



Views of Nature of a Delta City: Seeking a New Balance Between Nature and Technology in the Rotterdam Region

Han Meyer

Abstract

The contemporary Dutch delta landscape is shaped by both natural processes and engineered infrastructure. For centuries, sedimentation, erosion, dikes, dams and drainage systems worked together in the reclamation and urbanization of this swampy landscape. From the late nineteenth century onward, however, the idea of technical "mastery over nature" increasingly displaced this balance. While it enabled major economic growth, it also damaged delta ecosystems and weakened the role of natural processes in flood protection and freshwater management. This shift is especially visible in the Rotterdam region, transformed from a dynamic estuary into an industrial port landscape organized around a rigid shipping channel. Facing two meters of sea level rise, energy and economic transitions and urban development, the region must rethink its water system. This article compares two approaches: a polder strategy based on large-scale technical infrastructure, and an estuary strategy combining natural processes with technical interventions.

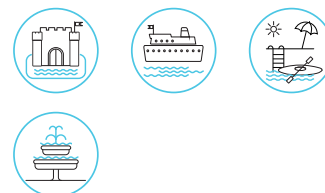
Policy Recommendations

- Regional and national water authorities, together with port authorities, should treat natural water processes as active components of long-term strategies for reducing flood risk, increasing biodiversity and securing freshwater availability.
- Local, regional and national public authorities should develop a new balance between the economic priorities of the port economy and the ecological conditions needed for the long-term sustainability of the delta landscape.
- Museums, journals and academic institutions in urbanism, hydraulic engineering, landscape architecture and urban history should give more attention to historical and contemporary examples of building with natural processes in deltaic cities.

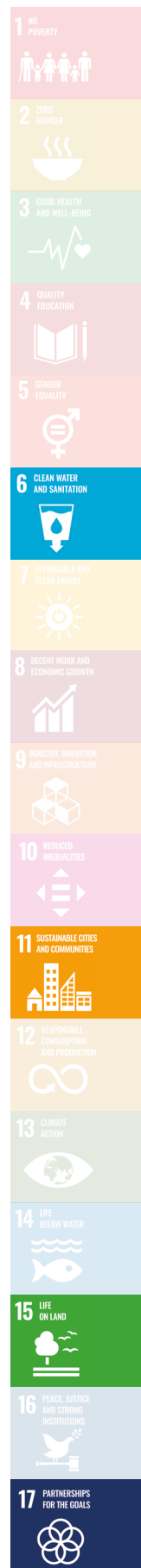
KEYWORDS

dynamic natural systems
technical infrastructure
sedimentation
erosion
delta landscape

WATER VALUES



< Fig. 1 Rotterdam, view from Brieneoord island, one of the major sites of the program 'The River as a Tidal Park' (Source: Han Meyer, 2025).



Introduction

"God created the world, but the Dutch created the Netherlands" is a saying heard often in the Netherlands. It suggests the marshy delta of the Rhine and Meuse rivers has been entirely remade and manipulated by human hands. This seems particularly true for the Rotterdam region. This is the area where the Rhine and Meuse rivers flow into the sea and for centuries was highly dynamic, with the boundary between water and land constantly shifting due to meandering river branches that regularly overflowed their banks, and the deposited silt and sand leading to the formation of new land. This fickle landscape now seems to have been brought completely under control and is considered "the safest delta in the world" (Glas 2019). Over the course of the twentieth century, the Rotterdam region has also become the most urbanized and industrialized region in the Netherlands.

However, since the beginning of the twenty-first century, there have been increasing calls for drastic changes to the spatial development of the estuary area. There are several arguments for this: increasing sea level rise, the need to transform the industrial economy into a more sustainable and non-fossil economy, and changing views and developments regarding the relationship between city and river. Numerous proposals have been developed for a new approach to the estuary, and they differ in terms of technical aspects, costs and impacts on land use. The proposals also align with different broad narratives that represent contrasting views of what constitutes "nature" and how the relationship between nature and humans is perceived.

