Expanding rivers, preserving heritage

A Study on expanding the rivers while preserving riverfronts industrial heritage

Research paper
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AR3AH115 Graduation Studio
Revitalising Heritage 2024/25

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25/10/2024

Abstract

This research investigates the interplay between flood risk management and the preservation of industrial heritage in Zwijndrecht, a region characterized by its complex relationship with water management. The study analyzes historical transformations of the landscape from the 1850s to the present, highlighting the transition from a predominantly polder landscape to extensive industrial development following the implementation of river management interventions. The analysis reveals vulnerabilities in current water management strategies, particularly in light of climate change and recent flooding events. The research explores innovative solutions for expanding the Oude Maas River while safeguarding the region's industrial heritage, ultimately aiming to balance the imperatives of flood prevention and cultural preservation. By assessing the feasibility of lowering outer dikes and creating buffer zones, this study contributes to ongoing discussions on sustainable water management practices in heritage rich urban environments.

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1. Introduction

1.1 Context

The Netherlands, with much of its land lying below sea level, has long faced significant challenges in water management due to its unique geography (Blom & Sande, 2019). Water has historically served as both a vital resource for transportation and land reclamation, and a constant threat due to frequent flooding. Major innovations, such as the Delta Works project following the devastating 1953 flood, reflect the country's ongoing efforts to manage water. However, the floods of the 1990s revealed the limitations of traditional flood prevention strategies. In response, the 'Room for the River' project was introduced to mitigate flood risks by creating more space for rivers, particularly in rural or less densely populated areas (Sijmons, Feddes, Luiten, et al., 2017).

Despite these initiatives, climate change continues to introduce new challenges, including rising sea levels and increased rainfall (Blom & Sande, 2019). Cities like Dordrecht and Zwijndrecht now face recurring issues with elevated water levels, causing frequent street flooding (Koster, 2022; Koster & Broekhuizen, 2023). To protect areas as Dordrecht and Zwijndrecht from future flood risks this research focuses on exploring how a new 'Room for the River' project can be implemented in the outer dike area of Zwijndrecht, Figure 1.

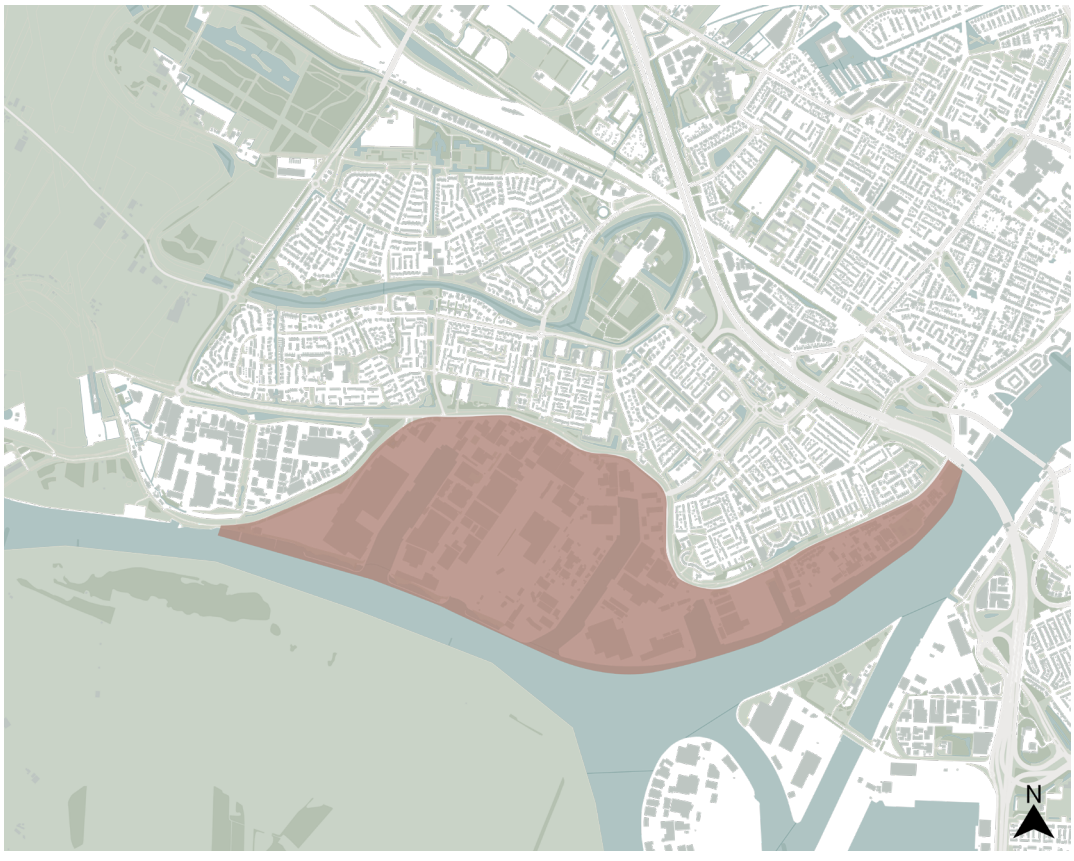


Figure 1: Map research location in Zwijndrecht (made by author, 2024)

1.2 Problem Statement

Recent flooding events in Dordrecht (2020, 2023) have highlighted weaknesses in current water management systems (Huibregtse, 2023). While flood prevention has been prioritized, growing climate risks demand more innovative solutions. One potential strategy is to implement a new 'Room for the River' project. However, the initial program focused on rural areas, which has proven insufficient in the face of climate change. New, suitable locations must be considered, including urban areas with vacant industrial heritage buildings on outer dikes. This research explores the possibility of using these sites for flood mitigation and accepting the challenge of preserving heritage structures. Therefore, the key research question is:

How can the Oude Maes River in Zwijndrecht be expanded while preserving the region's industrial heritage sites?

1.3 Significance of the Research

This research aims to balance flood prevention and heritage preservation, addressing a gap in studies that typically focus on these issues separately. By exploring how flood mitigation can be achieved without sacrificing heritage, this study offers practical solutions for Zwijndrecht's outer dikes. Further the results could serve as a model for other regions facing similar climate and heritage preservation challenges.

1.4 Methodology

This research begins with a landscape analysis of Zwijndrecht, utilizing height maps to assess its current relationship with the Oude Maas river. Historical landscape changes are examined through a comparative analysis of maps from 1850, 1900, 1950, and 2000, to understand how industrial development has shaped the landscape and influenced its heritage value.

A catalogue of all existing industrial buildings in the area is then created. By mapping these buildings according to their construction periods, before 1850, 1900, 1950, 2000, and after 2000, the study provides insights into the area's industrial evolution and its architectural significance.

Drawing inspiration from the 'Room for the River' projects and related literature, a new urban strategy is developed for the area. Within this strategy, three architectural design solutions are proposed and tested in the reshaped landscape:

- Excavation around industrial heritage sites
- Floating platforms underneath industrial heritage sites
- New foundations underneath industrial heritage sites

These design solutions are specifically tested on the Schokbeton site at Lindtsedijk 14 in Zwijndrecht. The outcomes are critically evaluated based on several criteria: water level impacts, accessibility, functionality, risk, cost, and sustainability. This assessment aims to determine the most effective approach for balancing flood resilience with the preservation of industrial heritage.

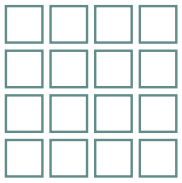
The complete research plan is illustrated in Figure 2.

How can the Oude Maes River in Zwijndrecht be expanded while preserving the region's industrial heritage sites?

Mapping of historic landscape

Analyses by mapping of the landscape in 1850, 1900, 1950 and 2000

Catalogue of industrial heritage



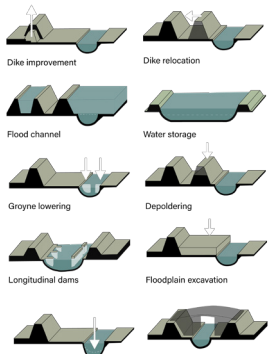
Creating an catalogue of all the existing industrial buildings

Mapping of industrial heritage

With help of the catalogue mapping all the industrial buildingsconstructed before, 1850, 1900, 1950, 2000 and 2024

P1

Studying previous landscape interventions



Studying literature about previous landscape interventions to come up with solutions for the outer dike area of Zwijndrecht

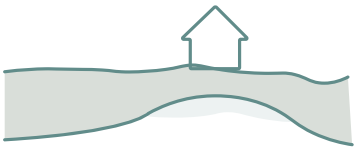
Proposing a new urban strategy

The historic landscape and industrial heritage analyses together with the literature of the previous landscape analyses will be the inspiration for a new urban strategy which will be implemented as a case study in the outer dike area of Zwijndrecht

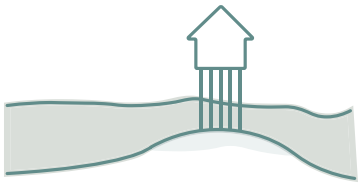
P2

Excavating around heritage

Floating heritage

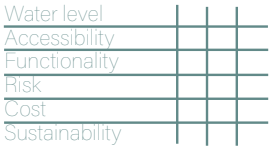


New foundation below heritage



Three different design solutions that enable the preservation of industrial heritage within the new urban strategy proposal will be analysed.

Evaluation



Finally, the three design solutions will be evaluated and compared to determine which option is most suitable for the Schokbeton site.

P3

Design

P4/P5

Figure 2: Research plan, explaining the steps taken with time indications (Made by author, 2024

2. Landscape analyses of Zwijndrecht

This study focuses on the outer dike area of Zwijndrecht (Figure 3), which has been separated from the town of Zwijndrecht by a dike. As shown in Figure 4, the elevation differences indicate that the dike rises approximately 4.5 m above NAP (Normaal Amsterdams Peil), while the outer dike area is situated around 3.5 m above NAP. In contrast, the town within the dike lies significantly lower, at -0.75 m NAP.

