PROGRAMMA AANSLUITING WIND OP ZEE (PAWOZ)-EEMSHAVEN

Heritage Impact Assessment of the UNESCO World Heritage Site the Wadden Sea

Ministry of Climate and Green Growth

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SUMMARY

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INTRODUCTION

1.1 Objective of PAWOZ

In the Climate Agreement (2021) the European Union and the Dutch government set the goals to achieve a 55 % reduction in CO_2 emissions by 2030 and to become climate-neutral by 2050. Climate-neutral means ensuring no harmful substances are emitted that alter the climate. To achieve these goals, the generation of wind energy at sea is being considered as one of the solutions. Research by the Dutch government indicates that there is space for multiple wind farms in the North Sea, including northwards of the Dutch Wadden Islands. These offshore wind farms will produce both electricity and hydrogen. These wind farms can generate significant amounts of renewable energy. However, in order to use this energy, it must be transported to the mainland through high voltage electricity cable systems (hereinafter: cable systems) or hydrogen pipelines (hereinafter: pipelines).

The program 'Programma Aansluiting Wind Op Zee - Eemshaven' (PAWOZ or 'Offshore Wind Connection Program - Eemshaven' in English), investigates potential routes in order to transfer energy produced in offshore wind farms to the mainland, more specifically to the Eemshaven. These potential routes not only cross the North Sea and the mainland, but also the UNESCO World Heritage site the Wadden Sea.

1.2 World Heritage in Dutch law

Since 2009, the Wadden Sea has been recognized as a UNESCO Natural World Heritage Site under the World Heritage Convention (1972). This designation entails a commitment to safeguarding the Wadden Sea's Outstanding Universal Value (OUV), encompassing its geomorphological processes, ecological dynamics, and rich biodiversity. Dutch national legislation pertaining to activities that could impact World Heritage is addressed within the framework of the 'Omgevingswet' (Environmental law), more specifically within the 'Besluit activiteiten leefomgeving' (Bal) (Environmental activities decree) and the 'Besluit kwaliteit leefomgeving' (Bkl) (Quality of the living environment decree).

Article 5.131 of the Bkl mandates an 'Omgevingsplan' (Environmental plan) must consider the preservation of the OUV of World Heritage. Furthermore, article 9.2 of the Bkl stipulates that the Minister of Climate Policy and Green Growth is prohibited from issuing a 'Projectbesluit' (project decision) if a project poses a threat to any OUVs. Chapter 14 of the Bal delineates national regulations concerning activities that directly or indirectly affect World Heritage. Specifically, article 14.7 of the Bal mandates safeguarding of World Heritage properties to prevent its damage or destruction (Cultural Heritage Agency of the Netherlands, et al., 2024, p.8).

The initiator of an activity is obliged to take all necessary measures to prevent any adverse effects on the OUV of the World Heritage Site. This duty of care is fundamental to the protection of World Heritage. However, the assessment of activities against the OUV of the Wadden Sea is not sufficiently ensured in the Nature Conservation Act nor in the Environmental Planning Act system. The geological and ecological processes, biodiversity values, and the integrity of the Wadden Sea are not covered by the Natura 2000 conservation objectives for the Wadden Sea, nor is there any other provision for assessing activities and projects against these components of the OUV (Bastmeijer and Philippart, 2024). Therefore, a Heritage

Impact Assessment (HIA) is needed in the case of PAWOZ, which will be further detailed in the following paragraph.

The site manager (the organization appointed as the custodian responsible for managing the relevant World Heritage Site) has a duty to promptly inform the Minister of Education, Culture, and Science of any planned activities that may impact the OUV of the World Heritage Site (article 10.49 Omgevingsbesluit).

1.3 PAWOZ in Heritage Impact Assessment

The areas in which the potential routes are projected host a variety of users and functions. On the mainland, there are extensive areas of fertile agricultural land, industry, onshore windfarms and the port of Eemshaven. At sea, navigation, fishing- and tourist activities are common, and diverse marine life thrives within. Given the potential implications of the routes for both society and environment, an Environmental Impact Assessment (EIA) and Integrated Impact Assessment (IIA) were conducted. These assessments were carried out to clarify the environmental impact of each potential route.

Considering that the potential routes intersect with the UNESCO World Heritage site the Wadden Sea, this HIA was conducted concurrently with the EIA and IIA. The HIA ensures timely evaluation of the potential impact on the OUV of the Wadden Sea. The HIA assessment is based on findings in the EIA sub-reports Nature and Seabed (In Dutch: MER sub-rapporten Natuur en Bodem op Zee). In line with the EIA, this HIA only assesses the effects of the installation of one cable system or one pipeline per year. The HIA assessment is conducted after technical and spatial optimization and effect mitigation of the routes. The findings of this HIA serve as a crucial component of decision-making information in determining the preferred solution.

1.4 Method

This research report employs the Heritage Impact Assessment (HIA) method, jointly developed by UNESCO and the advisory bodies to the World Heritage Committee, ICCROM, ICOMOS, and IUCN. The HIA methodology was created to foster cross-sectoral, multidisciplinary collaboration to identify solutions for protecting World Heritage properties and its appropriate adaptation to societal developments.

The Guidance and Toolkit for Impact Assessment in a World Heritage Context (UNESCO, et al., 2022) (from now referred to as: HIA Guideline) elucidates how HIAs help to gain insight in how project-related proposed activities may impact the OUV of World Heritage properties.

HIAs are conducted at the outset of project planning to identify any potential conflicts between proposed activities and the OUV of a particular site. Activities that jeopardize the OUV should be avoided. Given the irreplaceable nature of World Heritage, any necessary activities should prioritize minimizing impacts.

Based on the standard HIA method, but applied to the context of the Wadden Sea, this HIA research process involves five key steps:
1 Methodology description (Chapter 2).
2 Baseline and assessment method of the conservation values (OUVs) of the World Heritage property the Wadden Sea (Chapter 3).
3 Description of the proposed action, optimization and mitigation measures (Chapter 4).
4 Evaluation of the impacts of the proposed action on the OUVs of the World Heritage property (Chapter 5) and cumulative effects (Chapter 6).
5 Conclusion, compensation measures and recommendations for further HIAs of the Wadden Sea (Chapter 7).

Throughout the HIA process, engaging site holders of the relevant World Heritage Site is crucial. These participatory engagements aim to proactively explore mitigating measures to minimize impacts on the site's core qualities. The participatory process of PAWOZ is detailed in the sub-report Stakeholder Management Plan (PAWOZ deelrapport Omgeving).

2

HIA METHODOLOGY

The rich diversity of heritage sites worldwide underscores the varying impacts they can experience. In order to comprehend the ramifications of activities on UNESCO sites, UNESCO has developed the HIA method. The HIA method involves conducting research to assess the impacts of proposed activities on the OUV of a World Heritage Site. The principal focus lies in safeguarding the integrity and authenticity of these heritage sites, thereby preventing and mitigating adverse effects. This chapter sets out the HIA methodology as outlined by UNESCO advisory bodies. In Section 3.3 the methodology of the HIA applied to the Wadden Sea is specified.

2.1 World Heritage Convention and Statement of Outstanding Universal Value

The World Heritage Convention is an international treaty adopted by the United Nations (UN) in 1972. The treaty establishes that cultural and natural sites, due to their OUV, should be protected in the future. These sites are included on the UNESCO World Heritage list. The Netherlands has signed the treaty and is therefore bound by its provisions.

The UNESCO Statement of Outstanding Universal Value includes the criteria of world heritage that constitute the OUV of a site. The ten criteria established by UNESCO (Annex I) describe aspects that make heritage of exceptional significance and of international importance for current and future generations, thus requiring permanent protection (UNESCO, 2023).

2.1.1 Outstanding Universal Value (OUV)

A HIA assesses the effects of project-related proposed activities on the OUV of the respective World Heritage. The OUV consists of the cultural and natural qualities that characterize the World Heritage. Heritage that meets at least one of the ten criteria for OUV (Annex I), and the conditions for integrity, protection and management (and in the case of *cultural* World Heritage also authenticity), is deemed 'of Outstanding Universal Value' and is thus eligible for the World Heritage List (UNESCO, 2023).

Integrity

Integrity is a measure of the wholeness and intactness of the natural and/or cultural heritage and its attributes:

- The extent to which the World Heritage Site includes all elements necessary to express its OUV.
- Whether it is of adequate size to ensure the complete representation of the features and processes which convey the World Heritage Site's significance.
- Whether it has been protected from adverse effects of development and/or neglect.

Authenticity is not considered a criterion for natural heritage and therefore not included in this assessment.

Protection and management

Protection and management relate to how a World Heritage Site's OUV, including its integrity and/or authenticity, are sustained and enhanced over time.

2.2 Assessment alternatives and impact on the World Heritage site

A critical part of the HIA-method is identifying, predicting, and subsequently evaluating impacts.

2.2.1 Identifying impacts

The aim of the impact identification is to determine what would happen to the attributes of a World Heritage Site if a proposed action took place. Attributes are the elements of a World Heritage site that convey its OUV and make them understandable. They can be physical, tangible features, but can also be intangible aspects such as social arrangements or cultural practices. An impact is the interaction of the proposed action with an attribute of the World Heritage Site. The impact assessment distinguishes three types of impact.

Direct impact
Direct impacts destroy or change the OUV of a World Heritage site as an immediate consequence of the proposed action. They are usually spatially close to the activity that causes them. For example, significant increase in noise levels at a natural heritage site reduces the quality of bird habitats.

Indirect impact
Indirect impacts are the effects that affect the OUV of a World Heritage site that are not immediately caused by the proposed action itself but occur as a result of the direct impacts. They are secondary consequences that are usually spatially removed from the initial activity and occur in the wider setting of the site. For example, changes in natural water flow downstream of a new dam affecting the OUV of a heritage site dependent on natural water fluctuation patterns.

Cumulative impact
Cumulative impact is the accumulation of multiple (small) disturbances to the OUV of the heritage site. These impacts consider the aggregate effect of past, present and reasonably foreseeable future actions and how they interact with each other. For example, multiple projects leading to progressive loss of natural habitat and associated animal species (UNESCO, et al., 2022).

2.2.2 Predicting impacts

Once impacts are identified, the likely scale and nature of these impacts are predicted. Impact prediction compares the current situation of the World Heritage Site (Chapter 3.1) with the situation in which the proposed action takes place (Chapter 4). Predictions of potential impacts can include a range of characteristics (Table 2.1).

Table 2.1 Characteristics of potential impacts and prompt questions as part of an impact assessment.

Impact characteristic	Prompt question
Magnitude	What change will occur?
Type	Is the impact positive or negative?
Extent	Which area will be affected by the impact?
Duration	How long will the impact last?
Frequency	How often will this impact occur?
Reversibility	Can this impact be reversed? If yes, is it easy to reverse?
Likelihood	How likely is it that this impact will occur?

2.2.3 Evaluating impacts

Impact evaluation determines whether the predicted effects of the proposed action are significant or not. This evaluation (Chapter 5) is conducted by scoring the impact of the proposed action/alternative on individual attributes that convey the Wadden Sea's OUV. This score ranges from 'major positive' to 'major negative' impact, in line with the HIA Guideline (UNESCO, et al., 2022).

Based on individual evaluations of the attribute per OUV (Chapter 5), the proposed action/alternative's overall impact on the OUV is concluded (Chapter 6). According to the HIA methodology, the impact evaluation results in conclusions regarding the extent to which the proposed action is acceptable in regard to the OUV. The possible conclusions as stated in the HIA Guideline (UNESCO, et al., 2022) are listed below.

If the proposed action has a negative effect on the OUV, three conclusions are distinguished:
- The negative effect is negligible and of no concern.
- The negative effect is significant but acceptable after mitigating measures are taken.
- The negative effect is significant and cannot be reduced by mitigating measures: the proposed action should not take place. However, within the context of PAWOZ, which is deemed crucial for achieving climate goals, compensation measures are being investigated before concluding that the proposed action should not proceed (see further explanation in Chapter 7.3).

If the proposed action has a positive effect on the OUV, three conclusions are distinguished:
- The positive effect is beneficial for the World Heritage and of no concern.
- A positive effect is indirect and can be achieved through a specific alternative or modifying the proposed action.
- The objective of the proposed action will not achieve the positive effect and therefore should not take place.

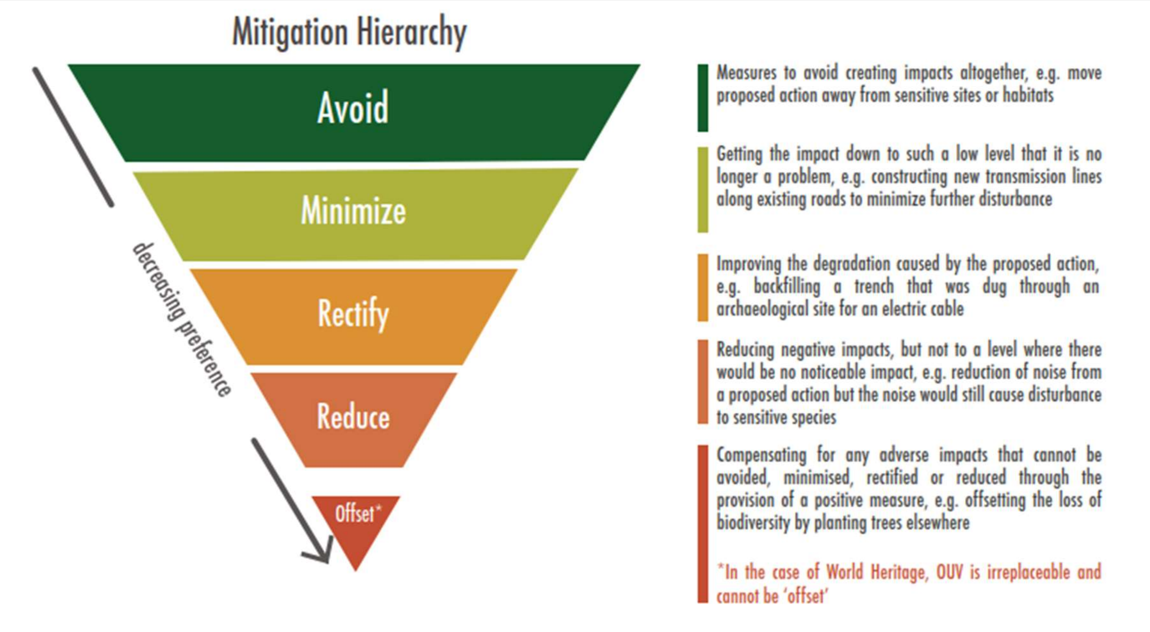
However, this HIA is based on the planEIA which means that further research is still needed to assess all effects. Therefore, the scoring of the alternatives in this HIA includes *possible* significant effects that *cannot be ruled out*. Also, the reduction of effects by mitigation is not yet evaluated in this phase of the program. Therefore, in this HIA, as in the planEIA, the assessment is based on *the prospect of* mitigation or compensation (See further elaboration in Chapter 3.3.1). In the conclusion (Chapter 7), recommendations for further data collection and further development of a Wadden Sea specific HIA method needed for improved evaluation is given. Only after the projectEIA is confirmed, in which preferred alternatives are further developed, conclusions can be drawn regarding the *acceptability* of the proposed action regarding the OUV of the Wadden Sea.

Impact assessment table
The HIA Tool 3 is an impact assessment table from the HIA Guideline (UNESCO, et al., 2022). This tool is used to present the evaluation of potential impacts of the proposed activities (see Annex II).

2.3 Mitigating negative impacts

If the proposed action has a negative impact on the OUV, mitigation should be considered to avoid or minimize any negative impacts. A 'mitigation hierarchy' is used in the HIA Guideline (UNESCO, et al., 2022), ranging from the preferred 'avoidance', through 'minimize', 'rectify', 'reduce' and 'offset' (see Figure 2.1). In the case of World Heritage, the OUV is irreplaceable and cannot be 'offset'. The best outcome for the World Heritage is to avoid negative impacts entirely. This includes the dismissal of the proposed action, or its relocation away from the World Heritage Site. However, as mentioned before, compensation measures are being investigated within the context of PAWOZ before concluding that the proposed action should not proceed (see further explanation in Chapter 7.3).

Figure 2.1 The World Heritage 'Mitigation hierarchy' from the HIA Guideline

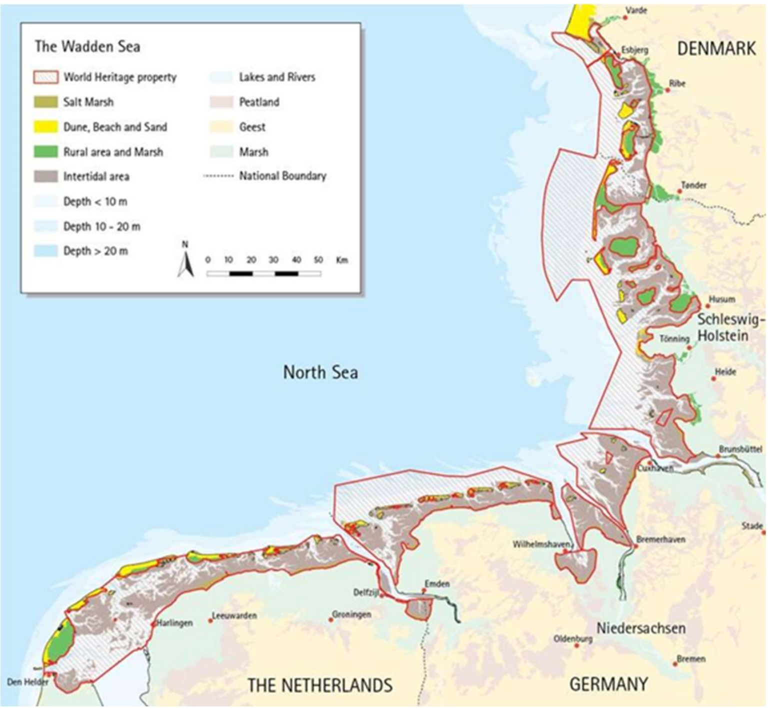


3

HIA OF THE WADDEN SEA

The Wadden Sea is an UNESCO world (natural) heritage site since 2009 because of its unique geological and ecological conservation values. It includes property in The Netherlands, Germany and Denmark, of which 4000 km^2 is located in The Netherlands (Figure 3.1).

Figure 3.1 Map of the World Heritage Site Wadden Sea and its major habitats (Common Wadden Sea Secretariat, retrieved 12-09-2024).



The Wadden Sea is a relatively shallow sea that extends from the province of North Holland in the Netherlands to Germany and Denmark. It is the world's largest intertidal ecosystem, covering almost 15.000 km^2. The tidal cycle is the driving factor of the natural processes in the Wadden Sea. The Wadden Sea contains a large number of transition zones between land, sea, fresh water and salt water, shallow and deep. Subtidal channels, tidal flats, seagrass meadows, mussel beds, sandbanks, mudflats, salt marshes, beaches, and dunes provide a habitat for a great diversity of plant and animal species, including marine mammals. Additionally, the Wadden Sea serves as an important nursery ground for juvenile fish and serves as a breeding and wintering ground for 10 to 12 million migratory birds each year (UNESCO, accessed 2024).

3.1 Current situation

3.1.1 Geological processes

The unique tidal system of the Wadden Sea has been shaped in the past 7000 years. Its morphology is influenced by natural processes including tides and sediment exchange. It is also affected by human interventions such as the closure of the Zuiderzee (1932) and Lauwersmeer (1969) and land reclamation efforts. Human interventions have reduced water retention and altered sedimentation and erosion patterns (Deltares, 2019).

Hydrodynamics

The Wadden Sea area is influenced by river discharge from the Rijn, Maas, Schelde, and Eems, leading to significant fluctuations in temperature and salinity. The tidal system ensures a continuous exchange of water between the Wadden Sea and the North Sea, with approximately 300 million m³ of water flowing in and out during each tidal cycle. At low tide, 60 % to 80 % of the Wadden Sea is exposed, and water current speeds are highest in the channels. Waves in the Wadden Sea are lower than in the North Sea due to the shelter provided by the barrier islands.

Freshwater flows into the Wadden Sea from the IJsselmeer, the Ems, Lauwersmeer, and several smaller inlets. The salinity of the Wadden Sea water varies greatly, with average values ranging from 20 to 30 psu. The water is turbid due to the influx of silt, and sediment concentrations range from 5 to 100 mg/l, increasing during storms. In the Ems estuary, sediment concentrations are much higher and aggravated by continuous dredging operations. Since the 1950s, sediment concentrations in the Eems River have increased tenfold due to channel deepening.

Morphology and seabed dynamics

The Dutch part of the UNESCO Wadden Sea site is defined by its natural intertidal and subtidal areas. The seabed morphology of the Wadden Sea is primarily driven by tidal processes. Large volumes of water and sediment flow in and out of the Wadden Sea each tidal cycle, creating a dynamic pattern of channels and tidal flats. Sediment is continuously exchanged between channels, flats, and the outer delta. Silt and fine sand are mainly transported as suspended sediment, contributing to natural turbidity, while the transport of (coarser) sand occurs close to the seabed. Vegetated salt marshes and pioneer salt marshes along the edges of the Wadden Sea trap sediment.

The Wadden Sea consists of several tidal basins (or sea inlet systems), which are basins behind a sea inlet between two Wadden Islands that alternately fill and empty under the influence of tidal currents. Channels in such areas are connected to this sea inlet. Shallow areas called 'tidal divides' form at the boundaries between tidal basins, where fine sand and silt settle due to relatively low hydrodynamic energy. In the main channels with strong tidal currents, silt cannot settle, resulting in a sandy seabed.

Coastal foundation

The coastal foundation lies in the zone between the land and the NAP -20 m bed level contour, entirely within the Wadden Sea area. In 1990, the dynamic maintenance of the coastline was adopted, establishing the base coastline. The Dutch coast, including the Wadden Islands is eroding. When the coastline structurally lies behind the base coastline, it is locally replenished with sand via beach nourishments. This does not apply to the eastern ends of the Wadden Islands Ameland and Schiermonnikoog, where structural erosion is accepted as a natural process, affecting the required burial depth of cable systems and pipelines in these coastal zones. The base coastline has been adjusted several times since its establishment. Sand nourishments are also performed to allow the coastal foundation (up to NAP -20 m) to rise with the sea level.

Soil quality and composition

The seabed of the Wadden Sea mainly consists of sand, with finer sediment on the tidal flats compared to the channels. Approximately 10 % of the seabed material is silt, primarily originating from the cliffs along the French and English coasts, the Atlantic Ocean, and the Flemish Banks. This silt mainly settles on the landward side of the tidal flats and in the salt marshes, where the highest concentrations are found. The Wadden area also contains clay layers in the subsurface, particularly in the Ems estuary, where erosion-resistant layers such as pot clay and old tidal clay significantly influence the development of channels and flats.

No seabed contamination is known in the Wadden Sea area (PAWOZ EIA sub-report Seabed).

3.1.2 Ecological processes and biodiversity

Natural dynamics and ecotopes

The Wadden Sea consists of a complex network of deep channels and shallow waters with sand and silt banks of which large parts are exposed during low tide. These banks are intersected by a finely branched system of channels. The almost undisturbed natural dynamic of water and sediment flows, creates a varied landscape with smooth natural transitions between deep and shallow waters, sandy and silty sediments, salt and fresh waters and from land to sea. Natural processes ensure the maintenance and development of characteristic ecotopes and habitats, and the boundaries between land and water constantly change. Each ecotope has a characteristic combination of abiotic factors that provides a unique habitat for certain species.

Food web

The availability of light and nutrients is the precondition for life in the Wadden Sea. Single-celled algae in the water column (phytoplankton) and on the surfaces of tidal flats (microphytobenthos) form the basis of the food web. Bottom-dwelling animals such as shellfish (mussels, oysters, Baltic tellins, and cockles) live off these algae and in turn serve as food for birds, fish and crustaceans. In the water column, the food chain is driven by zooplankton, small aquatic animals that live off algae and decomposed plant and animal material (detritus). Zooplankton is consumed by small fish, which are the prey of fish-eating bird species and mammals. Fish eating marine mammals, the harbour porpoise, common and grey seal are currently at the top of the food web in the Wadden Sea.

Biodiversity

As an estuary, at the border of land and sea, the Wadden Sea is a diverse ecosystem with many different habitats that provide foraging, resting and/or reproductive grounds for many species. An unmistakable link in any marine ecosystem, including the Wadden Sea, are bio engineers such as mussels, oysters, eelgrass, tubeworms, and pioneer plants on the salt marshes. By forming physical structures (reefs, fields, beds), they can influence wave action, water and sediment storms and therefore locally modify the physical environment. These structures also provide shelter against predators, attachment substrate and foraging opportunities. Bio engineers are therefore an attractive habitat for a wide range of organisms and an essential part of the biodiversity in the Wadden Sea.

Migratory species

The Wadden Sea is not only important for its permanent inhabitants, but also has an essential role for migratory species. Millions of migratory birds use the rich foraging grounds of the Wadden Sea to refuel before continuing their routes to their breeding or wintering grounds. Similarly, migratory fish use the Wadden Sea to reach fresh water in the hinterland or salty offshore seas to complete their life cycles. In this way, the Wadden Sea is of global importance both for the international flyway of migratory birds and for the swimway and life cycle of fish (PAWOZ sub-report Nature).

3.1.3 Management and protection

The Wadden Sea and surrounding areas play a crucial role in the protection of various habitat types and species, supported by national and international protection regimes such as Natura 2000, OSPAR, Water Framework Directive (KRW in Dutch), and the National Ecological Network.

The following paragraphs are a summary from the PAWOZ EIA sub-report Nature in the Wadden Sea.

Natura 2000
The Wadden Sea and surrounding areas are recognized as Natura 2000 sites with specific goals for the conservation of natural values such as habitat types, animal and plant species. The Wadden Sea (including the Eems-Dollard) is designated as a Bird Directive and Habitat Directive site covering 271,771 hectares, aimed at conserving 15 habitat types, 9 habitat directive species, 13 breeding bird species, and 39 non-breeding bird species.

To protect natural values in Natura 2000 areas, measures have been taken to prevent disturbances of especially birds and seals. This is done through access restriction decisions (TBB), where areas are permanently or temporary restricted for human activities (Ministerie van LNV, 2020). These restrictions are detailed in the 'Omgevingswet', Environmental Act in English, (Article 2.45, paragraph 1). The boundaries and periods of closure for these areas are annually adjusted based on the dynamics of the area.

OSPAR
The Wadden Sea includes various habitats such as mussel and oyster beds that are protected under the OSPAR Convention. Species like the harbour porpoise and the kittiwake are also protected under OSPAR.

Water Framework Directive
The Water Framework Directive focuses on achieving good ecological and chemical status of the waters in the Wadden Sea and adjacent coastal areas. It also encompasses biological elements such as phytoplankton, macrofauna, fish and vegetation (seagrass and saltmarsh) as part of the ecological water quality.

National Ecological Network and bird areas
The Wadden Sea and surrounding areas fall under various protection regimes such as the National Ecological Network (NNN). These areas contain important management types such as salt marshes, tidal flats, and dune landscapes, which are crucial for the conservation of meadow birds, farmland birds, and geese. Additionally, there are specific areas designated throughout the study area for the protection of meadow birds, farmland birds, and geese. These areas are crucial for maintaining biodiversity and provide important resting and feeding places for many bird species.

3.2 Outstanding Universal Value of the Wadden Sea

The Wadden Sea World Heritage Outstanding Universal Value (OUV) consists of three components: criteria, integrity, and protection and management.

3.2.1 Criteria

The Statement of Outstanding Universal Value (SOUV) for the Wadden Sea (see Annex III) specifies how the heritage site meets three criteria for OUV that refer to natural characteristics (see overview of overall criteria Annex I):

1. Outstanding geological processes (criterion viii): 'The Wadden Sea is a depositional coastline of unparalleled scale and diversity. It is distinctive in being almost entirely a tidal flat and barrier system with only minor river influences, and an outstanding example of the large-scale development of an intricate and complex temperate-climate sandy barrier coast under conditions of rising sea-level. Highly dynamic natural processes are uninterrupted across the vast majority of the property, creating a variety of different barrier islands, channels, flats, gullies, saltmarshes and other coastal and sedimentary features (UNESCO, accessed 2024).'

2. Ongoing ecological and biological processes (criterion ix): 'The Wadden Sea includes some of the last remaining natural large-scale intertidal ecosystems where natural processes continue to function largely undisturbed. Its geological and geomorphologic features are closely entwined with biophysical processes and provide an invaluable record of the ongoing dynamic adaptation of coastal environments to global change. There are a multitude of transitional zones between land, sea and freshwater that are the basis for the species richness of the property. The productivity of biomass in the Wadden Sea is one of the highest in the world, most significantly demonstrated in the numbers of fish, shellfish and birds supported by the property. The property is a key site for migratory birds and its ecosystems sustain wildlife populations well beyond its borders (UNESCO, accessed 2024).'

3. Vital habitats for in-situ biodiversity conservation (criterion x): 'Coastal wetlands are not always the richest sites in relation to faunal diversity; however, this is not the case for the Wadden Sea. The salt marshes host around 2,300 species of flora and fauna, and the marine and brackish areas a further 2,700 species, and 30 species of breeding birds. The clearest indicator of the importance of the property is the support it provides to migratory birds as a staging, moulting and wintering area. Up to 6.1 million birds can be present at the same time, and an average of 10-12 million each year pass through the property. The availability of food and a low level of disturbance are essential factors that contribute to the key role of the property in supporting the survival of migratory species. The property is the essential stopover that enables the functioning of the East Atlantic and African-Eurasian migratory flyways. Biodiversity on a worldwide scale is reliant on the Wadden Sea (UNESCO, accessed 2024).'

The SOUV also details the fulfilment of integrity, and protection and management requirements for the Wadden Sea. The subsequent section presents these descriptions.

Integrity

The protected area of the Wadden Sea World Heritage site encompasses all ecosystem components and features (species, habitats, ecological processes) that form a natural and dynamic Wadden Sea area. The area is of sufficient size to maintain its typical ecosystems. Important features and values are protected from threats such as fishery, tourism, construction of energy infrastructure, commercial activities, extraction of natural resources and impacts of climate change by a management and monitoring system (UNESCO, accessed 2024).

Protection and Management

The maintenance of hydrological and ecological processes of the contiguous tidal flat system of the Wadden Sea is carried out through protection and management by local regimes and a Trilateral cooperation between the Netherlands, Germany, and Denmark. Human influences are regulated, and activities or developments are strictly controlled or even prohibited. An ecosystem approach is applied, ensuring that management and protection measures are integrated with other important activities, including fisheries, shipping, and tourism (UNESCO, accessed 2024).

3.2.2 Substantiating the OUV of the Wadden Sea into attributes

The OUV of the Wadden Sea is linked to geological, ecological and biological processes (although ecological and biological processes are distinct, they will hereafter be referred to as 'ecological processes' for readability), as well as biodiversity. It is also linked to the integrity and protection of these conservation values, for example, by preserving the adequate size of the heritage site and ensuring good management.

Attributes

The Wadden Sea Academy is an interdisciplinary research initiative dedicated to studying the Wadden Sea and its surrounding coastal areas. The academy supports scientific research to understand the complex ecological, environmental, and social dynamics of the Wadden Sea region. Bastmeijer and Philippart (2024) wrote a Memo in which a first list of attributes is proposed to assess the OUV of the Wadden Sea. The list of attributes from the Memo has been chosen in this HIA as the baseline for this assessment because it is more comprehensive, even though it largely aligns with the attributes used in The Integrated Management Plan for One Wadden Sea World Heritage (The SIMP) (Common Wadden Sea Secretariat, 2023).