This article first addresses how views on the relationship between technology and nature have

changed over time. It then turns to the current debate on nature and technology by considering two proposals for the Rotterdam region, each based on different assumptions regarding how we can deal with the complexity of natural processes, uncertainty and adaptability.

A Brief History of Working with Natural Processes

The process of inhabiting and developing the Dutch delta region is one long history of trade-offs and choices between working with or against the dynamics of the natural system. This dynamic essentially involves two processes: erosion due to the scouring action of flowing water and sedimentation resulting from the transport and deposition of sand and silt by rivers and the sea. Cities have played a key role in this large-scale landscape reorganization. In cities, the hydraulic structures of dikes, dams, drainage canals, locks and harbors converged. These structures also determined the composition of the urban plan.

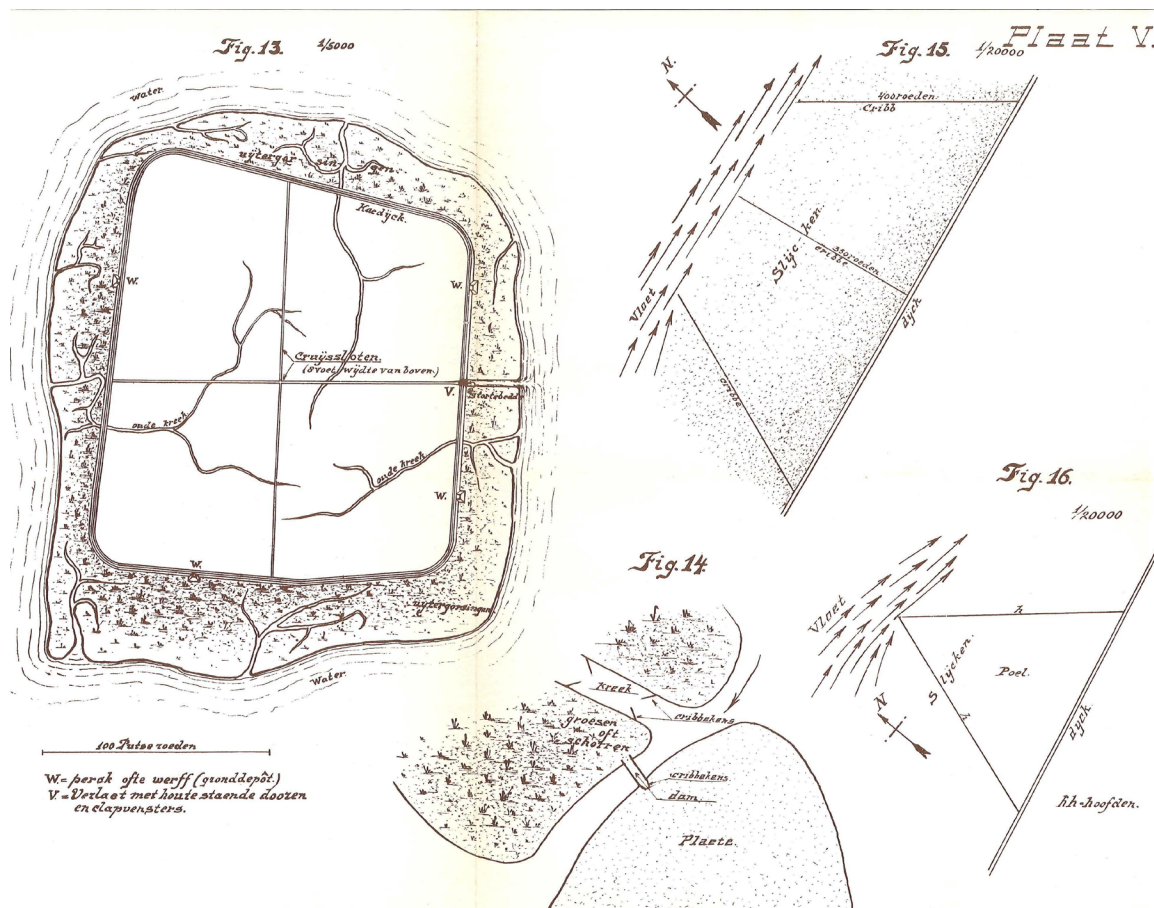
The continuous accretion of new sediment on the outside of dikes was long considered an advantage. Andreas Vierlingh's "Tractaet van Dyckagie" (Treatise on dike construction), from the mid-sixteenth century, argues that the combination of dikes with new accretions provides additional protection because the salt marshes and mudflats outside the dikes act as a buffer during storm surges, dampening wave run-up (De Hullu and Verhoeven 1920; fig. 2). The combination of the rationally organized polder landscape and urban waterfronts with the "wild" growth of salt marshes and mudflats was valued not only for its practical advantages but also as an important aesthetic aspect of the cityscape. In the seventeenth century, cityscape painting flourished, with famous