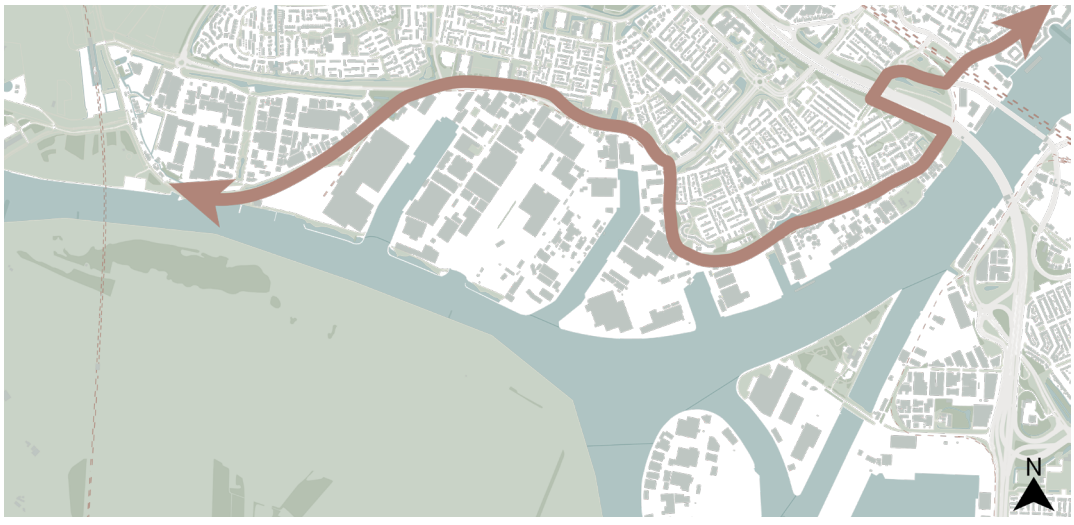
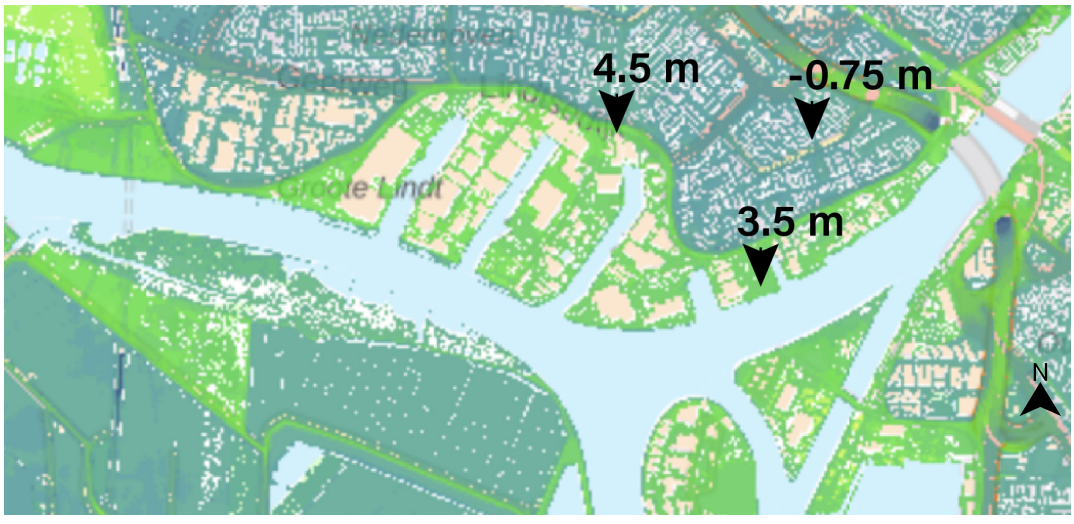


Figure 3: Map highliting the dike in Zwijndrecht (made by author, 2024)



Legend

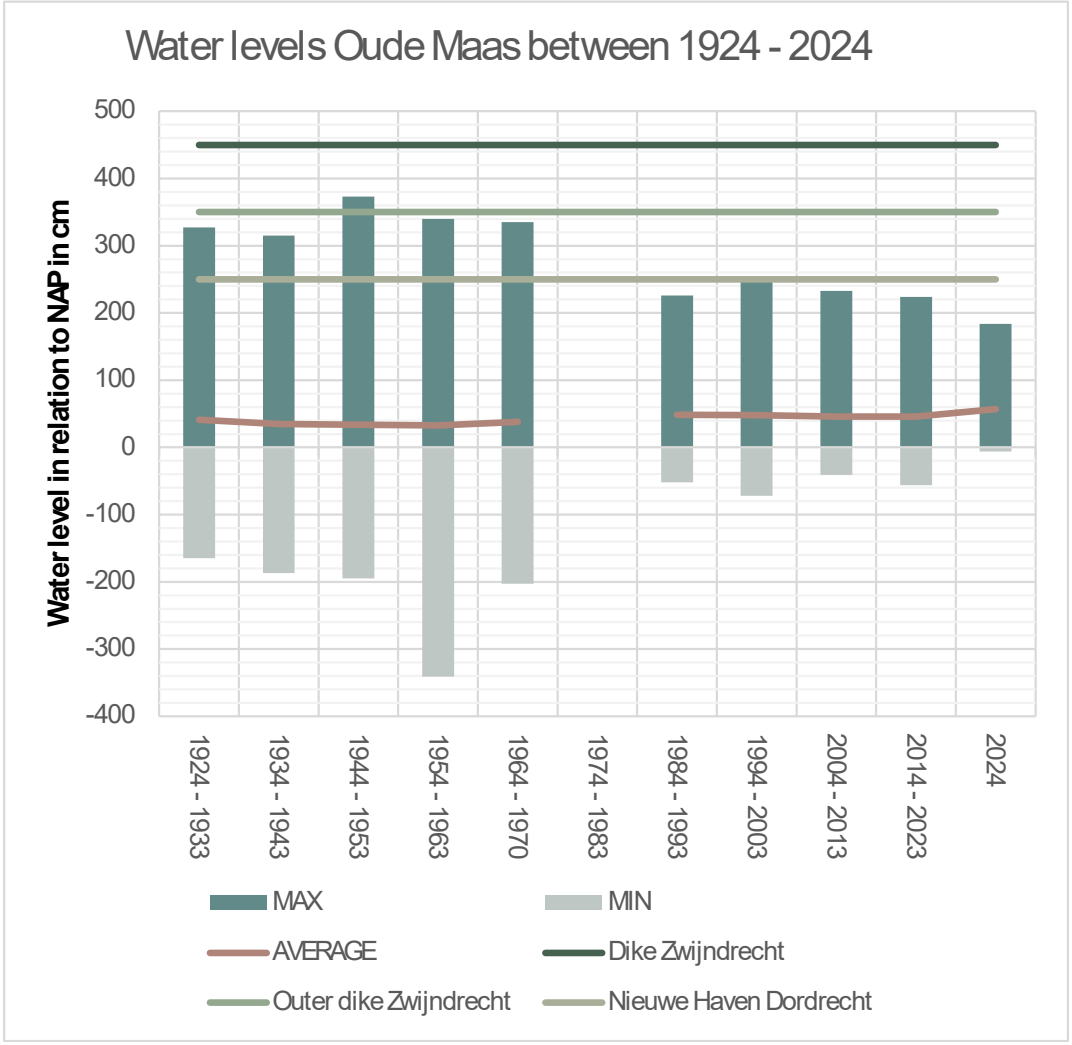
-10 m	11 m	26 m
-3 m	18 m	32 m
4 m	25 m	62 m

Figure 4: Height map Zwijndrecht relative to NAP (Actueel Hoogtebestand Nederland, 2024)

During the Watersnoodramp in 1953, the water level of the Oude Maas around Dordrecht reached 3.73 m above NAP (Rijkswaterstaat, 1953). This surge meant that even the higher industrial area, with an elevation of 3.5 m NAP, was overflowed, and the dike, at 4.5 m NAP, offered minimal protection. Despite their height, the dikes were unable to withstand the force of the water and failed in several locations, resulting in the flooding of Zwijndrecht.

Table 1 presents the average water levels recorded in Dordrecht between 1924 and 2024, based on data from Rijkswaterstaat (n.d.). A gap in the data, likely caused by the construction of the Delta Works, reflects a lack of measurements between 1970 and 1983. Following this period, the difference between the highest and lowest recorded water levels appears to narrow, possibly due to the regulatory effects of the Delta Works. However, the average water level remains consistent, at approximately 0.5 m above NAP. Despite the reduced fluctuation in water levels, the Nieuwe Haven in Dordrecht (Figure 5), one of the lower-lying areas, remains vulnerable, as water levels occasionally exceed its height of 2.5 m above NAP. These data points are essential for understanding the current conditions affecting the region and for informing future flood management strategies. A potential solution could be expanding the Oude Maas River by lowering the outer dike area and creating a buffer zone for the river water.

Table 1: Graph water levels Oude Maas (Made by author, 2024)



Legend

-10 m	11 m	26 m
-3 m	18 m	32 m
4 m	25 m	62 m

Figure 5: Height map Zwijndrecht to Dordrecht (Actueel Hoogtebestand Nederland, 2024)

3. Historical analyses of Zwijndrecht

3.1 Historical analysis of the landscape

Zwijndrecht landscape transformed significantly over time as illustrated in Figure 6. In the 1850s, the region was largely characterized by polders with limited functional use. By the early 20th century, river management interventions, including the construction of groynes, began to shape the landscape. However, it was after 1950 that the area underwent rapid industrialization, transitioning from a predominantly green and undeveloped region to one dominated by industrial sites and harbours connected to the river.

In the 1850s, the polder landscape naturally retained both river water and rainwater, allowing for a more fluid interaction between land and water. However, the subsequent structuring and hardening of the harbour area transformed the river landscape, making it less natural and imposing more rigid boundaries. These changes have increased the likelihood of flooding, as excessive water now encounters fewer natural buffers, heightening the risk of overflow and potential damage.

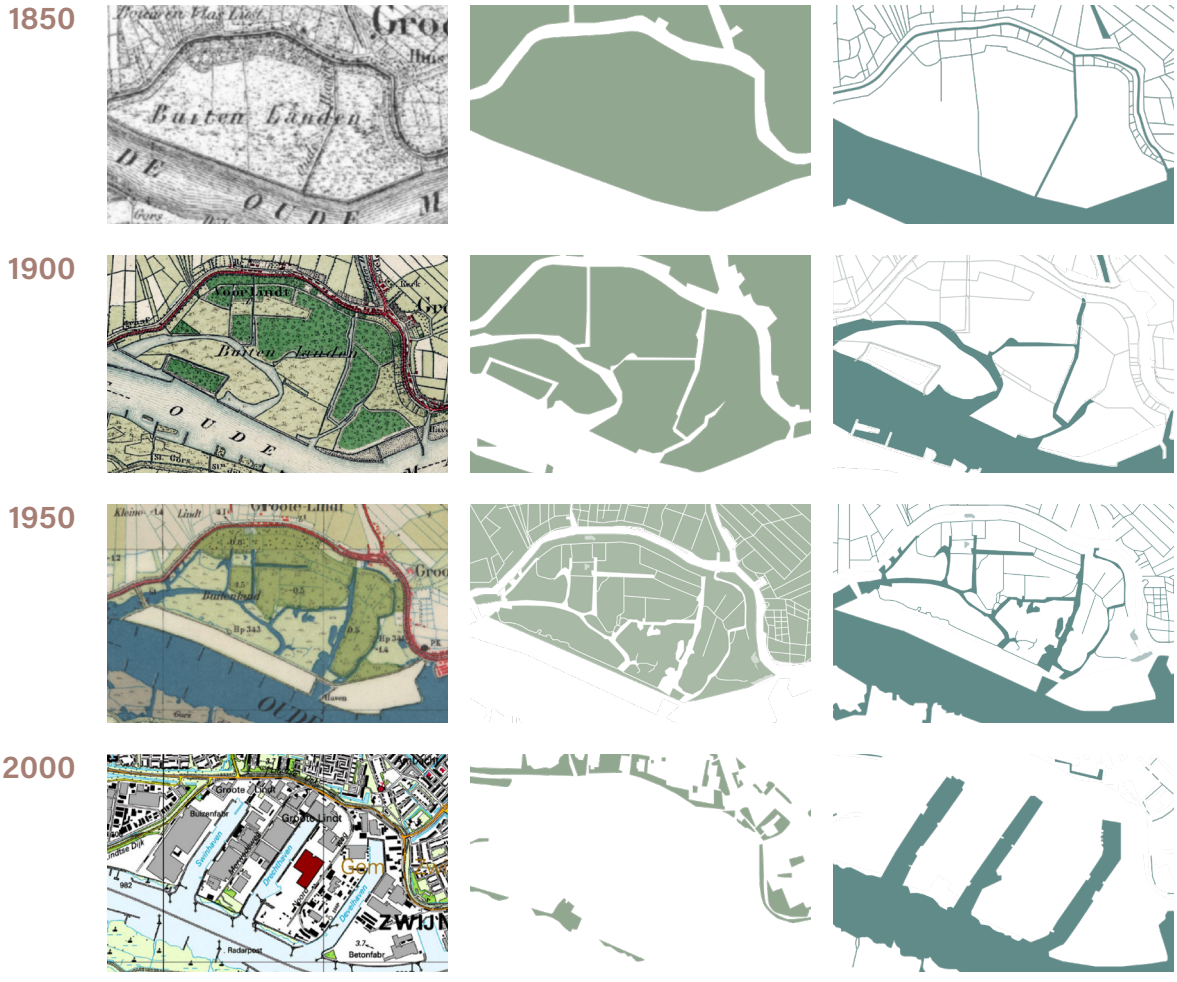


Figure 6: Historical landscape analysis (Made by author, 2024; Topotijdreis, n.d.)

