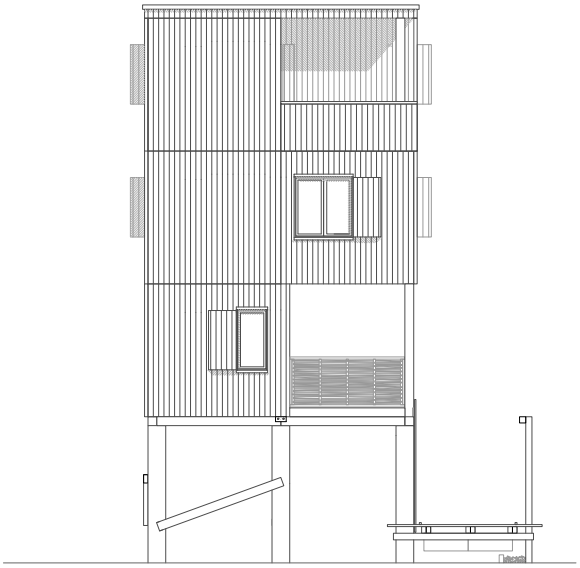
Typical facade



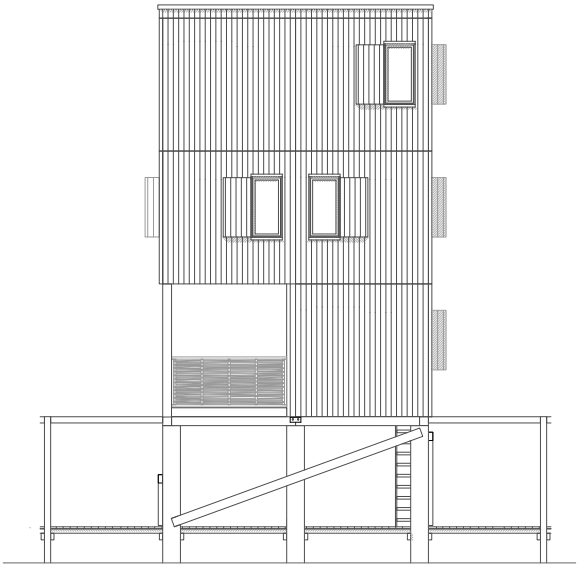
North



East

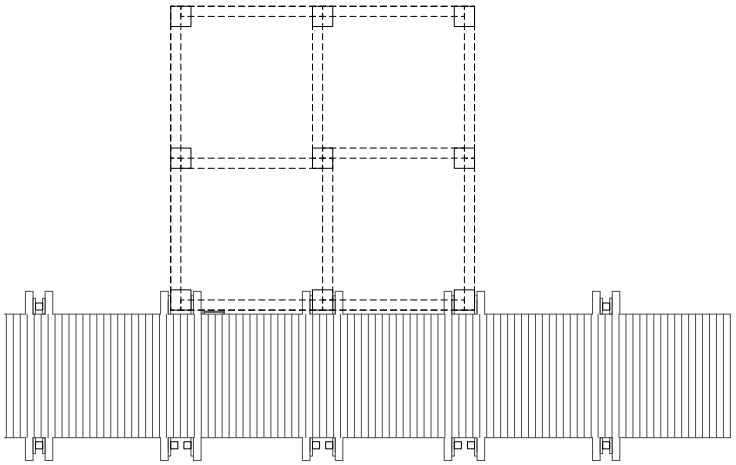


South

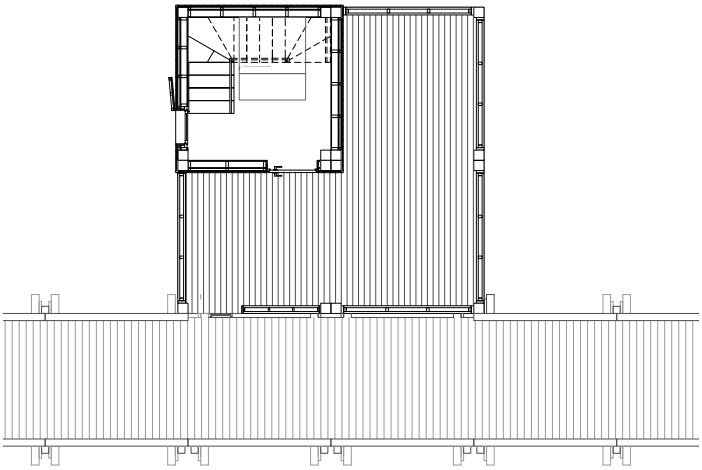


West

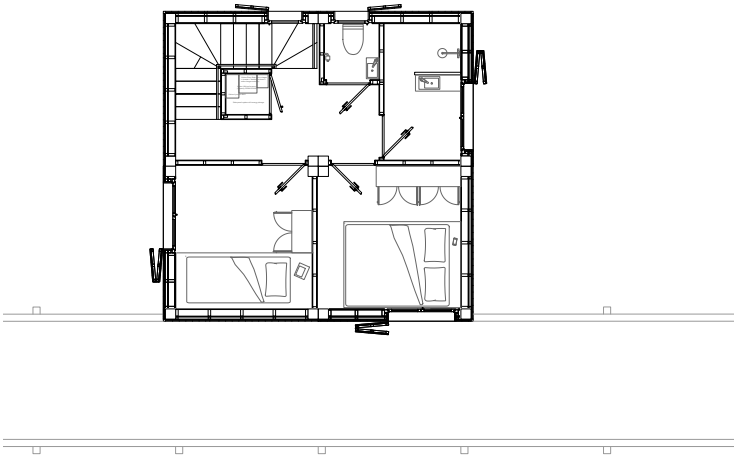
Typical floorplan



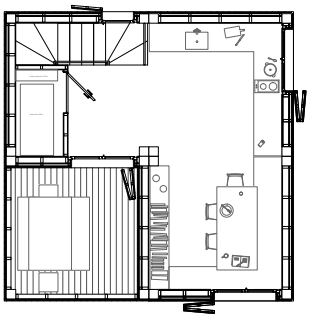
+1 meter



+ 4 meters