names like Aelbert Cuyp and Jacob van Ruisdael, along with numerous lesser-known and anonymous painters who depicted the combination of urban waterfronts with mudflats, reed beds and riparian forests as a key aspect of the beauty of the city in the delta landscape (Van Suchtelen and Wheelock 2008; fig. 3).

Moreover, these landscapes of salt marshes, mudflats and creeks offered an enormous wealth of food. In the nineteenth century, large salmon fisheries were located in and around Rotterdam. Mussels and oysters were also abundant and constituted an important food source for the urban population (IJsselmonde Regional Archives n.d.).

Different Visions on Nature and Technology

The eighteenth and nineteenth centuries saw spectacular developments in the world of natural sciences and technology. On the one hand, new technological inventions such as the steam engine led to new possibilities for reducing the reliance on natural processes. The German engineer Johann Gottfried Tulla (1770–1828) personified the belief that technology could be used to tame nature. He earned his nickname, "Tamer of the Rhine," from his life's work of converting the labyrinth of Rhine rivers between Karlsruhe and Basel into a single channel. The project proved disastrous, destroying the region's ecosystem,



^ Fig. 2 Illustration in Andries Vierlingh's *Tractaet van Dyckagie* [Treatise on diking] (c. 1575), on how to reclaim accreted land. In this image, figure 13 shows how to build a ring dike, while existing creeks can be maintained for drainage. Outside the dike, accretions are maintained and stimulated as part of the flood defense system (Source: Hullu, Verhoeven (eds.), 1920).