3.2 Historical analysis of the industrial heritage

Figure 7 illustrates the evolution of industrial sites in Zwijndrecht, showing that no industrial activity existed in the area during the 1850s. The first major development occurred in 1930 with Sime Darby Oils constructing buildings along the Oude Maas River (see Appendix 02 for details). Industrial expansion accelerated after 1950, as land reclamation from harbour construction reshaped the landscape, leading to the loss of the polder and green spaces. After 2000, industrial growth slowed, and as global economic conditions shifted, some industries relocated, leaving older buildings near central Zwijndrecht gradually vacant.

To honour the industrial period up to 2000, which brought jobs and opportunities to Zwijndrecht and established its significance, it is crucial to preserve the town's industrial heritage sites, even as their future remains uncertain. A strategic plan is needed that not only safeguards these historical industrial sites but also integrates sustainable measures to retain river and rainwater in the landscape, as was naturally done before 1850. This approach would balance heritage preservation with environmental resilience, allowing the area to maintain its historical and ecological integrity.

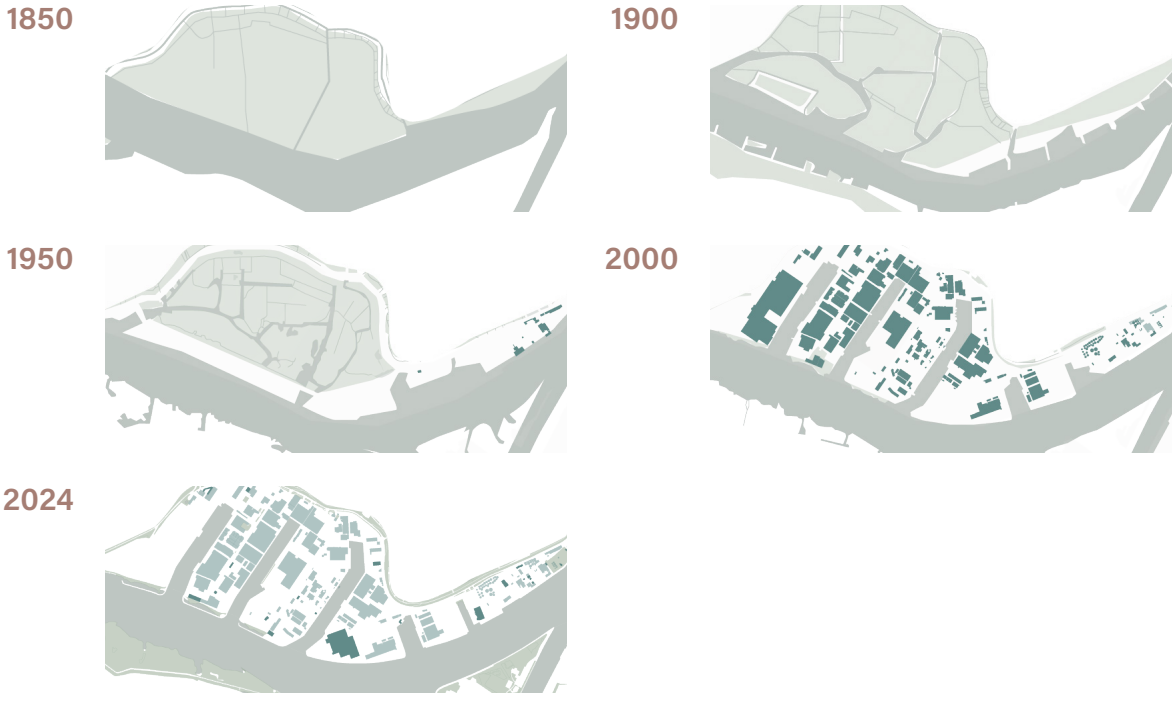


Figure 7: Analysis industrial heritage (Made by author, 2024)

4. New landscape design

4.1 Room for the River

As part of the landscape redesign for the outer dike area in Zwijndrecht, the 'Room for the River' project serves as a key reference, offering a toolbox (Figure 8) of landscape interventions aimed at enhancing water management (Sijmons, Feddes, Luiten, et al., 2017).

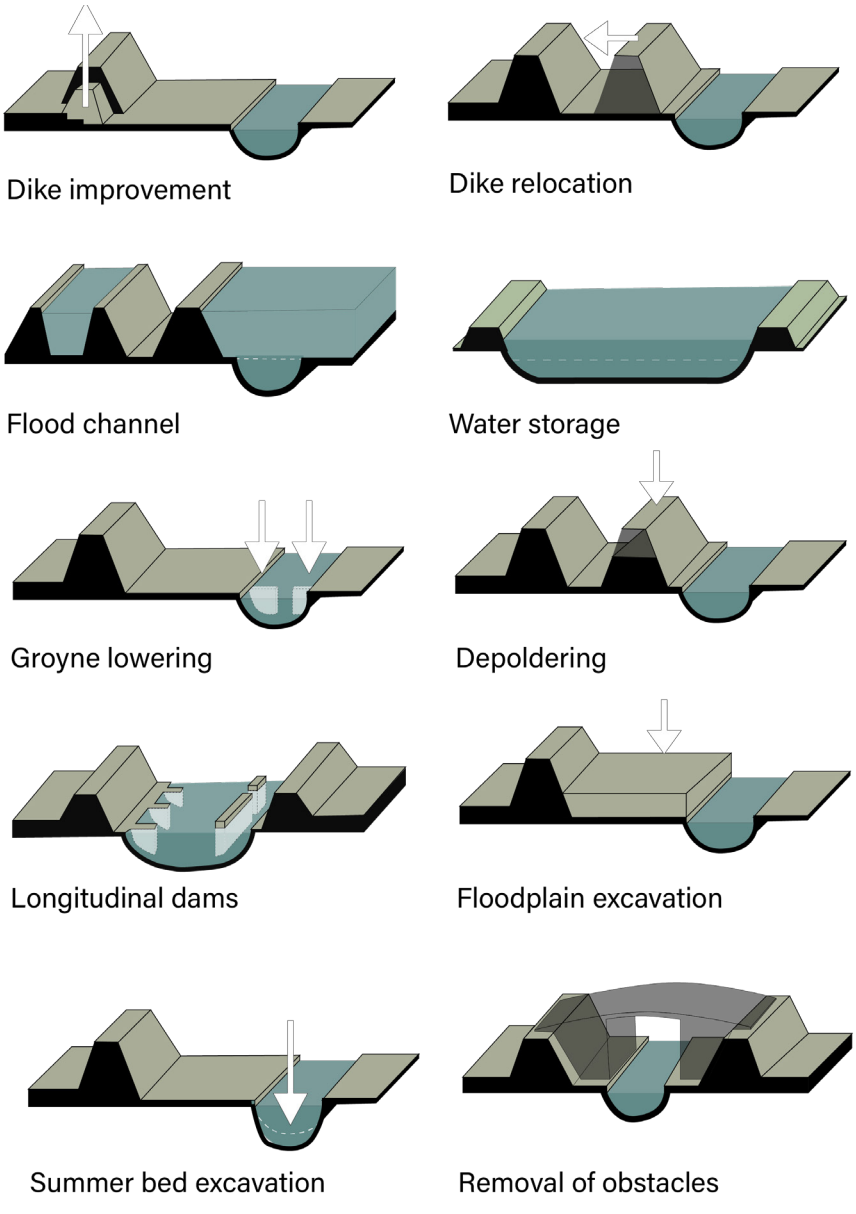


Figure 8: 'Room for the River' toolbox. Adapted from Room for the River (p 22.) by D. Sijmons, Y. Feddes, F. Feddes & E. Luiten, 2017.

These strategies have been successfully implemented at 34 locations across the Netherlands, providing a framework for similar interventions in Zwijndrecht. The goal is to better integrate water into the landscape while enhancing flood resilience and maintaining environmental balance.

4.2 Floodplain Excavation

For the outer dike area in Zwijndrecht, this study specifically focuses on the establishment of water storage areas through floodplain excavation. This will involve lowering the outer dike, currently at a height of 3.5 m above NAP (Figure 9), to 1 below NAP (Figure 10). Given that the average water level is approximately 0.5 m above NAP, this excavation would create a water depth of around 1.5 m in the outer dike area. While this depth would not support shipping activities, it would be sufficient for recreational purposes such as small boat sailing.

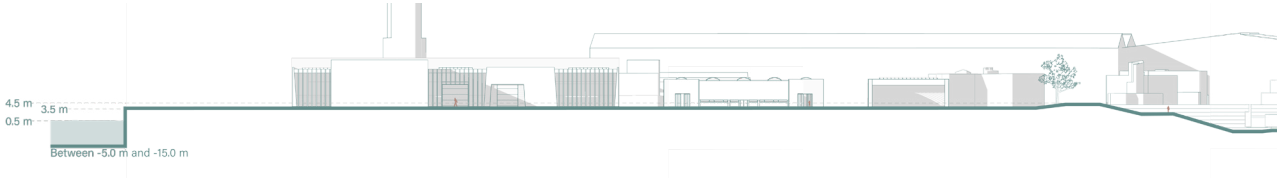


Figure 9: Urban section of the current situation of the outer dike area at Schokbeton Zwijndrecht, including heights in relation with NAP (Made by author, 2024)

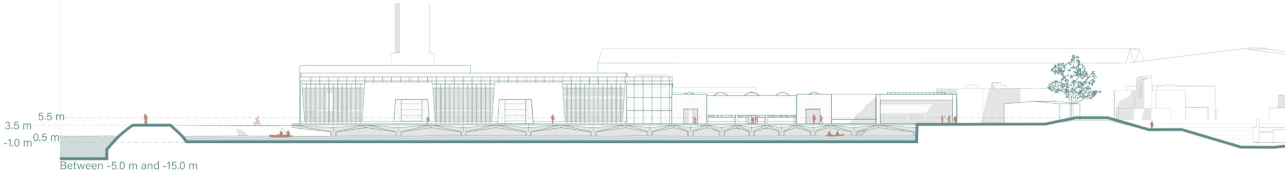


Figure 10: Urban section of the proposed situation of the outer dike area at Schokbeton Zwijndrecht, including heights in relation with NAP (Made by author, 2024)

The area under consideration spans 1.14 km^2, which, if fully flooded, could hold up to 2.11 km^3 of river water. This capacity would be a start to enhance the region's ability to manage excess water during periods of heavy rainfall, reducing the risk of flooding and contributing to longterm water management goals.