The list of attributes identified by the Wadden Sea Academy is provided below, categorized according to the three OUV-criteria:

1. Outstanding geological processes (criterion viii):

1 Size of the area where sediment is deposited.
2 Amount of river discharge.
3 Surface area of regions with salt gradients.
4 Rate of sea level rise.
5 Size of islands, sandbanks, channels, mudflats, and salt marshes.

2. Ongoing ecological processes (criterion ix):

6 Primary production (production by plants).
7 Production by animals, from shellfish to marine mammals.
8 Numbers of fish, shellfish, and birds.
9 Food availability for fish, shellfish, and birds.

3. Vital habitats for in-situ biodiversity conservation (criterion x):

10 Number of species (plants and animals) present in the salt marsh.
11 Number of species (plants and animals) in salt and brackish water areas.
12 Number of breeding bird species.
13 Fattening areas for migratory birds.
14 Roosting areas for migratory birds.
15 Wintering areas for migratory birds (km2).
16 Food supply for migratory birds.
17 Tranquility for migratory birds.
18 Numbers of birds and migratory birds.
19 Relative importance of the Wadden Sea for population sizes of migratory birds.
20 Biodiversity.

The potential impacts on these attributes will be assessed based on the characteristics of the impact including type of impact and its extent, duration, frequency, reversibility and likelihood, as shown before in Chapter 2, Table 2.1.

3.3 Wadden Sea specific HIA assessment method

Chapter 2 describes the general HIA methodology. This paragraph specifies the HIA methodology for the Wadden Sea.

3.3.1 Relationship HIA and EIA

The HIA is based on the Environmental Impact Reports conducted for PAWOZ, specifically:

- PAWOZ EIA sub-report Seabed.
- PAWOZ EIA sub-report Nature.

Table 3.1 provides an overview of the OUV-criteria, attributes (based on the Memo from the Wadden Academy), and the related components assessed in the EIA (Environmental Impact Assessment, Seabed and Nature sub-reports), and the effects of the activities as presented in the EIA. Below the table the approach is explained in more detail.

Table 3.1 Overview of the OUVs and attributes that are assessed in this HIA based on related components and effects of PAWOZ as presented in the EIA (Nature and Seabed sub-reports). * Habitat type includes the typical species of intertidal flats (Natura 2000 habitat type H1140) and submerged sandbanks (Natura 2000 habitat type H1110). These typical species are fish, shellfish and other benthos species (species living in or on the sediment). ** Habitat type includes the typical species of salt marsh habitat types (Natura 2000 habitat type H1330, H1320 and H1310). These typical species involve saltmarsh vegetation. *** In the HIA only migratory birds with a strong Wadden Sea dependency are evaluated (see explanation below the table).

OUV-criteria	Attribute	EIA	Effects of PAWOZ that could affect the attribute
viii) geological processes	Size of the area where sediment is deposited	Natural morphodynamic and hydrodynamic processes	- Sedimentation and erosion; - Change in seabed levels; - Change in waves and current dynamics
	Quantity of river discharge	Hydrology	- Change in current dynamics; - Change in salt gradients
	Surface of areas with salt gradients	Natural morphodynamic and hydrodynamic processes	- Change in fresh water inflow from rivers and canals; - Change in current dynamics
	Rate of sea level rise	Global and regional scale consequence of climate change	- Sedimentation and erosion
	Size of barrier islands, sandbanks, channels, mudflats, and salt marshes	Natural morphodynamic and hydrodynamic processes	- Sedimentation and erosion; - Change in substrate dynamics; - Change in seabed levels; - Change in waves and current dynamics
ix) ecological processes	Primary production	Primary production	- Increase in turbidity
	Production by animals, from shellfish to marine mammals	Habitat type (typical species) * Marine mammals Birds (all) Fish	- Increase in turbidity; - Increase in sedimentation; - Change in substrate dynamics
	Numbers of fish, shellfish and birds	Fish Habitat type (typical species) * Birds (all)	- Increase in underwater sound and vibrations; - Increase in optical disturbance and light; - Increase in turbidity; - Change in substrate dynamics; - Increase in above water sound and vibrations; - Increase in sedimentation; - Presence of electromagnetic fields (only applicable for cable systems)
	Food availability for fish, shellfish and birds	Primary production Habitat type (typical species) * Fish Birds (all)	- Increase in sedimentation; - Change in substrate dynamics; - Increase in underwater sound and vibrations; - Increase in turbidity
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	Habitat type (typical species) ** Breeding birds Birds (all)	- Increase in above water sound and vibrations; - Increase in optical disturbance and light

OUV-criteria	Attribute	EIA	Effects of PAWOZ that could affect the attribute
	Number of species (plants and animals) occurring in marine and brackish water areas	Marine mammals Fish Habitat type (typical species) * Birds (all)	- Increase in sedimentation; - Increase in turbidity; - Change in substrate dynamics; - Increase in above water sound and vibrations; - Increase in optical disturbance and light; - Presence of electromagnetic fields; - Increase in underwater sound and vibrations
	Number of species of breeding birds	Breeding birds	- Increase in above water sound and vibrations; - Increase in optical disturbance and light; - Increase in turbidity
	Fattening areas for migratory birds (foraging area)	Non-breeding birds Habitat type (typical species) *	- Change in substrate dynamics; - Increase in above water sound and vibrations; - Increase in optical disturbance and light; - Incrase in turbidity; - Increse in sedimentation; - Increase in underwater sound and vibrations
	Roosting areas migratory birds (High-tide refuge areas)	Non-breeding birds	- Increase in optical disturbance and light; - Increase in above water sound and vibrations
	Wintering areas for migratory birds		Not scored, as it is overarching for Fattening areas for migratory birds and Roosting areas for migratory birds
	Food supply migratory birds	Habitat type (typical species) * Fish	- Change in substrate dynamics; - Increase in underwater sound and vibrations; - Increase in turbidity
	Tranquility for migratory birds	Non-breeding birds	- Increase in optical disturbance and light; - Increase in above water sound and vibrations; - Increase in underwater sound and vibrations
	Relative importance of the Wadden Sea for population sizes of migratory birds	Non-breeding birds***	- - - Change in sediment dynamics - Increase in optical disturbance and light; - Increase in above water sound and vibrations; - Increase in turbidity; - Increase in sedimentation; - Increase in underwater sound and vibrations
	Biodiversity		Not scored, as it is overarching with the 'Number of species (plants and animals) occurring on the salt marsh' and the 'Number of species (plants and animals) occurring in marine and brackish water areas'.

Scoring the attribute 'relative importance of the Wadden Sea for population sizes of migratory birds'

The attribute 'relative importance of the Wadden Sea for population sizes of migratory birds' was scored as follows. First, based on the Wadden Sea Quality Status report 'East Atlantic Flyway' (Roomen et al., 2022) a list of bird species with strong Wadden Sea dependency was made.[1] Second, per route it was assessed whether these bird species would be affected by the activities of PAWOZ, with the aid of the appropriate assessment that is conducted for PAWOZ.

[1] These are the bird species in Appendix 1 of Roomen et al. (2022) that scored '1' in the last column 'Wadden Sea dependency' , indicating strong Wadden Sea dependency for their flyway.

Motivation of unscored effects

Effects of heating of cables have not been considered in both the EIA and HIA. This is because the cable systems in PAWOZ are buried at such depths that they do not cause any effect on benthic organisms living in the sediment or phytoplankton living in the water column. A literature review by National Grid Viking Link (2017) indicates, that when cables are buried more than 0.75 m deep, the sediment in the upper 20 cm will not heat up with more than 2° C. The cable systems in PAWOZ are buried at depths ranging between 1 and 24 m in the Wadden Sea and North Sea and most of the benthic organisms in the Wadden Sea typically inhabit the upper few (10 cm) of the sediment (Reise, 1985). The magnitude of any effect of heating would therefore to be negligible.

Motivation of unscored attributes

Two attributes have not been assessed in this HIA. These attributes relate to the OUV biodiversity x). These attributes are not further assessed because they are overarching multiple attributes that have already been assessed (see Table 3.1). The attributes are:

- Wintering areas for migratory birds.
- Biodiversity.

Relating attributes to components

One OUV attribute often includes multiple components of the EIA (see Table 3.1). When this is the case, the 'worst case' scenario is followed. This means that the attribute will receive the score of the component that scored the most negative. For example, the attribute 'Number of fish, shellfish, and birds,' composes three EIA components: fish, birds, and habitat types (typical species). If the effect on fish and birds is marked as neutral in the EIA, but the effect on habitat type (typical species) is scored as negative, then the attribute will be scored negative in the HIA.

Evaluation of effects

To evaluate the effects on the attributes, a number of basic principles is followed:

Evaluation after optimization measures and mitigation prospects

The HIA assessment is drafted after technical and spatial optimization of the routes. Based on the results of the phase 1 planEIA impact assessment, the routes have been optimized (see further elaboration in the PAWOZ EIA main report). Optimization can involve:

- A design change, such as widening a corridor or distributing dredged material elsewhere.
- A condition in the program for a potential future project-EIA procedure, such as distributing sediment exclusively within the dredged channel and not beyond it.

For the optimized routes, a reassessment was conducted to determine if the optimization prevents the effects described in the impact assessment of the PAWOZ EIA sub-report Nature. The optimized routes were then re-evaluated. Subsequently, for all routes (optimized routes and routes that could not be optimized), possible mitigating measures to prevent significant effects were proposed (see section 16.1.2 in the PAWOZ EIA sub-report Nature). The effects of these mitigation measures have not been evaluated in the planEIA. This will be part of the next phase of the project (projectEIA). That is why the prospect of mitigation measures is considered in this HIA evaluation, but the effects of mitigation measures have not yet been evaluated in this HIA.

The available and possible mitigating measures related to effects on geological processes for the installation of cable systems and pipelines along the different routes directly relate to the design (for example, limiting burial depth) or the installation methodology (for example, limiting the required dimensions for access trenches or adjusting spreading locations). Therefore, these optimizations have been developed jointly with the technical route design track within PAWOZ. The mitigating measures (optimizations) that are considered technically feasible have been included in the design of the route alternatives and are therefore part of this HIA assessment.

In Chapter 4 the optimization and prospected mitigation measures of the routes are listed.

Evaluation of one cable system or pipeline

In the sub-reports on Nature and Seabed in the EIA, the impact assessment is based on the installation of one cable system or pipeline per route per year, so this approach is also used in this HIA.

Evaluation of installation and operational phase

Effects of both the installation/removal phase and the operational phase are evaluated. The majority of the effects concern the installation phase. As in the EIA, this HIA assigns the same impactscore to effects of activities during the removal phase as the effects of the installation phase. The underlying assumption is that the activities required to remove cable systems or pipelines at the end of their lifecycle will have equal or lesser impact than the initial installation activities. It is also assumed that cable systems and pipelines will be left in the seabed at the end of their lifecycle if this can be shown to have fewer negative effects than removal. In the operational phase, for cable systems, it only concerns the effects of electromagnetic fields, which have been included in this HIA evaluation. For pipelines, no effects in the operational phase were included. However, more effects in the operational phase can be expected, especially for the tunnel system (X: Tunnel route). The exact effects will only become clear in the project EIA (see section 2.2.1).

Evaluation follows an identical scoring scale of the EIA and HIA

The evaluation of effects is scored based on the scale used in the EIA (Table 3.2), which is to a large extent comparable with the HIA impact assessment table (see Annex II, and paragraph 2.2.3). However, in the EIA there are only two positive scores identified, while in the HIA three graduations of positive scores are possible. In the PAWOZ EIA sub-report Nature, scores range between 0 and ---. This is the same for this HIA.

Table 3.2 Comparison of scoring scales for the EIA and HIA

Score in the EIA	Description of score in EIA	Score in the HIA	Description of score in HIA (UNESCO et al., 2022, p.44)
- - -	Strong negative effect compared to the reference situation. A significant effect cannot be ruled out. No prospect of mitigation measures.	Major negative impact	The negative effect is possibly significant and cannot be reduced by mitigation measures: the proposed action should not take place.
- -	Negative effect compared to the reference situation. For now, significant effects cannot be ruled out, but there is sufficient prospect of mitigation measures.	Moderate negative impact	The negative effect is possibly significant but acceptable when mitigation measures will be taken.
-	Small negative effect compared to the reference situation. For now, significant effects can be ruled out by the prospect of mitigation measures.	Minor negative impact	The negative effect is negligible and of no concern.
0	Neutral compared to the reference situation. These are effects that do not make a difference compared to the reference situation.	Neutral	No change is expected to occur to the attribute.
+	Positive effect compared to the reference situation. These are effects that can lead to an improvement of the reference situation.	Minor positive impact	"The positive impact does not reach objectives set for the proposed action (e.g. flood defences would not be effective against predicted flooding events), so the proposed action (or that dimension of the proposed action) should not proceed."

Score in the EIA	Description of score in EIA	Score in the HIA	Description of score in HIA (UNESCO et al., 2022, p.44)
Not applicable in EIA method.	*Not applicable in EIA method.*	Moderate positive impact	A positive effect is indirect and a more positive impact can be achieved through selecting a specific alternative or modifying the action.
+ +	Strong positive effect compared to the reference situation. These are effects that can lead to a strong improvement of the reference situation.	Major positive impact	The positive effect is beneficial for the World Heritage and raises no concerns.

Hereby it is important to note that in the PAWOZ EIA sub-report Nature the scope of the Wadden Sea area (Waddengebied) also includes the North Sea coastal zone, while in the HIA this is not the case (only if effects in the North Sea coastal zone will also be noticeable within the Wadden Sea world heritage boundary which is further explained in Chapter 4.1). Moreover, the EIA sup-report Nature is based on Natura 2000 conservation values which does not fully cover the scope of OUV conservation values. Therefore, scores in the EIA and HIA are not always 1:1 comparable.

Annex IV includes the HIA assessment table applied to the setting of the Wadden Sea which is used in Chapter 5 to present the impact assessment of proposed activities of PAWOZ.

Evaluation of integrity

Integrity is a component of the OUV of the Wadden Sea (as described in Chapter 2.1). The UNESCO Operational Guidelines specifies what integrity means for natural heritage sites with Wadden Sea specific examples. The table below (Table 3.3) outlines the questions discussed in this HIA to assess the impact of proposed activities on the integrity of the heritage site.

Table 3.3 Specification of integrity assessment in this HIA

OUV-criteria	Operational Guidelines UNESCO (2023)	HIA
viii) geological processes	'Properties proposed under criterion viii) should contain all or most of the key interrelated and interdependent elements in their natural relationships (note 5, paragraph 93).'	Does the route interrupt the natural dynamics and interconnectedness of the morphological elements of the Wadden Sea?
ix) ecological processes	'Properties proposed under criterion ix) should have sufficient size and contain the necessary elements to demonstrate the key aspects of processes that are essential for the long-term conservation of the ecosystems and the biological diversity they contain (note 5, paragraph 94).'	Does the route have negative effects on species, habitats, and processes?
x) biodiversity	'Properties proposed under criterion x) "should contain habitats for maintaining the most diverse fauna and flora characteristic of the biogeographic province and ecosystems under consideration (note 5, paragraph 95)." Wadden Sea specific example mentioned: "a property containing wide ranging species should be large enough to include the most critical habitats essential to ensure the survival of viable populations of those species; for an area containing migratory species, seasonal breeding and nesting sites, and migratory routes,	Does the route affect elements that are essential to the migratory path of birds? Does the route affect breeding areas?

OUV-criteria	Operational Guidelines UNESCO (2023)	HIA
	wherever they are located, should be adequately protected (note 5, paragraph 95).'	

In Chapter 5 the integrity is discussed and scored per OUV using the HIA scoring scale (Table 3.2) as a guideline. All possible effects are discussed from neutral to major negative impact, thereby following the results of the HIA impact table that is conducted per route. Also here, we assume the worst-case scenario. So when one of the attributes scores as a 'major negative impact', this will also count for the integrity of that route.

Evaluating the impacts of nitrogen deposition

Exact calculations of nitrogen deposition have not been made at this stage of the project due to uncertainty about the installation phase of the proposed activities. In the EIA, only a rough risk estimate has been made based on distance to determine which habitats on which routes are sensitive to nitrogen deposition. This mainly concerns dune and salt marsh habitats, as nitrogen can positively influence the succession of certain plant species, while other (typical) species can be suppressed and overgrown. This process can also affect the habitat of target species of Natura 2000 sites. What the exact nitrogen deposition on which habitat and route is will be determined in the next phase of the project. Therefore, effects of nitrogen are not part of the impact assessment of the HIA.

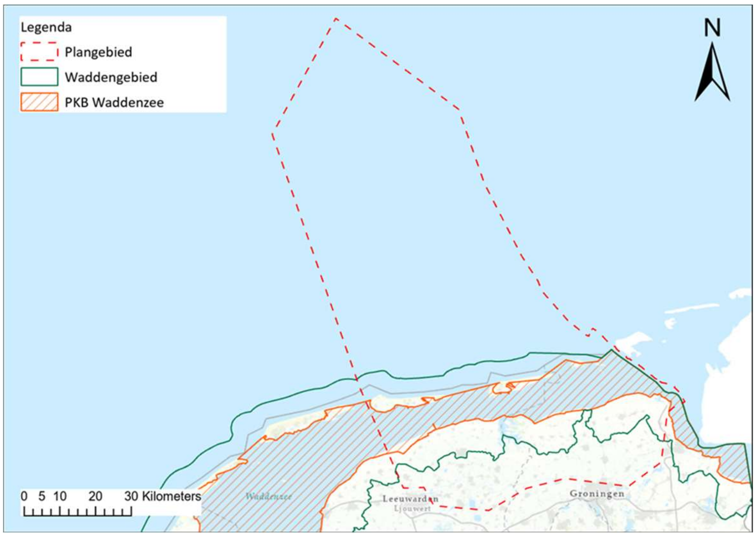
4

THE PROPOSED ACTION IN THE WADDEN SEA

4.1 Scope: Distinction World Heritage site, buffer zone and wider setting

The scope of this HIA is part of the heritage site in The Netherlands and on the border with Germany in which actions are proposed for the installation of cable systems and pipelines (marked in orange) and within the plan area (red dotted), see Figure 4.1.

Figure 4.1 Plan area of PAWOZ that includes part of the World Heritage Site Wadden Sea in The Netherlands and Germany



In some cases, a buffer zone of the World Heritage site is also designated. The buffer zone serves as protection to prevent negative impacts on the heritage site. In the case of the Wadden Sea there is no official buffer zone designated. However, there are proposed actions that take place within the planning area outside the heritage boundary such as Horizontal Directional Drilling (HDD) to cross primary dikes that can have an impact on the natural heritage site. The impact of these activities will therefore also be considered in this HIA, because even if a proposed action occurs outside the heritage boundary, within its buffer zone or wider setting, there is a possibility that it can have a negative impact on the natural heritage site.

4.2 The proposed action

The proposed action for PAWOZ is to establish infrastructure to transport energy from wind farms in the North Sea to the national high-voltage grid in the Eemshaven and the Dutch hydrogen network nearby the Eemshaven. These include the wind farm Ten Noorden van de Waddeneilanden (TNW, 700 Megawatts) and the wind farm Doordewind (DDW, 4 Gigawatts). More wind parks may be added in the future for a maximum of 10.7 GW for electricity and 36-42 GW for hydrogen. The energy generated by these wind farms must be transported to the national high-voltage grid of TenneT or the Hydrogen Network Netherlands of Gasunie, located near Eemshaven on the mainland. This can be done through electricity cable systems or, if the electricity is converted to hydrogen, via pipelines. The goal of PAWOZ is to investigate where there is sufficient space to install cable systems, pipelines, and the associated stations in the North Sea, the Wadden region, and on land (Figure 4.2). Potential routes are investigated. These routes cross the heritage site the Wadden Sea. In the EIA and IIA it is investigated how much space is needed for cable and pipeline systems per route, since for each route there are different users and regulations as well as configuration options for cable systems and pipelines (see Table 4.1). Also, an investigation is being conducted into whether a multi-tube tunnel system between the Ballonplaat, located in the North Sea, and the Eemshaven can be used to bundle cable systems and pipelines, thereby minimizing the impact of crossing the Wadden Sea (PAWOZ EIA main report).

Figure 4.2 Plan area PAWOZ: two wind farms (DDW and TNW) in the North Sea are connected to the mainland, crossing the heritage site the Wadden Sea

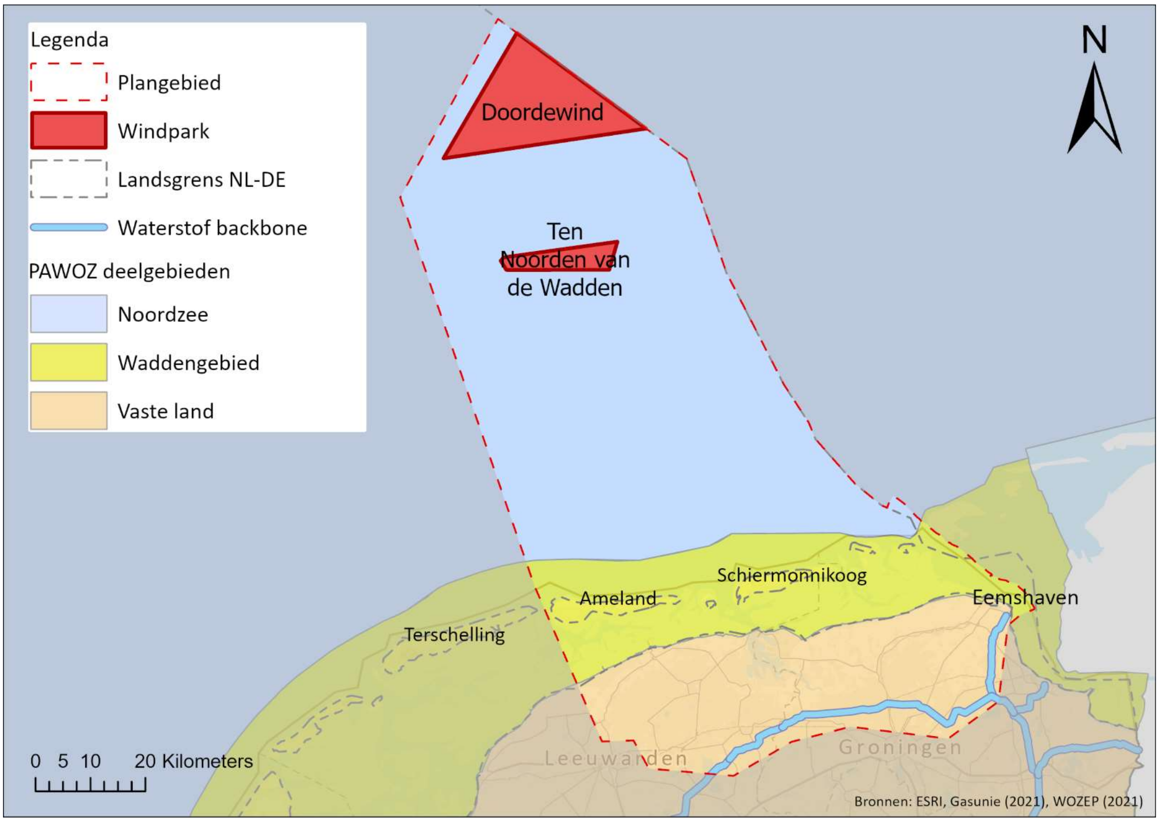


Table 4.1 Investigated configuration of the routes through the Wadden Sea

Route	Route Name	Variant	Maximum Technically Feasible Configuration to be Investigated	Corridor (width)
II	Oude Westereems route	A, A1 for cable systems, 1 pipeline variant	6 cable systems or 3 cable system or 1 cable system and 3 pipelines or 2 cable systems and 1 pipeline	800 m (for cable systems) 500 m (for pipeline)
V	Boschgat route	A, A1, A2	1 cable system	130 m
VII	Schiermonnikoog Wantij route	A, A1 for cable systems, 1 pipeline variant	7 cable systems and 3 pipelines	1500 m (for cable systems) 2000 m (for pipelines)
VIII	Ameland Wantij route		3 pipelines	2000 m
IX	Zoutkamperlaag route	A, A1, A2	3 pipelines	200 m

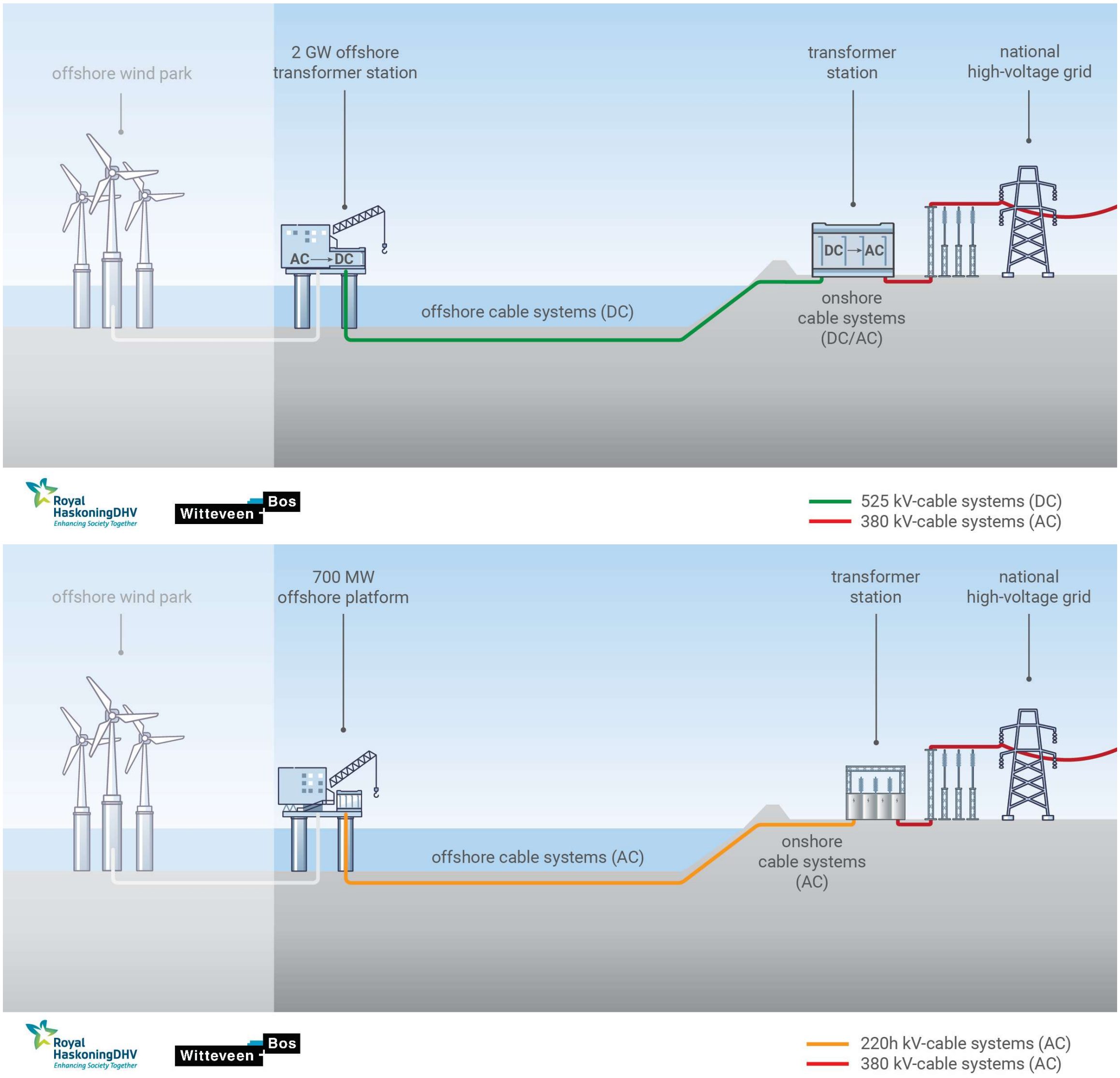
X	Tunnel route	multi-tube* (multiple tunnel tubes)	5 (DC) cable systems and 2 pipelines	160 m

* With one energy carrier per tunnel tube.

4.2.1 Electrical connection network at sea and on land

PAWOZ is investigating space for transporting electricity with 525 kV (2 GW) direct current (DC-)cable systems and 220 kV (350 MW) alternating current (AC-)cable systems. In both the DC- and AC-cable systems, the generated electricity is transported from a sea platform through cable systems in the seabed to the mainland. Subsequently, the electricity is led to a transformer station (for AC) or converter station (for DC) via onshore cable systems. There, the voltage level is converted to 380 kV. Finally, the electricity is transported to a 380 kV high-voltage station where it is connected to the national high-voltage grid. For every cable system, the components of electrical connections are depicted in (Figure 4.3) (PAWOZ EIA main report). The cables will be buried at least 1.0 m depth in the sediment, but at many sections the burial depth is much larger.

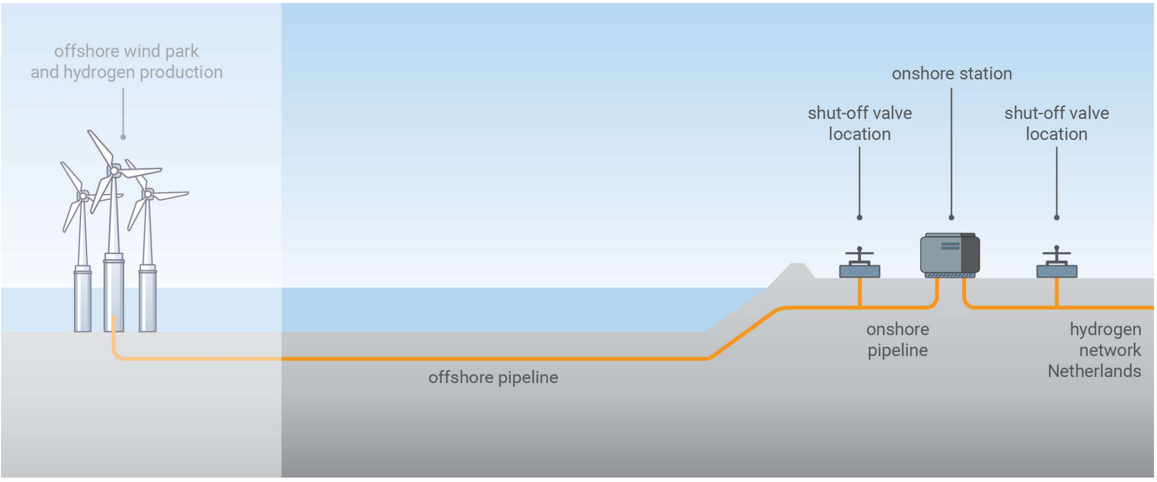
Figure 4.3 Schematic illustration of an electricity network (upper: direct current, lower: alternating current)



4.2.2 Hydrogen connection network at sea and on land

The proposed action for the hydrogen connection network consists of pipelines for transporting hydrogen and other components (see Figure 4.4). The hydrogen pipelines at sea facilitate the transport of hydrogen from offshore platforms (where hydrogen is produced) to the mainland. The area where the pipes come ashore is the landing zone. The hydrogen pipelines on land continue the transport of hydrogen across the mainland until they connect to the Dutch hydrogen network that is being developed by Hynetwork (100 % subsidiary of Gasunie, www.hynetwork.nl). Positioned between the offshore and onshore hydrogen pipelines are valve locations. These valves can close the pipelines to stop the flow of hydrogen. Additionally, a valve location is situated at the point of connection to the Dutch hydrogen network. Situated between the valve locations is a hydrogen landing station. This station serves various functions, including pressure measurement within pipelines and monitoring the quality of the hydrogen (PAWOZ EIA main report).