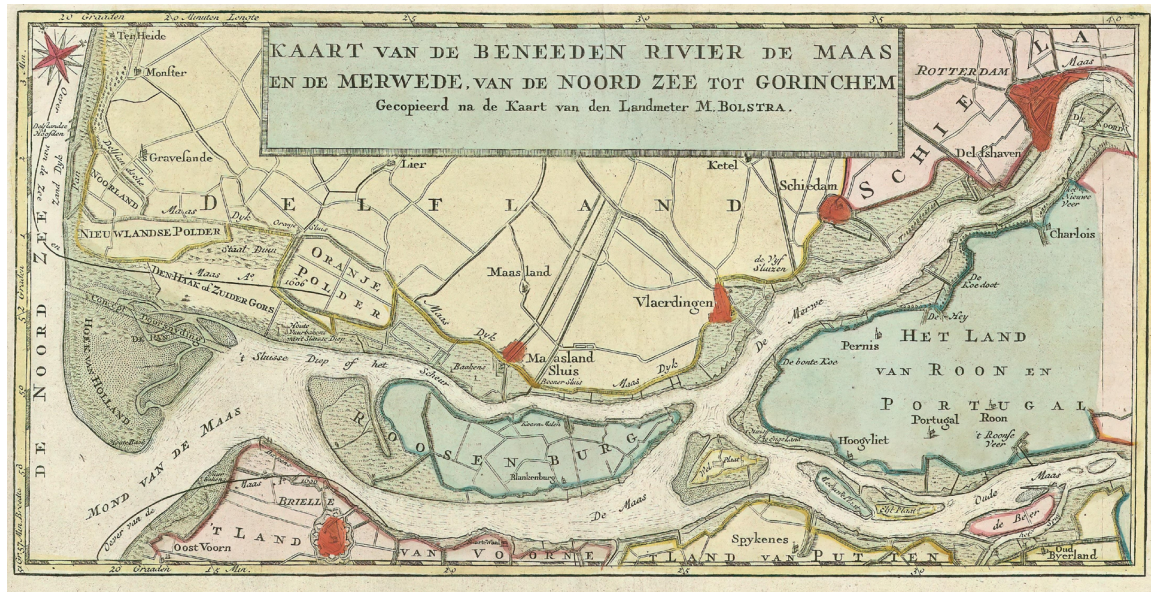


^ Fig. 3 View of Rotterdam, 1780. Citizens relax in rowboats among reed beds and mudflats on the south bank of the river New Meuse with a view of the city. In the foreground, the God of the Meuse and the monogram of the United East India Company and the West India Company. Oil painting (Source: Anonymous, 1780; private collection of Han Meyer).

while the new channel was unnavigable due to its high current (Blackbourn 2006). On the other hand, scientific research, along with the invention of new measuring instruments, led to greater knowledge of the workings of natural processes and the complexity of natural systems. The German explorer and natural scientist Alexander von Humboldt (1769–1859) played a central role in developing the concept of “Nature” (with a capital “N”) as a coherent, complex and evolutionary system in which strata, ecosystems, climate fluctuations and human civilizations are interrelated. In his 1850 book *Views of Nature*, Von Humboldt warned against radical interventions in these systems, the consequences of which would be incalculable and irreparable (Von Humboldt 2014; Wulf 2015). Tulla’s dramatic project underscored Von Humboldt’s point.

The Nieuwe Waterweg: “This Mastery over Nature”

During the same period, a young engineer, Pieter Caland, was grappling with a problem at the mouth of the Rhine. In the mid-nineteenth century, as an employee of Rijkswaterstaat (the Directorate-General for Public Works and Water Management), he was tasked with finding a solution to the increasing siltation of the Nieuwe Maas estuary, which was making the port of Rotterdam increasingly inaccessible to maritime shipping. His proposal was based on an idea hatched over a century earlier by surveyors Nicolaas Cruquius and Melchior Bolstra: to cut through the accreted “De Beer” headland at its mouth, creating a new canal (fig. 4). Based on a comparison with other European ports on river estuaries (Glasgow on the Clyde, Le Havre



^ Fig. 4 Mouth of the Meuse (Source: Izaak Tirion and Melchior Bolstra, 1769. Public domain, via Wikimedia Commons).



^ Fig. 5 Map of the New Waterway after intensified dredging, 1901 (Source: de Groot and Marinkelle, 1916).

on the Seine), Caland hypothesized that the river would further erode the new mouth itself, creating a deeper channel from the sea to the port (de Groot and Marinkelle 1916).

Caland's plan led to the opening of the Nieuwe Waterweg (New Waterway) in 1872 but proved unsuccessful. The new mouth was not eroded but silted up again, despite repeated dredging. What Caland could not have known at the time was that the silting of the Nieuwe Maas was not so much caused by sediment transported by the river and deposited in the estuary, but

primarily by sand and silt brought into the estuary from the sea by the tidal currents. Only after the invention and application of new dredging techniques (using trailing suction hopper dredgers), 20 years after the opening of the Nieuwe Waterweg, was it possible to maintain the channel's depth (de Groot and Marinkelle 1916; Horn-Van Nispen et al. 1994; fig. 5). The fact that this operation was ultimately successful, thanks to the use of new technology, significantly increased faith and confidence in the possibility of controlling natural processes. "This mastery over Nature was a milestone in



^ Fig. 6 Rotterdam port area in 2025 (Source: Rotterdam Port Authority, 2025).

the history of the Dutch nation," stated Johan van Veen (1948), who would become the architect of the Delta Works in the 1950s.