4.3 Longitudinal Dams

In addition to floodplain excavation, a longitudinal dam will be implemented in the urban strategy. Applying the concept of a longitudinal dam to the outer dike area in Zwijndrecht would offer multiple benefits (Collas et al., 2018):

1. Protection of the industrial heritage site from waves caused by passing ships and reduced current speeds.
2. Creation of a safe recreational area in the smaller shore channel, separated from the main shipping route.
3. Enhanced water level control, allowing more water to flow into the outer dike area during high water levels, and enabling water to be pumped out during drought conditions.

The combination of lowering the outer dike and longitudinal dam construction offers a sustainable solution for the outer dike area in Zwijndrecht. This approach improves the flood resilience, while creating new opportunities for recreation and water management. Figure 10 shows the current state of the area, while Figure 11 illustrates the proposed landscape intervention. The proposed plan identifies all industrial buildings constructed before 2000 as part of the area's industrial heritage, reflecting the rapid development that occurred between 1950 and the early 2000s.

Figure 11: Current situation map of Zwijndrecht (Made by author, 2024)

Figure 12: Proposed situation map of Zwijndrecht (Made by author, 2024)

5. Heritage above water

Having assessed the impact of lowering the outer dike and constructing a longitudinal dam, the subsequent step is to analyse the effects of various architectural interventions designed to preserve the industrial heritage within the outer dike area. To ensure the protection of these heritage sites, three specific interventions will be tested: excavation around heritage buildings, the use of floating platforms, and the introduction of new foundations underneath the heritage buildings. These interventions will be applied to the industrial heritage site of N.V. Schokbeton for evaluation.

5.1 N.V. Schokbeton

N.V. Schokbeton, founded in 1932 by Gerrit Lieve and Matthijs Leeuwrik, was a pioneering company in the production of schokbeton, a denser and harder type of concrete created through shockinduced compression. The company became internationally renowned, distributing its patented schoktables and techniques to over 30 countries and playing a key role in postwar prefabrication projects. Despite its success, changing industry technologies and market challenges led to the bankruptcy of its subsidiary Loveld Zwijndrecht in 2016, marking a significant shift in its history (Historische Vereniging Zwijndrecht, 2016).

Although the Schokbeton factory was originally built as a functional production facility with three main halls, the Schokhal, the Modelmakerij, and the Montagehall (Figure 16 & Figure 17). The Schokbeton factory also served as a showcase for the versatility of Schokbeton technology, a feature still evident in its architectural design and construction today.This dual function not only highlights the factory's industrial purpose but also its architectural and material innovation, positioning it as an important case study in mid-20th century construction techniques (Figure 14 & Figure 15).

Figure 13: Location Schokbeton (Made by author, 2024)

Figure 14: Drone picture of Schokbeton site (PIER14, n.d.)

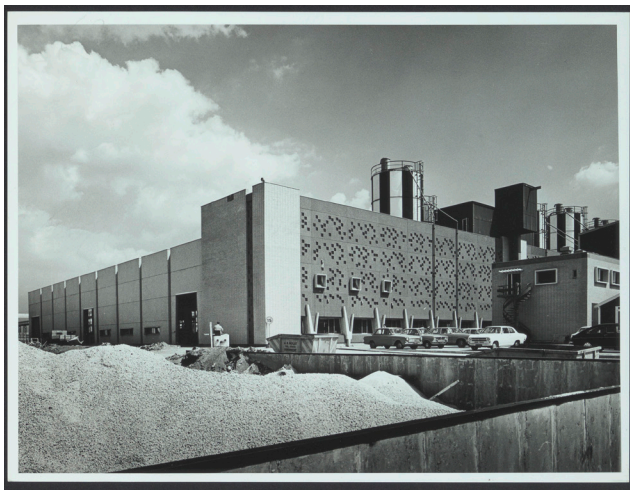


Figure 15: Picture Schokhal (Regionaal archief Dordrecht, n.d.)

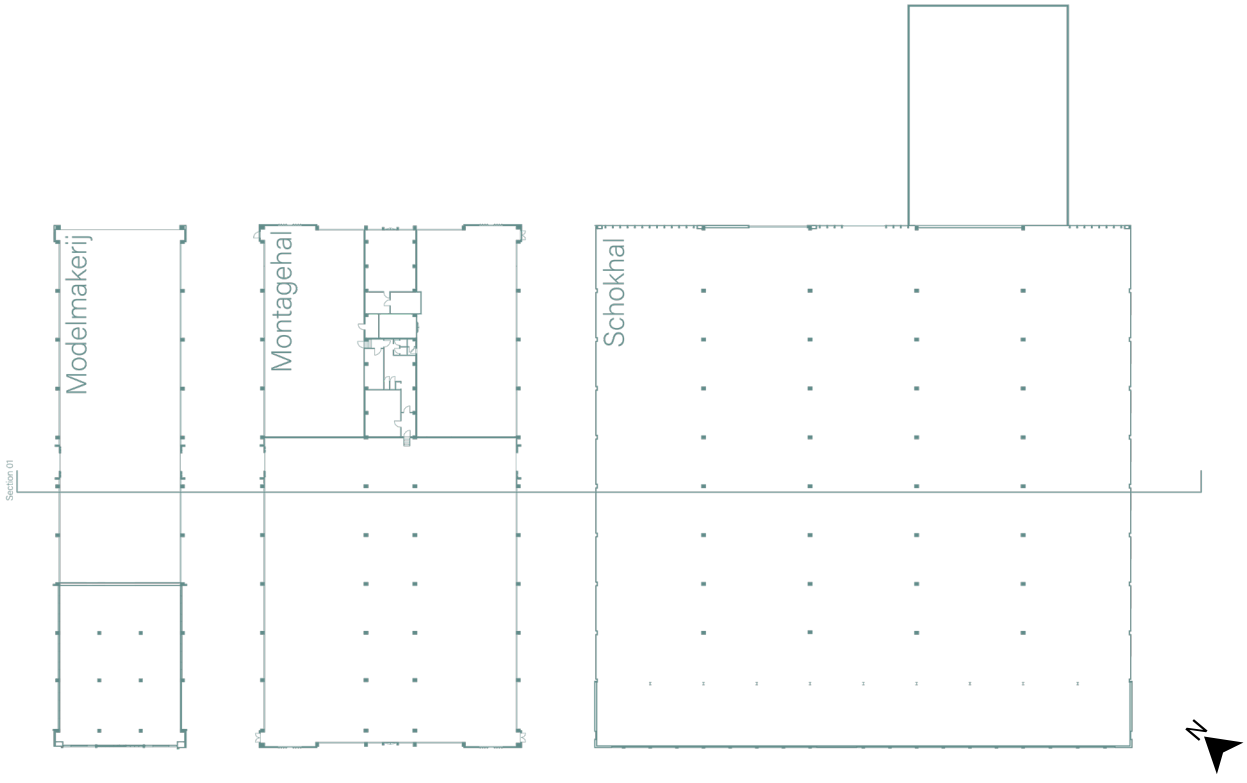


Figure 16: Groundfloor plan Schokbeton (Made by author, 2024)

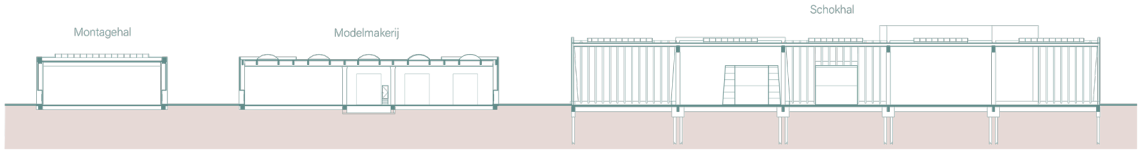


Figure 17: Section 01 Schokbeton (Made by author, 2024)

5.2 Excavation around the industrial heritage

The first method of floodplain management explored in this study involves the excavation of the outer dike area surrounding the Schokbeton site. Although the 'Room for the River' project is relatively new and this research marks the first analysis of industrial heritage preservation within its context, excavation around heritage structures is a well established practice in the Netherlands. A notable example can be found in the terpen landscapes of the northern Netherlands, where raised mounds, or terpen, were constructed around 600 BCE to protect settlements from rising sea levels (Nieuwhof et al., 2018).

Between 1840 and 1940, the fertile soil of these terpen attracted significant excavation efforts, both in vacant terpen and around inhabited areas (Nieuwhof et al., 2018). However, this excavation led to unforeseen challenges, particularly soil subsidence, which caused damage to existing structures and necessitated costly repairs (Industriespoor.nl, n.d.). Although terraced excavation methods have been used to mitigate these risks, they have not always been fully effective (Deng et al., 2021).

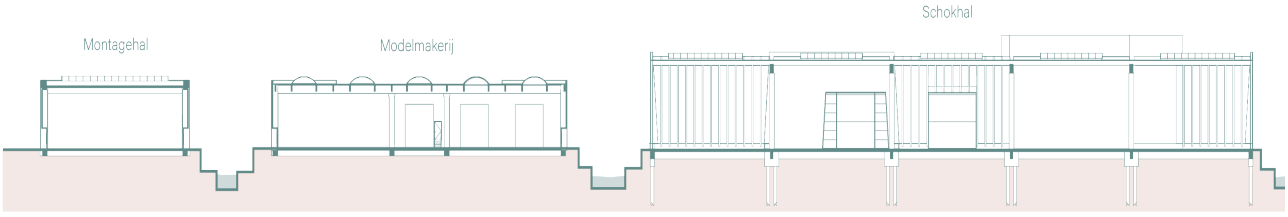


Figure 18: Section Schokbeton excavating outer dike around the industrial heritage (Made by author, 2024)

Figure 18 illustrates the proposed intervention of outer dike excavation at the Schokbeton site using terraced slopes. This approach allows a controlled, limited amount of water to enter the area while maintaining accessibility between the factory halls. The Montagehal remains connected to the mainland, ensuring ease of access, while the Modelmakerij and Schokhal are situated on isolated landforms. This could easily be solved by connecting the sites with small bridges. This setup facilitates access and makes it possible to connect the site to the sewage system and electrical grid, ensuring future functionality.

Importantly, the proposed intervention does not disturb the foundations of the existing buildings, reducing the risk of structural damage. However, soil subsidence remains a potential concern. Despite this, the excavation strategy is relatively cost effective and offers a sustainable solution for allowing limited water ingress while preserving the site's industrial heritage.

5.3 Excavation with floating heritage

This preservation method explored for the Schokbeton site involves assessing the feasibility of floating the structure. This approach requires the construction of an air filled concrete box beneath the existing foundation to provide buoyancy. As detailed in Appendix 03, an estimated 17,599.00 m^3 of air is necessary to support the weight of the site. Given that the surface area of Schokbeton is 15,156.03 m^2, the required depth of the air filled construction would be 1.16 m. Including an additional 0.2 m for the thickness of the concrete box, the total required depth becomes 1.26 m. Considering the water depth at the site is 1.5 m, this leaves only 0.24 m of clearance for water (Figure 19).