Figure 4.4 Schematic illustration of a hydrogen connection (source: Gasunie)



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4.2.3 Tunnel system

As an alternative to the electricity grid and hydrogen network described in the previous paragraphs, it has been investigated whether cable systems or pipelines can be installed in a drilled multi-tube tunnel system below the Wadden Sea. Within the framework of PAWOZ, this tunnel system is one of the potential routes (see paragraph 4.3.6), the X: Tunnel route. The principles of this alternative differ from the ones of the other routes.

For the development of the tunnel system an entry point in the North Sea and an exit point on land in or near the Eemshaven are needed. The entry point in the North Sea is situated on the Ballonplaat. For the exit point search areas in and near the Eemshaven are used. The tunnel system comprises multiple tunnel tubes which accommodate the cable systems and pipelines. From the entry point as well as the exit point cable systems and pipelines go to respectively the wind farms and point of connections on land using conventional construction methods. The cable systems link to the national high-voltage grid, while the pipelines integrate with the Dutch hydrogen network (PAWOZ EIA main report).

4.2.4 Installation techniques for cable systems and pipelines at sea and land

There are various cable system and pipeline installation techniques used at sea. For the installation of cable systems and pipelines in the Wadden Sea, the principle of 'bury and would like to forget' is applied. This principle aims to bury cable systems and pipelines deep enough, so they do not become exposed over time. The burial depth is determined based on a burial depth study. Installation vessels are used to bury cable systems and pipelines. Dredging may be necessary to achieve sufficient water depth for installation vessels or to achieve the required burial depth. HDD is used for crossing coastlines and islands. The duration of cable system and pipeline installation work at sea depends on factors such as the installation technique, cable system or pipeline length, and route. PAWOZ operates under the premise that a maximum of one cable system or pipeline is installed per year. The installation of the tunnel system includes the construction of an entry point in the North Sea through dredging and sand spraying and the construction of shafts for installing tunnel tubes. Annex 5 gives an elaborate overview of different installation techniques (PAWOZ EIA main report).

4.3 Investigated alternatives

PAWOZ investigates various routes for energy infrastructure. There are routes crossing the North Sea and mainland, but this HIA focusses only on the routes that cross the UNESCO heritage site the Wadden Sea. Among the routes under investigation, six traverse the Wadden Sea. Several of these routes offer variants, i.e. when part of the route differs from the main route. Table 4.2 names the routes that are evaluated in this HIA.

Table 4.2 Routes within the Wadden Sea heritage site of which effects are evaluated in this HIA

Route	Route name
II	Oude Westereems route - cable system (variant A and A1)
II	Oude Westereems route - pipeline
V	Boschgat route - cable system (variant A, A1 and A2)
VII	Schiermonnikoog Wantij route - cable system (variant A and A1)
VII	Schiermonnikoog Wantij route - pipeline
VIII	Ameland Wantij route - pipeline
IX	Zoutkamperlaag route - pipeline (variant A1 and A2)
X	Tunnel route - cable system and pipeline

The naming of the routes is not sequential (I, II, III etc.), because several routes have been eliminated in earlier phases of the project for various reasons, for example because the route was expected to cause significant negative impact on geomorphology and ecology. The location of the routes is presented in Figure 4.5. The map shows route numbers (such as A, II, etc.) in combination with the accompanying variants (A, A1, etc.). For example II-A is the II: Oude Westereems (land)route variant A. In Figure 4.6 the borders of the World Heritage site are marked to show in more detail the location of the routes within the heritage site.

Figure 4.5 The investigated routes within PAWOZ plan area

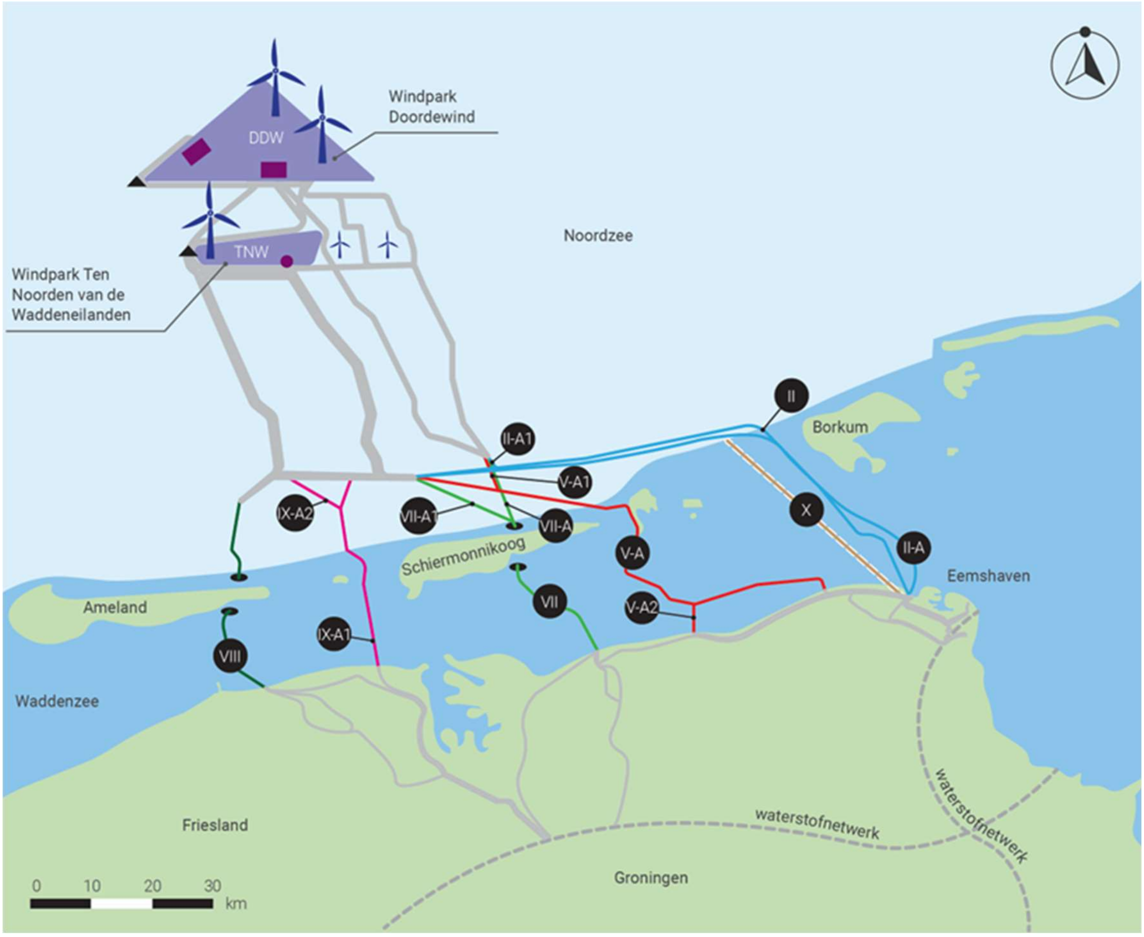
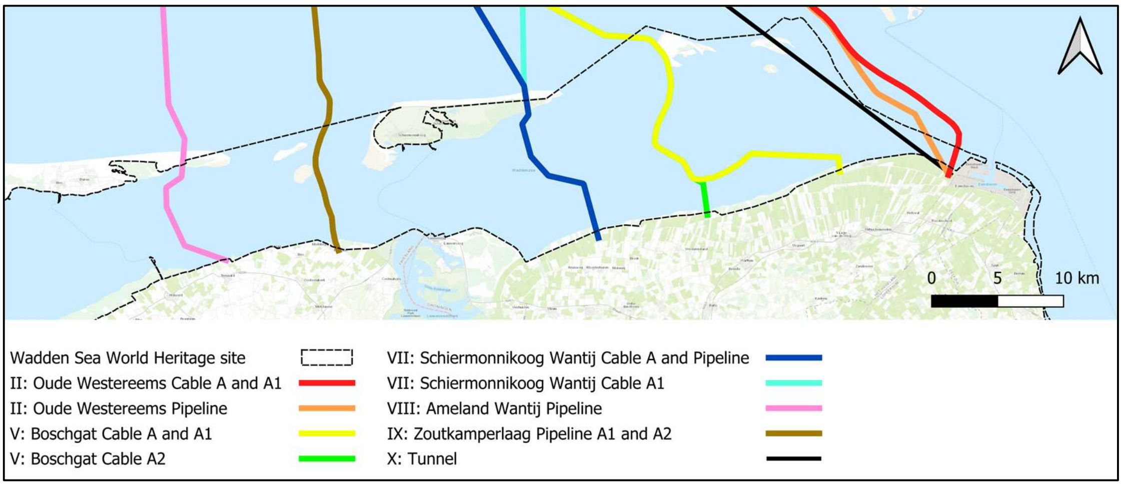


Figure 4.6 The investigated routes within the Wadden Sea World Heritage site



In line with the EIA, this HIA only assesses the effects of the installation of one cable system or one pipeline per year.

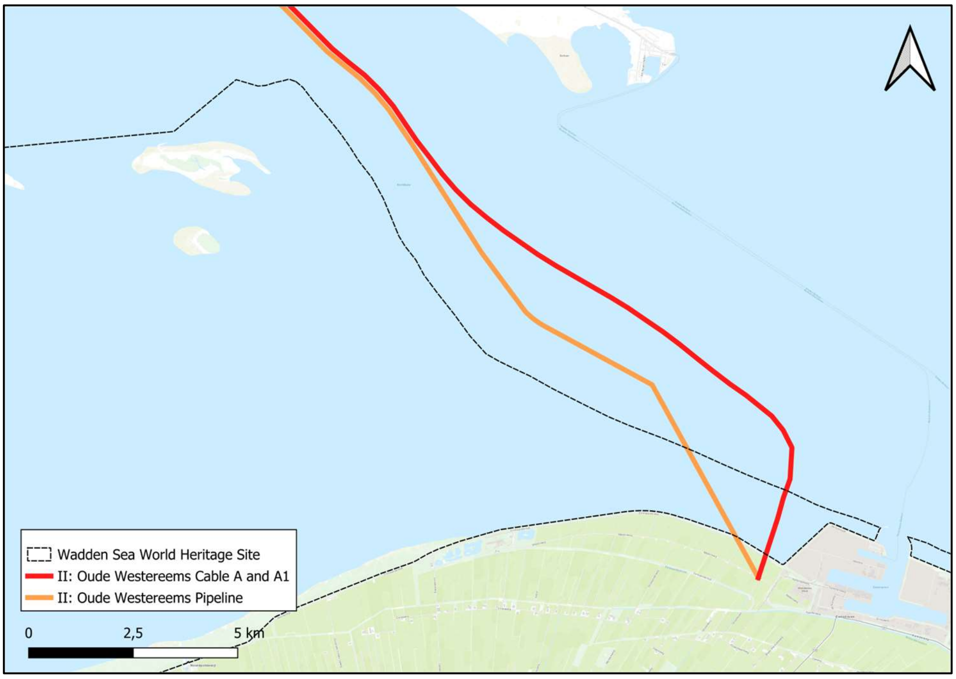
The HIA methodology prescribes to also discuss the necessity of the proposed action, or in other words, the alternative in which no action is taken. For PAWOZ, the alternative in which the proposed action does not take place is not considered a realistic option. Without constructing electricity and hydrogen connections, the energy generated by the wind farms cannot be used on land to meet Dutch energy demand and climate goals. Energy supply is recognized as an imperative reason of public interest and is considered a matter of public safety according to the Emergency Ordinance. The importance of this project is explained in the PAWOZ Program Document.

4.3.1 II: Oude Westereems route

The II: Oude Westereems route (Figure 4.7) is being considered for the installation of a pipeline and a cable system. Its routing strategy involves tracing morphologically stable deep sections within the Ems Estuary, potentially reducing burial depth. Departing from the mainland, the route intersects the primary dike at Eemshaven-West before curving north-westward to track the Oude Westereems channel.

This route encompasses three distinct variants: one tailored for a pipeline and two designed for a cable system. The cable system variants begin to diverge approximately 10 kilometers north of Schiermonnikoog, outside the Wadden Sea. Within the boundaries of the Wadden Sea World Heritage site, both cable system variants adhere to the same trajectory and will be assessed in the same way in the HIA. Even though this route is largely located outside of the heritage site, all effects of activities along the route are evaluated because they can impact the nearby heritage site.

Figure 4.7 Location of the II: Oude Westereems route



Installation method of the cable system
The cable system is installed along most of the route using a vertical injector or a trencher. Localized dredging is required to achieve sufficient water depth for installation vessels. The route crosses the primary dike and existing cable systems along the coast with an HDD.

Installation method of the pipeline
The pipeline is installed by using a pipelaying vessel and trenching equipment (S-lay). On the route through the Ems channel, preparatory dredging work is necessary to achieve the desired burial depth. The route crosses the primary dike and existing cable systems along the coast with a drilled segment tunnel approximately 6 km long.

Optimization measures

This HIA assesses the effects of activities on this route after optimization. This means the route has already been optimized before this assessment was made with the following measures:

- During the installation of pipelines over the 6 km long section of the pipeline route between the COBRA-cable and the actual location of the Eemsgeul, obstruction in the Eemsgeul itself will be avoided.
- Widening of the corridor from 500 m to a minimum of 700 m and a maximum of 1,300 m for the cable system.
- Widening of the corridor from 500 m to a minimum of 500 m and a maximum of 700 m for the pipeline.
- Dredging activities for the installation of the pipeline will be limited, and the material will be spread elsewhere to minimize permanent changes in the seabed dynamics and the occurrence of a turbidity plume due to the dispersal of dredged material.

Mitigation measures for II: Oude Westereems route cable system

For this route the following mitigation measures are in prospect:

- *To limit effects of changes in sediment dynamics on typical species:* Avoid high concentrations of sensitive typical species (locations with high ecological value (hotspots) and seagrass) (quality Natura 2000 habitat type H1140A). Hotspots are currently not known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of underwater sound and vibrations on marine mammals:* Keep subtidal channels for foraging near haul-out sites (for resting, moulting and breeding) accessible for seals during the period from May up to and including August. An onboard marine mammal observer will safeguard that these requirements are met.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on breeding birds:* No working activities from April up to and including August near (within 600 m) locations of breeding birds or limiting noise levels to 47 dB (A) and use barriers.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on high tide roosts:* No working activities during high tide near (within 600 m) high-tide roost sites of (migrating) birds or limit noise levels to 47 dB (A) and use barriers.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on seals:* Avoid seals at haul-out sites (keep at least 1500 m distance) during the period from May up to and including August. An onboard marine mammal observer will safeguard that these requirements are met.

Mitigation measures for II: Oude Westereems route pipeline

For this optimized route the following mitigation measures are in prospect:

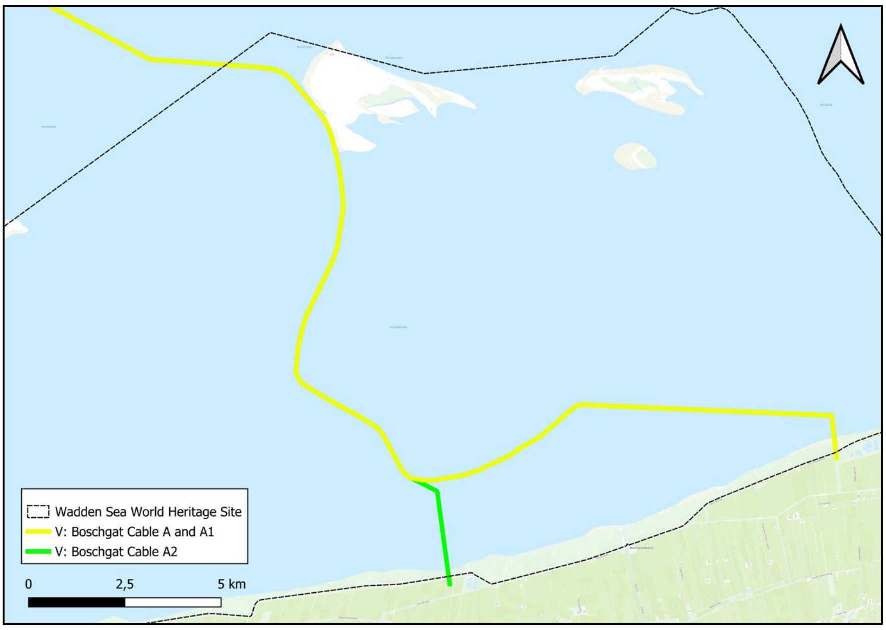
- *To limit effects of turbidity on non-breeding birds:* Ensure a limited increase in turbidity (maximum 20 %) from January until and including March in the Wadden Sea.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on breeding birds:* No working activities from April up to and including August near (within 600 m) locations of breeding birds or limiting noise levels to 47 dB (A) and use barriers.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on high tide roosts:* No working activities during high tide near (within 600 m) high-tide roost sites of (migrating) birds or limit noise levels to 47 dB (A) and use barriers.

4.3.2 V: Boschgat route

The V: Boschgat route (Figure 4.8) is only being considered for one cable system. The route crosses the primary dike in Groningen at the Uithuizen location (variants A and A1). Variant A2 crosses the primary dike more westwards. All variants pass through the tidal flats towards the Southeast Lauwers channel. It then follows the Southeast Lauwers and Boschgat channels before heading northwards. At the most westerly point of Rottumerplaat, the route continues in a northwesterly direction.

Variants A and A1 diverge approximately 7,5 kilometer north of Schiermonnikoog, in the North Sea. Within the boundaries of the Wadden Sea World Heritage site, these variants adhere to the same trajectory.

Figure 4.8 Location of the V: Boschgat route



Installation method of the cable system
On the tidal flats, a tidal flat trencher is used. In subtidal channels, floating equipment with a vertical injector or trencher is employed. The route crosses the primary dike and existing cable systems using HDD.

Optimization measures
This HIA assesses the effects of activities on this route after optimization. This means the route has already been optimized before this assessment was made with the following measure:
- Dredging activities will be limited, and the material will be spread elsewhere to minimize permanent changes in the seabed dynamics and the occurrence of a turbidity plume due to the dispersal of dredged material.

Mitigation measures
For this optimized route the following mitigation measures are in prospect:
- *To limit effects of turbidity on non-breeding birds:* Ensure a limited increase in turbidity (maximum 20 %) from January until and including March in the Wadden Sea.
- *To limit effects of changes in sediment dynamics on typical species:* Avoid high concentrations of sensitive typical species (hotspots and seagrass) (quality Natura 2000 habitat type H1140A). Hotspots are currently not known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of changes in sediment dynamics on non-breeding birds:* Avoid essential food hotspots for relevant non-breeding bird species. The importance and exact location of food hotspots per bird species is not yet known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on breeding birds:* No working activities from April up to and including August near (within 600 m) locations of breeding birds or limiting noise levels to 47 dB (A) and use barriers.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on high tide roosts:* No working activities during high tide near (within 600 m) high-tide roost sites of (migrating) birds or limit noise levels to 47 dB (A) and use barriers.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on open water:*
  - No working activities from November until and including March during high water (open water) in the Wadden Sea (in regard to the common goldeneye).

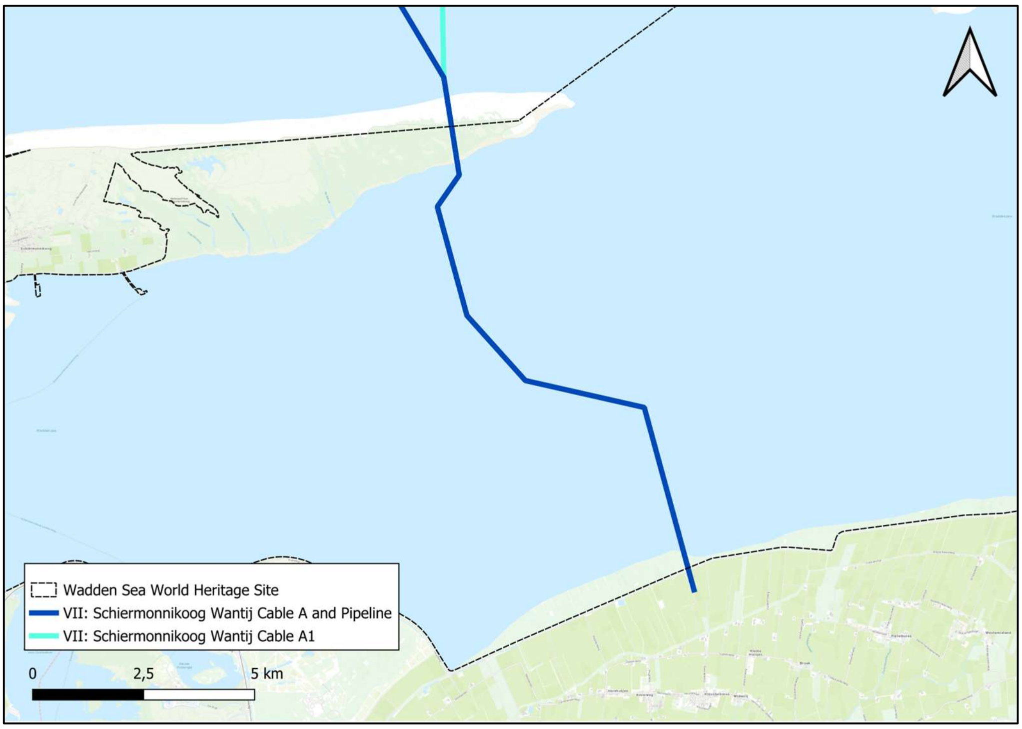
- No working activities from January until and including March during high water (open water) in the Wadden Sea (in regard to the common merganser).

4.3.3 VII: Schiermonnikoog Wantij route

The VII: Schiermonnikoog Wantij route (Figure 4.9) is being considered for both a cable system and a pipeline. The route crosses the primary dike at the coast of Groningen near Kloosterburen and then follows the tidal flat towards Schiermonnikoog. Subsequently, the route crosses Schiermonnikoog and continues northwards through the North Sea coastal zone.

This route encompasses three variants: two for a cable system and one for a pipeline. Within the confines of the Wadden Sea World Heritage site, all variants overlap and will not be assessed individually.

Figure 4.9 Location of the VII: Schiermonnikoog Wantij route



Installation method of the cable system

On the tidal flats, a tidal flat trencher is used to install the cable system. The cable system is drilled underneath the primary dike and the island of Schiermonnikoog using HDD. North of Schiermonnikoog, the cable system is buried using a trencher or a vertical injector. Preparatory dredging work is required because the area is otherwise too shallow for the installation vessels.

Installation method of the pipeline

The tidal flat between Groningen and Schiermonnikoog, as well as the island of Schiermonnikoog itself, will be crossed using a series of consecutive HDD operations. The pipeline will pass under the island of Schiermonnikoog using HDD. North of Schiermonnikoog, an open excavation will be made in the surf zone using a cofferdam to bury the pipeline at depth. Subsequently, the pipeline will be installed using the 'S-Lay' technique. In deeper waters, a pipelaying vessel with trenching equipment will be utilized.

Optimization measures

This HIA assesses the effects of activities on this route after optimization. This means the route has already been optimized before this assessment was made with the following measures:

- Widening of the corridor from 1,500 m to a minimum of 1,500 m and a maximum of 4,000 m for the cable system.
- Widening of the corridor from 2,000 m to a minimum of 2,000 m and a maximum of 4,000 m for the pipeline.

Mitigation measures for VII: Schiermonnikoog Wantij route cable system
For this optimized route the following mitigation measures are in prospect:
- *To limit effects of sedimentation of typical species*:
  · Prevention of sedimentation of shellfish banks in the Wadden Sea.
  · Prevention of sedimentation of seagrass beds in the Wadden Sea.
- *To limit effects of changes in sediment dynamics on typical species:* Avoid high concentrations of sensitive typical species (hotspots and seagrass) (quality Natura 2000 habitat type H1140A). Hotspots are currently not known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of changes in sediment dynamics on non-breeding birds:* Avoid essential food hotspots for relevant non-breeding bird species. The importance and exact location of food hotspots per bird species is not yet known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on breeding birds:*
  · No working activities from April up to and including August near (within 600 m) locations of breeding birds or limiting noise levels to 47 dB (A) and use barriers.
  · Disturbance of foraging breeding birds will be avoided as much as possible during the breeding period. The exact foraging locations per species are not known yet. Research needs to be conducted to identify these locations.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on high tide roosts:* No working activities during high tide near (within 600 m) high-tide roost sites of (migrating) birds or limit noise levels to 47 dB (A) and use barriers.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on open water:*
  · No working activities from November until and including March during high water (open water) in the Wadden Sea (regarding the common goldeneye).
  · No working activities from January until and including March during high water (open water) in the Wadden Sea (regarding the common merganser).
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on tidal flats:* No working activities from July until and including September near the moulting and foraging area of the spoonbill at Lutjewad and above Westpolder (regarding the spoonbill).
- *To limit effects of above water sound and vibrations, and optical disturbance and light on seals:* Avoid seals at haul-out sites (keep of at least 1500 m distance) during the period from May up to and including August. An onboard marine mammal observer will safeguard that these requirements are met.

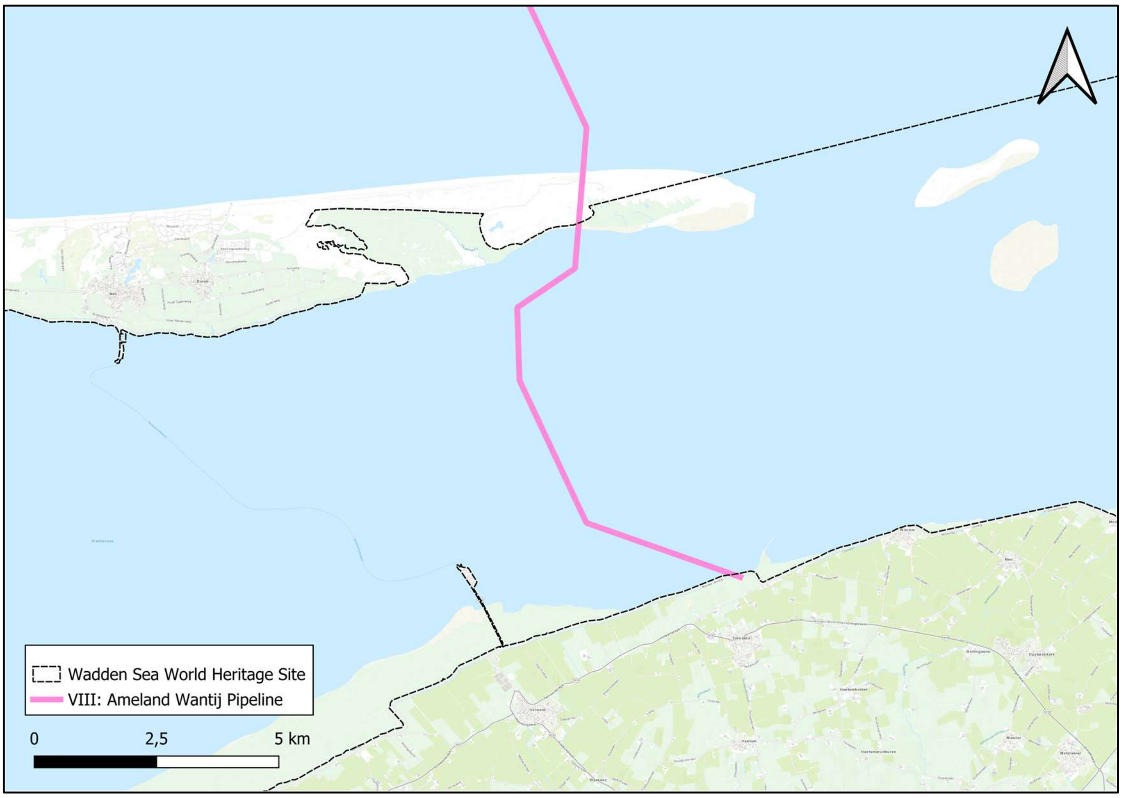
Mitigation measures for VII: Schiermonnikoog Wantij pipeline
For this optimized route the following mitigation measures are in prospect:
- *To limit effects of changes in sediment dynamics on typical species:* Avoid high concentrations of sensitive typical species (hotspots and seagrass) (quality Natura 2000 habitat type H1140A). Hotspots are currently not known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of changes in sediment dynamics on non-breeding birds:* Avoid essential food hotspots for relevant non-breeding bird species. The importance and exact location of food hotspots per bird species is not yet known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on breeding birds:*
  · No working activities from April up to and including August near (within 600 m) locations of breeding birds or limiting noise levels to 47 dB (A) and use barriers.
  · Disturbance of foraging breeding birds will be avoided as much as possible during the breeding period. The exact foraging locations per species are not known yet. Research needs to be conducted to identify these locations.

- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on high tide roosts:* No working activities during high tide near (within 600 m) high-tide roost sites of (migrating) birds or limit noise levels to 47 dB (A) and use barriers.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on open water:*
  - No working activities from November until and including March during high water (open water) in the Wadden Sea (regarding the common goldeneye).
  - No working activities from January until and including March during high water (open water) in the Wadden Sea (regarding the common merganser).
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on tidal flats:* No working activities from July until and including September near the moulting and foraging area of the spoonbill at Lutjewad and above Westpolder (regarding the spoonbill).

4.3.4 VIII: Ameland Wantij route

The VIII: Ameland Wantij route (Figure 4.10) is the most western route and is only considered for a pipeline. The basis of this route is to follow the tidal flats between the Frisian coast (around Ternaard) and Ameland. The route crosses the primary dike near Ternaard and then follows the tidal channel towards Ameland. Subsequently, the route crosses the eastern part of Ameland and continues northward through the North Sea coastal zone.

Figure 4.10 Location of the VIII: Ameland Wantij route



Installation method of the pipeline

The tidal flat will be crossed using a series of consecutive HDD operations. Pipelines will be drilled under the eastern part of Ameland using HDD. North of Ameland, an open excavation will be created in the surf zone using a cofferdam to bury the pipeline at depth. The pipeline will then be installed using the 'S-Lay' technique. In deeper waters, a pipelaying vessel with trenching equipment will be used for burial.

Optimization measures
There are no optimization measures for this route.

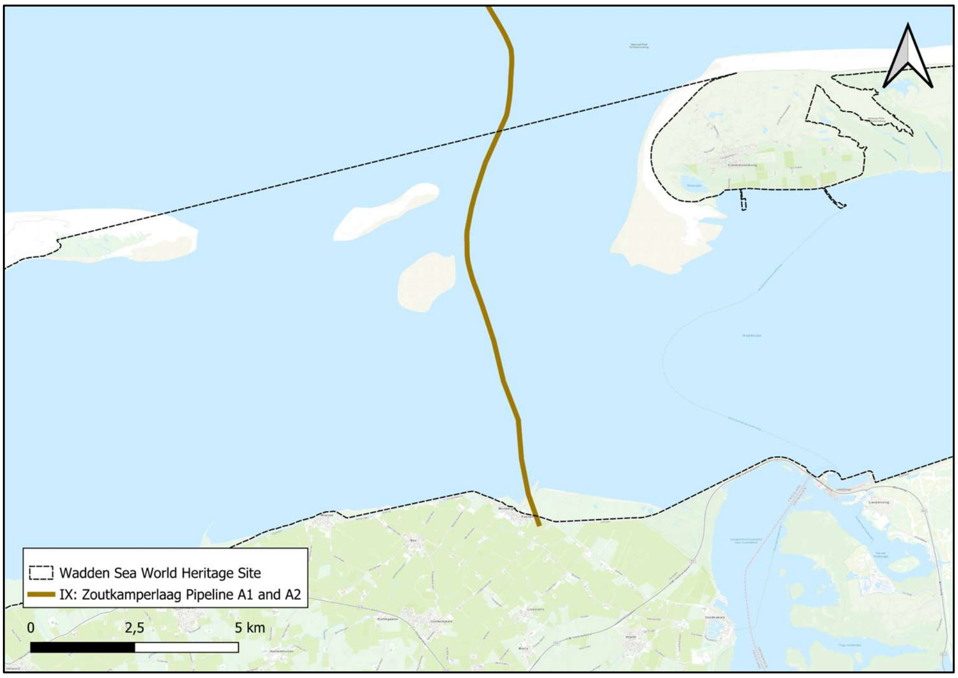
Mitigation measures
For this route the following mitigation measures are in prospect:
- *To limit effects of changes in sediment dynamics on typical species:* Avoid high concentrations of sensitive typical species (hotspots and seagrass) (quality Natura 2000 habitat type H1140A) Hotspots are currently not known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of changes in sediment dynamics on non-breeding birds:* Avoid essential food hotspots for relevant non-breeding bird species. The importance and exact location of food hotspots per bird species is not yet known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on breeding birds:*
  - No working activities from April up to and including August near (within 600 m) locations of breeding birds or limiting noise levels to 47 dB (A) and use barriers.
  - Disturbance of foraging breeding birds will be avoided as much as possible during the breeding period. The exact foraging locations per species are not known yet. Research needs to be conducted to identify these locations.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on high tide roosts:* No working activities during high tide near (within 600 m) high-tide roost sites of (migrating) birds or limit noise levels to 47 dB (A) and use barriers.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on open water:* No working activities from January until and including March during high water (open water) in the Wadden Sea (regarding the common merganser).
- *To limit effects of above water sound and vibrations, and optical disturbance and light on seals:* Avoid seals at haul-out sites (keep of at least 1500 m distance) during the period from May up to and including August. An onboard marine mammal observer will safeguard that these requirements are met.