In the postwar decades, Rotterdam's port area rapidly expanded westward along the Nieuwe Waterweg. This came at the expense of more than 90 per cent of the intertidal areas, which formed a unique landscape of beaches, dunes, tidal marshes and mudflats, which were home to an enormous diversity of plant and animal species. The Netherlands' most famous conservationist and the founder of the Dutch Society for Nature Conservation, Jac. P. Thijsse, passionately advocated for the preservation of this unique nature reserve because of its vital importance to the global ecosystem of migratory fish and birds (Thijsse 1938). His pleas, however, were in vain. The expansion of the port along the Nieuwe Waterweg was also diametrically opposed to the views of the Directorate-General for Public Works and Water Management (Rijkswaterstaat) and the Ministry of Public Works. These parties argued that further deepening of the Nieuwe Waterweg for port de-

velopment would lead to increasing the influence of the sea on the hinterland, resulting in higher water levels near Rotterdam and greater salt intrusion into the hinterland.

Despite all objections, the "mastery of nature" in the estuary area continued and the port plans were implemented. The final result, in 2025, is the largest contiguous port area in the world, covering over 120 km² (fig. 6). The argument about higher water levels was countered with the construction of new and higher dikes along the river (Lucas 1958; Lucas 1968) and, in the 1990s, with the construction of a storm surge barrier in the Nieuwe Waterweg. This Maeslant barrier is closed when water levels rise more than 3 m above mean sea level and the areas outside the dikes are at risk of flooding.

The Rediscovery of Nature

The industrialization of the estuary landscape was applauded for its resulting economic progress and successful "battle against the water,"



^ Fig. 7 Reinterpretation of the urban river landscape of Rotterdam: the Nieuwe Maas river and adjacent embankments. The blue-colored embankments were initially alluvial deposits; later they were raised and built upon (Source: Paul Achterberg, City Planning Department, City of Rotterdam, 1990).

with no significant flooding taking place for over 70 years. But there was also growing concern about the serious consequences for nature and the environment. The concern about unforeseen consequences was not unique to this location. The idea that natural landscapes cannot be restrained by a man-made straitjacket received theoretical support in the 1960s from people like the French historian Fernand Braudel and the American landscape architect Ian McHarg. Both argued that landscapes are dynamic systems, with very slow but unstoppable processes of change (the “longue durée”) caused by, among other things, climate change (Braudel 1966; McHarg 1969). The message was that it is crucial to consider these slow but fundamental processes of change in natural systems. In the world of Rotterdam’s urban

development, this perspective led to a call for an approach that thoroughly studied the genesis of the underlying landscape and explored how historically developed structures could be incorporated in the new urban design (Palmboom 1987; de Hoog 1990). It led to a new understanding and treatment of the river and its riparian areas as a coherent and dynamic whole (Meyer 1999; fig. 7).

The need to accommodate change in natural systems held true at the scale of the entire river system. This was evident in the Netherlands in the 1990s, when the Dutch flood protection system nearly collapsed twice under the increasing volumes of water that had to be handled during peak discharges. This led to the Room for the River program of 2005–2015.

Instead of further raising dikes and constricting the riverbed, the riverbed was widened at crucial points in the river landscape. This restored and enhanced the ecological and cultural qualities of the river landscape (Sijmons et al. 2017). The program bypassed the Rotterdam region, which was considered too complex. However, in Rotterdam the River as Tidal Park program was established, with the goal of restoring as many intertidal zones as possible along and between urban riverbanks and therefore reviving some