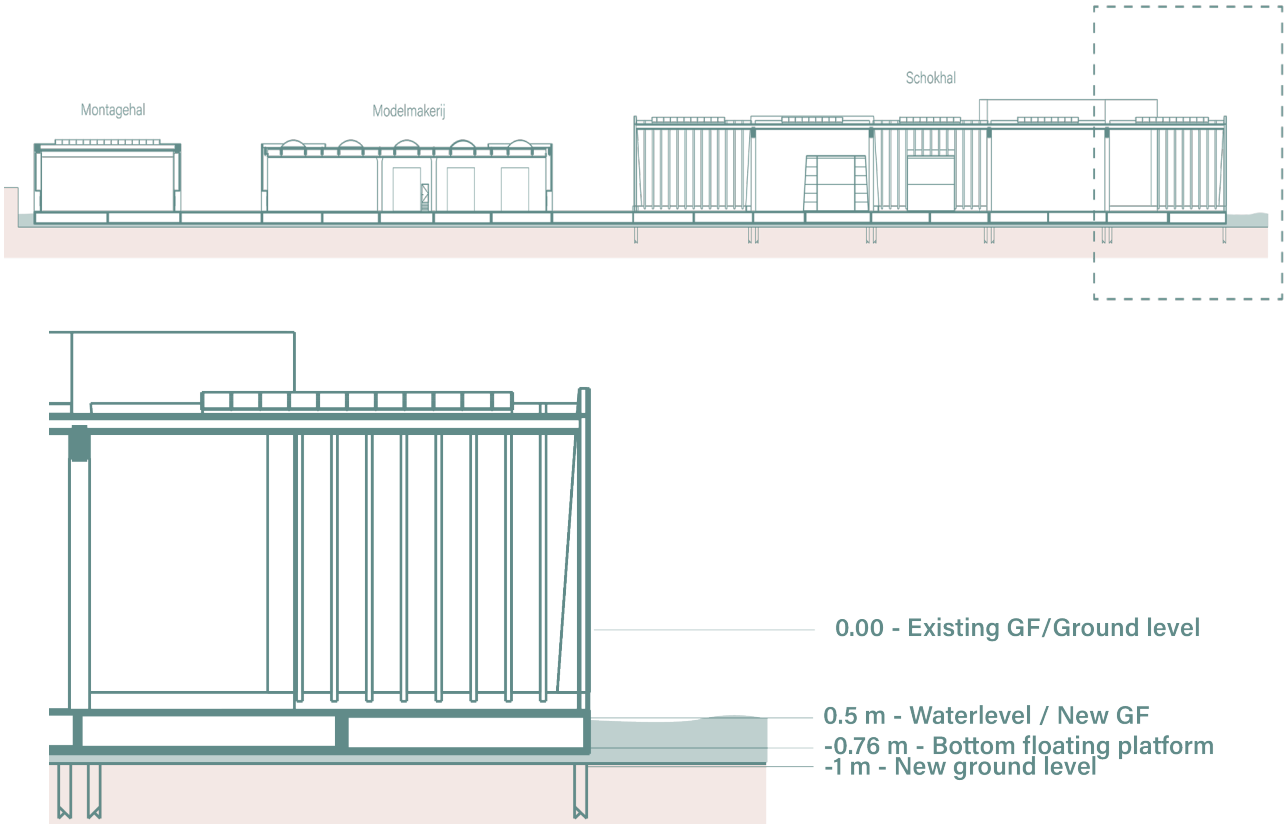


Figure 19: Section and fragmented section of floating Schokbeton (Made by author, 2024)

The 0.24 m of clearance available for water poses significant limitations, raising concerns regarding the feasibility of the proposed intervention. However, the buoyancy also creates opportunities during higher water levels. Furthermore, the construction of the site on a floating platform would lead to a misalignment between the ground floor level and the existing site conditions, thereby altering its connection to the surrounding environment. As water levels fluctuate, ensuring consistent accessibility to the building would present a challenge, potentially jeopardizing its functionality. To be functional the structure must be self-sufficient in terms of energy and water supply, further it requires an alternative to connect to the sewerage system. Despite these challenges, a well engineered floating concrete structure could provide a durable solution, enabling the Schokbeton site to persist in a future characterized by rising water levels.

5.4 Excavation with heritage supported by new foundation

The final method of outer dike excavation analysed involves not only excavating the area of the Schokbeton site but also constructing a new foundation beneath the industrial heritage buildings. This foundation would function similarly to a bridge, supporting the structures while allowing water to flow freely underneath. This concept leverages established engineering principles and issues used in bridge design. In particulary principles to address scouring, a main cause of bridge collapse due to sediment erosion around foundations, with studies indicating that octagonal pier shapes and smaller piers are most effective in minimizing scour depth (Farooq & Ghumman, 2019).

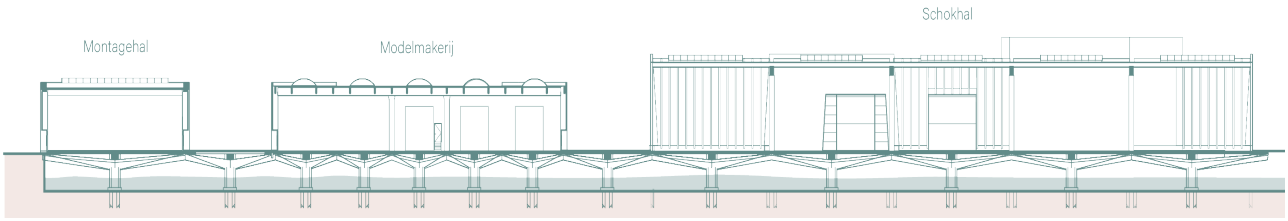


Figure 20: Section Schokbeton on piers after excavation of site (Made by author, 2024)

Figure 20 illustrates a section of the Schokbeton site after the proposed excavation, where the industrial halls are supported by a new pier-based structure. This intervention allows river water to flow freely beneath the buildings, maximizing the use of the area below. The new foundation design also facilitates access to the buildings and could incorporate connections to the sewage system and electrical grid of Zwijndrecht, ensuring the site's full functionality.

However, this intervention poses significant risks. Removing all soil beneath the buildings could cause irreversible damage to the structures, requiring extreme caution during implementation. Additionally, the material and engineering required for this solution make it a costly endeavour. Nevertheless, once completed, this intervention offers a durable, long-term solution that preserves Zwijndrecht's industrial heritage for the future.

6. Results

The analysis of Zwijndrecht reveal that the town is geographically protected by a dike, which historically separated it from the adjacent industrial zone. This dike serves the important function of shielding Zwijndrecht from flooding. However, historical analysis of the outer dike area demonstrates significant expansion since the 1850s, particularly between 1950 and 2000. During this period, the once green polder landscape was largely replaced by industrial facilities and residential neighbourhoods designed to accommodate the growing workforce. The expansion also involved strategic changes to the river landscape, appropriating segments of the river to support industrial transportation. This altered the natural water management system, replacing permeable land with hard surfaces that repel water and increase pressure on the river, heightening flood risks.

By reviewing previous 'Room for the River' projects, this study proposes a new 2-step landscape intervention. The outer dike area of Zwijndrecht would be lowered to allow river water to enter, with an average depth of 1.5 m. Additionally, a longitudinal dam would be introduced to create two river channels. This intervention ensures the continuation of shipping activities, while also creating a new channel that offers recreational opportunities and minimizes the impact on the industrial heritage in the area.

However, lowering the outer dike area presents challenges for the preservation of Zwijndrecht's industrial heritage, particularly in the zones that experienced rapid industrial development between 1950 and 2000. This period was crucial for Zwijndrecht's growth, as it created numerous job opportunities, transformed the town's economic landscape, and leveraged its strategic location for global trade. It is essential to preserve the remnants of this industrial boom to honour its significance.

To address these challenges, three potential interventions were studied at the former N.V. Schokbeton site, allowing river water to enter the area while preserving its industrial structures. These interventions include:

1. Excavating around the industrial heritage
2. Floating the industrial heritage on a platform
3. Constructing a new foundation beneath the industrial heritage

The following matrix summarizes the evaluation of each option:

Table 2: Evaluation summary of industrial heritage (IH) preservation options (Made by author, 2024)

	Excavating around IH	Floating IH	New foundation underneath IH
Water impact level	-	+	++
Accessibility	++	--	++
Functionality	+	-	++
Risk	+	--	--
Cost	++	-	--
Sustainability	-	++	+

Legend	
++	Significant improvement
+	Positive impact
-	Negative impact
--	Problematic impact

Each of the factors mentioned in Table 2 play a crucial role in determining the most suitable technique for safeguarding the site while ensuring its long-term viability. An evaluation of these factors provides the following insights:

Water Level Impact:
Constructing a new foundation beneath the industrial heritage has the greatest impact on water flow, as it allows the river to move freely beneath the structures. This approach maximizes flood mitigation by enabling unobstructed river movement while preserving the industrial heritage. In contrast, the option of placing the industrial heritage on a floating platform may appear less effective in the current context, but it offers a unique advantage: the structures can rise with the water level, providing long-term adaptability to fluctuating river conditions.

Accessibility:
The floating industrial heritage concept introduces accessibility challenges, as it lowers the buildings to the water level, severing their connection to the dike and the town. Additionally, floating structures require complete self-sufficiency, disconnected from the town's sewage and electrical systems, which poses significant operational difficulties.

Functionality:
Like accessibility, the floating solution complicates functionality due to the need for self-sufficiency. In contrast, the new foundation and excavation approaches allow for better integration with existing infrastructure and services, making them more practical for long-term use.

Risk:
Excavating around the industrial heritage poses the lowest risk because it does not interfere with the structures themselves, with the primary concern being soil subsidence. In contrast, the floating and new foundation options involve greater risks, particularly during construction and afterward, as they require significant modification to the site.

Cost:
Excavating around the industrial heritage is the most cost-effective solution, as it requires fewer materials. The other two options are more costly due to the need for additional structural components, such as floating platforms or new foundations.

Sustainability:
While all three interventions extend the lifespan and utility of the Schokbeton industrial halls, the floating solution offers the highest sustainability in the long term. Its flexibility allows for future rises in river levels, making it adaptable to potential climate change impacts. The new foundation also improves sustainability by enabling free river movement, though it does not alter the ground floor level, leaving the buildings vulnerable to extreme flooding events.

7. Discussion

The first key topic of discussion is the rationale behind the project's location. Previous 'Room for the River' initiatives have typically been situated in narrow sections of rivers where the flow is stronger, and the risk of damage from high water levels is greater. However, historical landscape analysis shows that the Zwijndrecht area was once part of a natural water management system, which was significantly altered with the advent of industrialization. Restoring the original landscape and its natural water management functions seems a logical solution for improving flood resilience.

Another important question raised by this research is whether the proposed intervention is sufficient to address the broader challenges posed by climate change. Previous studies on 'Room for the River' projects have indicated that these measures, although effective locally, may not be adequate on their own to fully mitigate the effects of climate change. Similarly, the relatively small area of Zwijndrecht under consideration here is unlikely to solve larger scale issues. However, the principles and approaches tested in this project could be applied to other areas, potentially as part of a larger, multi-site strategy combined with additional interventions.