4.3.5 IX: Zoutkamperlaag route

The IX: Zoutkamperlaag route (Figure 4.11) is only considered for a pipeline. The route crosses the primary dike from the Frisian mainland (west of Lauwersmeer). The route follows the subtidal channels of the tidal basin Zoutkamperlaag between Het Rif and Schiermonnikoog and west of the 'Gronden van het Plaatgat' and continues in a northern direction towards the North Sea.

This route encompasses two variants. These diverge approximately 10 kilometres northwest of Schiermonnikoog. Within the boundaries of the Wadden Sea World Heritage site, the variants overlap and will therefore not be assessed individually.

Figure 4.11 Location of the IX: Zoutkamperlaag route



Installation method of the pipeline
Both variant crosses the primary dike using HDD. In the channel, the pipeline is placed to depth by using a pipelaying vessel with burial equipment (post-trenching), and S-lay technique is applied over a short segment.

Optimization measures
This HIA assesses the effects of activities on this route after optimization. This means the route has already been optimized before this assessment was made with the following measures:
- (Western variant) dredging activities will be limited, and the material will be spread elsewhere to minimize permanent changes in the seabed dynamics and the occurrence of a turbidity plume due to the dispersal of dredged material.

Mitigation measures
For this optimized route the following mitigation measures are in prospect:
- *To limit effects of turbidity on breeding birds and typical species:* No working activities in the growing season of primary production and in the breeding period (half March with and until August) or ascertain at most a limited increase of turbidity in the aforementioned period in the Wadden Sea (max. 20 %).
- *To limit effects of turbidity on non-breeding birds:* Ensure a limited increase in turbidity (maximum 20 %) from January until and including March in the Wadden Sea.
- *To limit effects of sedimentation on mammals:* Distribute dredged sediment in the dredged slot.
- *To limit effects of changes in sediment dynamics on typical species:* Avoid high concentrations of sensitive typical species (hotspots and seagrass) (quality Natura 2000 habitat type H1140A) Hotspots are currently not known in sufficient detail and need to be mapped based on actual data on and in the vicinity of the route.
- *To limit effects of underwater sound and vibrations on mammals:* Keep subtidal channels for foraging near haul-out sites accessible for seals during the period from May up to and including August. An onboard marine mammal observer will safeguard that these requirements are met.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on breeding birds:* No working activities from April up to and including August near (within 600 m) locations of breeding birds or limiting noise levels to 47 dB (A) and use barriers.

- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on high tide roosts:* No working activities during high tide near (within 600 m) high-tide roost sites of (migrating) birds or limit noise levels to 47 dB (A) and use barriers.
- *To limit effects of above water sound and vibrations, and optical disturbance and light on non-breeding birds on open water:*
  - No working activities fin January in the Wadden Sea (in regard to the common eider).
  - No working activities from January until and including March during high water (open water) in the Wadden Sea (in regard to the common merganser).
- *To limit effects of above water sound and vibrations, and optical disturbance and light on seals:* Avoid seals at haul-out sites (keep of at least 1500 m distance) during the period from May up to and including August. An onboard marine mammal observer will safeguard that these requirements are met.

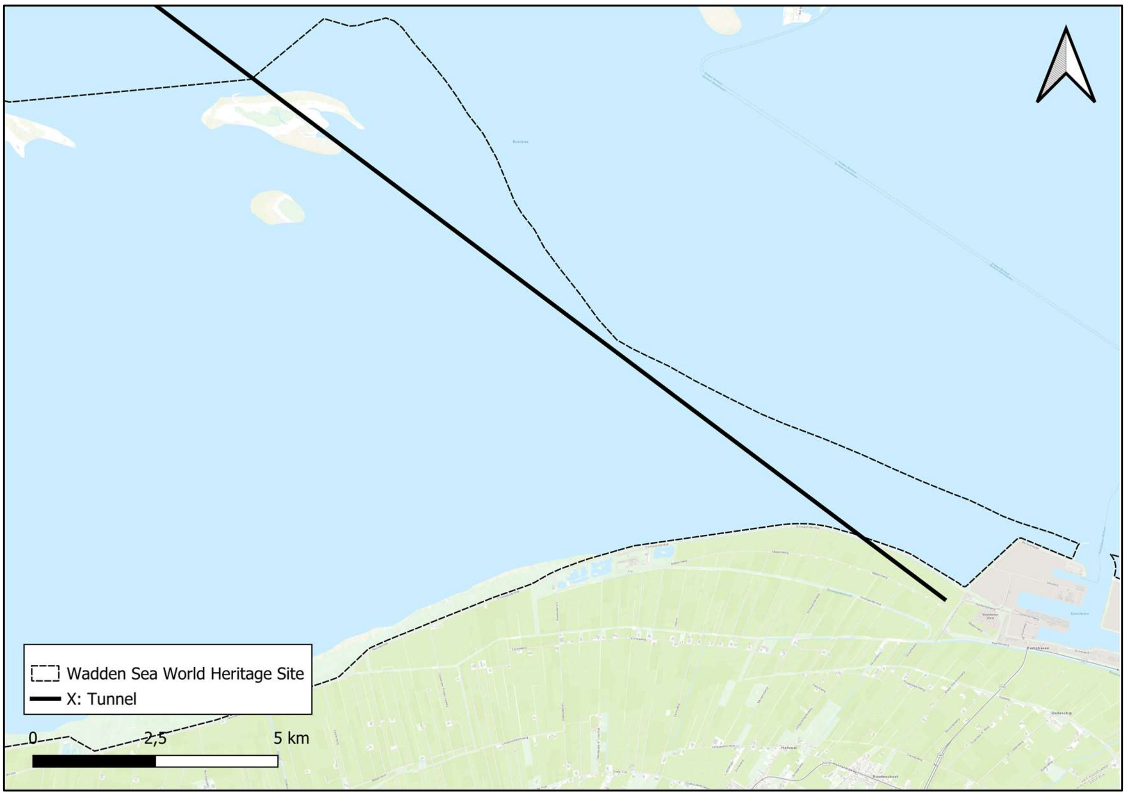
4.3.6 X: Tunnel route

The X: Tunnel route (Figure 4.12) has a length of approximately 26 km. The X: Tunnel route starts at the entry point in the North Sea and ends at the exit point onshore. The onshore exit point is planned in the vicinity of the Eemshaven. The offshore entry point is located in the Ems-Dollard treaty area, approximately 12 km west of Borkum on the Ballonplaat.

From the entry point North Sea, heading westwards, the cable systems and pipelines will follow the II: Oude Westereems route deep below the seabed. Towards the mainland a maximum of seven tunnel tubes are directed in a straight line from the entry point North Sea to the exit point near the Eemshaven. The tunnels descend deep into the seabed (approximately 35 to 45 meters below NAP, or Amsterdam Ordnance Datum in English). On the mainland near the Eemshaven, the tunnels emerge onto land, from where the cable systems and pipelines follow the II: Oude Westereems landroute (onshore) to the points of connection on land.

The offshore entry point, the Eemshaven exit point, and the multi-tube tunnel system itself must be accessible for management, maintenance, and the installation of (additional) cable systems and pipelines throughout the tunnel system's lifespan. Additionally, the entry and exit points of the tunnel are used for the management and maintenance of the tunnel itself, its installations, and the cable systems/pipelines within the tunnels. Therefore, they must remain accessible and available throughout the lifespan of the tunnel system.

Figure 4.12 Location of the X: Tunnel route



Installation method of the tunnel system

The activities for the construction of the North Sea entry point consist of the following steps: dredging of an access channel, constructing a sea wall, spraying sand, building breakwaters, constructing a quay, and dredging a harbour basin.

Once the entry point is completed, two shafts with combi-walls will be built for the first three tunnel tubes. From these shafts, tunnel tubes can be drilled at depth. Subsequently, the next two shafts and four tunnel tubes can be constructed. The shafts at the exit point onshore near the Eemshaven are similar to the shafts at the North Sea entry point. The tunnel tubes will be drilled from both sides: from the entry point and the exit point.

Next, in each tunnel tube, a cable system or pipeline will be installed separately. Cable systems will be pulled into the tunnel tubes using a monorail. Pipelines will be driven into the tunnel tubes in segments on a rail and then welded together

Optimization measures

There are no optimization measures for this route.

Mitigation measures

For this route there are no mitigation measures in prospect.

5

IMPACT ASSESSMENT OF PAWOZ ROUTES ON THE OUV OF THE WADDEN SEA

This chapter discusses per route the effects of proposed actions on the attributes that sustain the OUV of the Wadden Sea. The impact on the integrity of the heritage site is also discussed.

5.1.1 II: Oude Westereems route - cable system (variant A and A1)

This route offers two variants for a cable system, A and A1. These two variants for cable systems have not been assessed separately because the effects of activities in the Wadden Sea are the same as the route diverges outside the heritage site, in the North Sea coastal zone.

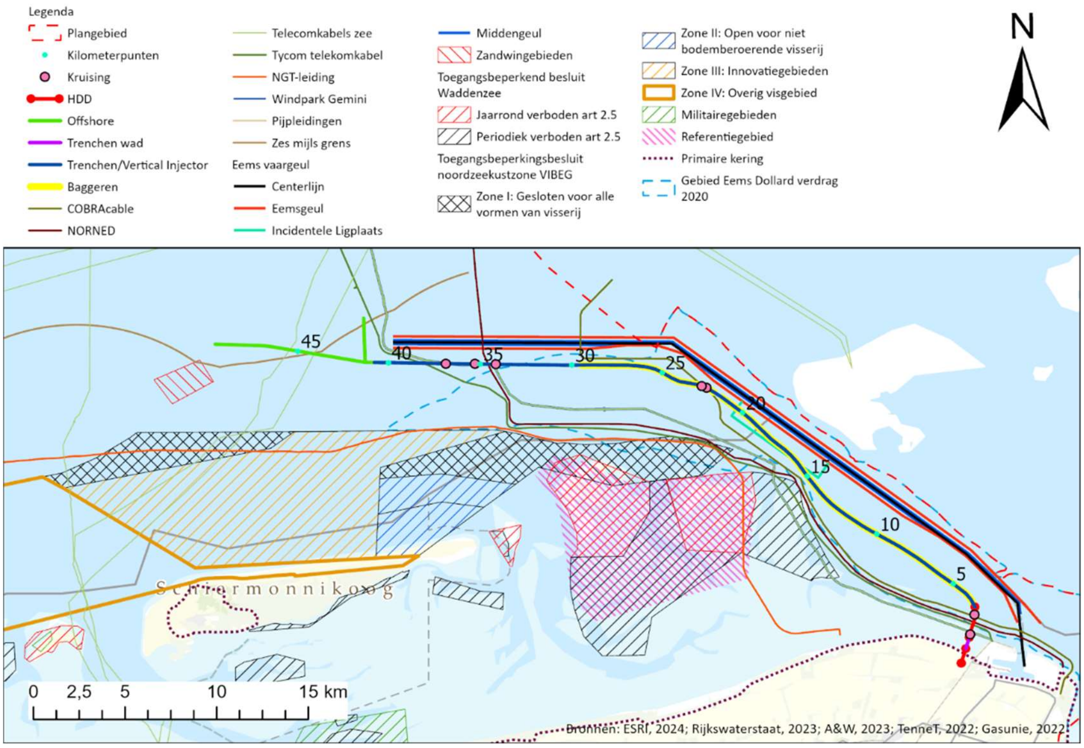
Activities

The activities occurring along II: Oude Westereems route for variant A and A1 are (see Figure 5.1):

- Installation of the cable system with vertical injector/trencher.
- Localized dredging (to create access trenches for installation vessels).
- HDD to cross the primary dike and existing cable systems along the coast.
- And installation of entry points for the HDD.

Over the whole trajectory (Wadden Sea and North Sea) cable systems are buried in the sediment at depths between 1 m and 24 m depending on the exact location.

Figure 5.1 Proposed activities for cable installation on the II: Oude Westereems route



Evaluation of impacts

Table 5.1 gives an overview of the evaluation of impact on each attribute. The impact on each OUV of the Wadden Sea are discussed below.

Impact on OUV viii) geological processes

The effects of the installation of a cable system with vertical injector/trencher on this route are limited. There are local and temporary disturbances of the seabed that will recover quickly because of natural dynamics. Dredging (for access of installation equipment) causes more negative effects because large quantities of sediment are dredged. These dredging works take place mostly in shallow parts. Mainly on the west side of the corridor significant quantities need to be dredged. This will cause disturbance to the seabed. However, recovery will take place because of natural dynamics. Therefore, the impact of these activities via disturbance of the seabed on the size of barrier islands, sandbanks, channels, mudflats and saltmarshes is *minor negative*.

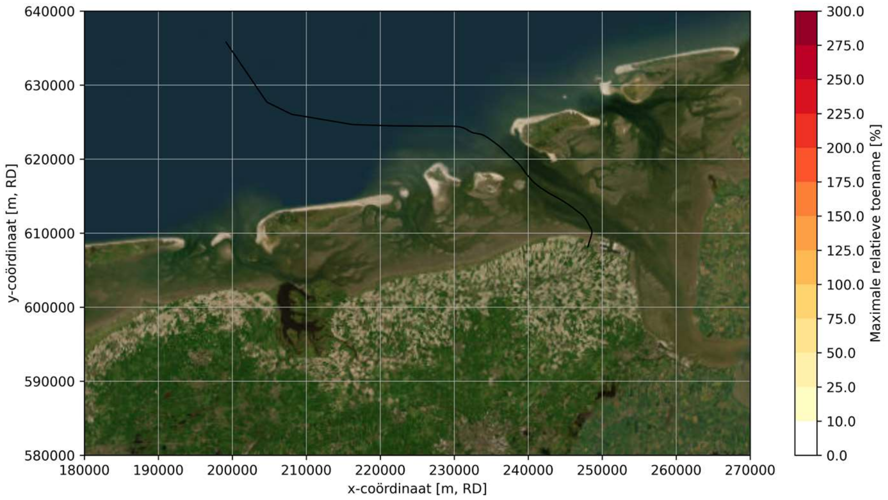
The installation of the cable system does not lead to any significant changes in freshwater inflow from rivers or canals into the Wadden Sea. Furthermore, the processes that cause mixing of water with different salinities are not significantly altered so that there is no significant effect on the surface area of regions with salt gradients. The activities do not affect the rate of sea level rise and have no significant effect on the ability of the UNESCO area and its tidal basins to respond to sea level rise. Finally, the activities have no significant effect on the size of the tidal basins, ebb tidal deltas, salt marshes or shallow coastal zones, where sediment is deposited. Therefore, the impact of the activities on these attributes is *neutral*.

Impact on OUV ix) ecological processes

Within the UNESCO area, HDD is used to install the cable system underneath the salt marsh. It is still unclear where the exit point of the HDD will exactly be located. The HDD is crossing a potential sea grass area and benthic diversity hotspots (locations with many different species living in and on top of the seafloor). Seagrasses and benthic organisms are very sensitive to changes in sediment dynamics. Depending on the exact location, the activities could affect the primary and secondary production in this area (Taal et al., 2015; Zhao et al., 2019; Tulp et al., 2022; Baptist & Leopold, 2010). However, it is possible to avoid seagrass locations and benthos diversity hotspots via mitigation measures (see Chapter 4.3.1). Therefore, the impact of this activity via a change in sediment dynamics is scored as a *moderative negative impact*.

Outside the UNESCO boundary, the cable system (approximately 25 km) is installed by dredging and burying it underneath the sediment. Approximately 7.800 m^3 silt will be dredged during a total of 41 days. The surface area that is affected, however, is small, and the increase of turbidity will not exceed >5 mg/L (absolute numbers). The sediment plume is therefore not visible in Figure 5.2. Primary production by phytoplankton, shellfish and visual hunting birds and fish will therefore not be hampered. Additionally, the dredged sediment will be deposited at a licensed location (P3) and will also not cause an impact. Therefore, the impact off this activity via sedimentation and turbidity is scored as *neutral*.

Figure 5.2 Maximum percentage of relative increase of the daily average background concentration during the simulation of the installation of the cable system in the II: Oude Westereems route. The sediment plume is not visible as the surface area is small and the concentrations relatively low (Mustafa & van Engelen, 2024)



The activities and associated shipping traffic cause an increase in underwater sound and vibrations. Fish and fish-eating birds typically demonstrate avoidance behaviour as result of continuous sound (Weilgart et al., 2018; Anderson Hansen et al., 2020). while the settlement and growth of invertebrates can be negatively affected by this kind of disturbance. Therefore, underwater sound and vibrations as a result of the activities has a *minor negative impact*.

The use of ships, trencher and HDD cause above water sound and vibrations, optical disturbance and an increase in the use of artificial light. Two mitigation measures for birds (paragraph 4.3.1) are in prospect that can potentially reduce the disturbance of birds. Therefore, this impact is scored *moderate negative*.

Impact on OUV x) biodiversity

Dredging on this route does not cause effects via turbidity and sedimentation on shellfish, birds, and fish living in marine and brackish areas (see impact on OUV ix) ecological processes for an explanation). Therefore, the impact of this activity via sedimentation and turbidity on biodiversity attributes is scored as *neutral*.

The HDD and trencher can affect seagrass and benthos via a change in sediment dynamics (see impact on OUV ix) ecological processes for an explanation). Therefore, this activity has a *moderate negative impact* on the number of species in marine and brackish water areas. Fattening areas of birds are evaluated as *neutral* by this effect, because the amount of suitable bird food available is low and therefore there will be no impact. This also accounts for migratory bird species with a strong dependence on the Wadden Sea.

Dredging and the sound of ship engines generate underwater sound and vibrations that can negatively affect marine mammals, such as seals and harbour porpoises by continuous and impulse sounds (Erbe et al., 2019). Marine mammals are extremely sensitive for underwater sound and vibrations (Mikkelsen et al., 2019; Schaffeld et al., 2022). Additionally, resting seals suffer from above water sound and vibrations, optical disturbance and light (Erbe et al., 2019). The route crosses an area that is very important for seals. There is a prospect of mitigation measures for seals (paragraph 4.3.1). Therefore, the impact of under and above water sound and vibrations, and optical disturbance and light on mammals living in marine and brackish water areas are evaluated as *moderative negative*.

The use of ships, trencher and HDD cause above water sound and vibrations, optical disturbance and an increase in the use of artificial light. This can affect breeding birds (for example on the salt marsh), birds on high tide roosts and the tranquility for birds (Kleijn, 2008). Of the migratory bird species with a strong dependency on the Wadden Sea (van Roomen et al., 2002) ringed plover, grey lag goose, common greenshank, northern pingtail and Eurasian curlew use the high tide roost in the vicinity of this route. The appropriate assessment indicates that especially for the European oyster, pied avocet and ringed plover mitigation measures need to be taken to prevent significant effects. There are prospective mitigation measures for breeding and non-breeding birds (paragraph 4.3.1). Therefore, this impact is scored as a *moderate negative*.

During the operational phase, electromagnetic fields of cable systems can cause behavioural changes in fish, especially elasmobranch species (Bedore & Kajiura, 2013; Taormina, et al., 2018). The tope shark uses the Wadden Sea as nursery ground. Also shark behaviour can be affected by electromagnetic fields. Therefore, this is considered to cause *minor negative impact* for species living in marine and brackish areas.

Impact on integrity

Does the route interrupt the natural dynamics and interconnectedness of the morphological elements of the Wadden Sea?

Geological processes are directly, temporarily impacted by proposed installation techniques for cable systems. This has a *minor negative impact* on the integrity of the heritage site as it will not permanently alter the size of the heritage site nor the key interrelated and interdependent elements in their natural relationships.

Does the route have negative effects on species, habitats, and processes?

Direct negative effects of installation activities on intertidal species (benthos and seagrass) can be avoided by a prospective mitigation measure. Subtidal species (fish and mammals) can be affected by underwater sound and vibrations produced by additional shipping activities. In addition, electromagnetic fields can affect the swimway of some fish species which are sensitive to this (Nyqvist et al., 2020; Hutchison et al., 2020a; Hermans & Schilt, 2024, in prep.). To limit the effects of above water sound and vibrations, and optical disturbance and light, mitigation measures are in prospect to reduce the effects on birds and seals. Regarding ecological processes, the effects of dredging on primary production will be small, as the increase in turbidity will not exceed >5 mg/L (absolute numbers). During the operational phase, electromagnetic field of the cable system can have an impact on the habitat of fish species. Depending on the fish species, this can lead to behavioural changes such as attraction or avoidance of the cable system, however this does not have a major impact. Regarding the effects on species, habitats and processes, impact on the integrity of the Wadden Sea heritage site is *moderate negative* for this route.

Does the route affect elements that are essential to the migratory path of birds?

Fattening areas of migratory birds will not severely be affected by the activities. The amount of suitable bird food in this area is already small. Above water sound and vibrations, and optical disturbance and light can affect resting migratory birds on high tide roosts. There is a mitigation measure in sight to reduce these effects (paragraph 4.3.1.). Regarding migratory birds, the impact on integrity of the Wadden Sea heritage site is *moderate negative* for this route.

Does the route affect breeding areas?
Breeding birds are not hampered by turbidity. However, above water sound and vibrations, optical disturbance and light can disturb the tranquility of breeding birds (Krijgsveld et al., 2022). There is a mitigation measure in prospect that can reduce these effects. Regarding breeding birds, the impact on integrity of Wadden Sea heritage site is *moderate negative for* this route.

Table 5.1 Evaluation of the impact of the II: Oude Westereems route - cable system

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
viii) geological processes	Size of barrier islands, sandbanks, channels, mudflats and saltmarshes	Disturbance of seabed (change in seabed level, substrate dynamics, wave and current dynamics)	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Amount of river discharge	Change in fresh water inflow and current velocities	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Surface area of regions with salt gradients	Changes in fresh water inflow an/or mixing of waters with different salinity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Rate of sea level rise	Large scale effect on water levels or ability of tidal basin to respond to sea level rise	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Size of the area where sediment is deposited	Change in area of tidal basin, ebb tidal delta or shallow coastal zone	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
ix) ecological processes	Primary production	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Production by animals, from shellfish to marine mammals	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Numbers of fish, shellfish and birds	Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative effect
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Food availability for fish, shellfish and birds	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Number of species (plants and animals) occurring in marine and brackish water areas	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Presence of electromagnetic fields	Once	Long-term	Reversible	Reversible	Permanent	Some change	Negative	Minor negative impact
		Underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Number of species of breeding birds	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Fattening areas for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Roosting areas for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Food supply for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Tranquility for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Relative importance of the Wadden Sea for population sizes of migratory birds	Change in substrate dynam ics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
Integrity	viii) geological processes	Effects on interconnectedness of the morphological elements								Minor negative impact
	ix) ecological processes	Effects on species, habitats, and processes								Moderate negative impact
		Effects on migratory path of birds								Moderate negative impact
	x) biodiversity	Effects on breeding areas								Moderate negative impact

5.1.2 II: Oude Westereems route - pipeline

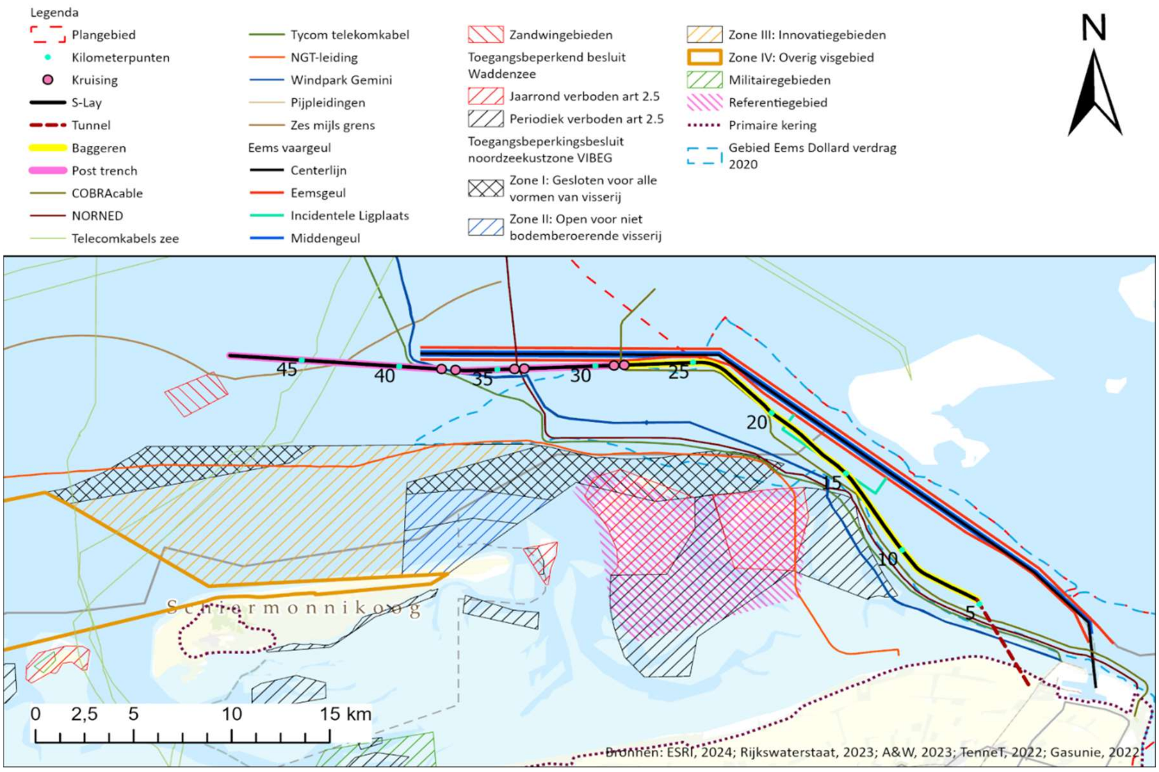
This route concerns the installation of a pipeline.

Activities

The activities occurring along the II: Oude Westereems route for installing a pipeline are (see Figure 5.3):

- Installation of pipeline with pipelaying vessel and trenching equipment (S-lay and post-trench).
- Localized dredging (to make access trench for installation vessels); and dredging in the Eems-Dollard (outside UNESCO area).
- Drilled segment tunnel of 6 km to cross primary dike and existing cables along the coast and underneath the seagrass field and saltmarsh.

Figure 5.3 Proposed activities for pipeline installation on the II: Oude Westereems route



Evaluation of impacts

Table 5.2 gives an overview of the evaluation of impact on each attribute. The impact on each OUV of the Wadden Sea are discussed below.

Impact on OUV viii) geological processes

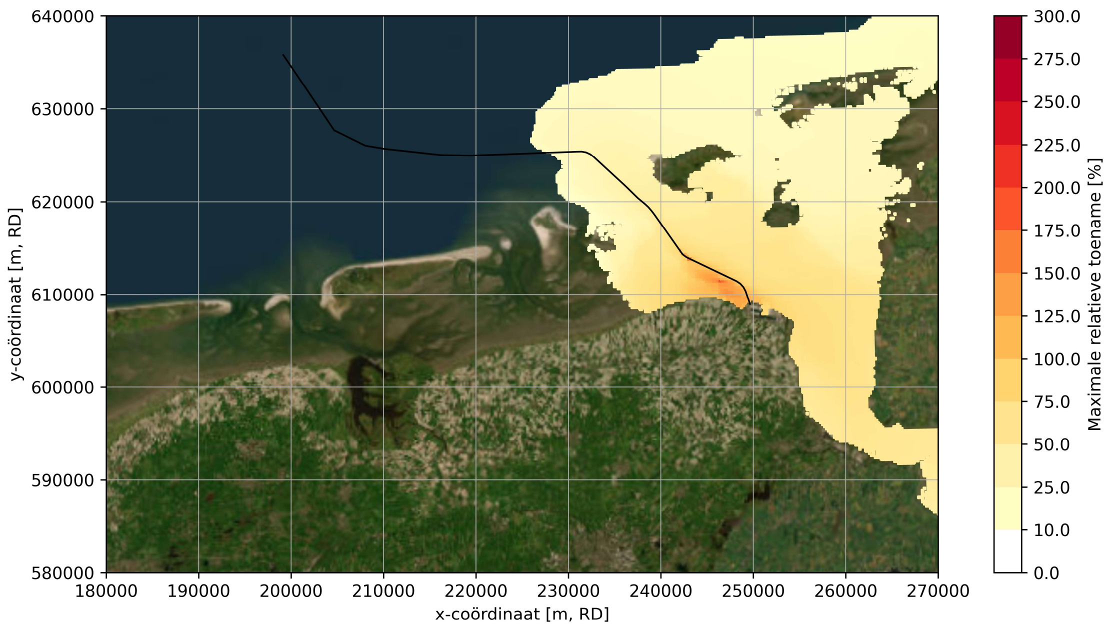
For the installation of a pipeline larger quantities need to be dredged compared to for a cable system, which causes larger negative effects. These effects will recover naturally over time but are deemed moderately negative due to the large dredging volumes. A drilled segment tunnel is used to cross the primary dike and existing cable systems along the coast. Access pits of limited size are being dug and filled up after usage. This has minor negative effects, that are negligible. Overall, the impact of these activities via disturbance of the seabed on the size of barrier islands, sandbanks, channels, mudflats and saltmarshes is *moderate negative*.

The installation of the pipeline does not lead to any significant changes in freshwater inflow from rivers or canals into the Wadden Sea. Furthermore, the processes that cause mixing of water with different salinities are not significantly altered so that there is no significant effect on the surface area of regions with salt gradients. The activities do not affect the rate of sea level rise and have no significant effect on the ability of the UNESCO area and its tidal basins to respond to sea level rise. Finally, the activities have no significant effect on the size of the tidal basins, ebb tidal deltas, salt marshes or shallow coastal zones, where sediment is deposited. Therefore, the impact of the activities on these attributes is *neutral*.

Impact on OUV ix) ecological processes
For the installation of the pipeline a segment tunnel will be used from the mainland. Organisms living in or on the seafloor (benthos) will therefore not be affected. Consequently, the food source for benthos-feeding fish and birds will not be changed by the activity. Therefore, the impact of this activity via a change in sediment dynamics is scored as *neutral*.