+ 7 meters



+ 10 meters

Sustainability

Cabins are entirely off-grid

Solar panels

composting toilet

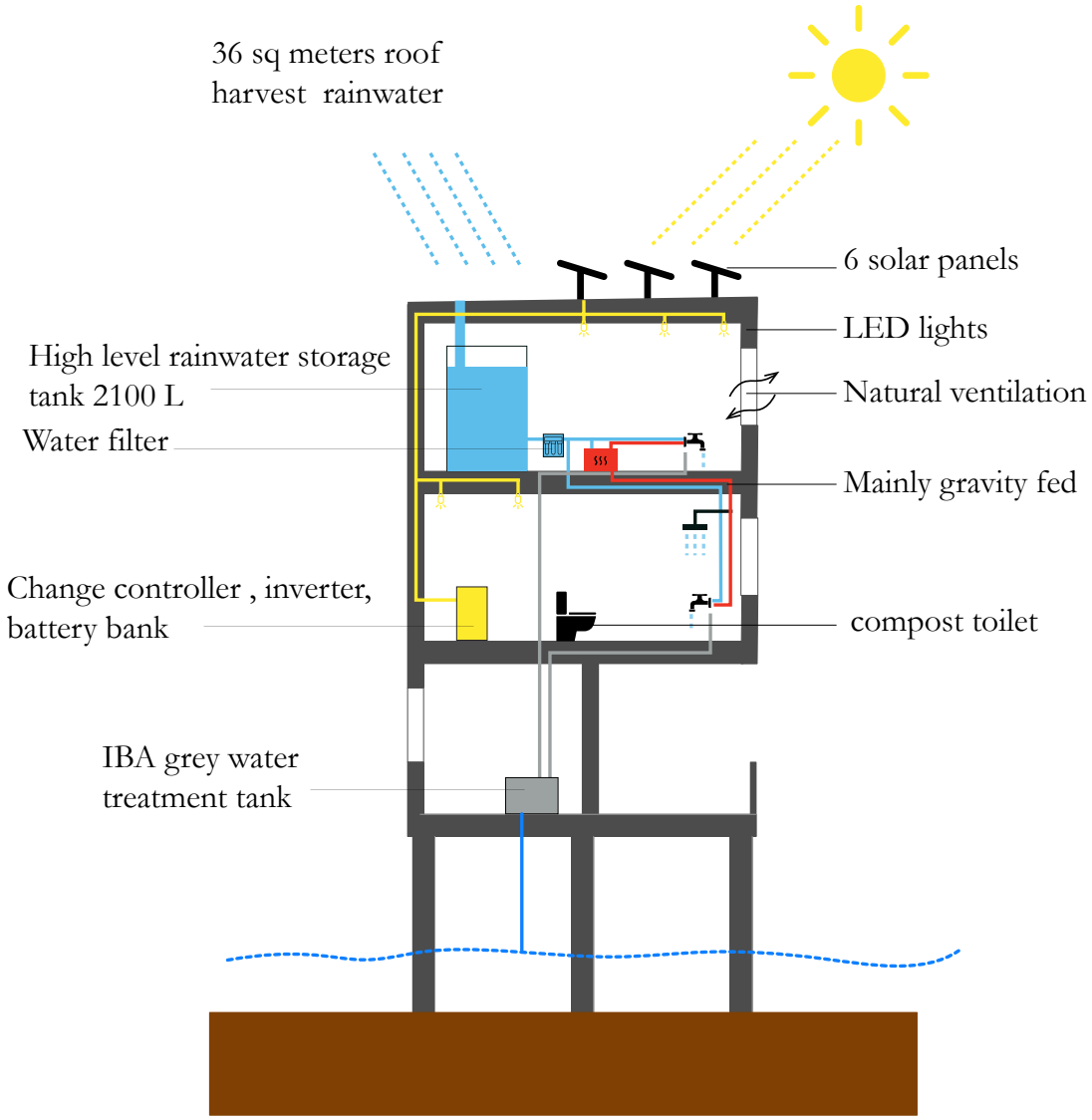
rainwater harvest

water filter

grey water treatment

LED lights

gravity based



BRIDGING THE DIKE

an architectural intervention to unlock environmental engineering as a common ground