A further point of discussion concerns the flood risks specific to this area, which are relatively low. The decision to implement an intervention here stems from the fact that, despite its rich industrial heritage, the area does not contain any significant residential zones. This makes it a safer environment for experimental, risk-heavy interventions, as there is no immediate threat to human life. Subsequently, the industrial landscape of Zwijndrecht is undergoing rapid transformation due to factors like globalization and economic shifts. Although many factories are still operational, changes in the global economy cause companies to relocate to more strategic sites, necessitating new strategies for the future of the industrial heritage in this area.

Additionally, the interventions examined in this study focus primarily on one site, the former Schokbeton factory. This was a deliberate choice due to the scope of the research, but limits the credibility of the findings. Different locations could yield different outcomes. Similarly, the proposed water level of 1.5 m plays a significant role in shaping the results. Future research should explore multiple landscape scenarios to provide a more extensive understanding of potential outcomes.

Finally, the structural interventions considered in this study are based on limited research due to the paper's scope. They are intended to offer preliminary insights into how industrial heritage can coexist with water management strategies. This study should be viewed as a first step towards developing a vision for how the Netherlands can adapt to rising water levels while preserving its industrial heritage. Further research is needed to explore these possibilities in greater detail and at a broader scale.

8. Conclusion

In conclusion, this research has investigated innovative strategies for flood mitigation in Zwijndrecht's outer dike area, emphasizing the preservation of the region's valuable industrial heritage. The research underscores the importance of integrating heritage preservation with modern water management practices in a landscape shaped by historical industrial development. By analysing the landscape's evolution and the impacts of industrialization, this study highlights the urgent need for approaches that address flood risks while honouring the area's historical significance.

The landscape analysis reveals that Zwijndrecht's geographical features pose significant opportunities. The existing dike protects the low-lying town from flooding, and there is potential to raise the dike further for enhanced future protection. However, the loss of the natural polder outside the dike due to mid-20th-century industrial expansion has increased flood risks in areas like the Nieuwe Haven in Dordrecht, where dikes are less resilient.

This research aligns with the principles of the 'Room for the River' project, advocating for a framework that enhances water management by allowing more natural river flow. Unlike the 'Room for the River' project, this study also prioritizes respect for the region's industrial heritage. The proposed excavation of the outer dike area and longitudinal dam strategies not only mitigate flood risks but also create recreational opportunities and renew the connection between the landscape and water. This dual approach promotes a sustainable environment where heritage preservation and ecological balance coexist.

The proposed design solutions, excavation around heritage sites, floating platforms, and new foundations, offer strategies to enhance flood resilience while limiting compromises of the area's historical value. Each solution was assessed against criteria like water level impact, accessibility, functionality, risk, cost, and sustainability. The excavation approach, allowing for controlled water ingress, emerges as the most cost-effective and low-risk option, preserving the integrity of heritage structures like the former N.V. Schokbeton factory. In contrast, the floating platform solution, though ambitious, faces significant challenges regarding structural alignment and service connectivity, which could affect the functionality of historic buildings. New foundations provide a long-term strategy to facilitate water flow beneath structures, but this approach carries construction risks and potential structural damage during implementation.

These interventions illustrate the complex relationship between heritage preservation and modern water management, setting a precedent for future projects in similar contexts. By fostering a dialogue between architectural innovation and environmental resilience, this study contributes to efforts to protect Zwijndrecht's industrial heritage while adapting to climate change realities.

Given the complexity of these challenges, future research should be expanded by exploring diverse scenarios that can enhance flood resilience while celebrating the area's industrial heritage. By investigating a range of approaches, subsequent studies can develop strategies that help similar areas navigate modern water management complexities while honouring their industrial heritage. Through collaborative efforts, Zwijndrecht can cultivate a vibrant community that embraces its industrial past while adapting to climate change, ensuring the town remains a historically rich and resilient space for generations to come.

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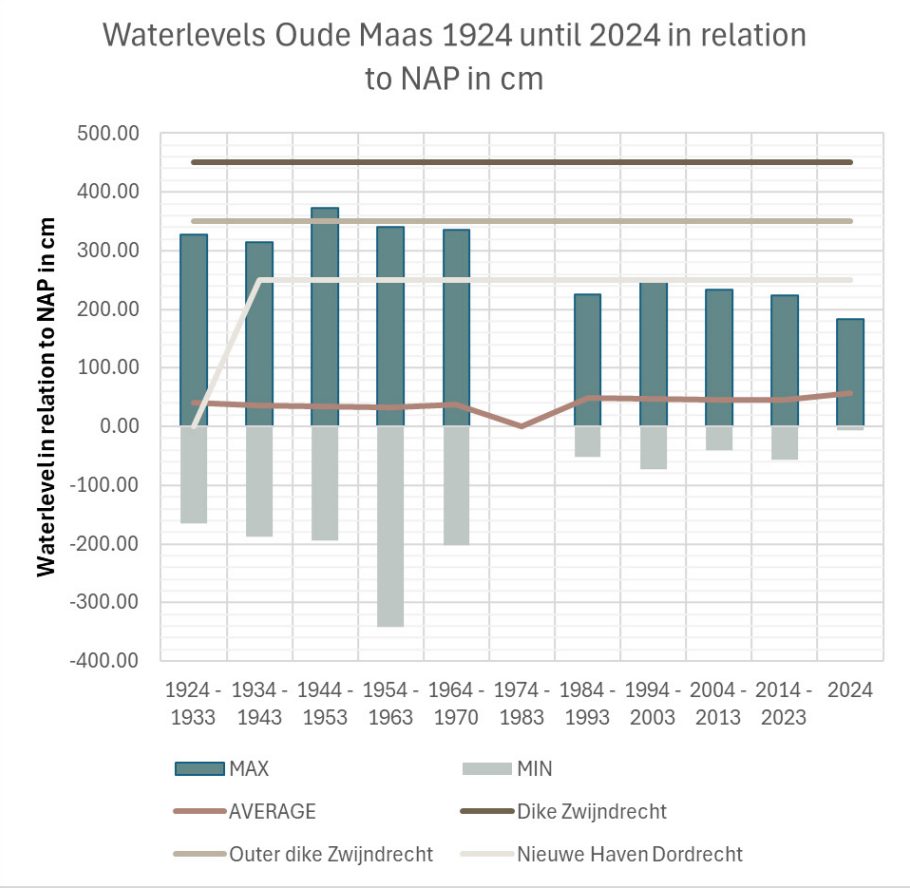
Appendices

Appendix 01 - Waterlevel Dordrecht

PERIOD	AVERAGE	MAX	DATE MAX	MIN	DATE MIN
1924 - 1933	41.00	327.00	26/11/1928	-165.00	27/02/1933
1934 - 1943	35.05	315.00	06/12/1940	-187.00	18/12/1938
1944 - 1953	33.57	373.00	01/02/1953	-195.00	06/01/1947
1954 - 1963	32.58	340.00	23/12/1954	-341.00	11/11/1954
1964 - 1970	37.91	335.00	10/12/1965	-203.00	15/03/1964
1974 - 1983		NO DATA		NO DATA	
1984 - 1993	48.39	226.00	24/01/1986	-52.00	30/11/1993
1994 - 2003	47.93	250.00	28/01/1994	-72.00	12/03/1996
2004 - 2013	45.75	233.00	06/01/2012	-41.00	13/10/2004
2014 - 2023	45.89	224.00	10/02/2020	-56.00	02/03/2018
2024	56.95	184.00	15/01/2024	-6.00	31/08/2024



Reference: Rijkswaterstaat. (2024). Waterhoogte Oppervlaktewater t.a.v. Normaal Amsterdams Peil in cm between 01-01-2024 and 31-05-2024.

Appendix 02 - Catalogue of the industrial buildings in the outer dike of Zwijndrecht

This document contains a catalogue of all the buildings that are related to the maritime industry of the outer dike area of Zwijndrecht in 2024

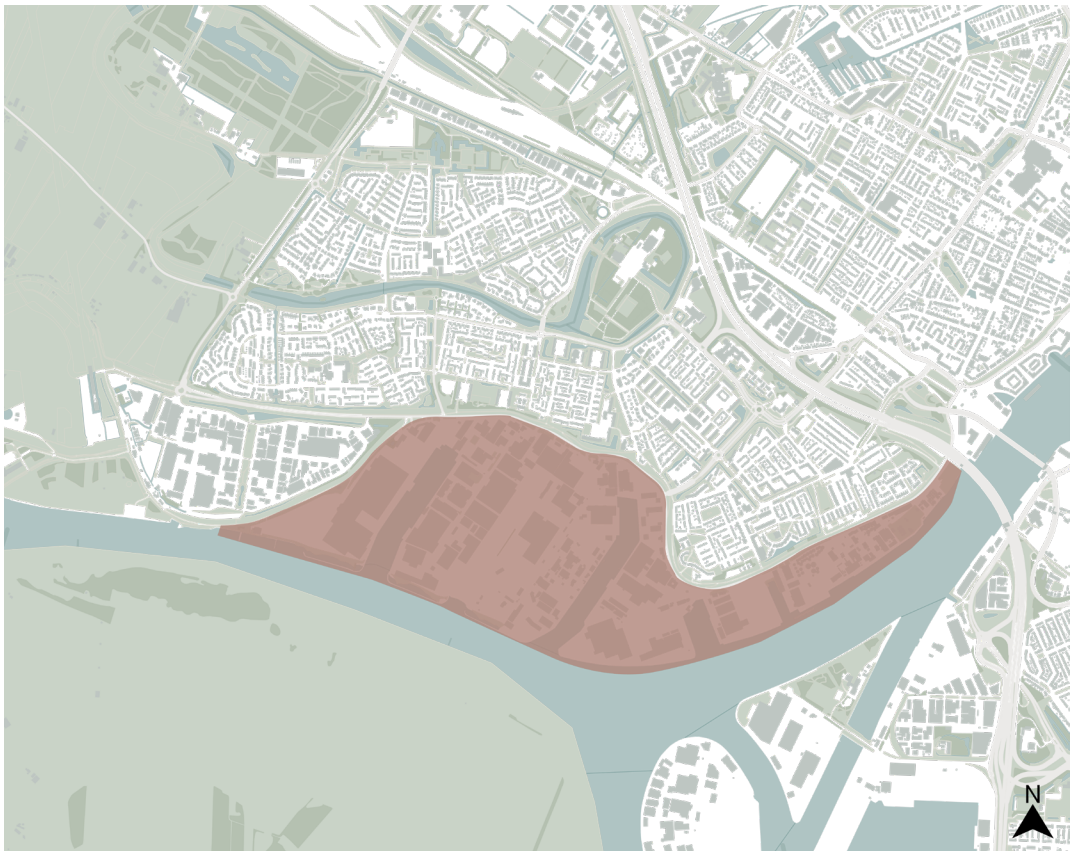


Figure 1: Map research location in Zwijndrecht (made by author, 2024)

Table 1: Catalogue of industrial buildings in the outer dike area of Zwijndrecht

1. Van Leeuwen Buizen

Adress: Lindtsedijk 120, Zwijndrecht
Function: Office Van Leeuwen Buizen
Start company: 1924
Construction year: 2010