The majority of the pipeline is installed by dredging and burying it underneath the sediment. Approximately 414.700 m^3 silt will be dredged during a total of 128 days. The surface area that is affected is large and the increase of turbidity will exceed 5 mg/L (absolute numbers) for more than 200 days, of which 130 days have an absolute increase of >50 mg/L and 12 days have an absolute increase of 250 mg/L (Figure 5.4). This has a strong negative effect on primary production, typical species (like shellfish living in and on the sea floor) and fish Taal et al., 2015; Zhao et al., 2019; Tulp et al., 2022; Baptist & Leopold, 2010). Mitigation measures are not in sight in this stage of the program. Therefore, the impact of this activity via turbidity is scored as a *major negative impact*.

Figure 5.4 Maximum percentage of relative increase of the daily average background concentration during the simulation of the installation of the pipeline on the II: Oude Westereems route (Mustafa & van Engelen, 2024)



Dredged sediment will be deposited in the dredged slot after the laying of the pipeline. Therefore, surrounding habitat (submerged sandbanks) will largely stay intact. However, small effects on (typical) species living in or on the seafloor cannot be totally ruled out. Therefore, the impact of this activity via sedimentation is scored as a *minor negative impact*.

The activities and associated shipping traffic cause an increase in underwater sound and vibrations. Fish and fish-eating birds typically demonstrate avoidance behaviour as result of continuous sound, (Weilgart et al., 2018; Anderson Hansen et al., 2020) while the settlement and growth of invertebrates can be negatively affected by this kind of disturbance although evidence is rare (Cervello et al., 2023; Olivier et al., 2023). Therefore, underwater sound and vibrations as a result of the activities has a *minor negative impact*.

The use of ships, dredging and drilling cause above water sound and vibrations, optical disturbance and an increase in the use of artificial light. Mitigation measures for breeding birds and non-breeding birds are in prospect (paragraph 4.3.1). Therefore, this impact is scored as a *minor negative impact*.

Impact on OUV x) biodiversity
Organisms living in or on top of tidal flats will not be affected by a change of sediment dynamics, as the segment tunnel will pass below the tidal flats. Consequently, the food supply for birds living on tidal flats and fattening areas for migratory birds will not be directly negatively affected. The impact via a change in sediment dynamics is therefore scored as *neutral.*

Dredging causes effects via turbidity on shellfish (Compton et al.,(2017), fish-eating birds (Darby et al., 2022), and fish (Tulp et al., 2022), living in marine and brackish areas (see impact on OUV ix) ecological processes for an explanation). This also has a negative effect on the fattening areas and food supply of migratory birds. Therefore, the impact of this activity via turbidity on associated biodiversity attributes is scored as a *major negative impact.* For non-breeding birds (including migratory species with a strong dependence on the Wadden Sea) there is a mitigation measure in prospect. Therefore, turbidity has a *moderate negative impact* on the attributes relevant to migratory birds.

Dredged sediment will be deposited in the dredged slot after laying of the pipeline. Small effects on (typical) species living in or on the seafloor cannot be totally ruled out (Rozemeijer & Smith, 2017). In addition, the II: Oude Westereems route is passing seal haul-outs from where seals are swimming to the deeper channel (where the pipeline is installed) to forage. However, this gully is relatively large and very dynamic. The deposited sediment will spread relatively fast and the effect on seals is limited. Therefore, the impact of this activity via sedimentation is scored as a *minor negative impact*.

Dredging, drilling and the sound of ship engines generates underwater and above sound and vibrations that can negatively affect marine mammals, such as seals and harbour porpoises by continuous and impulse sounds (Erbe et al., 2019) .Mammals are extremely sensitive for underwater sound and vibrations (Mikkelsen et al., 2019; Schaffeld et al., 2022). The route crosses an area that is very important for seals. Currently, there are no mitigation measures in prospect to reduce these effects. Therefore, the effects of underwater and above water sound and vibrations, and optical disturbance and light on mammals living in marine and brackish water areas are evaluated to have a *major negative impact.* For breeding and non-breeding birds, two mitigation measures are in prospect resulting in *minor negative impact* on the attributes that involve birds. For details on the affected migratory species *see* Chapter 5.1.1.

Impact on integrity
Does the route interrupt the natural dynamics and interconnectedness of the morphological elements of the Wadden Sea?
Dredging causes most negative impacts on geological processes, especially dredging for the installation of the pipeline as this requires dredging of larger quantities. This has a temporary, *moderate negative impact* on the integrity of the heritage site because the natural dynamics are disturbed. The dredging works will not permanently alter the size of the heritage site. The key interrelated and interdependent elements in their natural relationships will be restored by natural processes on a timescale of years.

Does the route have negative effects on species, habitats, and processes?
Benthos species living on the tidal flats will not directly be affected as a segment tunnel from the mainland is used. However, the enormous amount of dredged sediment will lead to a significant increase in turbidity. This negatively impacts primary production in the area because sunlight is obscured, which can limit algae growth (Taal et al., 2015; Zhao et al., 2019; Tulp et al., 2022; Baptist & Leopold, 2010).
As a result, primary production (biomass from algae) and secondary production (biomass created by benthic organisms) are affected. As the base of the food web is negatively impacted, it also has consequences for higher levels in the food web (fish, birds, marine mammals). Because the dredged sediment will be deposited in the dredged slot, only minor effects on the habitat of subtidal species

(benthos, fish, seals) are expected. Sound and vibrations, light and optical disturbance associated with the activities will cause negative effects on especially seals (Erbe *et al.*, 2019). Currently, there are no mitigation measures in sight to limit disturbance of seals. For birds, mitigation measures are in sight. Regarding the effects on species, habitats and processes, impacts on the integrity of the Wadden Sea heritage site are *major negative* for this route.

Does the route affect elements that are essential to the migratory path of birds?
Fattening areas of migratory birds will be especially affected by the dredging activities. Visual hunting birds (e.g., species of ducks and terns) may find it harder to locate and catch prey (Compton et al. (2017), but a mitigation measure is in prospect to limit these effects. Underwater and above water sound and vibrations can also affect foraging fish-eating migratory birds or birds resting on high tide roosts. However, mitigating measures are in prospect to limit effects on breeding and non-breeding birds. Regarding migratory birds, the impact on integrity of the Waden Sea heritage is *major negative* for this route.

Does the route affect breeding areas?
Turbidity can hamper the ability of visually hunting birds to track and catch prey below water. Above water sound and vibrations, optical disturbance and light can disturb the tranquility of breeding birds (Krijgsveld *et al.*, 2022). A mitigation measure is in prospect that can limit these effects, this is also the case for the effects of turbidity on migrating birds, therefore the impact of turbidity on migrating birds is moderate negative for this route. Regarding breeding areas, the impact on integrity of the Wadden Sea heritage site is *major negative* for this route.

Table 5.2 Evaluation of the impact of the II: Oude Westereems route - pipeline

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
viii) geological processes	Size of barrier islands, sandbanks, channels, mudflats and saltmarshes	Disturbance of seabed (change in seabed level, substrate dynamics, wave and current dynamics)	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Amount of river discharge	Change in fresh water inflow and current velocities	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Surface area of regions with salt gradients	Changes in fresh water inflow an/or mixing of waters with different salinity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Rate of sea level rise	Large scale effect on water levels or ability of tidal basin to respond to sea level rise	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	Size of the area where sediment is deposited	Change in area of tidal basin, ebb tidal delta or shallow coastal zone	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
ix) ecological processes	Primary production	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
	Production by animals, from shellfish to marine mammals	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Numbers of fish, shellfish and birds	Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in above water sound and vi-brations	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative impact
		Increase in sedi-mentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Food availability for fish, shellfish and birds	Increase in sedi-mentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Change in sub-strate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in un-derwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in tur-bidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	Increase in above water sound and vi-brations	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Moderate nega-tive impact
		Increase in opti-cal disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate nega-tive impact
	Number of species (plants and animals)	Sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	occurring in marine and brackish water areas									
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
	Number of species of breeding birds	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
	Fattening areas for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Roosting areas for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	Food supply for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Tranquility for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Relative importance of the Wadden Sea for population sizes of migratory birds	Change n substrate dynam ics	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
Integrity	viii) geological processes	Effects on interconnectedness of the morphological elements								Moderate negative impact
	ix) ecological processes	Effects on species, habitats, and processes								Major negative impact
		Effects on migratory path of birds								Major negative impact
	x) biodiversity	Effects on breeding areas								Major negative impact

5.1.3 V: Boschgat route- cable system (variant A and A1 together)

This route offers three variants (A, A1, A2) for installing a cable system. Here we present the effects on variant A and A1 together as the route diverges outside of the heritage site (route A diverges to the left, A1 diverges to the right). Route A2 has a different exit point on the mainland (lands at the left point).

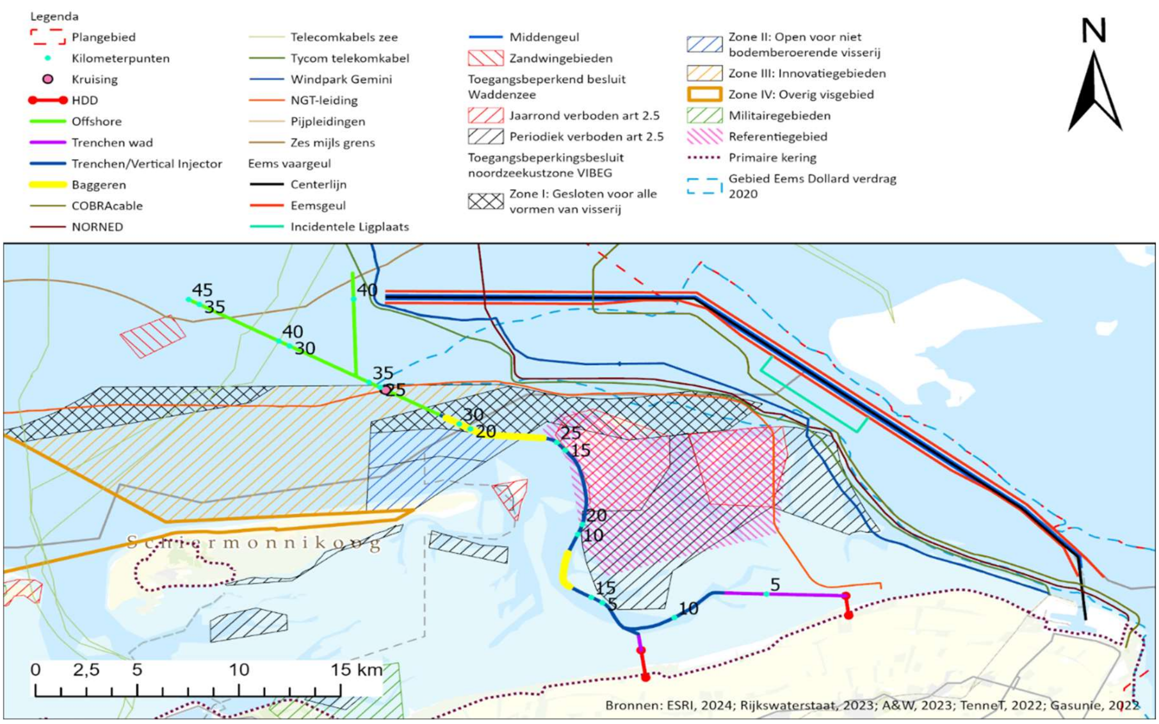
Activities

The activities for the V: Boschgat route variants A/A1/A2 are (see Figure 5.6):

- Installation of cable system with vertical injector/trencher (on shallow tidal flats).
- Installation of cable system with floating equipment with vertical injector/trencher (in the deeper subtidal channels).
- HDD to cross primary dike and existing cables along the coast; and installation of entry points for the HDD.
- Dredging (to make access trench for installation vessels).
- Increased number of ships and ship movements during installation.

Over the whole trajectory (Wadden Sea and North Sea) cable systems are buried in the sediment at depths between 1 m and 16 m depending on the exact location.

Figure 5.6 Proposed activities for cable system installation on V: Boschgat route



Evaluation of impacts

Table 5.3 gives an overview of the evaluation of impact on each attribute. There are no differences between among variants. The impact on each OUV of the Wadden Sea are discussed below.

Impact on OUV viii) geological processes

Installation of cable systems with a tidal flat trencher on shallow mud flats and floating equipment with vertical injector/trencher in the subtidal channels cause localized and temporary negative effect on mudflats. The impact is neutral as the mudflats will likely recover relatively fast. HDD to cross primary dike and existing cable systems along the coast causes negligible impact because access pits are filled up after usage.

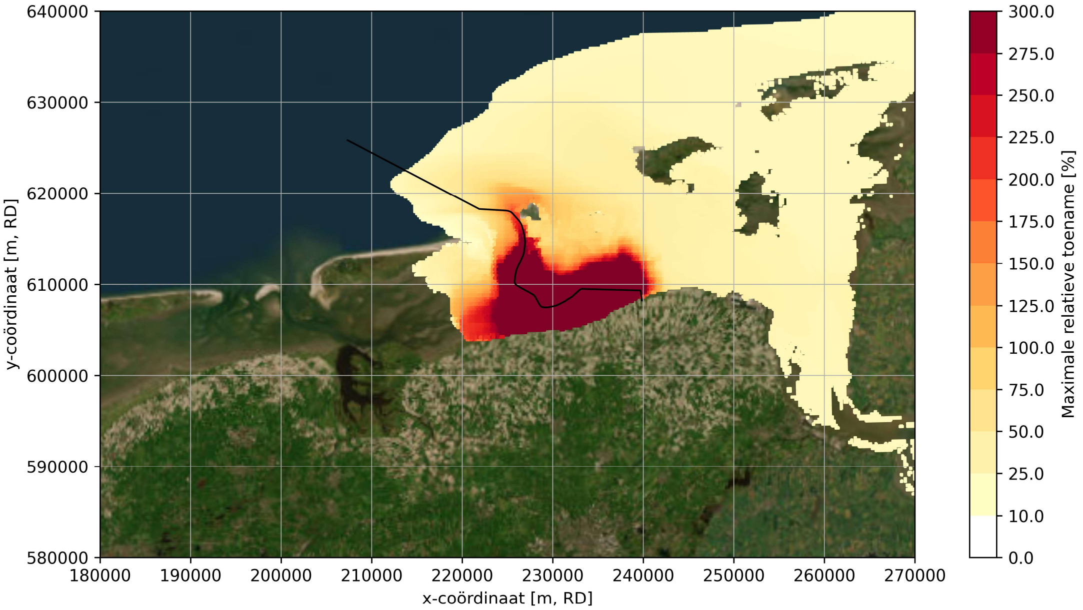
to widen the natural channel causes moderate negative impact as it causes local and temporary disturbance to tidal channels. Dredged material is spread directly after burial of cable systems and as much as possible within the channel, so not on a mudflat, which would cause more negative effects. However, the amount of sediment deposited into the channel is very large, almost completely filling up the channel. Therefore, the impact of these activities via disturbance of the seabed on the size of barrier islands, sandbanks, channels, mudflats and saltmarshes is *moderate negative*.

The installation of the cable system does not lead to any significant changes in freshwater inflow from rivers or canals into the Wadden Sea. Furthermore, the processes that cause mixing of water with different salinities are not significantly altered so that there is no significant effect on the surface area of regions with salt gradients. The activities do not affect the rate of sea level rise and have no significant effect on the ability of the UNESCO area and its tidal basins to respond to sea level rise. Finally, the activities have no significant effect on the size of the tidal basins, ebb tidal deltas, salt marshes or shallow coastal zones, where sediment is deposited. Therefore, the impact of the activities on these attributes is *neutral*.

Impact on OUV ix) ecological processes
For all variants the installation of the cable system a HDD will be used from the mainland to cross the primary dike and salt marsh, where it emerges onto the mudflat. The presence of the exit point causes local destruction of benthic live. From the exit point a trencher will be used to bury the cable system in the intertidal flats. The trencher is crossing areas with a high number of species living in or on top of the mudflats, like sea grass and shellfish banks. These mudflats are also important foraging areas for birds (Soudijn *et al*., 2022). Two mitigation measures are in prospect to reduce these effects. Therefore, the effect is scored as a *moderate negative impact.*

For some areas on the route dredging is necessary. For variant A/A1 approximately 268.000 m^3 silt will be dredged during a total of 152 days. The surface area that is affected is large (Figure 5.7) and the increase of turbidity will exceed >5 mg/L (absolute numbers) for more than 200 days, of which 135 days have an absolute increase of >50 mg/L and 18 days have an increase of 250 mg/L. For variant A2 approximately 323.600 m m^3 silt will be dredged during a total of 181 days. The surface area that is affected is large and the increase of turbidity will exceed 5 mg/L (absolute numbers) for more than 200 days, of which 169 days have an absolute increase of >50 mg/L and 31 days have an absolute increase of 250 mg/L. The turbidity effects of variant A2 are stronger than the effects of variant A/A1. However, both routes have significant negative effects on primary production, typical species (like shellfish living on the sea floor) and visual hunting birds and fish. There are no mitigation measures in sight to reduce these effects. Therefore, the effect of this activity via turbidity is scored as a major negative impact.

Figure 5.7 Maximum percentage of relative increase of the daily average background concentration during the simulation of the installation of the cable system on the V: Boschgat route variant A/A1 (Mustafa & van Engelen, 2024)



As a result of the dredging activities, sedimentation will take place in nearby gullies. The sediment layer will have a thickness between 3.3- 7.5 m for all variants. Because of the relatively large surface area at some locations, typical species (Baltic tallin, sea grass, cockle, mussel) could be smothered and not survive (Rozemeijer & Smith, 2017), and the habitat of fish is negatively affected. The effects of sedimentation cannot be mitigated. Therefore, the effects of sedimentation are scored as a *major negative impact*.

The activities and associated shipping traffic cause an increase in underwater sound and vibrations. Fish and fish-eating birds typically demonstrate avoidance behaviour as a result of continuous sound, (Weilgart et al., 2018; Anderson Hansen et al., 2020), while the settlement and growth of invertebrates can be negatively affected by this kind of disturbance (Cervello et al., 2023; Olivier et al., 2023). Therefore, underwater sound and vibrations as a result of the activities has a *minor negative impact*.

The use of ships, dredging and drilling causes above water sound and vibrations, optical disturbance and an increase in the use of artificial light. Mitigation measures are in prospect that can potentially reduce these effects for breeding and non-breeding birds (paragraph 4.3.1). Therefore, this impact is scored as a *moderate negative impact*.

Impact on OUV x) biodiversity

Organisms living in on or top of the tidal flats (benthos and sea grass) will be negatively affected by the change of sediment dynamics as a result of the HDD-exit point and trenching (van der Heide et al., 2007; Rozemeijer & Smith, 2017). Consequently, the food supply for birds living on the tidal flats and fattening areas for migratory birds will be affected (Soudijn et al., 2022). This counts for example for the ringed plover, dunlin, red knot, ruddy turnstone, common redshank, Eurasian curlew, grey plover and spotted redshank which have a strong dependency on the Wadden Sea. Mitigation measures are in prospect to limit these effects. Therefore, these effects via change in substrate dynamics are scored as a *moderate negative impact*.

Dredging causes effects via turbidity on shellfish (Compton et al., 2017), fish-eating birds (Darby et al., 2022),and fish (Tulp et al., 2022), living in marine and brackish areas (see impact on OUV ix) ecological processes for an explanation). There is a mitigation measure in sight to reduce the effects of turbidity. Therefore, effects of turbidity are scored as *moderate negative* effects.

In addition, dredged sediment will be deposited on gullies, the large amount of sediment will almost fill the gullies, smothering potential species that live on the seafloor, and restricting the flow of water in the gullies on low tide. This also negative effects on the habitat of mammals and fish. Therefore, effects of turbidity and sedimentation on associated biodiversity attributes are scored as *a major negative impact* for most attributes. However, there are is a mitigation measures in sight for non-breeding birds. Therefore, for non-breeding (migratory) birds the effect of turbidity is scored as a *moderate negative impact*.

Dredging, drilling and the sound of ship engines generates underwater sound and vibrations that can negatively affect marine mammals, such as seals and harbour porpoises (Erbe et al., 2019). Mammals are extremely sensitive for underwater sound and vibrations (Mikkelsen et al., 2019; Schaffeld et al., 2022). Additionally, resting seals suffer from above water sound and vibrations, optical disturbance and light (Erbe et al., 2019). The route crosses an area that is very important for seals. Currently, there are no mitigation measures in prospect to reduce these effects. Therefore, the impact of under and above water sound and vibrations, and optical disturbance and light on mammals living in marine and brackish water areas are evaluated as *major negative*. negatively affect marine mammals, such as seals and harbour porpoises (Erbe et al., 2019). Mammals are extremely sensitive for underwater sound and vibrations (Mikkelsen et al., 2019; Schaffeld et al., 2022). Additionally, resting seals suffer from above water sound and vibrations, optical disturbance and light (Erbe et al., 2019). The route crosses an area that is very important for seals. Currently, there are no mitigation measures in prospect to reduce these effects. Therefore, the impact of under and above water sound and vibrations, and optical disturbance and light on mammals living in marine and brackish water areas are evaluated as *major negative*.

he above menstioned effects affect breeding birds (for example on the salt marsh), birds on high tide roosts and the tranquility for birds (Kleijn, 2008). Of the migratory bird species with a strong dependency of the Wadden Sea (van Roomen et al., 2002) multiple species use the high tide roosts in the vicinity of this route. The appropriate assessment indicates that mitigation measures are needed to avoid disturbance of pied avocet, eider, ringed plover, lesser black-backed gull. common tern, Eurasian curlew and spotted redshank. To reduce the effects of above water sound and vibrations, light and optical disturbance multiple mitigation measures are in prospect for birds. Therefore, these effects are scores *as moderative negative impacts* for attributes including birds.

During the operational phase, electromagnetic fields of cable systems can cause behavioural changes in fish, especially elasmobranch species (Bedore & Kajiura, 2013; Taormina, et al., 2018). The tope shark uses the Wadden Sea as nursery ground. Also shark behaviour can be affected by electromagnetic fields. Therefore, this is considered a *minor negative effect* for species living in marine and brackish areas.

Impact on integrity

Does the route interrupt the natural dynamics and interconnectedness of the morphological elements of the Wadden Sea?

Geological processes are directly, temporarily impacted by proposed installation techniques for the cable system. This has a *moderate negative impact* on the integrity of the heritage site as it will not permanently alter the key interrelated and interdependent elements in their natural relationships.

Does the route have negative effects on species, habitats, and processes?

The negative effects of trenching on seagrass, benthic species and bird habitat (foraging grounds) can be potentially mitigated by avoiding locations with high ecological value (hotspots). Turbidity and sedimentation as a result of dredging activities have the largest impact on species, habitats and processes (Candolin & Rahman 2023; Rippen et al., 2020; Royal HaskoningDHV, 2021). The enormous amount of dredged sediment will lead to a significant increase in turbidity in all variants. This negatively impacts primary production in the area because sunlight is obscured, which can limit algae growth. This affects primary production (biomass from algae) and secondary production (biomass created by benthic organisms). As the base of the food web is negatively impacted, it also has consequences for higher levels in the food web (fish, birds, marine mammals). Dredged sediment will be deposited on nearby gullies, with a high risk of smothering typical species. In addition, the habitat of mammals is negatively affected by the thick layer of sediment. Sound (above and below water), light and optical disturbance associated with the activities will cause negative effects on especially seals. Currently, there are no mitigation measures in sight to reduce these effects. In addition, electromagnetic fields can affect the swimway of some fish species who are sensitive to this (Nyqvist et al., 2020; Hutchison et al., 2020a; Hermans & Schilt, 2024, in prep.). For birds, mitigation measures are prospected. Regarding the effects on species, habitats and processes, impacts on the integrity of the Wadden Sea heritage site are *major negative* on this route.

Does the route affect elements that are essential to the migratory path of birds?
Fattening areas of migratory birds will be especially affected by the dredging activities. Visual hunting birds (e.g., species of ducks and terns) may find it harder to locate and catch prey (Tulp et al., 2022). To reduce the effects of turbidity on non-breeding birds a mitigation measure is in prospect. Shellfish growth and survival can be hampered in high turbid waters (Glorius, 2018; Glorius & Meijboom, 2020; Rippen et al., 2020), especially when turbidity levels are relatively high during a long period of time. This might lead to local food reductions for birds, while this area is known for its rich foraging grounds. However, a mitigation measure is in prospect to reduce these effects. Above water sound and vibrations, light and optical disturbance can also affect foraging and resting migrating birds (Kleijn, 2008). However, multiple mitigation measures are in prospect that can reduce these effects. Regarding migratory birds, the impact on integrity of the Waden Sea heritage is *major negative* on this route.

Does the route affect breeding areas?
Above water sound and vibrations, optical disturbance and light can disturb the tranquility of breeding birds (Krijgsveld et al., 2022). A mitigation measure is in sight to reduce these effects. Regarding breeding areas, the impact on integrity of the Wadden Sea heritage site is *major negative* on this route.

Table 5.3 Evaluation of the impact of the V: Boschgat route variants A/A1/A2

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
viii) geological processes	Size of barrier islands, sandbanks, channels, mudflats and saltmarshes	Disturbance of seabed (change in seabed level, substrate dynamics, wave and current dynamics)	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
	Amount of river discharge	Change in fresh water inflow and current velocities	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Surface area of regions with salt gradients	Changes in fresh water inflow an/or mixing of waters with different salinity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Rate of sea level rise	Large scale effect on water levels or ability of tidal basin to respond to sea level rise	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Size of the area where sediment is deposited	Change in area of tidal basin, ebb tidal delta or shallow coastal zone	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
ix) ecological processes	Primary production	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
	Production by animals, from shellfish to marine mammals	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
	Numbers of fish, shellfish and birds	Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Major negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Major negative impact
		Presence of electromagnetic fields	Once	Long-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Food availability for fish, shellfish and birds	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Major negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Major negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Number of species (plants and animals) occurring in marine and brackish water areas	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Electromagnetic fields	Once	Long-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	Number of species of breeding birds	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
	Fattening areas for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	Roosting areas for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
	Food supply for migratory birds	Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Tranquility for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Minor negative impact
	Relative importance of	Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Major negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	the Wadden Sea for population sizes of migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Minor negative impact
Integrity	viii) geological processes	Effects on interconnectedness of the morphological elements								Moderate negative impact
	ix) ecological processes	Effects on species, habitats, and processes								Major negative impact
		Effects on migratory path of birds								Major negative impact
	x) biodiversity	Effects on breeding areas								Major negative impact

5.1.4 VII: Schiermonnikoog Wantij route - cable system (variant A and A1)

This route offers two variants for a cable system and one for a pipeline. This paragraph sets out the effects of a cable system on this route. The VII: Schiermonnikoog Wantij route A and A1 for a cable system diverges outside the heritage site, so they are not assessed separately in this report.

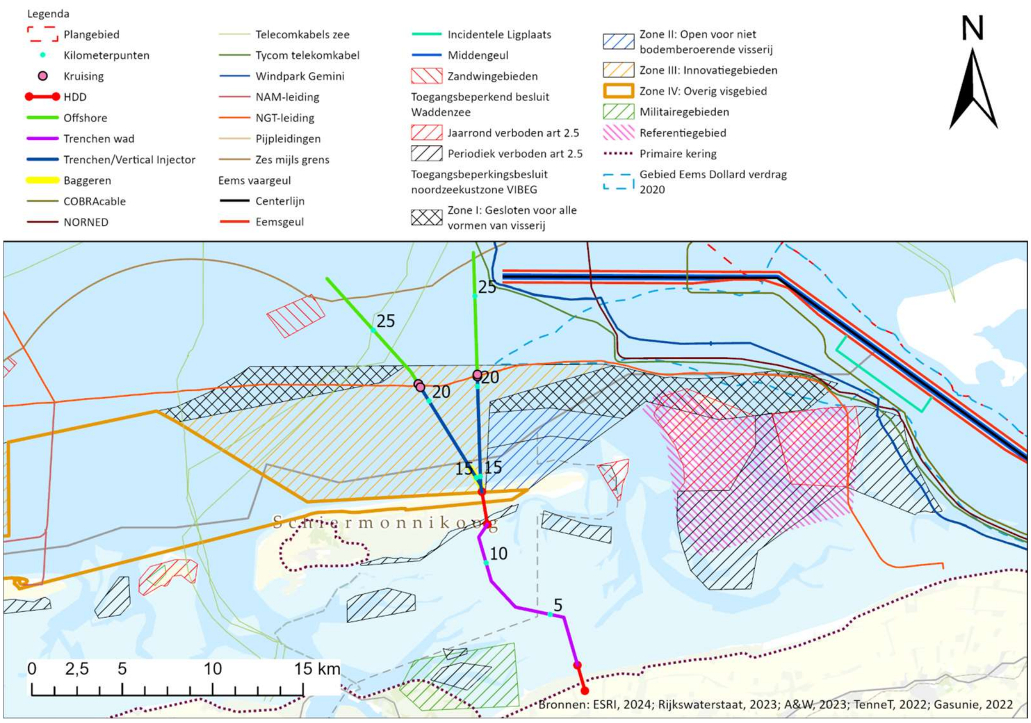
Activities

The activities taking place at the VII: Schiermonnikoog Wantij route for cable system variant A and A1 are (see Figure 5.8)

- HDD (under the primary dike and the island of Schiermonnikoog); and installation of entry points for the HDD.
- Installation of cable system using a tidal flat trencher (on shallow tidal flats).
- Installation of cable system with floating equipment and trencher/vertical injector (outside of UNESCO site, north of Schiermonnikoog).
- Dredging (to make access trench for installation vessels).
- Increased number of ships and ship movements during installation.

Over the whole trajectory (North Sea and Wadden Sea) cable systems are buried in the sediment at depths between 1 m and 12 m depending on the exact location.

Figure 5.8 Proposed activities for cable system installation on the VII: Schiermonnikoog Wantij route



Evaluation of impacts

Table 5.4 gives an overview of the evaluation of impact on each attribute. The impact on each OUV of the Wadden Sea are discussed below.

Impact on OUV viii) geological processes

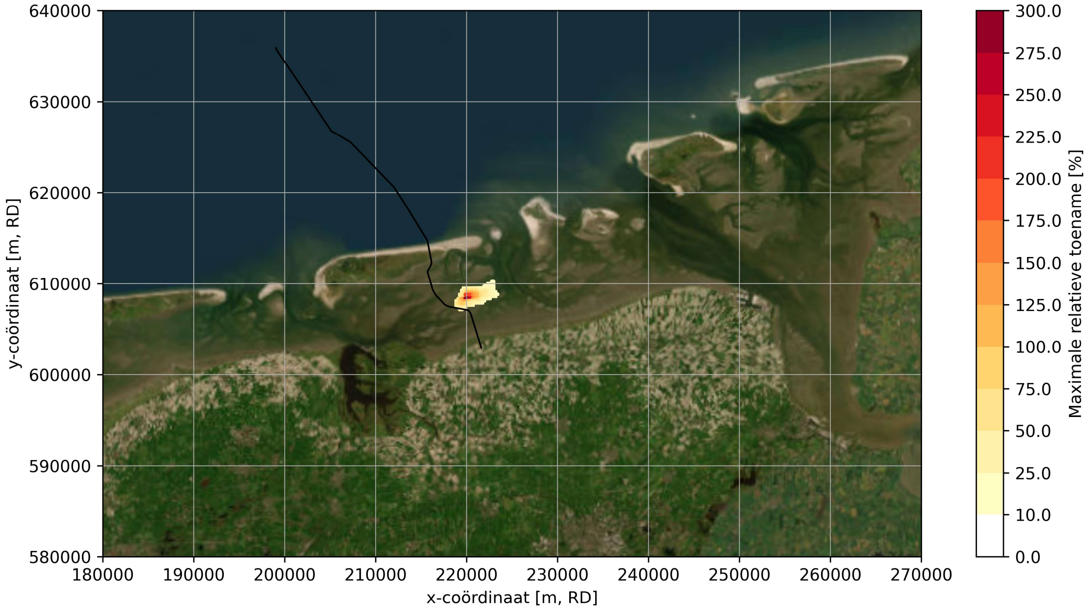
A wad trencher is used to install the cable system on shallow tidal flats. This has minor negative impact because the impacted area is small and will recover fast because of natural dynamics. HDD is used to install the cable system under the primary dike and the island of Schiermonnikoog. An access pit is being dug on a mudflat. The pit is of limited size and will be filled up after usage. This has negligible impact on the quality of the mudflat. A trencher/vertical injector is used to install the cable system north of Schiermonnikoog. North of Schiermonnikoog, an access channel will be dredged so that the cable system installation vessel can arrive in closer vicinity to the coast. This will remain visible for several years before the trench is naturally filled up. So, North of Schiermonnikoog, the effects are relatively long-lasting, but these effects only affect a small portion of the overall route. Therefore, the impact of these activities via disturbance of the seabed on the size of barrier islands, sandbanks, channels, mudflats and saltmarshes is *minor negative*.