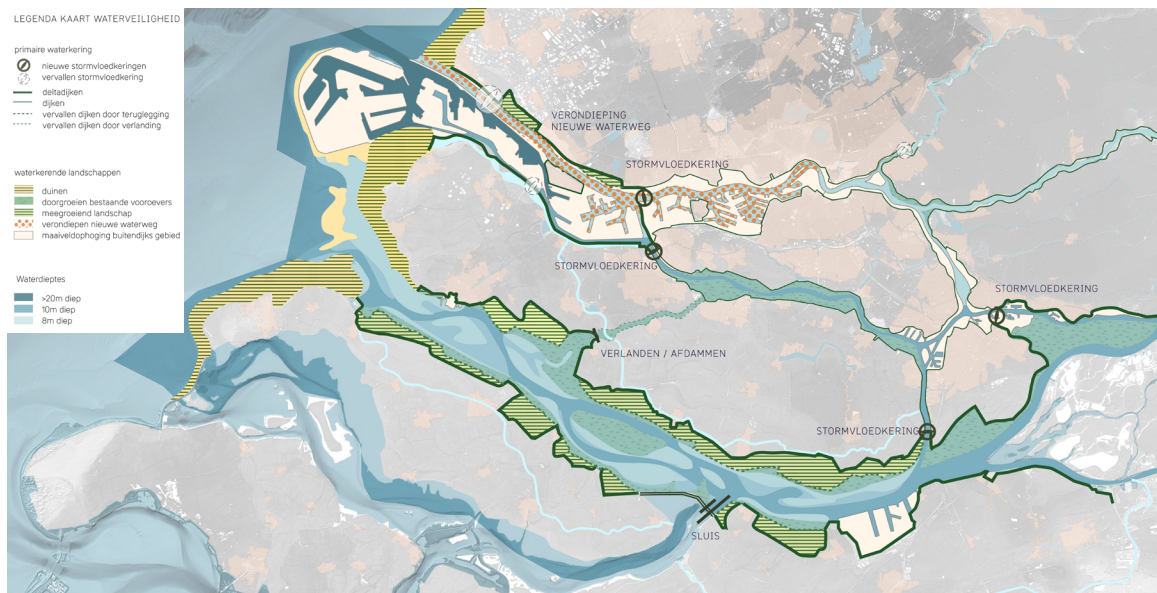
of the lost delta nature (fig. 8). The program was later expanded to cover a larger part of the estuary area (Province of South Holland n.d.).

Nature-with-Technology vs. Technology-with-Nature

In 2009, the National Delta Program was launched with the aim of protecting the Netherlands against flooding and ensuring a reliable



^ Fig. 8 Rotterdam Nieuwe Maas – Nieuwe Waterweg estuary, river as tidal park (Source: De Urbanisten, 2014 - 2017).



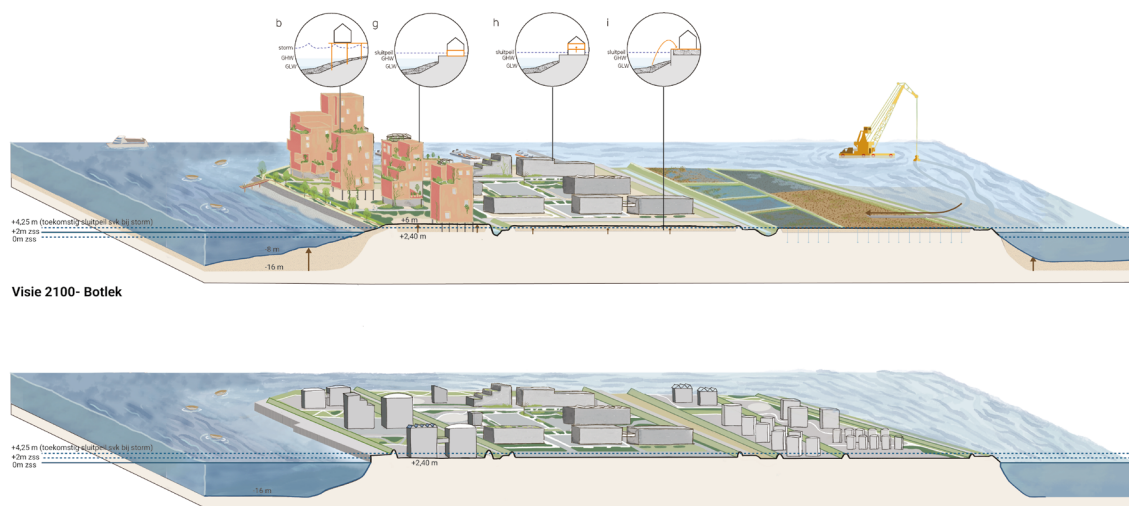
^ Fig. 9 Estuary strategy showing river discharge via an open Haringvliet. New silt deposits on the banks of the Haringvliet create a “growing landscape” that protects against high water. Siltation of the Nieuwe Maas reduces high water levels in the Rotterdam region (Map: H+N+S Landscape Architects, 2026; source: IABR Delta Rijnmond-Drechtsteden 2100).