2. Van Leeuwen Buizen

Adress: Lindtsedijk 100, Zwijndrecht
Function: Productionhall van Leeuwen Buizen
Start company: 1924
Construction year: 1990

3. Van Leeuwen Buizen

Adress: Lindtsedijk 100, Zwijndrecht
Function: Office Van Leeuwen Buizen
Start company: 1924
Construction year: 1990

4. P.B. Bezemer Automaterialen en Garagebedrijf B.V.

Adress: Lindtsedijk 94
Function: Garage
Start company: 1979
Construction year: 1975

5. Printing company/office space/Partially vacant

Adress: Lindtsedijk 88
Function: Office space / printing company
Start company: -
Construction year: 2009

6. Opnieuw en co

Adress: Dubbelweg 1
Function: Secondhand store
Start company: Unknown
Construction year: 1975

7. Van Der Ham en Giessen

Adress: Dubbelweg 3, Zwijndrecht
Function: Wholesale for welding etc. equipment
Start company: 1972
Construction year: 1975

8. Various officebuildings

Adress: Dubbelweg 21, Zwijndrecht
Function: Various offices
Start company: -
Construction year: 1975

9. Scheepswerf gebroeders Kooiman

Adress: Lindtsedijk 86, Zwijndrecht
Function: Shipwarf
Start company: 1884
Construction year: 1975

10. Scheepswerf gebroeders Kooiman

Adress: Lindtsedijk 86, Zwijndrecht
Function: Shipwarf
Start company: 1884
Construction year: 1900

11. Scheepswerf gebroeders Kooiman

Adress: Lindtsedijk 86, Zwijndrecht
Function: Shipwarf
Start company: 1884
Construction year: 1997

12. Scheepswerf gebroeders Kooiman

Adress: Lindtsedijk 78, Zwijndrecht
Function: Shipwarf
Start company: 1884
Construction year: 2011

13. Scheepswerf gebroeders Kooiman

14. Scheepswerf gebroeders Kooiman

15. Praktijkcentrum Kooiman Piping

Adress: Lindtsedijk 78, Zwijndrecht
Function: Shipwarf
Start company: 1884
Construction year: 1980

Adress: Lindtsedijk 76, Zwijndrecht
Function: Shipwarf
Start company: 1884
Construction year: 1967

Adress: Lindtsedijk 74, Zwijndrecht
Function: Education
Start company: -
Construction year: -

16. Blue Amigo

Adress: Merwedeweg 1, Zwijndrecht
Function: Office
Start company: 1970
Construction year: 1975

17. Scheepswerf Gebroeders Kooiman

Adress: Merwedeweg 3, Zwijndrecht
Function: Others
Start company: 1884
Construction year: 1970

18. Erem Industrial Automation

Adress: Merwedeweg 5, Zwijndrecht
Function: Industry
Start company: 1957
Construction year: 1969

19. Atlas Copco Nederland

Adress: Merwedeweg 7, Zwijndrecht
Function: Compressed air products office
Start company: 1873
Construction year: 1969

20. Atlas Copco Nederland

Adress: Merwedeweg 7, Zwijndrecht
Function: Compressed air products storage
Start company: 1973
Construction year: 1974

21. Aluned

Adress: Merwedeweg 9, Zwijndrecht
Function: Aluminium production
Start company: 1987
Construction year: 1980

22. Hollimex

Adress: Kilweg 2, Zwijndrecht
Function: Steelproduction
Start company: 1980
Construction year: 1980

23. Danpoort

Adress: Kilweg 6, Zwijndrecht
Function: Abrasives producent
Start company: 1932
Construction year: 1980

24. Van Drimmelen

Adress: Merwedeweg 12, Zwijndrecht
Function: Supplier of wood and board material
Start company: 1923
Construction year: 1979

25. Van Drimmelen

26. De Oliebron

27. De Oliebron

Adress: Merwedeweg 12, Zwijndrecht
Function: Supplier of wood and board material
Start company: 1923
Construction year: 1979

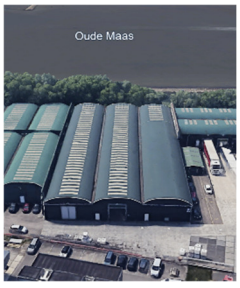
Adress: Merwedeweg 17, Zwijndrecht
Function: Lubricant industry
Start company: 1891
Construction year: 1967

Adress: Merwedeweg 17, Zwijndrecht
Function: Lubricant industry
Start company: 1891
Construction year: 2012

28. De Oliebron

Adress: Merwedeweg 17, Zwijndrecht
Function: Lubricant industry
Start company: 1891
Construction year: 2000

29. De Oliebron



Adress: Merwedeweg 17, Zwijndrecht
Function: Lubricant industry
Start company: 1891
Construction year: 2000

30. De Oliebron

Adress: Merwedeweg 17, Zwijndrecht
Function: Lubricant industry
Start company: 1891
Construction year: 2000

31. BPG Zwijndrecht

Adress: Merwedeweg 20, Zwijndrecht
Function: Wood supplier office
Start company: 1949
Construction year: 2011

32. BPG Zwijndrecht

Adress: Merwedeweg 18, Zwijndrecht
Function: Woodsupplier
Start company: 1949
Construction year: 1977

33. Van Drimmelen

Adress: Merwedeweg 14, Zwijndrecht
Function: Supplier of wood and board material
Start company: 1923
Construction year: 1979

34. Van Drimmelen

Adress: Merwedeweg 14, Zwijndrecht
Function: Supplier of wood and board material
Start company: 1923
Construction year: 1985

35. Meesterwerk B.V.

Adress: Merwedeweg 12, Zwijndrecht
Function: Supplier of wood and board material
Start company: -
Construction year: 2012

36. Molendijk & Zuidgeest

Adress: Merwedeweg 12, Zwijndrecht
Function: Woodworkers
Start company: 2012
Construction year: 1985

37. Van Drimmelen

Adress: Merwedeweg 12, Zwijndrecht
Function: Supplier of wood and board material
Start company: 1923
Construction year: 1978

38. Van Drimmelen

Adress: Merwedeweg 12, Zwijndrecht
Function: Supplier of wood and board material
Start company: 1923
Construction year: 1978

39. Unknown

Adress: Merwedeweg 10, Zwijndrecht
Function: -
Start company: -
Construction year: 1996

40. Agro Delta Groep

Adress: Merwedeweg 8, Zwijndrecht
Function: Storage
Start company: 1948
Construction year: 1978

41. COZO Opslag

Adress: Ijsselweg 2, Zwijndrecht
Function: Grainstorage
Start company: 1963
Construction year: 1964

42. Hans Boodt Mannequin

Adress: Amerweg 10, Zwijndrecht
Function: Mannequin outlet
Start company: 2002
Construction year: 1966

43. Hans Boodt Mannequin

Adress: Merwedeweg 6, Zwijndrecht
Function: Mannequin outlet
Start company: 2002
Construction year: 1968

44. Neele-vat logistics

Adress: Amerweg 4, Zwijndrecht
Function: Warehouse
Start company: 1975
Construction year: 1962

45. Agro Delta Groep

Adress: Lindtsedijk 62, Zwijndrecht
Function: Storage
Start company: 1948
Construction year: 1967

46. Agro Delta Groep

Adress: Lindtsedijk 62, Zwijndrecht
Function: Storage
Start company: 1948
Construction year: 1968

47. Ni-Ho Lasbedrijf

Adress: Lindtsedijk 62, Zwijndrecht
Function: Welding company
Start company: 1985
Construction year: 1968

48. Aluminium Kunststof XL

Adress: Lindtsedijk 60, Zwijndrecht
Function: Aluminium and plastic products supplier
Start company: -
Construction year: 1968

49. Oceanco Zwijndrecht

Adress: Noordweg 8, Zwijndrecht
Function: Shipwarf office
Start company: 1987
Construction year: 1968

50. Oceanco Zwijndrecht

Adress: Noordweg 8, Zwijndrecht
Function: Shipwarf storage
Start company: 1987
Construction year: 1968

51. Oceanco Zwijndrecht

Adress: Noordweg 8, Zwijndrecht
Function: Shipwarf storage
Start company: 1987
Construction year: 1968

52. Oceanco Zwijndrecht

Adress: Noordweg 8, Zwijndrecht
Function: Shipwarf storage
Start company: 1987
Construction year: 1968

53. Oceanco Zwijndrecht

Adress: Noordweg 8, Zwijndrecht
Function: Shipwarf storage
Start company: 1987
Construction year: 1992

54. Oceanco Zwijndrecht

Adress: Noordweg 8, Zwijndrecht
Function: Shipwarf storage
Start company: 1987
Construction year: 1980

55. Bedrijfsschool

Adress: Noordweg 6, Zwijndrecht
Function: Education
Start company: -
Construction year: 1972

56. Asfaltnu

Adress: Noordweg 2, Zwijndrecht
Function: Asfalt company
Start company: 1990
Construction year: 2008

57. Asfaltnu

Adress: Noordweg 2, Zwijndrecht
Function: Asfalt company
Start company: 1990
Construction year: 1995

58. Asfaltnu

Adress: Noordweg 2, Zwijndrecht
Function: Asfalt company
Start company: 1990
Construction year: 1995

59. Univar Solutions

Adress: Noordweg 3, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1992

60. Univar Solutions

Adress: Noordweg 3, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 2008

61. Univar Solutions

Adress: Noordweg 3, Zwijndrecht
Function: Chemical distributor
Start company: 1949

62. Univar Solutions

Adress: Noordweg 3, Zwijndrecht
Function: Chemical distributor
Start company: 1949

63. Univar Solutions

Adress: Noordweg 3, Zwijndrecht
Function: Chemical distributor
Start company: 1949

Construction year: 1985

64. Univar Solutions

Adress: Noordweg 3, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1995

Construction year: 1992

65. Univar Solutions

Adress: Noordweg 3, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1995

Construction year: 1975

66. Univar Solutions

Adress: Noordweg 3, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1976

67. Univar Solutions

Adress: Noordweg 3, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: **2015**

68. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1976

69. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 2020

70. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1976

71. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1976

72. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1965

73. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1965

74. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1980

75. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1965

76. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1965

77. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1965

78. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1969

79. Univar Solutions

Adress: Noordweg 5, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1970

80. Univar Solutions

Adress: Noordweg 11, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1960

81. Univar Solutions

Adress: Noordweg 11, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1985

82. Univar Solutions

Adress: Noordweg 11, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1985

83. Univar Solutions

Adress: Noordweg 11, Zwijndrecht
Function: Chemical distributor
Start company: 1949
Construction year: 1965

84. Multi Engineering

Adress: Noordweg 15, Zwijndrecht
Function: Engineering industry, building & infra and maritime & offshore.
Start company: 1998
Construction year: 1964

85. Multi Engineering

Adress: Noordweg 15, Zwijndrecht
Function: Engineering industry, building & infra and maritime & offshore.
Start company: 1998
Construction year: 1960

86. Bandenhotel Ames Autobedrijf BV

Adress: Noordweg 17, Zwijndrecht
Function: Car garage
Start company: 1905
Construction year: 1974

87. Preko

Adress: Noordweg 19, Zwijndrecht
Function: Stair repair
Start company: 2002
Construction year: 1977