The installation of the cable system does not lead to any significant changes in freshwater inflow from rivers or canals into the Wadden Sea. Furthermore, the processes that cause mixing of water with different salinities are not significantly altered so that there is no significant effect on the surface area of regions with salt gradients. The activities do not affect the rate of sea level rise and have no significant effect on the ability of the UNESCO area and its tidal basins to respond to sea level rise. Finally, the activities have no significant effect on the size of the tidal basins, ebb tidal deltas, salt marshes or shallow coastal zones, where sediment is deposited. Therefore, the impact of the activities on these attributes is *neutral*.

Impact on OUV ix) ecological processes
For the installation of the cable system a HDD will be used from the mainland to cross the primary dike and salt marsh, where it emerges onto the mudflat. In addition, HDD will be used to lead the cable system underneath Schiermonnikoog. The entry and exit points need to be excavated and causes changes in sediment dynamics that have a negative impact on local benthic live (Glorius, 2018; Glorius & Meijboom, 2020; Rippen et al., 2020). A trencher will be used to bury the cable system in the intertidal flats. The route over the intertidal flats is crossing areas with a high number of species living in or on top of the mudflats, like sea grass and shellfish. These mudflats are also important foraging areas for birds. Mitigation measures are in prospect to reduce the effects of changes in substrate dynamics (see paragraph 4.3.3.). Therefore, the effect is scored as a *moderate negative impact.*

For some locations on the route dredging is necessary. Approximately 300 m^3 silt will be dredged during a total of 40 days. The surface area that is affected is relatively small (Figure 5.9) and the increase of turbidity will exceed 5 mg/L (absolute numbers) for 42 days, of which 20 days have an absolute increase of >50 mg/L and 7 days have an absolute increase of 250 mg/L. This could potentially affect primary production, benthos (like shellfish living on the sea floor) and visual hunting birds and fish. However, because of the small affected surface area, the short duration of turbidity and the relative low levels of turbidity opposed to the background concentrations, the effect is scored as a *minor negative impact*.

Figure 5.9 Maximum percentage of relative increase of the daily average background concentration during the simulation of the installation of the cable system on the VII: Schiermonnikoog Wantij route. For the installation of this cable system three of these access channels need to be dug, this is the simulation of the average one (Mustafa & van Engelen, 2024)



As a result of the dredging activities, sedimentation will take place in nearby gullies of the Wadden Sea. The sediment layer will have a thickness between 1.7- 2.5 m and will cover a relatively small surface area, where typical species (Baltic tallin, sea grass, cockle, mussel) could be smothered and probably will not survive (Rippen et al., 2020). However, mitigation measures are in prospect to reduce these effects. Therefore, the effects of sedimentation are scored as a *moderate negative impact*.

Over the largest part of the route the cable system will be buried during low tide with the trencher. Material will be transported via vessels to accessible gullies. The number of vessels needed is marginal for this route. Consequently, the amount of underwater sound and vibrations that is produced is also minimal. Therefore, underwater sound and vibrations as a result of the activities is scored *as a minor negative impact*.

The use of ships, trenching, dredging and drilling cause above water sound and vibrations, optical disturbance and an increase in the use of artificial light. Multiple bird species make use of the high tide roosts in the vicinity of the route. Multiple mitigation measures for breeding and non-breeding birds are in prospect to reduce these effects (paragraph 4.3.3). Therefore, this impact was scored as a *moderate negative effect*.

Impact on OUV x) biodiversity

Organisms living in or on top of the tidal flats (benthos and sea grass) will be negatively affected by the change of sediment dynamics as a result of the HDD entry and exit points and trenching. Consequently, the food supply for birds living on the tidal flats and fattening areas for migratory birds will be affected (Candolin & Rahman 2023). This counts for example for the ringed plover, dunlin, red knot, Eurasian oystercatcher, ruddy turnstone, common redshank, Eurasian curlew, grey plover and spotted redshank which have a strong dependency on the Wadden Sea. However, mitigation measures are in sight that can reduce these effects (see paragraph 4.3.3). Therefore, these effects via change in substrate dynamics are scored as a *moderate negative impact*.

Dredging can cause effects via turbidity on shellfish (Compton et al.,2017), fish-eating birds (Darby et al., 2022), fish (Tulp et al., 2022), and mammals living in marine and brackish areas that can cascade down the food web. However, the amount of dredged and sediment is marginal, the affected surface area is relatively small, and the effects are temporal. Therefore, the impact of dredging via turbidity on associated biodiversity attributes is scored as a *minor negative impact.*

Dredged sediment that is deposited in nearby gullies can smother seagrass, shellfish and other benthic species(Glorius, 2018; Glorius & Meijboom, 2020; Rippen et al., 2020). Shellfish and benthic species important food sources for birds. However, mitigation measures are in prospect that can reduce these effects. Therefore, the impact of sedimentation is scored as a *moderate negative impact.*

The number of vessels used on this route is limited. Resulting in only a small increase in underwater sound and vibrations, which has a marginal impact on mammals (Erbe et al., 2019), benthos, (Cervello et al., 2023; Olivier et al., 2023). and birds. Therefore, the effect of underwater sound and vibrations is scored as a *minor negative impact*.

Most of the above water sound and vibrations, light and optical disturbance is produced during work activities at low tide (HDD, excavations, etc.). These activities can disturb seals on the haul-out sites. However, the relative importance of this area for seals is low. During the reproductive season and seals' shedding period (sensitive season), it is important that seals are not disturbed (Cremer et al., 2017). However, a mitigation measure is in prospect to reduce these effects. Therefore, the impact of these disturbance effects is scored as a *moderate negative impact*.

The activities also cause above water sound and vibrations, optical disturbance and an increase in the use of artificial light. This can affect breeding birds (for example on the salt marsh), birds on high tide roosts and the tranquility for birds (Kleijn, 2008). Of the migratory bird species with a strong dependency of the Wadden Sea (van Roomen et al., 2002), multiple species use the high tide roosts in the vicinity of this route. The appropriate assessment indicates that mitigation measures are needed to avoid disturbance of the pied avocet, lesser black-backed gull, common tern, Eurasian spoonbill, common greenshank, northern pintail, brent geese, common redshank, Eurasian curlew, spotted redshank. These mitigation measures in prospect to limit disturbance of birds. Therefore, disturbance effects for bird attributes have been scored as *moderative negative impacts.*

During the operational phase, electromagnetic fields of cable systems can cause behavioural changes in fish, especially elasmobranch species (Bedore & Kajiura, 2013; Taormina, et al., 2018). The tope shark uses the Wadden Sea as a nursery ground. Also shark behaviour can be affected by electromagnetic fields. Therefore, this is considered a *minor negative impact* for species living in marine and brackish areas.

Impact on integrity

Does the route interrupt the natural dynamics and interconnectedness of the morphological elements of the Wadden Sea?

Geological processes are directly, temporarily impacted by proposed installation techniques for the cable system, especially dredging and trenching. This has a *minor negative impact* on the integrity of the heritage site as it will not permanently alter the key interrelated and interdependent elements in their natural relationships.

Does the route have negative effects on species, habitats, and processes?

The negative effects of trenching on seagrass, benthic species and bird habitat (foraging grounds) can be reduced by avoiding locations with high ecological value (hotspots). Turbidity as a result of dredging activities has a small impact on species, habitats and processes (Candolin & Rahman 2023; Rippen et al., 2020; Royal HaskoningDHV, 2021). The volume of dredged sediment is relatively small, resulting in a marginal affected area and only temporal turbidity effects, which only very locally can cause minimal effects on primary and secondary production. Dredged sediment is spread in nearby gullies where it can affect the survival of benthic species. However, a mitigation measure is in sight to reduce this effect. Underwater sound and vibrations produced by ships are not substantial on this route and habitats of fish and mammals largely remain undisturbed. Sound, light and optical disturbance associated with the activities will cause negative effects on especially seals and birds. However, various mitigation measures to reduce effects on birds and seals are in prospect. Finally, electromagnetic fields can affect the swimway of some fish species who are sensitive to this (Nyqvist et al., 2020; Hutchison et al., 2020a; Hermans & Schilt, 2024, in prep.). Regarding the effects on species, habitats and processes, impacts on the integrity of the Wadden Sea heritage site are *moderate negative* for this route.

Does the route affect elements that are essential to the migratory path of birds?
Fattening areas of migratory birds will be mostly affected by trenching, as the route is projected on a valuable foraging area for birds. However, a mitigation measure is in prospect to reduce these effects. HDD drilling and trenching causes above water sound and vibrations, optical and light disturbance that can impact resting and foraging migratory birds. However, various mitigation measures are in prospect that can reduce these disturbance effects. Regarding migratory birds, the impact on integrity of the Wadden Sea heritage is *moderate negative* for this route.

Does the route affect breeding areas?
Above water sound and vibrations, optical disturbance and light can disturb the tranquility of breeding birds (Krijgsveld et al., 2022). However, a mitigation measure is in sight to reduce these effects. Regarding breeding areas, the impact on integrity of the Wadden Sea heritage site is *moderate negative* for this route.

Table 5.4 Evaluation of the impact of the VII: Schiermonnikoog Wantij route - cable system (variant A and A1)

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
viii) geological processes	Size of barrier islands, sand-banks, channels, mudflats and saltmarshes	Disturbance of sea-bed (change in sea-bed level, substrate dynamics, wave and current dynamics)	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Amount of river discharge	Change in fresh water inflow and current velocities	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Surface area of regions with salt gradients	Changes in fresh water inflow an/or mixing of waters with different salinity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Rate of sea level rise	Large scale effect on water levels or ability of tidal basin to respond to sea level rise	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Size of the area where sediment is deposited	Change in area of tidal basin, ebb tidal delta or shallow coastal zone	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
ix) ecological processes	Primary production	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Production by animals, from shellfish to marine mammals	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
	Numbers of fish, shellfish and birds	Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Presence of electromagnetic fields	Once	Long-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Food availability for fish, shellfish and birds	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Number of species (plants and animals)	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	occurring in marine and brackish water areas									
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Presence of electromagnetic fields	Once	Long-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Number of species of breeding birds	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Fattening areas for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Roosting areas for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Irreversible	Temporary	Some change	Negative	Moderate negative impact
	Food supply for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Tranquility for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Relative importance of the Wadden Sea for population sizes of migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some to large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
Integrity	viii) geological processes	Effects on interconnectedness of the morphological elements								Minor negative impact
	ix) ecological processes	Effects on species, habitats, and processes								Moderate negative impact
		Effects on migratory path of birds								Moderate negative impact
	x) biodiversity	Effects on breeding areas								Moderate negative impact

5.1.5 VII: Schiermonnikoog Wantij route - pipeline

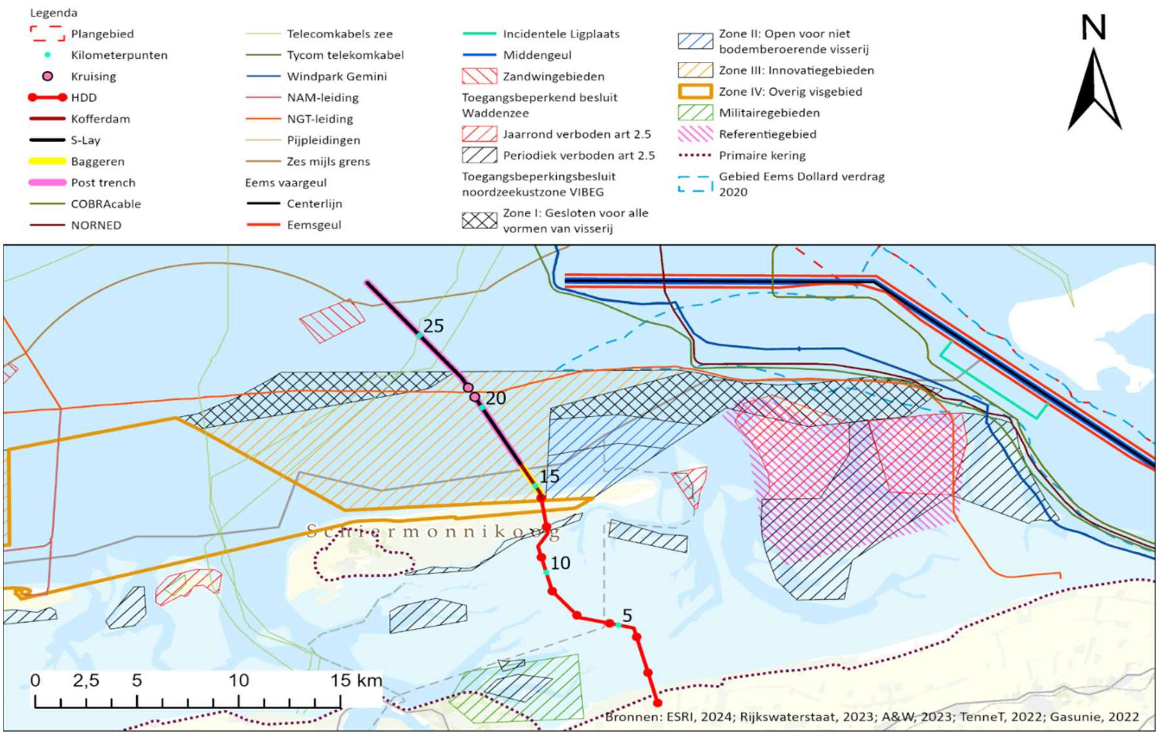
This route concerns the installation of a pipeline.

Activities

The activities taking place along the VII: Schiermonnikoog Wantij route for installing the pipeline are (see Figure 5.10):

- HDD to cross tidal flat between Groningen and Schiermonnikoog and pass under island Schiermonnikoog; including installation of (eight) entry points for the HDD.
- Increased number of movements of vehicles on the tidal flat during low tide, during installation.
- Open excavation and cofferdam to bury the pipeline at depth north of Schiermonnikoog.
- S-lay technique to install the pipeline.
- Dredging to achieve access trench for installation vessels.

Figure 5.10 Proposed activities for pipeline installation on the VII: Schiermonnikoog Wantij route



Evaluation of impacts

Table 5.5 gives an overview of the evaluation of impact on each attribute. The impact on each OUV of the Wadden Sea are discussed below.

Impact on OUV viii) geological processes

Multiple HDDs are used to cross the tidal flat between Groningen and Schiermonnikoog, to pass the pipeline under the island Schiermonnikoog and cross the primary dike at the northern side of Schiermonnikoog. This will be done in sections. In total, eight access pits will be excavated. These pits are small and will be filled up afterwards, so do not alter the size or quality of coastal or sedimentary features. The effect of using HDD for the installation of pipelines on this route is therefore negligible. Open excavation and a cofferdam are used to bury the pipelines at depth north of Schiermonnikoog. Sand will be dredged, and a vessel will be used to lay the pipeline. The presence of the cofferdam is expected to lead to erosion of the coastline on the east side and sedimentation on the west side. During the storm season, sediment will naturally redistribute. The trench will be replenished after the pipeline is installed. Therefore, the impact of these activities via disturbance of the seabed on the size of barrier islands, sandbanks, channels, mudflats and saltmarshes is *minor negative*.

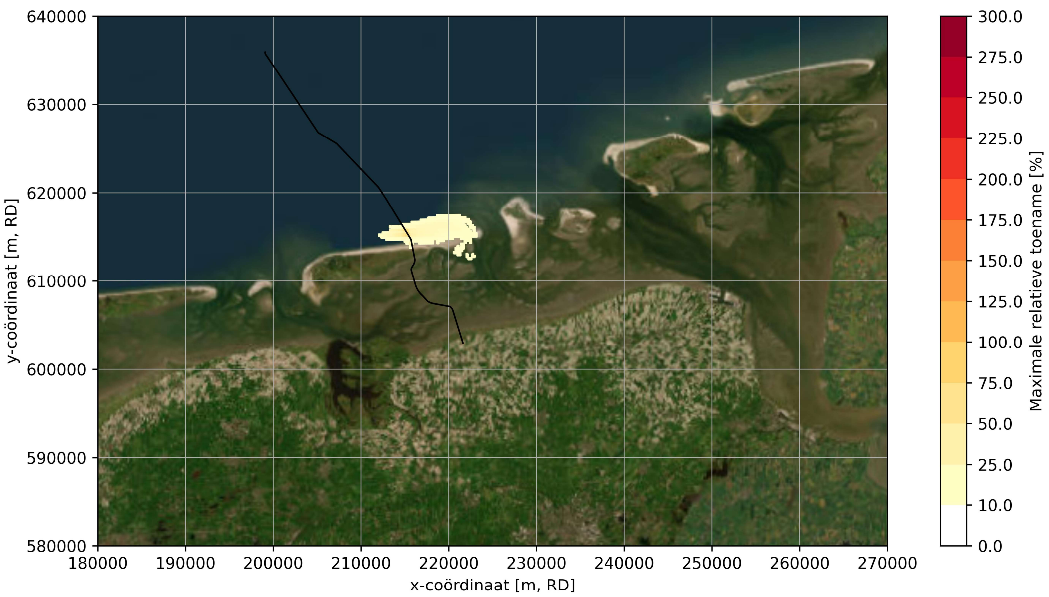
The installation of the pipeline system does not lead to any significant changes in freshwater inflow from rivers or canals into the Wadden Sea. Furthermore, the processes that cause mixing of water with different salinities are not significantly altered so that there is no significant effect on the surface area of regions with salt gradients. The activities do not affect the rate of sea level rise and have no significant effect on the ability of the UNESCO area and its tidal basins to respond to sea level rise. Finally, the activities have no significant effect on the size of the tidal basins, ebb tidal deltas, salt marshes or shallow coastal zones, where sediment is deposited. Therefore, the impact of the activities on these attributes is *neutral*.

Impact on OUV ix) ecological processes

For the installation of the pipeline a series of HDDs will be used from the mainland to the North Sea, crossing the tidal flats and Schiermonnikoog. Eight entry and exit points need to be excavated. The extend of disruption of benthic life depends on the exact location of this HDD entry and exit points. Seagrasses, shellfish beds and typical mudflat species are present in the area, representing a rich foraging ground for birds. Mitigation measures are in prospect to limit effects of changes in substrate dynamics on typical species and non-breeding birds. Therefore, the effect (change in substrate dynamics) is scored as a *moderate negative impact.*

Dredging will be needed for the access of installation vessels. Approximately 2.500 m^3 silt will be dredged during a total of 10 days. The surface area that is affected is relatively small (Figure 5.11) and the increase of turbidity will exceed 5 mg/L (absolute numbers) for 12 days, in which concentrations will not be higher than 50 mg/L. Most of the turbidity will occur in the North Sea coastal zone. Because of the small affected surface area, the short duration of turbidity, the relative low levels of turbidity opposed to the background concentrations, and the location of the turbidity, the effect on primary production, benthos and birds will be small. Therefore, the effect is scored as a *minor negative impact*.

Figure 5.11 Maximum percentage of relative increase of the daily average background concentration during the simulation of the installation of the pipeline on the VII: Schiermonnikoog Wantij route (Mustafa & van Engelen, 2024)



As a result of the dredging activities, sedimentation will take place in the North Sea coastal zone, outside the boundary of the Wadden Sea World Heritage. This could have negative effects on local species, but these fall outside of the spatial scope of this HIA. Therefore, the effect of sedimentation is scored as *neutral*.

The building of HDD entry and exit points in the Wadden Sea will be done during low tide. Therefore, the effects of underwater sound and vibrations are scored as *neutral*. In the North Sea coastal zone also trenching will take place, which produces extra underwater sound and vibrations. However, these effects fall outside the spatial scope of this HIA.

The use of HDD and excavations of entry and exit points cause above water sound and vibrations, optical disturbance and an increase in the use of artificial light. Multiple bird species make use of the high tide roosts in the vicinity of the route. Multiple mitigation measures are in sight to reduce these effects for breeding and non-breeding birds. Therefore, these effects are scored as a *moderate negative impact*.

Impact on OUV x) biodiversity

Organisms living in or on top of the tidal flats (benthos and sea grass) will be negatively affected by the change of sediment dynamics as a result of the HDD entry and exit points (Glorius, 2018; Glorius & Meijboom, 2020; Rippen et al., 2020). Consequently, the food supply for birds living on the tidal flats and fattening areas for migratory birds will be locally affected (see Chapter 5.1.5). Mitigation measures are in prospect to reduce these effects. Therefore, these effects via changes in substrate dynamics are scored as a *moderate negative impact*.

Dredging can cause effects via turbidity on shellfish (Compton et al.,2017), fish-eating birds (Darby et al., 2022), fish (Tulp et al., 2022), and mammals living in marine and brackish areas that can cascade down the food web. However, the amount of dredged material and sediment is marginal, the affected surface area is relatively small, the effects are temporal and occur mostly in the North Sea coastal zone. Therefore, the impact of dredging via turbidity on associated biodiversity attributes is scored as a *minor negative impact*.

The dredged sediment is deposited in the North Sea coastal zone, outside the boarder of the Word heritage site. Therefore, the impact of sedimentation is scored as *neutral*.

The number of vessels used on this route is limited, because of the use of HDDs during low tide. As a result, the increase of underwater sound and vibrations is negligible, and the habitat of fish and mammals is not affected in the Wadden Sea. Therefore, the impact of underwater sound and vibrations is scored as *neutral*. The effects of underwater sound are more severe in the North Sea coastal zone, but this area falls outside the boarder of the Wadden Sea World Heritage.

Most of the above water sound and vibrations, light and optical disturbance is produced by the HDD and the trencher during work activities at low tide. These activities can disturb seals on the haul-out sites that are crossed by this route. However, the relative importance of this area for seals is low. During the reproductive season and seals' shedding period (sensitive season), it is important that seals are not disturbed (Cremer et al., 2017). Outside the sensitive season seals can more easily locate to different haul-out sites areas. However, it is not possible to avoid working activities during the sensitive season for seals as there are no mitigation measures in sight. Therefore, the impact of these disturbance effects is scored as a *major negative impact*.

The activities also cause above water sound and vibrations, optical disturbance and an increase in the use of artificial light. This can affect breeding birds (for example on the salt marsh), birds on high tide roosts and the tranquility for birds (Kleijn, 2008). Of the migratory bird species with a strong dependency of the Wadden Sea (van Roomen et al., 2002), multiple species use the high tide roosts in the vicinity of this route. The appropriate assessment indicates that mitigation measures are needed to avoid disturbance of the pied avocet, lesser black-backed gull, common tern, Eurasian spoonbill, common greenshank, northern pintail, brent geese, common redshank, Eurasian curlew, spotted redshank. There are mitigation measures in prospect to limit disturbance of birds. Therefore, disturbance effects for bird attributes have been scored as *moderative negative impacts*.

Impact on integrity

Does the route interrupt the natural dynamics and interconnectedness of the morphological elements of the Wadden Sea?

Geological processes will be temporarily impacted by proposed installation techniques for the cable system on this route. This has a *minor negative impact* on the integrity of the heritage site as it will not permanently alter the key interrelated and interdependent elements in their natural relationships.

Does the route have negative effects on species, habitats, and processes?

Changes in sediments can cause negative effects on seagrass, benthic species and bird habitat (foraging grounds) (Rippen et al., 2020; van der Heide et al., 2007). However, mitigation measures are in prospect to reduce these effects. Turbidity as a result of dredging activities has a small impact on species, habitats and processes (Candolin & Rahman 2023; Rippen et al., 2020; Royal HaskoningDHV, 2021). The volume of dredged sediment is relatively small, resulting in a marginal affected area and only temporal turbidity effects, which can only very locally cause minimal effects on primary and secondary production (mostly in the coastal zone). Dredged sediment is spread outside the Wadden Sea heritage site, with no effects on species and habitats in the Wadden Sea. Underwater sound and vibrations produced by HDD is limited, as working activities take place during low tide. Sound, light and optical disturbance associated with the activities will cause negative effects on especially seals (Cremer et al., 2017) and birds (Kleijn, 2008). While various mitigation measures are prospected for birds, disturbance of seals cannot be mitigated. Regarding species, habitats and processes, impacts on the integrity of the Wadden Sea heritage site are *major negative* for this route.

Does the route affect elements that are essential to the migratory path of birds?

Fattening areas of migratory birds will be mostly affected by HDD entry and exit points, as the route is projected on a valuable foraging area for birds (Soudijn et al., 2022).. However, a mitigation measure is in prospect to reduce these effects. HDD drilling and excavations of entry and exit points cause above water sound and vibrations, optical and light disturbance that can impact resting and foraging areas of migratory birds. However, various mitigation measures are in prospect to reduce these disturbance effects. Regarding migratory birds, the impact on integrity of the Wadden Sea heritage is *moderate negative* for this route.

Does the route affect breeding areas?

Above water sound and vibrations, optical disturbance and light can disturb the tranquility of breeding birds (Krijgsveld et al., 2022). Two mitigation measures are in prospect to reduce these effects. Regarding breeding areas, the impact on integrity of the Wadden Sea heritage site is *moderate negative* for this route

Table 5.5 Evaluation of the impact of the VII: Schiermonnikoog Wantij route - pipeline

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
viii) geological processes	Size of barrier islands, sand-banks, channels, mudflats and saltmarshes	Disturbance of sea-bed (change in sea-bed level, substrate dynamics, wave and current dynamics)	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative impact
	Amount of river discharge	Change in fresh water inflow and current velocities	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Surface area of regions with salt gradients	Changes in fresh water inflow an/or mixing of waters with different salinity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Rate of sea level rise	Large scale effect on water levels or ability of tidal basin to respond to sea level rise	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Size of the area where sediment is deposited	Change in area of tidal basin, ebb tidal delta or shallow coastal zone	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
ix) ecological processes	Primary production	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
	Production by animals, from shellfish to marine mammals	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
	Numbers of fish, shellfish and birds	Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
	Food availability for fish, shellfish and birds	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Number of species (plants and animals) occurring in marine and brackish water areas	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
o		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
		Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Major negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
	Number of species of breeding birds	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
	Fattening areas for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
		Underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
	Roosting areas for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Irreversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Food supply for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Tranquility for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
	Relative importance of the Wadden Sea for population sizes of migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
Integrity	viii) geological processes	Effects on interconnectedness of the morphological elements								Minor negative impact
	ix) ecological processes	Effects on species, habitats, and processes								Major negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Effects on migratory path of birds								Moderate negative impact
	x) biodiversity	Effects on breeding areas								Moderate negative impact

5.1.6 VIII: Ameland Wantij route - pipeline

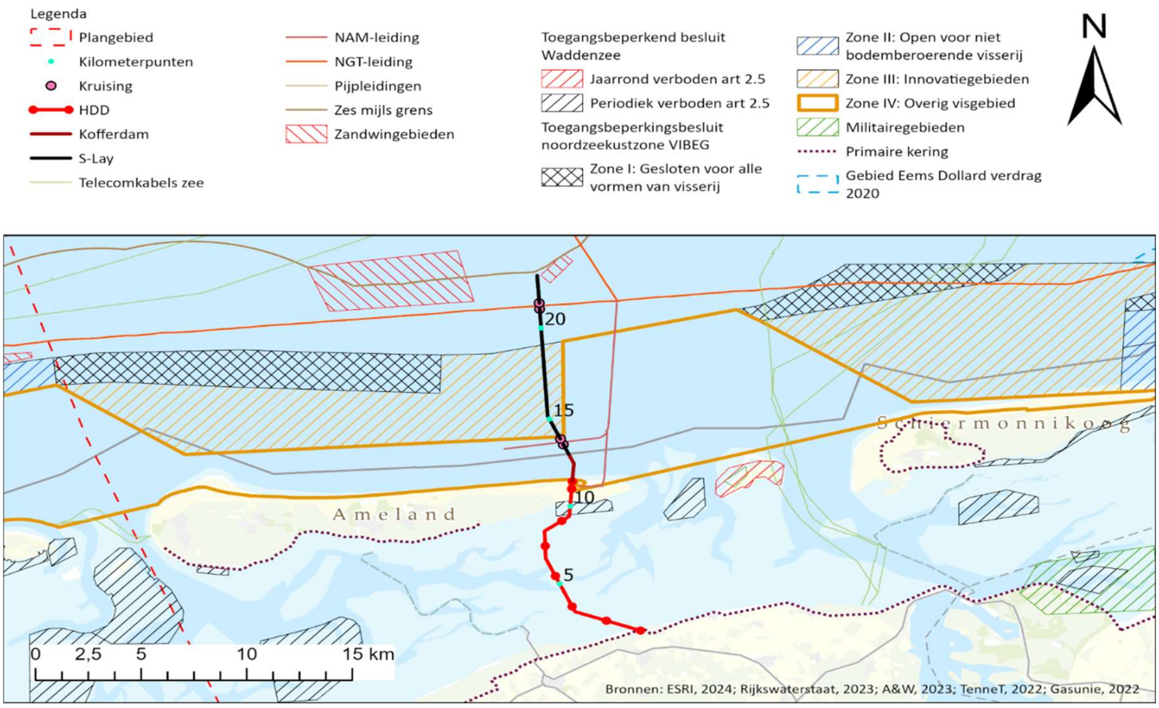
This route concerns the installation of a pipeline.

Activities

The activities taking place at the VIII: Ameland Wantij route for installing pipelines are (see Figure 5.12):

- Installation of a pipeline using HDD to cross tidal flat and pass below the eastern tip of the island of Ameland, including installation of several entry points for the HDD.
- Installation of a pipeline with a pipeline laying vessel with trenching equipment (S-lay technique).
- An open excavation will be created in the surf zone using a cofferdam to bury the pipeline at depth North of Ameland (outside UNESCO site).
- Increased vehicle movements on the tidal flat during low tide, during installation.

Figure 5.12 Proposed activities for pipeline installation on the VIII: Ameland Wantij route



Evaluation of impacts

Table 5.6 gives an overview of the evaluation of impact on each attribute. The impact on each OUV of the Wadden Sea are discussed below.

Impact on OUV viii) geological processes

The difference between this route and the VII: Schiermonnikoog Wantij route are trenching lengths and number of drilled access pits. However, the effects of the proposed actions are comparable. HDD is being used to drill pipelines across tidal flat and under the eastern part of the island Ameland. Drilling will be done in sections. Several access pits will be excavated. These pits are small and will be replenished with sediment after usage, therefore causing a negligible impact on size and quality of tidal flats. An open excavation will be created in the surf zone using a cofferdam to bury the pipeline at depth North of Ameland. Sand will be dredged to allow access to the pipeline installation vessel. The presence of the cofferdam is expected to lead to erosion of the coastline on the east side and sedimentation on the west side. During the storm season, sediment will naturally redistribute. The trench will be replenished after the pipeline is installed. Therefore, the effects of this intervention are expected to be minor negative. A pipeline vessel with trenching equipment (S-lay technique) will be used for burial in deeper waters. Trenching has neutral impact in the deep waters of the North Sea because there are strong waves and strong currents, so because of natural dynamics the geomorphological system will recover quickly. Therefore, the impact of these activities via disturbance of the seabed on the size of barrier islands, sandbanks, channels, mudflats and saltmarshes is *minor negative*.