supply of freshwater. The Rotterdam region is a particular focus (van Alphen and Bloemen 2023; Meyer 2017; Meyer 2025). In this region, any additional raising and strengthening of the river dikes will be an extremely complex and costly undertaking (Kolen and Botterhuis 2025). There are also many areas outside the dikes, where more than 60,000 people live, and these areas will become increasingly vulnerable to flooding due to sea level rise (Rotterdams Weerwoord 2022). While the Maeslant storm surge barrier is intended to protect these areas outside the dikes from flooding, this protection is limited due to its relatively high failure rate (1:100) and its limited technical durability (until 2070).

The many plans and ideas for the future of the region can be grouped under two broad headings. The first comprises proposals aimed at restoring – as much as possible – the natural system of rivers and tributaries, working with processes of sedimentation and erosion rather than against them. The second builds on the idea of a “conquest of nature” and includes proposals and plans that aim to completely isolate Dutch territory from the sea.

These two approaches also formed the basis for two submissions to a competition organized by the Eo Wijers Foundation in 2023 (Harsma et al. 2023), which were developed in a design workshop under the auspices of the International Architecture Biennale Rotterdam (IABR), and with the cooperation of the Municipality of Rotterdam, the Municipality of Dordrecht, the Delta Program/Rijkswaterstaat, the Port of Rotterdam Authority and the Province of South Holland. The two visions were presented as the “estuary strategy” and the “polder strategy” (Teunissen 2026).

The estuary strategy aims to maximize the benefits of the natural dynamics of sediment transport, which can ensure that both the riverbed of the Nieuwe Waterweg and the shorelines of the Haringvliet estuary, located further south, can rise with rising sea levels. This process can be organized by constructing new dikes parallel to the existing primary dikes along the Haringvliet. In the area between the old dikes, sediment can be trapped during high water (fig. 9). Concerning the Nieuwe Waterweg, research has shown that ceasing dredging operations within a few decades will lead



^ Fig. 10 Estuary strategy showing a possible transformation from the current port landscape with oil storage tanks (bottom) to a mixture of new urban developments, circular industries and a dynamic estuarine landscape (top) (Image: H+N+S Landscape Architects, 2026; source: IABR Delta Rijnmond-Drechtsteden 2100).



^ Fig. 11 Polder strategy showing main river discharge via the Haringvliet, with a dam at its mouth. The Nieuwe Waterweg will also be closed by a dam. The existing flood defense system, indicated in red, will be enhanced (Map: De Urbanisten, 2026; source: IABR Delta Rijnmond-Drechtsteden 2100).

to significant siltation of the Nieuwe Waterweg (Kleinhaus et al. 2026). This siltation will, in turn, reduce tidal amplitude and salinity intrusion (Hensen 2021; Iglesias 2022). To withstand storm surges, it will still be necessary to build several smaller storm surge barriers to protect the area outside the dikes during periods of extremely high water levels. New urban residential areas on vacant port sites can be designed to create new relationships between these residential areas and the dynamic nature of the delta, with its fluctuating water levels and constant siltation (fig. 10). The estuary strategy can be summarized as a “nature-based solution,” but with additional support from man-made technology.