88. HSDO

Adress: Noordweg 21, Zwijndrecht
Function: Hydraulic installations
Start company: -
Construction year: 1994

89. BeCar Parts

Adress: Lindtsedijk 58, Zwijndrecht
Function: Car garage
Start company: -
Construction year: 1993

90. BeCar Parts

Adress: Lindtsedijk 58, Zwijndrecht
Function: Car garage
Start company: -
Construction year: 1993

91. Factorylab

Adress: Lindtsedijk 52, Zwijndrecht
Function: Supplier for building and industry sensors
Start company: 2016
Construction year: 1975

92. Straatman B.V.

Adress: Lindtsedijk 54, Zwijndrecht
Function: Dredging equipment supplier
Start company: 1902
Construction year: 1975

93. Schmitt Anchors & Chaincables

Adress: Kreekweg 10, Zwijndrecht
Function: Anchors & Chaincables supplier
Start company: 1862
Construction year: 1967

94. Schmitt Anchors & Chaincables

Adress: Kreekweg 8, Zwijndrecht
Function: Anchors & Chaincables supplier office
Start company: 1862
Construction year: -

95. A.M. Bruinsma B.V.

Adress: Lindtsedijk 30, Zwijndrecht
Function: Shiprepari works
Start company: 2006
Construction year: 1960

96. A.M. Bruinsma B.V.

Adress: Lindtsedijk 30, Zwijndrecht
Function: Shiprepari works
Start company: 2006
Construction year: 1960

97. A.M. Bruinsma B.V.

Adress: Lindtsedijk 30, Zwijndrecht
Function: Shiprepari works
Start company: 2006
Construction year: 1960

98. Cordeel

Adress: Lindtsedijk 22, Zwijndrecht
Function: Contractor
Start company: 1934
Construction year: 2013

99. Cordeel

Adress: Lindtsedijk 22, Zwijndrecht
Function: Contractor
Start company: 1934
Construction year: 1992

100. Cordeel

Adress: Lindtsedijk 22, Zwijndrecht
Function: Contractor
Start company: 1934
Construction year: 2013

101. TATA Steel

Adress: Oudemaasweg 1, Zwijndrecht
Function: Steelproduction
Start company: 1999
Construction year: 1954

102. TATA Steel

Adress: Oudemaasweg 1, Zwijndrecht
Function: Steelproduction
Start company: 1999
Construction year: 1955

103. TATA Steel

Adress: Oudemaasweg 1, Zwijndrecht
Function: Steelproduction
Start company: 1999
Construction year: 1955

104. TATA Steel

Adress: Oudemaasweg 1, Zwijndrecht
Function: Steelproduction
Start company: 1999
Construction year: 1970

105. TATA Steel

Adress: Oudemaasweg 1, Zwijndrecht
Function: Steelproduction
Start company: 1999
Construction year: 1965

106. TATA Steel

Adress: Oudemaasweg 1, Zwijndrecht
Function: Steelproduction
Start company: 1999
Construction year: 1985

107. TATA Steel

Adress: Oudemaasweg 1, Zwijndrecht
Function: Steelproduction
Start company: 1999
Construction year: 1970

108. TATA Steel

Adress: Oudemaasweg 1, Zwijndrecht
Function: Steelproduction
Start company: 1999
Construction year: 1985

109. Mercury Diesel

Adress: Oudemaasweg 5, Zwijndrecht
Function: Ship engine supplier
Start company: 1939
Construction year: 1954

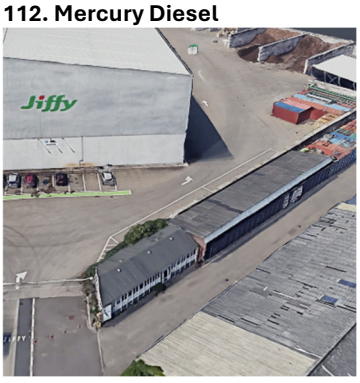
110. Mercury Diesel

Adress: Oudemaasweg 5, Zwijndrecht
Function: Ship engine supplier
Start company: 1939
Construction year: 1954

111. Mercury Diesel

Adress: Oudemaasweg 5, Zwijndrecht
Function: Ship engine supplier
Start company: 1939
Construction year: 1954

112. Mercury Diesel



Adress: Oudemaasweg 5, Zwijndrecht
Function: Ship engine supplier
Start company: 1939
Construction year: 1954

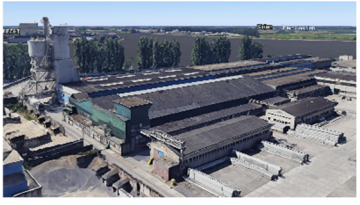
113. Mercury Diesel

Adress: Oudemaasweg 5, Zwijndrecht
Function: Ship engine supplier
Start company: 1939
Construction year: 1954

114. Jiffy Group

Adress: Oudemaasweg 1, Zwijndrecht
Function: Factory for plant growing solutions
Start company: 1960
Construction year: 2016

115. Bouwcenter Logus-De Hoop Zwijndrecht



Adress: Lindtsedijk 18, Zwijndrecht
Function: Hardware shop
Start company: 2012
Construction year: 1971

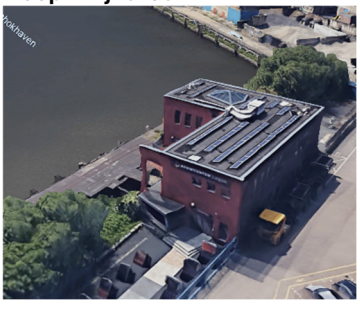
116. Bouwcenter Logus-De Hoop Zwijndrecht

Adress: Lindtsedijk 18, Zwijndrecht
Function: Hardware shop
Start company: 2012
Construction year: 1971

117. Bouwcenter Logus-De Hoop Zwijndrecht

Adress: Lindtsedijk 18, Zwijndrecht
Function: Hardware shop
Start company: 2012
Construction year: 1971

118. Bouwcenter Logus-De Hoop Zwijndrecht



Adress: Lindtsedijk 18, Zwijndrecht
Function: Hardware shop
Start company: 2012
Construction year: 2009

119. Schokbeton

Adress: Lindtsedijk 14, Zwijndrecht
Function: Abandoned concrete factory
Start company: 1932
Construction year: 1935

120. Schokbeton

Adress: Lindtsedijk 14, Zwijndrecht
Function: Abandoned concrete factory
Start company: 1932
Construction year: 1977

121. Schokbeton

Adress: Lindtsedijk 14, Zwijndrecht
Function: Abandoned concrete factory
Start company: 1932

122. Schokbeton

Adress: Lindtsedijk 14, Zwijndrecht
Function: Abandoned concrete factory
Start company: 1932

123. Schokbeton

Adress: Lindtsedijk 14, Zwijndrecht
Function: Abandoned concrete factory
Start company: 1932

Construction year: 1977

Construction year: 1977

Construction year: 1977

124. Schokbeton

Adress: Lindtsedijk 14, Zwijndrecht
Function: Abandoned concrete factory
Start company: 1932
Construction year: 1977

125. Schokbeton

Adress: Lindtsedijk 14, Zwijndrecht
Function: Abandoned concrete factory
Start company: 1932
Construction year: 1977

126. Schokbeton

Adress: Lindtsedijk 14, Zwijndrecht
Function: Abandoned concrete factory
Start company: 1932
Construction year: 1977

127. A. Nobel en Zn

Adress: Uilenkade 100, Zwijndrecht
Function: Supplier of filters, fuels and marine materials
Start company: 1967
Construction year: 2010

128. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1985

129. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1984

130. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2010

131. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1930

132. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1984

133. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1930

134. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1930

135. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1930

136. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2000

137. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2010

138. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1930

139. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1930

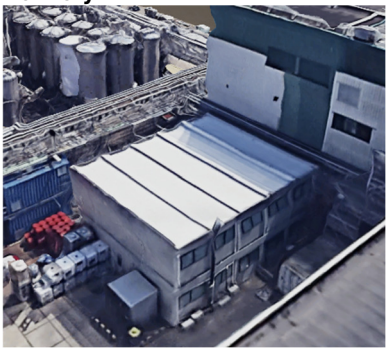
140. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1930

141. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1984

142. Sime Darby Oils Zwijndrecht Refinery B.V.



Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2021

143. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2021

144. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1930

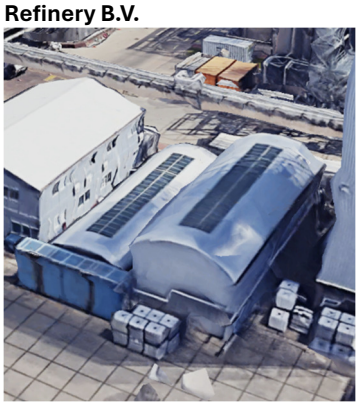
145. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2021

146. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1984

147. Sime Darby Oils Zwijndrecht Refinery B.V.



Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2021

148. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1925

149. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1950

150. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1950

151. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2023

152. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1975

153. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2007

154. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1980

155. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2022

156. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2004

157. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1978

158. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1978

159. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1960

160. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1960

161. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1960

162. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 1960

163. Sime Darby Oils Zwijndrecht Refinery B.V.

Adress: Lindtsedijk 8, Zwijndrecht
Function: Oil refinery
Start company: 1910
Construction year: 2022

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Appendix 03 - Calculation floating platforms

Weight N.V. Schokbeton			
	Weight Concrete kg/m3	Weight Masonry kg/m3	
	2450.00	1800.00	
	Concrete m3	Brick m3	Total weight in kg
Montagehal			
West façade	8.44	4.25	
East façade	2.85	4.05	
North façade	53.18	7.83	
South façade	53.18	7.83	
Interior	0.00	25.68	
Construction	71.85	0.00	
Roof	284.32	0.00	
Floor 01	267.67	0.00	
Floor 02	49.43	0.00	
Total	**790.92**	**49.63**	
Weight	**1937761.35**	**89341.20**	**2027102.55**
Modelmakerij			
West façade	17.36	43.70	
East façade	17.36	43.70	
North façade	40.40	7.17	
South façade	40.40	7.17	
Interior	0.00	139.92	
Construction	601.16	0.00	
Roof	74.54	0.00	
Floor 01	381.656	0.00	
Floor 02	24.606	0.00	
Floor 03	15.509	0.00	
Floor 04	15.509	0.00	
Total	**1228.50**	**241.64**	
Weight	**3009815.2**	**434959.20**	**3444774.40**
Schokhal			
West façade	140.37	46.77	
East façade	278.00	0.00	
North façade	114.84	25.95	
South façade	114.84	25.95	
Interior	0.00	0.00	
Construction	741.80	0.00	
Roof	130.49	0.00	
Floor 01	2051.28	0.00	
Floor 02	83.89	0.00	
Floor 03	24.64	0.00	
Total	**3680.14**	**98.68**	
Weight	**9016338.10**	**177615.00**	**9193953.10**
		Mschokbeton	**14665830.05**
		20% error margin	**17598996.06**

$$Vlucht = \frac{Mschokbeton}{\rho water}$$

Mschokbeton + 20%	17598996.06	kg
ρ water	1000	kg/m3
V air	17599.00	m3
Area Schokbeton	15156.03	m2
Depth Floating platform	**1.16**	**m**