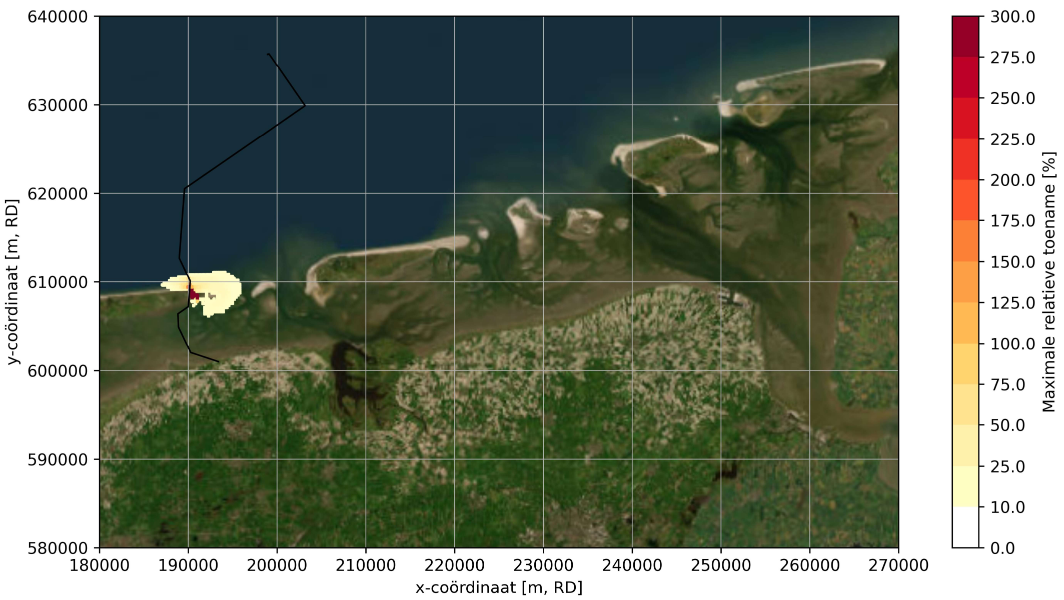
The installation of the pipeline system does not lead to any significant changes in freshwater inflow from rivers or canals into the Wadden Sea. Furthermore, the processes that cause mixing of water with different salinities are not significantly altered so that there is no significant effect on the surface area of regions with salt gradients. The activities do not affect the rate of sea level rise and have no significant effect on the ability of the UNESCO area and its tidal basins to respond to sea level rise. Finally, the activities have no significant effect on the size of the tidal basins, ebb tidal deltas, salt marshes or shallow coastal zones, where sediment is deposited. Therefore, the impact of the activities on these attributes is *neutral*.

Impact on OUV ix) ecological processes

For the installation of the pipeline a series of HDDs will be used from the mainland to the North Sea, crossing the tidal flats and the eastern point of the island of Ameland. Multiple entry and exit points need to be excavated. The extend of disruption of benthic life depends on the exact location of this HDD entry and exit points. Shellfish beds and typical mudflat species are present in the area, although the number of species is lower than the area that the VII: Schiermonnikoog Wantij route is intersecting. Mitigation measures are in prospect to mitigate the effects of changes in substrate dynamics. Therefore, the effect is scored as a *moderate negative impact.*

Dredging will be needed for the access of the pipeline installation vessel. Approximately 3.500 m^3 silt will be dredged during a total of 9 days. The surface area that is affected is relatively small (Figure 5.13) and the absolute increase of turbidity will exceed 5 mg/L for 12 days, of which 11 days concentrations are higher than 50 mg/L and one day concentrations exceed 250 mg/L. Most of the turbidity will occur in the North Sea coastal zone and in the tidal flats (Figure 5.12). Because of the small affected surface area, the short duration of turbidity, the relative low levels of turbidity opposed to the background concentrations, and the location of the turbidity, the effect on primary and secondary production (by benthic organisms) will be small (Taal et al., 2015; Zhao et al., 2019; Tulp et al., 2022; Baptist & Leopold, 2010). Therefore, the effect is scored as a minor negative impact.

Figure 5.13 Maximum percentage of relative increase of the daily average background concentration during the simulation of the installation of the pipeline on the VIII: Ameland Wantij route (Mustafa & van Engelen, 2024)



As a result of the dredging activities, sedimentation will take place in the North Sea coastal zone, outside the boundary of the Wadden Sea World Heritage, where it can have effect on typical species occurring there. No sedimentation will occur in the Wadden Sea, because here only HDDs are used. Therefore, the effect of sedimentation is scored as *neutral*.

The building of HDD entry and exit points will be done in the Wadden Sea during low tide. Therefore, the effects of underwater sound and vibrations are scored as *neutral*. In the North Sea coastal zone trenching and the presence of vessels can cause an increase in underwater sound and vibrations, but this effect falls outside the scope of this HIA.

The use of HDD and excavations of entry and exit points cause above water sound and vibrations, optical disturbance and an increase in the use of artificial light. Multiple bird species make use of the high tide roosts in the vicinity of the route. However, multiple mitigation measures for birds are in prospect that can reduce these effects (paragraph 4.3.4). Therefore, these effects were scored as a *moderate negative impact*.

Impact on OUV x) biodiversity

Organisms living in or on top of the tidal flats (benthos and sea grass) will be negatively affected by the change of sediment dynamics as a result of the HDD entry and exit points (Glorius, 2018; Glorius & Meijboom, 2020; Rippen et al., 2020). Consequently, the food supply for birds living on the tidal flats and fattening areas for migratory birds will be locally affected. However, mitigation measures are in prospect to reduce these effects of changes in substrate dynamics (see paragraph 4.3.4). Therefore, these effects via change in substrate dynamics are scored as a *moderate negative impact*.

Dredging can cause effects via turbidity on shellfish (Compton et al., 2017), fish-eating birds (Darby et al., 2022), fish (Tulp et al., 2022) and mammals living in marine and brackish areas that can cascade down the food web. However, the amount of dredged material and sediment is marginal, the affected surface area is relatively small, the effects are temporal and occur mostly in the North Sea coastal zone. Therefore, the impact of dredging via turbidity on associated biodiversity attributes is scored as a *minor negative impact*.

As the dredged sediment is deposited in the North Sea coastal zone and not in the Wadden Sea within the borders of the World Heritage site, the impact of sedimentation is scored as *neutral*.

The number of vessels used on this route is limited, because of the use of HDDs during low tide in the Wadden Sea. As result, the increase of underwater sound and vibrations is negligible, and the habitat of fish and mammals is not affected in the Wadden Sea. Therefore, effect of underwater sound and vibrations is scored as *neutral*. In the North Sea, the effects of underwater sound and vibrations are more severe, but these fall outside the spatial scope of this HIA.

Most of the above water sound and vibrations, light and optical disturbance is produced by the HDD and the trencher during work activities at low tide. These activities can disturb seals on the haul-out sites that are crossed by this route. The relative importance of this area for seals is average. During the reproductive season and seals' shedding period (sensitive season), it is important that seals are not disturbed (Cremer et al., 2017). Outside the sensitive season seals can more easily located to different haul-out sites in different areas. To prevent disturbance of seals during the sensitive period, a mitigation measure is prospected. Therefore, the impact of above water sound and vibrations, and optical disturbance and light on mammals living in marine and brackish water areas are evaluated as moderate *negative*.

Can affect breeding birds (for example on the salt marsh), birds on high tide roosts and the tranquility for birds (Kleijn, 2008). Of the migratory bird species with a strong dependency of the Wadden Sea (van Roomen et al., 2002), multiple species use the high tide roosts in the vicinity of this route. The appropriate assessment indicates that mitigation measures are needed to avoid disturbance of the pied avocet, lesser black-backed gull, common tern, Eurasian spoonbill, eider and common redshank. These mitigation measures in prospect limit disturbance of birds. Therefore, disturbance effects for bird attributes have been scored as *moderative negative impacts.*

Impact on integrity

Does the route interrupt the natural dynamics and interconnectedness of the morphological elements of the Wadden Sea?
Geological processes are directly, temporarily impacted by proposed installation techniques for the pipeline. This has a *minor negative impact* on the integrity of the heritage site as it will not permanently alter the key interrelated and interdependent elements in their natural relationships.

Does the route have negative effects on species, habitats, and processes?
This route has negative effects on seagrass, benthic species and bird habitat (foraging grounds) via changes in sediment dynamics caused by excavations of the HDD. Mitigation measures are in prospect to reduce these effects. Turbidity as a result of dredging activities has a small impact on species, habitats and Processes (Candolin & Rahman 2023; Rippen et al., 2020; Royal HaskoningDHV, 2021). The volume of dredged sediment is relatively small, resulting in a marginal affected area and only temporal turbidity effects, which can only very locally cause minimal effects on primary and secondary production. Dredged sediment is spread outside Wadden Sea heritage site. Underwater sound and vibrations produced by HDD is limited, as working activities take place during low tide. Sound, light and optical disturbance associated with the activities will cause negative effects on especially seals and birds. However, mitigation measures are in prospect to reduce these effects. Regarding species, habitats and processes, impacts on the integrity of the Wadden Sea heritage site are *moderate negative* for this route.

Does the route affect elements that are essential to the migratory path of birds?
Fattening areas of migratory birds will be mostly affected by HDD entry and access points, as the route is crossing a valuable foraging area for birds (Soudijn et al., 2022). However, mitigation measures are in prospect to reduce these effects. HDD and excavations of entry and exit points cause above water sound and vibrations, optical and light disturbance that can impact resting and foraging migratory birds. However, various mitigation measures are in sight to reduce these disturbance effects. Regarding migratory birds, the impact on the integrity of the Wadden Sea heritage is *moderate negative* for this route.

Does the route affect breeding areas?
Above water sound and vibrations, optical disturbance and light can disturb the tranquility of breeding birds (Krijgsveld et al., 2022). When there are no working activities from April up to and including August near locations (within 600 m) of breeding birds or noise levels will be limited by using barriers (mitigation measure), there will be less effects. Regarding breeding areas, the impact on integrity of the Wadden Sea heritage site is *moderate negative* for this route.

Table 5.6 Evaluation of the impact of the VIII: Ameland Wantij route - pipeline

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
viii) geological processes	Size of barrier islands, sandbanks, channels, mudflats and saltmarshes	Disturbance of seabed (change in seabed level, substrate dynamics, wave and current dynamics)	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Minor negative
	Amount of river discharge	Change in fresh water inflow and current velocities	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Surface area of regions with salt gradients	Changes in fresh water inflow an/or mixing of waters with different salinity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Rate of sea level rise	Large scale effect on water levels or ability of tidal basin to respond to sea level rise	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Size of the area where sediment is deposited	Change in area of tidal basin, ebb tidal delta or shallow coastal zone	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
ix) ecological processes	Primary production	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
	Production by animals, from shellfish to marine mammals	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some to large change	Negative	Moderate negative impact
	Numbers of fish, shellfish and birds	Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some to large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
	Food availability for fish, shellfish and birds	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some to large change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
	Number of species (plants and animals) occurring in marine and brackish water areas	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some to large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Number of species of breeding birds	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
	Fattening areas for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some to large change	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Roosting areas for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
	Food supply for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some to large change	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
	Tranquility for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
	Relative importance of the Wadden Sea for population sizes of migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some to large change	Negative	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Minor negative
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	None	Negative	Neutral
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
Integrity	viii) geological processes	Effects on interconnectedness of the morphological elements								Minor negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	ix) ecological processes	Effects on species, habitats, and processes								Moderate negative impact
		Effects on migratory path of birds								Moderate negative impact
	x) biodiversity	Effects on breeding areas								Moderate negative impact

5.1.7 IX: Zoutkamperlaag route - pipeline (variant A1 and A2)

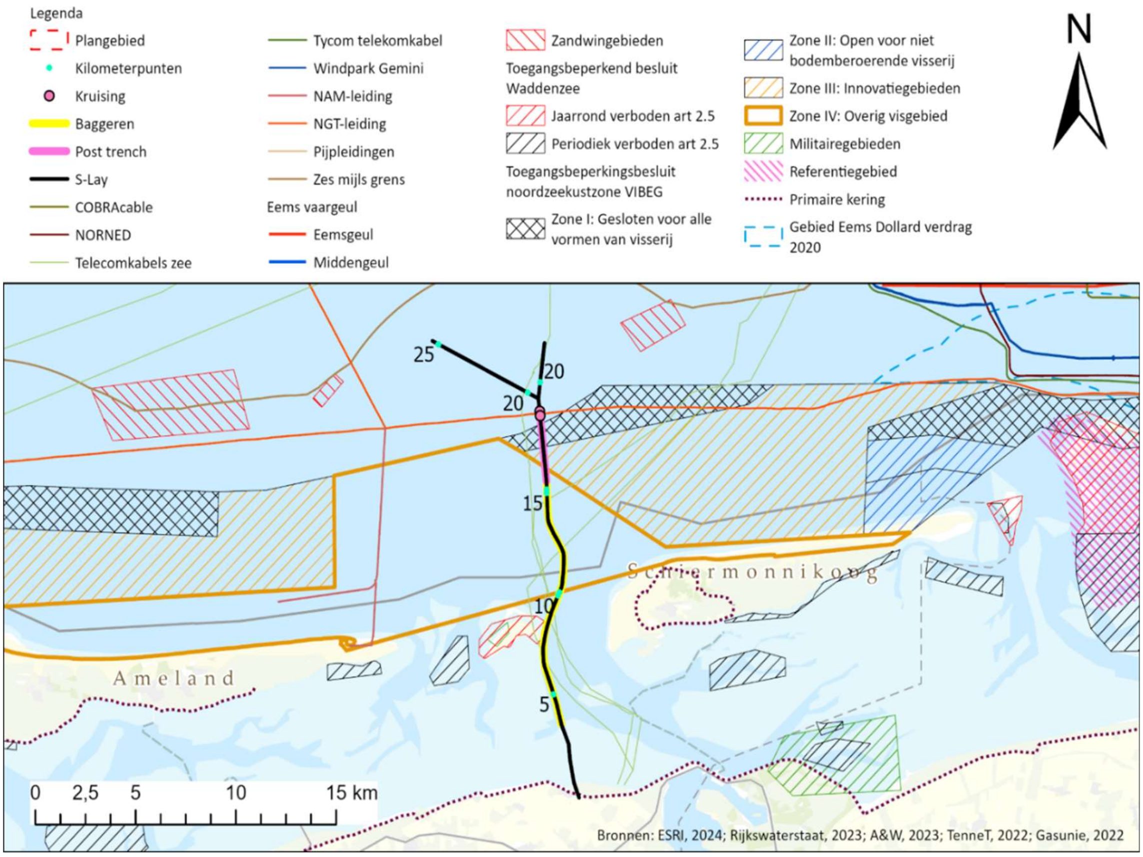
This route offers two variants for a pipeline, A1 and A2. The IX: Zoutkamperlaag route A1 and A2 only diverge outside the heritage site, so they are not assessed separately in this report.

Activities

The activities taking place at the IX: Zoutkamperlaag route for installing a pipeline are (see Figure 5.14):

- HDD to cross primary dike and existing cable systems along the coast.
- Pipelaying vessel with burial equipment is used to lay pipeline at depth (S-lay technique and post trench).
- Preparatory dredging (to achieve access trench for installation vessels) (dredged material is spread out directly in the access trench after burying the pipeline).

Figure 5.14 Proposed activities for pipeline installation on the IX: Zoutkamperlaag route



Evaluation of impacts

Table 5.7 gives an overview of the evaluation of impact on each attribute. The impact on each OUV of the Wadden Sea are discussed below.

Impact on OUV viii) geological processes

The variants of the route differ in the North Sea but have the same evaluation of impacts. For the installation of the pipeline HDD is used to cross primary dike on the mainland. Access pits will be replenished after usage, so its impact is neutral.

A significant volume will be dredged to dig an access channel of two kilometers close to the Wadden Sea coast within the existing deep tidal channel. After the pipeline is installed, the dredged trench will be partially replenished. The sediment dynamics in this area are limited, so it is expected to take several years for the channel to naturally recover and dispersed volume to be redistributed by natural processes. Therefore, the impact of these activities via disturbance of the seabed on the size of barrier islands, sandbanks, channels, mudflats and saltmarshes is *moderate negative*.

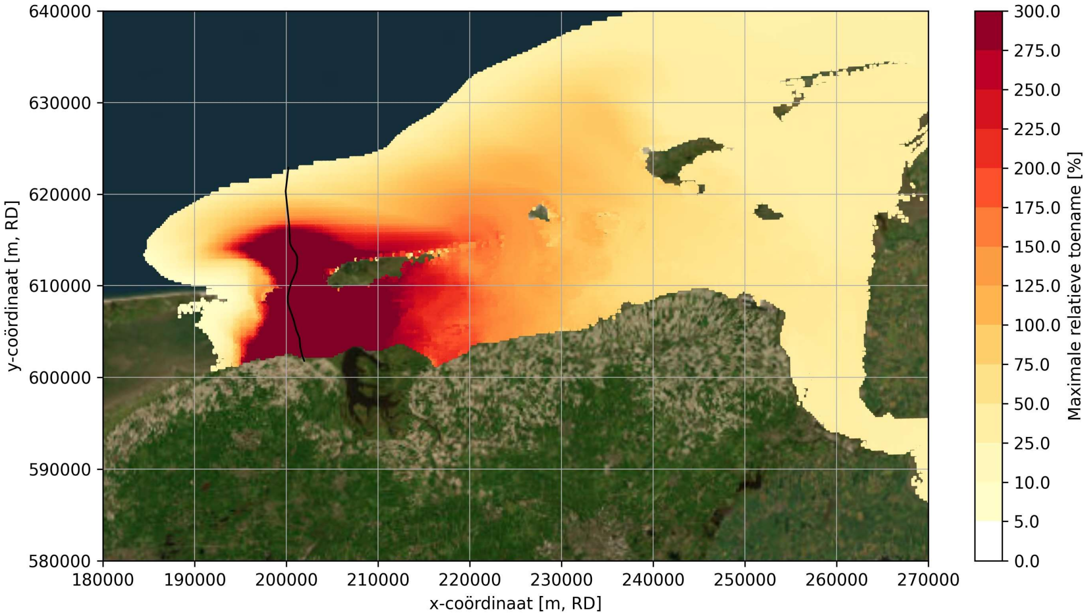
The installation of the pipeline system does not lead to any significant changes in freshwater inflow from rivers or canals into the Wadden Sea. Furthermore, the processes that cause mixing of water with different salinities are not significantly altered so that there is no significant effect on the surface area of regions with salt gradients. The activities do not affect the rate of sea level rise and have no significant effect on the ability of the UNESCO area and its tidal basins to respond to sea level rise. Finally, the activities have no significant effect on the size of the tidal basins, ebb tidal deltas, salt marshes or shallow coastal zones, where sediment is deposited. Therefore, the impact of the activities on these attributes is *neutral*.

Impact on OUV ix) ecological processes
For installation of the pipeline, a large amount of sediment is dredged. This causes large changes in the dynamics of substrate in the Wadden Sea which has a negative effect on benthic species (e.g. seagrass and shellfish) (Candolin & Rahman 2023; Rippen et al., 2020; Royal HaskoningDHV, 2021). However, mitigation measures are in prospect to reduce these effects (see paragraph 4.3.5). Therefore, the effect of changes in substrate dynamics is scored as a *moderate negative impact.*

Dredging activities also cause an increase in turbidity. Approximately 640.600 m^3 silt will be dredged during a total of 71 days. The surface area that is affected is large and the increase of turbidity will exceed 5 mg/L (absolute numbers) for more than 200 days, of which 150 days have an absolute increase of >50 mg/L and 65 days have an absolute increase of 250 mg/L (Figure 5.15). This has a negative effect on primary production, benthos (like shellfish living on the sea floor) and visual hunting birds and fish (Taal et al., 2015; Zhao et al., 2019; Tulp et al., 2022; Baptist & Leopold, 2010). However, mitigation measures are in prospect to limit effects on typical species, breeding and non-breeding birds. Therefore, the impact of this activity via turbidity is scored as a *moderate negative impact.*

Dredged sediment will be deposited in the dredged slot after the laying of the pipeline. Therefore, surrounding habitat (submerged sandbanks) will largely stay intact. However, small effects on (typical) species living in or on the seafloor and in the gullies (fish and invertebrate species) cannot be totally ruled out (Glorius, 2018; Glorius & Meijboom, 2020; Rippen et al., 2020). Therefore, the impact of this activity via sedimentation is scored as a *minor negative impact.*

Figure 5.15 Maximum percentage of relative increase of the daily average background concentration during the simulation of the installation of the pipeline on the IX: Zoutkamperlaag route (Mustafa & van Engelen, 2024)



The activities and associated shipping traffic cause an increase underwater sound. Fish (Weilgart et al., 2018; Anderson Hansen et al., 2020) and fish-eating birds (Kleijn, 2008) typically demonstrate avoidance behaviour as result of continuous sound, while the settlement and growth of invertebrates can be negatively affected by this kind of disturbance. Therefore, underwater sound has a *minor negative impact*.

The use of ships, dredging and drilling cause above water sound and vibrations, optical disturbance and an increase in the use of artificial light. Multiple mitigation measures for birds (paragraph 4.3.1) are in prospect that can reduce the disturbance of birds. Therefore, this impact was scored as a *moderate negative impact*.

Impact on OUV x) biodiversity

Organisms living in or on top of the tidal flats (benthos and sea grass) will be negatively affected by the change of sediment dynamics as a result of the dredging (Glorius, 2018; Glorius & Meijboom, 2020; Rippen et al., 2020). However, a mitigation measure is in prospect to mitigate these effects. Therefore, the effect is scored as a *moderate negative impact*. The food supply for birds living on the tidal flats and fattening areas for migratory birds can also be affected by changes in sediment dynamics. However, the route only marginally crosses tidal flats and the majority of the route follows the gullies. Foraging areas of birds are not in close vicinity of the route. Therefore, regarding food availability for birds (Soudijn et al., 2022), the effects of changes in substrate dynamics are scored as a *minor negative impact*.

Dredging causes effects via turbidity on shellfish (Compton et al., 2017), fish-eating birds (Darby et al., 2022), and fish (Tulp et al., 2022), living in marine and brackish areas (see impact on OUV ix) ecological processes for an explanation). This also has a negative effect on the fattening areas and food supply of migratory birds. However, mitigation measures are in prospect to mitigate the effects of turbidity on typical species, breeding and non-breeding birds. Therefore, the impact of this activity via turbidity on associated biodiversity attributes is scored as a *moderate negative impact*.

The effects of sedimentation on typical species, fish and mammals are reduced by optimalization of the route. Therefore, the impact of this activity via sedimentation is scored as a *minor negative impact*.

Dredging and the sound of ship engines generates underwater sound and vibrations that can negatively affect marine mammals, such as seals and harbour porpoises by continuous and impulse sounds (Mikkelsen et al., 2019; Schaffeld et al., 2022). Mammals are extremely sensitive for underwater sound and vibrations (Erbe et al., 2019). A mitigation measure is in prospect to prevent disturbance of mammals (see paragraph 4.3.5). Therefore, the impact of underwater sound and vibrations is scored as a *moderate negative impact* for mammals. The effects on benthos, fish and birds are discussed under the previous section (Impact on OUV ix) ecological processes).

The activities and associated shipping cause above water sound and vibrations, light and optical disturbance. These activities can disturb seals on the haul-out sites that are crossed by this route. The relative importance of this area for seals is average. During the reproductive season and seals' shedding period (sensitive season), it is important that seals are not disturbed (Cremer et al., 2017). Outside the sensitive season seals can more easily locate to different haul-out sites areas. To prevent disturbance of seals during the sensitive season a mitigation measure is in prospect.

The above mentioned effects can also affect breeding birds (for example on the salt marsh), birds on high tide roosts and the tranquility for birds (Kleijn, 2008). Of the migratory bird species with a strong dependency of the Wadden Sea (van Roomen et al., 2002), multiple species use the high tide roosts in the vicinity of this route. The appropriate assessment indicates that mitigation measures are needed to avoid disturbance of the pied avocat, eider duck, Eurasian curlew and spotted redshank (among others). For birds, also various mitigation measures are in prospect. Therefore, for birds and seals, disturbance effects have been scored as *moderative negative impacts*.

Impact on integrity

Does the route interrupt the natural dynamics and interconnectedness of the morphological elements of the Wadden Sea?

Dredging causes most negative impacts on geological processes, especially dredging for the installation of pipelines as this requires dredging of larger quantities. This has a temporary, *moderate negative impact* on the integrity of the heritage site because the natural dynamics are disturbed. The dredging works will not permanently alter the size of the heritage site. The key interrelated and interdependent elements in their natural relationships will be restored by natural processes on a timescale of years.

Does the route have negative effects on species, habitats, and processes?

The enormous amount of dredged sediment will lead to a significant increase in turbidity. This negatively impacts primary production in the area because sunlight is obscured, which can limit algae growth. This affects primary production (biomass from algae) and secondary production (biomass created by benthic organisms) (Taal et al., 2015; Zhao et al., 2019; Tulp et al., 2022; Baptist & Leopold, 2010). As the base of the food web is negatively impacted, it also has consequences for higher levels in the food web (fish, birds, marine mammals). Because the dredged sediment will be deposited in the dredged slot, only minor effects on the habitat of subtidal species (benthos, fish, seals) are expected. Underwater sound and vibrations can affect the quality of habitats of seals, diving birds, fish and benthos, but effects are expected to be minimal. Sound, light and optical disturbance associated with the activities will cause negative effects on especially seals and birds. For birds and seals, mitigation measures are in prospect to reduce these effects (see below). Regarding, species, habitats and processes, the impact on integrity of the Wadden Sea heritage is *moderate negative* for this route.

Does the route affect elements that are essential to the migratory path of birds?

Fattening areas of migratory birds will be especially affected by the dredging activities. Visual hunting birds (e.g., species of ducks and terns) may find it harder to locate and catch prey (Soudijn et al., 2022). Foraging areas on tidal flats are not in the vicinity of the route. Underwater and above water sound and vibrations can also affect foraging fish-eating migratory birds or birds on high tide roosts. However, mitigation measures are in sight to reduce these effects. Regarding migratory birds, the impact on integrity of the Wadden Sea heritage is *moderate negative* for this route.

Does the route affect breeding areas?
Above water sound and vibrations, optical disturbance and light can disturb the tranquillity of breeding birds (Krijgsveld et al., 2022). However, a mitigation measure is in prospect to reduce these effects. Regarding breeding areas, the impact on integrity of the Wadden Sea heritage site is *moderate negative* for this route.

Table 5.7 Evaluation of the impact of the IX: Zoutkamperlaag route - pipeline

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
viii) geological processes	Size of barrier islands, sandbanks, channels, mudflats and saltmarshes	Disturbance of seabed (change in seabed level, substrate dynamics, wave and current dynamics)	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative	Moderate negative impact
	Amount of river discharge	Change in fresh water inflow and current velocities	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Surface area of regions with salt gradients	Changes in fresh water inflow an/or mixing of waters with different salinity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Rate of sea level rise	Large scale effect on water levels or ability of tidal basin to respond to sea level rise	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Size of the area where sediment is deposited	Change in area of tidal basin, ebb tidal delta or shallow coastal zone	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
ix) ecological processes	Primary production	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
	Production by animals, from shellfish to marine mammals	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
	Numbers of fish, shellfish and birds	Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
	Food availability for fish, shellfish and birds	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
	Number of species (plants and animals) occurring in marine and brackish water areas	Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative change	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Large change	Negative change	Moderate negative impact
	Number of species of breeding birds	Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
	Fattening areas for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
		Underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
	Roosting areas for migratory birds	Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
	Food supply for migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	Tranquility for migratory birds	Optical disturbance and light	Once)	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
	Relative importance of the Wadden Sea for population sizes of migratory birds	Change in substrate dynamics	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
		Increase in optical disturbance and light	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in above water sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative	Moderate negative impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Moderate negative impact
		Increase in sedimentation	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact
		Increase in underwater sound and vibrations	Once	Short-term	Irreversible	Reversible	Temporary	Some change	Negative change	Minor negative impact

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
Integrity	viii) geological processes	Effects on interconnectedness of the morphological elements								Moderate negative impact
	ix) ecological processes	Effects on species, habitats, and processes								Moderate negative impact
		Effects on migratory path of birds								Moderate negative impact
	x) biodiversity	Effects on breeding areas								Moderate negative impact

5.1.8 X: Tunnel route

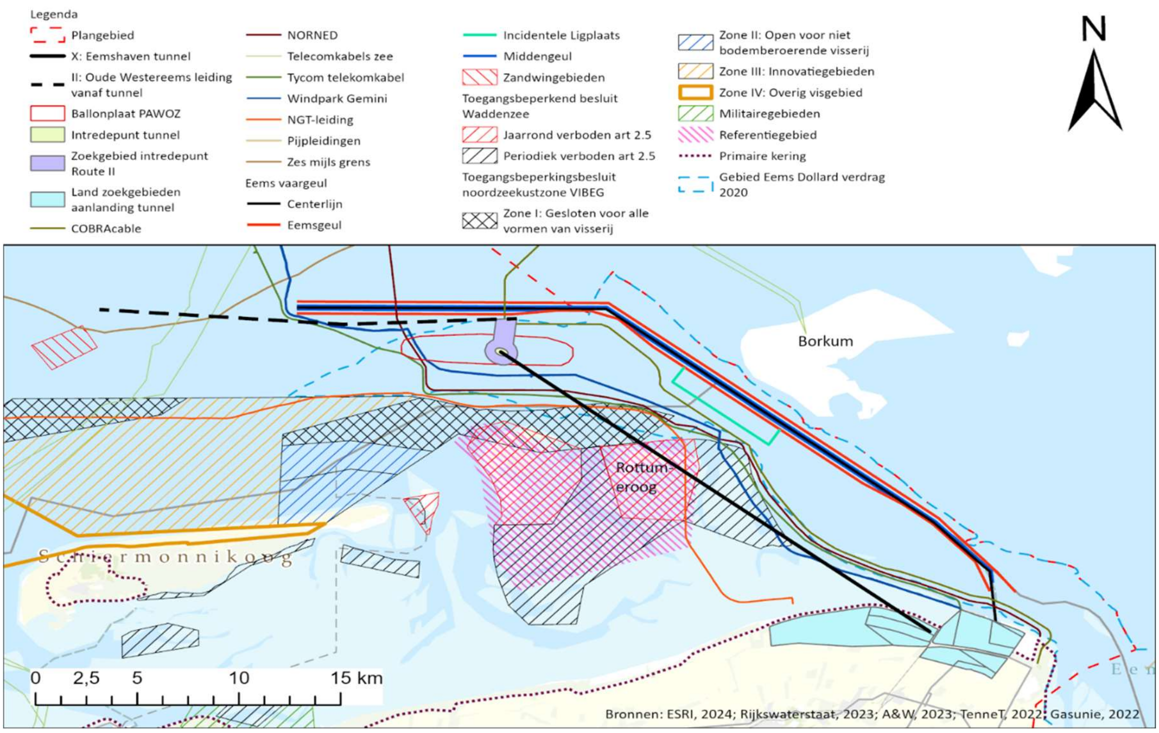
On this route the construction of a tunnel is being assessed.