The polder strategy demonstrates that achieving a closed coastline requires not only a dam in the Nieuwe Waterweg, but also the construction of a new ring dike around the entire Rotterdam metropolitan area (fig. 11). This will transform the Nieuwe Maas into a freshwater basin with a constant water level. This radical change in the river’s character, involving the replacement of the estuarine ecosystem with a freshwater environment, is being used by De Urbanisten to design new urban residential areas with the ground level close to the water’s surface. This makes the water directly accessible and usable from the new residential neighborhoods (fig. 12). The polder strategy can be summarized as a technical solution that involves installing



^ Fig. 12 Polder strategy showing an impression of a possible future relationship between city and river: a freshwater river basin with a stabilized water level, creating opportunities for housing environments and public spaces in close contact with the water (Image: De Urbanisten, 2026; source: IABR Delta Rijnmond-Drechtsteden 2100).

a new freshwater ecosystem within the urban area. The gradual transition from freshwater to salt water, characteristic of an estuary and essential to the delta ecosystem, will disappear completely.

The estuary strategy initially appears to have negative consequences for the port and shipping. However, under this strategy, most of the port remains accessible to the largest ships from the sea via the Caland Canal. The connection to the hinterland will also be maintained for medium-sized and smaller vessels. Only the Nieuwe Waterweg itself will no longer be navigable by the very largest oil tankers.

A key difference in the implementation of both strategies concerns the extent to which the physical adjustments to the flood protection system can generate support from local communities. The polder strategy involves the construction of a new, very large infrastructure project, which is only possible with strict management at a high scale, and which is difficult to adapt to new, changing circumstances in the long term – it is therefore not very adaptive.

The estuary strategy, on the other hand, involves a principle that can be implemented in many different ways and allows for location-specific solutions, with close involvement of local stakeholders and residents. Moreover, it is based on the principle of adaptation: With future changes in the rate of sea level rise, the adaptive zones can be adjusted relatively easily.

Concluding Remarks

This consideration of the history of the relationship between the city of Rotterdam and the river shows that there is almost always some combination of “working with nature” and “hard technology.” This combination was only reversed during the late nineteenth and twentieth centuries, when the idea that humans are capable of “mastery over nature” became prevalent. This historical perspective is crucial for the current debate, because the idea of “mastery over nature” persists in the popular narrative about the Dutch and especially about Rotterdam (Sennema and Van der Laar 2021). The earlier image of the city located in and working

with a natural delta landscape can be inspiring for the current and future approach to the water system, but it has largely fallen into oblivion.

A situation has now arisen in which a choice must be made between further intervening in the natural system or resuming the thread of collaboration with natural dynamics. It seems advisable to establish a new collaborative working agreement between humans and the natural system, enabling the natural system to recover while simultaneously making a significant contribution to flood safety in the region. Finally, both the estuary strategy and the polder strategy will have significant consequences for the port and the waterways. Siltation of the Nieuwe Waterweg (estuary strategy) as well as a dam in the Nieuwe Waterweg (polder strategy) can be seen as detrimental to the port and shipping. But they can also offer significant benefits. The port and shipping industry are facing a major challenge regarding energy transition. The lesson of Pieter Caland's dune cutting is that an intervention can serve as a catalyst – at the time, this led to the development and modernization of the port. Similarly, a new water management strategy for the estuary area can act as a catalyst in the coming years for the necessary transitions currently underway in the port and in shipping.

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Han Meyer was Professor Urban Design at Delft University of Technology (TU Delft) until 2019. He was the leader of the research program 'Delta Urbanism'. Before, he worked at the Project Organisation Urban Renewal of the City of Rotterdam for ten years. Currently, he is involved in TU Delft as a guest researcher. He conducts research on urban development in delta areas. He publishes books and articles, gives lectures and is an advisor of organizations in and outside the Netherlands.

Contact: V.J.Meyer@tudelft.nl