Activities

The activities taking place at the X: Tunnel route are (see Figure 5.16):

- Construction of the entry point on the Ballonplaat in the North Sea (includes construction of a dike, sand spraying, construction of breakwaters, construction of quay, dredging of basin).
- Construction of shafts at the entry point on the Ballonplaat and drilling of tunnel tubes under the Wadden Sea.
- Construction of shafts at the exit point tunnel near the Eemshaven and drilling of tunnel tubes.
- Management and maintenance of entry point during usage tunnel (yearly dredging to maintain access channel, and several ship movements to transport personnel and (small) materials to and from the entry point for the execution of management and maintenance).

Figure 5.16 Proposed activities for tunnel installation on the X: Tunnel route



Evaluation of impacts

Table 5.8 gives an overview of the evaluation of impact on each attribute. The impact on each OUV of the Wadden Sea are discussed below.

Impact on OUV viii) geological processes

The construction of shafts and drilling of tunnel tubes does not have direct impact on geological processes of the Wadden Sea as the tunnel will start on the mainland and then emerges on the Ballonplaat sandbank, where an island with entry point will be constructed. This island has dimensions of approximately 800 m by 450 m will be accessible in the operational phase by ships through an access channel that needs to be regularly dredged.

The island (entry point) affects water movement (currents and waves) and sediment transport. In the direct vicinity of the island this leads to a permanent influence on the bed levels of the Ballonplaat, which is a dynamic area by nature. The morphology of the Ballonplaat is expected to change due to the contraction of the current around the entry point, which causes erosion and possibly also gully formation on the north-east and south-west sides of the entry point. Sheltering effects are expected to lead to sedimentation on the north-west and south-east sides.

The effects of the island on water movement and sediment transport are limited in the neighboring reference area and Natura 2000 area south of the island (at the transition between Rottumeroog and Rottumerplaat with Huibertgat). During storms, there are greater changes in sediment transport in these areas. There will be no observable effects on the large-scale currents and sediment transport in the Eems-Dolland channel.

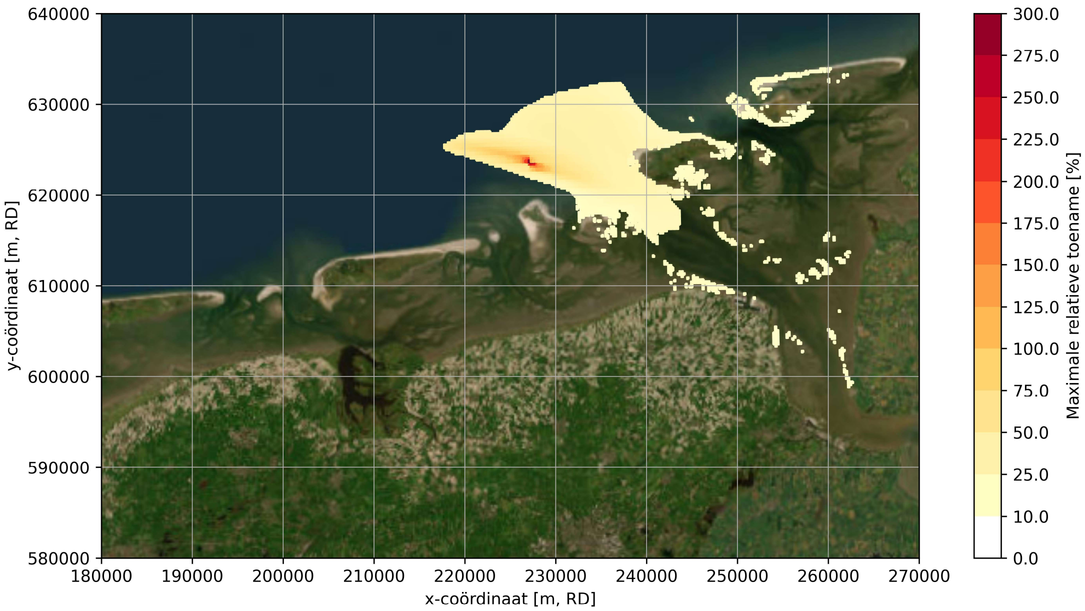
Because the entry point has a permanent effect on the natural morphological processes of neighboring tidal channels and flats (some of which are in Natura 2000 area of reference area) and because regular maintenance dredging works are required for the access channel, the impacts of this variant are scored as *moderate negative*. Although the effects are permanent, the effects are not deemed 'major negative' because the entry point only causes local effects which are small on the scale of the Wadden Sea.

The tunnel and island on the Ballonplaat do not lead to any significant changes in freshwater inflow from rivers or canals into the Wadden Sea. Furthermore, the processes that cause mixing of water with different salinities are not significantly altered so that there is no significant effect on the surface area of regions with salt gradients. The activities do not affect the rate of sea level rise and have no significant effect on the ability of the UNESCO area and its tidal basins to respond to sea level rise. Finally, the activities have no significant effect on the size of the tidal basins, ebb tidal deltas, salt marshes or shallow coastal zones, where sediment is deposited. Therefore, the impact of the activities on these attributes is *neutral*.

Impact on OUV ix) ecological processes
The tunnel will transect the Wadden Sea below ground, causing only small effects on attributes in the World Heritage site.

On the entry point of the Ballonplaat a harbour basin and access gully will be realized, causing a marginal increase in turbidity (Figure 5.16). The sediment that is released by the digging of the tunnel, causes a larger increase in turbidity. However, the increase in concentration is relatively low, and the affected areas relatively small, mostly covering area outside the boarders of the Wadden Sea World Heritage. Yet, some effects might be noticeable on primary production, (Taal et al., 2015; Zhao et al., 2019; Tulp et al., 2022; Baptist & Leopold, 2010) shellfish beds, seagrasses and birds. Therefore, the effect is scored as a *minor negative impact.*

Figure 5.17 Maximum percentage of relative increase of the daily average background concentration during the simulation of the construction of the pipeline on the X: Tunnel route (Mustafa & van Engelen, 2024)



Changes in substrate dynamics and sedimentation will be completely absent for this route and therefore indicated as ‘not applicable’ in Table 5.8.

Within the Wadden Sea area, no vessels will be used for the installation of the tunnel. The entry point is located on the Ballonplaat and the exit point on the mainland. The tunnel will cross the Wadden Sea at great depth below the sea floor. Consequently, no effects of underwater or above water sound and vibrations will occur. Similarly, the presence of light or other forms of optical disturbance are neglectable. These effects are therefore scored as *neutral* for this route in the Wadden Sea.

Impact on OUV x) biodiversity

As described in the previous section (impact on OUV ix) ecological processes) turbidity has a small effect on biodiversity attributes. These effects are scored as a *minor negative impact*.

Changes in substrate dynamics and sedimentation will be completely absent for this route and therefore indicated as ‘not applicable’ in Table 5.8.

Effects of underwater and above water sound and vibrations, light and optical disturbance do not occur within the borders of the Wadden Sea world heritage and are therefore scored as *neutral*.

Impact on integrity

Does the route interrupt the natural dynamics and interconnectedness of the morphological elements of the Wadden Sea?

Geological processes will be directly impacted by proposed installation techniques for the tunnel. The tunnel causes permanent, moderate negative impact on geological processes because the entry point will result in the disappearance of a shallow sandbank and will be accessed due to yearly dredging during the operational phase of the tunnel. This has a *moderate negative impact* on the integrity of the heritage site as it will permanently alter the key interrelated and interdependent elements in their natural relationships.

Does the route have negative effects on species, habitats, and processes?

Turbidity has only a small effect on species, habitats and processes. The affected area is relatively small and lays for the most part in the North Sea. Increased concentrations are very low. Therefore, the impact on primary production, seagrass, shellfish beds, fish and the foraging area is very small. Regarding, species, habitats and processes, the impact on integrity of the Wadden Sea heritage is *minor negative* for this route.

Does the route affect elements that are essential to the migratory path of birds?
Only turbidity has minimal effects on the foraging area of non-breeding birds. However, these birds can easily fly over to other areas in the Wadden Sea. Regarding migratory birds, the impact on integrity of the Wadden Sea heritage is *minor negative* for this route.

Does the route affect breeding areas?
No effects on breeding areas are expected. Regarding breeding areas, the impact on integrity of the Wadden Sea heritage site is *neutral* for this route.

Table 5.8 Evaluation of the impact of the X: Tunnel route

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
viii) geological processes	Size of barrier islands, sand-banks, channels, mudflats and saltmarshes	Permanent but local effect on the natural morphological processes of neighbouring tidal channels and bed disturbance in access channel due to dredging works.	Construction of island: once, maintenance dredging of access channel: frequently (weekly to monthly)	Short-term	Irreversible	Irreversible	Permanent	Large change	Negative	Moderate negative impact
	Amount of river discharge	Change in fresh water inflow and current velocities	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Surface area of regions with salt gradients	Changes in fresh water inflow an/or mixing of waters with different salinity	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Rate of sea level rise	Large scale effect on water levels or ability of tidal basin to respond to sea level rise	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral
	Size of the area where sediment is deposited	Change in area of tidal basin, ebb tidal delta or shallow coastal zone	Once	Short-term	Irreversible	Reversible	Temporary	Negligible	Negative	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
ix) ecological processes	Primary production	Increase in turbidity	Once	Short-term	Reversible	Reversible	Temporary	None	Neutral	Minor negative impact
	Production by animals, from shellfish to marine mammals	Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	None	Neutral	Minor negative impact
		Increase in sedimentation	Not applicable							
		Change in substrate dynamics	Not applicable							
	Numbers of fish, shellfish and birds	Increase in underwater sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
		Increase in optical disturbance and light	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Natural
		Increase in turbidity	Once	Short-term	Irreversible	Irreversible	Temporary	Some change	Neutral	Minor negative impact
		Change in substrate dynamics	Not applicable							
		Increase in above water sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in sedimentation	Not applicable							
	Food availability for fish, shellfish and birds	Increase in sedimentation	Not applicable							
		Change in substrate dynamics	Not applicable							
		Increase in underwater sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	None	Neutral	Minor negative impact
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	Increase in above water sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
		Increase in optical disturbance and light	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
	Number of species (plants and animals) occurring in marine and brackish water areas	Increase in sedimentation	Not applicable							

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	None	Neutral	Minor negative impact
		Change in substrate dynamics	Not applicable							
		Increase in above water sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
		Increase in optical disturbance and light	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
		Increase in underwater sound and vibrations	Once	Long-term	Irreversible	Irreversible	Temporary	Some	Neutral	Neutral
	Number of species of breeding birds	Increase in above water sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
		Increase in optical disturbance and light	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	None	Neutral	Minor negative impact
	Fattening areas for migratory birds	Change in substrate dynamics	Not applicable							
		Increase in above water sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in optical disturbance and light	Once	Long-term	Irreversible	Irreversible	Temporary	Some	Neutral	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Reversible	Temporary	None	Neutral	Minor negative impact
		Increase in sedimentation	Not applicable							
		Increase in underwater sound and vibrations	Once	Long-term	Irreversible	Irreversible	Temporary	Some	Neutral	Neutral
	Roosting areas for migratory birds	Increase in optical disturbance and light	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
		Increase in above water sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
	Food supply for migratory birds	Change in substrate dynamics	Not applicable							
		Increase in underwater sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
		Increase in turbidity	Once	Short-term	Irreversible	Irreversible	Temporary	Some	Neutral	Minor negative change
	Tranquility for migratory birds	Increase in optical disturbance and light	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		Increase in above water sound and vibrations	Once	Long-term	Irreversible	Irreversible	Temporary	Some	Neutral	Neutral
		Underwater sound and vibrations	Once	Long-term	Irreversible	Reversible	Temporary	None	Neutral	Neutral
Integrity	viii) geological processes	Effects on interconnectedness of the morphological elements								Moderate negative impact
	ix) ecological processes	Effects on species, habitats, and processes								Moderate negative impact
		Effects on migratory path of birds								Minor negative change
	x) biodiversity	Effects on breeding areas								Neutral

6

CUMULATIVE EFFECTS

In this HIA, an evaluation has been made to determine the effects of the installation of one cable system or pipeline per route on the three OUVs of the Wadden Sea (geological processes, ecological processes, and biodiversity). In Chapter 2, the HIA methodology is explained in more detail. The evaluation is based on the scoring method in the EIA, but also differs at some points. This is explained in Chapter 3. The results of the evaluation are presented in Chapter 5 per route.

For most of the routes there are minor and moderate negative effects expected after optimization measures (see Chapter 4 for the optimization measures per route). Hereby, it was taken into account whether mitigation measures are in prospect to reduce the effects. For a minority of the routes, no mitigation measures are in prospect, and major negative effects remain.

Wadden Sea OUVs are not only impacted by these isolated effects of a single activity on each route, but are impacted by the cumulative effects of all activities on the route, across multiple routes and of all the activities in the Wadden Sea. Also, climate change can contribute to the cumulative impact. This can lead to the conclusion that cumulation causes major negative effects on OUVs of the Wadden Sea.

Based on the PAWOZ EIA sub-reports Nature and Seabed, this chapter discusses:

- Effects within a route. To meet PAWOZ' objectives, multiple cable systems/pipelines or a combination of a cable system and a pipeline may be needed per route. In Chapter 6.2, the effects of multiple cable system(s) and/or pipeline(s) are assessed per route, and it has been indicated whether there is a prospect of installing multiple cable systems and/or pipelines on each route.
- Cumulative effects of other plans and projects in the Wadden Sea (including autonomous and future developments, which will be first introduced in the following sections 6.1.1 and 6.1.2). Effects from PAWOZ that are not significant (major negative) may become significant when the effects of all activities are combined. The cumulative effects have been considered on a higher (less detailed) level, appropriate to the level of detail of a planEIA. In the projectEIA, cumulative effects need to be examined in more detail.

6.1.1 Autonomous developments

To determine cumulative effects of the proposed routes on the OUVs of the Wadden Sea, it is necessary to describe autonomous developments and processes related to the heritage site. Autonomous developments result in changes within the planning area, which occur independently of the proposed activity and for which a decision has already been made. For example, when developments are established in a spatial plan and a permit has been granted.

Autonomous processes are inevitable for the future state of the site's characteristics. This includes, for example, sea level rise and other consequences of climate change. Generally, these processes only lead to significant changes over an extended period of time. A summary of most relevant autonomous development and processes as well as other future developments in the Wadden Sea is presented in the tables below (Table 6.1 and Table 6.2) based on the PAWOZ EIA sub-reports Nature and Seabed.

Table 6.1 Autonomous developments in the Wadden Sea related to its OUVs: geological processes, ecological processes, and biodiversity

Autonomous development	Description
Baseline coastline	The Netherlands has a naturally eroding coastline; more sand disappears than is naturally supplied. In 1990, the baseline coastline was established. When the coastline at a location structurally lies behind the baseline coastline, the coast is locally replenished with sand nourishments. This does not apply to the eastern ends of the Wadden Islands, Ameland and Schiermonnikoog, where structural erosion is accepted. This has implications for the required burial depth of cable systems if they transect this part of the islands. The baseline coastline has been adjusted several times since its establishment in 1990. In addition to maintaining the baseline coastline, nourishments are also carried out to allow the coastal foundation (up to NAP -20 meters) to keep up with the rising sea level. In 2024 the nourishment program for 2024-2027 commenced. *The EIA sub-report Seabed examined whether the program has an effect on coastal maintenance (and thus on the required sand extraction). This is not the case. No cumulative effects occur on geomorphology thus neither on the OUV viii) ecological processes.*
Dredging maintenance	In the Wadden Sea, dredging activities are conducted to maintain sufficient depth in channels and harbours for shipping logistics. These dredging activities are appropriately assessed and included as regular maintenance in the Natura 2000 management plan for the Wadden Sea. In the past, some of the sand released during fairway maintenance in the Wadden Sea coastal zone could be extracted for sand trade. In 2016, Rijkswaterstaat initiated a decision-making process to gradually phase out this form of sand extraction from the Wadden Sea starting in 2018. Since 2022, no sand has been extracted from the Wadden Sea. The underlying philosophy is to keep as much sediment in the system as possible. *The principle in PAWOZ is that all sediment excavated in the Wadden Sea is also dispersed within the Wadden Sea. In the EIA sub-report Seabed it was investigated whether the interventions in PAWOZ have an effect on dredging requirements. This is not the case and therefore no cumulative effects occur on geomorphology thus neither on the OUV viii) geological processes. However, this activity is included in section 6.2.2 as it is relevant in the discussion of cumulative effects on the OUVs ecological processes and biodiversity.*
Safe operating space for gas and salt extraction under the Wadden Sea	Gas and salt are extracted below the Wadden Sea. Within the planning area, gas extraction by the Dutch Petroleum Company (NAM) takes place. This gas extraction occurs from land: on Ameland and from Blija since the 1980s and from Moddergat, Lauwersoog, and Vierhuizen since 2006. The 'hand on the tap' principle is applied to prevent nature impacts. This means that it is pre-assessed how much gas and salt can be extracted, so that the subsidence remains within the limits that the Wadden Sea can compensate for based on natural sedimentation of sand and silt. The government sets a safe operating space per subsidence area where gas or salt extraction occurs, within which the subsidence rate must remain. Sea level rise is also considered. The subsidence areas within the planning area for which operating spaces are established are Pinkegat (4.6 mm/year) and Zoutkamperlaag (3.6 mm/year) for the period 2021-2026. Both the actual subsidence and effects on nature are monitored to be able to reduce or stop extractions in time. The operating spaces are updated at least every 5 years. *In the EIA sub-report Seabed, it was investigated whether this program leads to additional subsidence due to erosion. This is not the case, so no accumulation of effects occurs on geomorphology thus neither on the OUV geological processes. However, this activity will be included in section 6.2.2 on cumulative effects on the OUVs ecological processes and biodiversity.*
Gas Extraction near Ternaard	The NAM (Dutch Petroleum Company) wants to extract gas from a yet untapped gas field north of Ternaard. A small part of that gas field is located below the mainland, while the majority lies beneath the Wadden Sea. The draft decisions for this project were available for public

Autonomous development	Description
	inspection in 2021. A final decision on the permit was expected in 2022 but was postponed due to a ruling by the Council of State regarding the construction exemption for nitrogen deposition. A decision on the final project was expected in 2024, but this too has been delayed, as on March 5, 2024, the State Secretary of Mining indicated that gas extraction in Ternaard is provisionally prohibited. *This will be included in chapter 6.2.2 on cumulative effects on the OUVs ecological processes and biodiversity.*
Eems-Dollard 2050 Program (ED2050)	In the Eems-Dollard 2050 Program (ED2050), governments, nature and environmental organizations, and businesses are working together to strengthen the natural and economic value and liveability of the Eems-Dollard. Various pilots are being conducted to reduce turbidity with different measures, for example through sediment extraction. The aim is to scale up in sediment extraction in the future to 1 million m^3 of sediment per year. In addition, the Supplement Natura 2000 Management Plan for the Eems-Dollard, which will be established in 2025, also focuses on research and measures to reduce turbidity. Several ED2050 projects in the second phase of the Eems-Dollard 2050 Program have been implemented since 2021, such as: the pilot for Raising Agricultural Land, IBP-VLOED, MIRT exploration of Eemszijlen, the development and operation of the intermediate area of the Double Dike for sediment capture, nature restoration, and salt-tolerant and wet crop cultivation, the monitoring of the Clay Ripening Facility, the construction of the Broad Green Dike, and the development of the Kleine and Groote Polder. The planning has been further detailed in the 2021-2026 Program Plan for the Eems-Dollard 2050 Program. *This does not influence the impact assessment.*

6.1.2 Future developments

Table 6.2 gives an overview of other future developments in the Wadden Sea related to its OUVs.

Table 6.2 Other future developments in the Wadden Sea related to geological processes, ecological processes, and biodiversity

Other future developments	Description
Restoration of quality of permanently submerged sandbanks (sublittoral) and mudflats and sandflats (littoral)	In the Wadden Sea, Natura 2000 requires to improve the maintenance of permanently submerged sandbanks (Natura 2000 habitat type). To support this goal, the gradual phase-out of bottom-disturbing mussel seed fishing is ongoing, allowing multi-year beds to develop more effectively. There is also a requirement to improve the quality of littoral mudflats and sandbanks (Natura 2000 habitat type). To achieve this, restoration of intertidal mussel banks and seagrass fields is necessary.
Measures to reduce impact of bottom-disturbing activities	The cumulative effect of seabed-disturbing activities such as fishing, channel maintenance, and replenishment works in the Wadden Sea and the North Sea coastal zone has been investigated on behalf of Rijkswaterstaat, the Ministry of Agriculture, Nature and Food Quality, and the Wadden Nature Coalition. Rijkswaterstaat will discuss the next steps with the involved parties, including further research. This will also take into account the recommendations of the Wadden Academy, which reviewed the report.
Programmatic Approach to Large Waters (PAGW)	The Programmatic Approach for Large Waters (PAGW) provides measures for the Wadden Sea to restore habitats and soften hard edges of the Wadden Sea by restoring gradual transitions between land and water, fresh and salt water. In the third phase of the PAGW

Other future developments	Description
	(2022), 15 million euro has been reserved for the Underwater Nature Wadden Sea project, which aims to improve fish populations and the food web, provide hard substrate for underwater nature restoration, and work on improving seagrass fields and habitats for fish.
Restoration of biogenic structures	The quality of the exposed flats and food availability for birds has declined due to mechanical shellfish fishing in the past. The Pacific oyster has been able to expand significantly on the flats. Today, most of the banks consist of mixed beds of Pacific oysters and mussels. As a result, the carrying capacity for shellfish-eating birds such as the oystercatcher and eider has permanently decreased. In recent years, research has been conducted in the Wadden Sea on the restoration of mussel beds. However, experiments aimed at restoring the beds have been largely unsuccessful, resulting in no significant improvement and no concrete management measures being implemented. In addition, the area of seagrass beds in the Dutch Wadden Sea has significantly decreased. Consequently, the total number of biogenic structures on the exposed flats is lower than optimal. In recent years, there has been considerable experimentation with seagrass restoration in the Wadden Sea, which has proven particularly successful at Griend. In the coming years, further experiments will be conducted on seagrass restoration. Since the restoration has only taken place locally so far, there has not yet been any substantial improvement in quality.
Climate Change	In the past century, the Wadden Sea has been a net importer of sand. This has so far compensated for the effects of sea-level rise and subsidence in the area. It is expected that this balance will hold for the coming decades as well. The western part of the Wadden Sea has been mostly impacted by the construction of the Afsluitdijk, resulting in deeper water and higher sensitivity to sea-level rise compared to the eastern Wadden Sea (Deltares, 2019). The long-term evolution depends on the climate scenario and the associated rate of sea-level rise. The effects of climate change on ecology are already noticeable in the Wadden Sea area and can increase in the future. It is still difficult to foresee the exact consequences because it is a current topic of research. The effects are currently most evident in marine habitats. Higher sea water temperatures have reduced the nursery function of the Wadden Sea for plaice and flounder. Drought and high summer temperatures lead to massive mortality of cockles, in particular. The cockle population has also declined due to higher water temperatures. High winter water temperatures lead to reduced shellfish spawning, preventing the stocks from recovering. In addition, high winter water temperatures lead to increased survival rates of crabs and shrimps. They can therefore predate more on shellfish larvae, resulting in a reduction of shellfish population (Beukema, J. J., Dekker, R., 2020). For coastal breeding birds, the risk of flooding has already increased in recent decades, sometimes with devastating effects and poor breeding results. Sea level rise will aggravate this, making especially breeding areas on salt marshes, higher susceptible to floodings. This will also affect other habitat types in the Wadden Sea that will increase or decrease in surface area.

6.2 Cumulative effects

This section discusses cumulative effects on the OUVs of the Wadden Sea based on the PAWOZ EIA sub-reports Nature and Seabed. In these sub-reports there is insight into the recovery time of various species and habitat types. To determine all cumulative effects, it is important to also take into account the extent of the impact and the recovery time of the impact. This consideration requires a higher level of detail then is used in the EIA's sub-reports. Also, at this stage, the cumulative effects of nitrogen deposition (eutrophication) have not been considered in the EIA sub-reports, as only a risk assessment of the effects has been conducted. In the project EIA, cumulative effects therefore need to be investigated in more detail, which can in turn be used to assess cumulative effects on the OUVs of the Wadden Sea.

6.2.1 Cumulative effects on geological processes

Effects within a route

The effects of installing cable systems or pipelines on the seabed are independent of previously installed cable systems or pipelines. For each proposed cable system or pipeline, the necessary work to achieve installation has been detailed, and the impacts have been assessed. Similar work is required for subsequent cable systems or pipelines. For example, an access channel needs to be created again, but at a different location. If a second cable system or pipeline is installed simultaneously with the first, the total effects will be (nearly) twice as large. If there is a long period between the first and second installation, the effects will occur twice, thereby almost doubling the duration period of the impacts. However, this does not apply to dredged access channels to provide access for installation equipment. If there is overlap between the required access channels for different cable systems or pipelines and they are installed simultaneously or shortly after one another, the dredging volume needed to create the second channel can be reduced. This could potentially make the summation of effects of the access channels smaller than the sum of the individual effects.

In conclusion, **the summation of negative effects on the OUV geological processes of the installation of multiple cable systems or pipelines within a route or within multiple routes can be expected to be larger than the effects of only one cable system or pipeline per route and also the recovery time of impacts will be longer.**

Cumulative effects of other projects and activities

It has also been considered whether a cumulation of effects occurs on the seabed with autonomous developments in the project area (see Table 6.1 and Table 6.2). **PAWOZ does not lead to cumulative effects on the seabed with autonomous developments, thus neither on the OUV geological processes** (PAWOZ EIA sub-report Seabed).

6.2.2 Cumulative effects on ecological processes and biodiversity

As there is a lot of overlap between the attributes of the two ecological OUVs iv) ecological processes and x) biodiversity, the cumulative effects on the two OUVs are discussed in general.

Whether cumulative effects are present depends on the following factors (find a more elaborate explanation of these factors in PAWOZ EIA sub-report Nature Chapter 17.6.1):

- Recovery time of benthic animals. The most sensitive species (shellfish) have a recovery time of 5–10 years, while the least sensitive species (worms) have a recovery time of approximately 1 year (Rippen et al., 2020). In general, the shorter the disturbance, the faster the recovery of certain benthic species. After a disturbance, mobile species such as nematodes and worms can return relatively quickly (within 1–6 months) (Dittmann et al., 1999). However, the recovery of total biomass, in particular, can take several years (>3 years). Complete recovery of large individuals of long-lived shellfish species can also take
- several years (>4 years). Since larger shellfish generally do not relocate, it may take more than 10 years for all age classes to be present again (Beukema et al., 1999).
- Changes in substrate dynamics can negatively affect the potential of an area as a settlement/expansion site for shellfish banks and seagrass.

- Recovery time of habitat quality depends on the recovery time of benthic animals and fish (typical tidal and subtidal species of brackish and marine waters), and the morphodynamic processes occurring during recovery. In channels, water currents are stronger, resulting in coarser sediment on the seabed. This affects the recovery time of benthic life (Royal HaskoningDHV, 2021).
- Recovery time of food availability for birds depends not only on the recovery of benthic life but also on the recovery times of fish. Little is known about the recovery time of fish. Fish can, either temporarily or permanently, choose a different habitat and exhibit altered (foraging) behaviour. These changes can affect, among other things, the survival and reproductive success of fish, as well as other trophic levels. Indirect negative effects may occur due to the displacement of prey (Candolin & Rahman, 2023). Whether, and especially when, fish become habituated to disturbances remains unclear.
- Frequent increase in turbidity can cause growth retardation in seagrass and shellfish. Turbidity can have a negative effect on photosynthesis, as light penetrates less deeply into the water column, and fine sediment can form a layer on the leaves of seagrass. The small seagrass *Zostera noltii*, found in the Wadden Sea, can survive for only a few weeks under low light conditions, while the large seagrass *Zostera marina* can survive for less than a year (Peralta et al., 2002; Erftemeijer & Lewis 2006). Turbidity can also cause additional stress for some shellfish, such as increased energy use from cleaning the gills, suffocation from sedimentation, and mortality due to oxygen depletion.
- Disturbance by noise and moving objects in birds shows recovery within two years if the source of the disturbance is removed. For species for which carrying capacity is insufficient, recovery is unlikely or will occur very slowly. Habituation may occur, but there is not enough known about this. Disturbance that results in an area being underused or not used at all also leads to underutilization of the potential food availability in the area, which can negatively affect the recovery of populations. Additionally, the animals may experience physiological stress responses, such as an increased heart rate and elevated stress hormone levels. This can be accompanied by higher energy consumption and stress-related consequences such as weight loss (Krijgsveld et al., 2022).
- The same applies to seals that, due to disturbance, leave their haul-out sites. Seals may adjust their behaviour in response to the disturbance and start using the haul-out sites at different, possibly less favorable, times. Regular short-term disturbances, such as from boats, can lead to seals entering the water more frequently and leaving their haul-out sites, but no large-scale permanent displacement is necessary (Paterson et al., 2019). The effect of (large) disturbances over several years is still unclear, but it may lead to changes in habitat use and reduced access to food-rich areas (Becker et al., 2011). It is still uncertain whether seals will return after prolonged (intensive) disturbance.

Effects within a route

The following paragraphs discuss the potential summation of effects related to the OUVs viii) ecological processes and ix) biodiversity, when installing multiple cable systems and/or pipelines per route.

II: Oude Westereems route - cable system

For this route, major negative effects from the installation of a cable system can be ruled out as mitigation measures are in sight. The effects are similar across the corridor's width and mainly relate to the disturbance of seals, breeding birds, and non-breeding birds. The effects on breeding and non-breeding birds due to disturbance can potentially be mitigated by maintaining a distance from breeding areas and high tide roosts (HVPs) or shielding noise. What the exact effects of mitigation measures are is uncertain at this stage of the project.

When installing multiple cable systems, a summation of residual effects may occur, possibly leading to major negative effects. The risk of a significant effect when installing a second cable system is present if installation takes place within birds’ recovery time (two years). If the next cable system is installed after the two-year recovery time, the risk of significant effects is likely low for species with sufficient carrying capacity but high for species with insufficient carrying capacity. More time between the installation of different cable systems may be needed to prevent 'semi-permanent' disturbance, but it is currently unclear how much time is required.

A minor negative effect on typical species (like shellfish and seagrass), fish, mammals and birds occurs due to underwater sound and vibrations. The risk of a significant effect when constructing a second cable system is present if installation activities take place within the recovery time of these species groups.

In conclusion, **the installation of multiple cable systems on this route is in prospect, provided sufficient consideration is given to species recovery times and the extent of residual effects. The project EIA should further investigate the exact effects, including the effects of nitrogen deposition.**

II: Oude Westereems route - pipeline
For pipeline installation, **major negative effects cannot be ruled out. This also applies to the installation of multiple pipelines or when a combination of a pipeline with a cable system is installed.** Chapter 7.3 discusses the possibility of compensation of major negative effects, this is not the case and therefore the effects of multiple pipelines is not investigated.

V: Boschgat route - cable system
For this route, **major negative effects from the installation of a cable system cannot be ruled out. This also applies to the installation of multiple cable systems**. Chapter 7.3 investigates the possibility of compensation of major negative effects, this is not the case and therefore the effects of multiple cables is not investigated.

VII: Schiermonnikoog Wantij route - cable system
For this route, major negative effects from the installation of a cable system can likely be ruled out as mitigation measures are in sight. Shellfish banks and benthic hotspots are located at various points within the corridor and should be avoided. The effects relate to the disturbance of seals, breeding birds, and non-breeding birds, and changes in substrate dynamics on habitat types. After taking mitigating measures, there may be residual effects:

- Haul-out sites for common seals during sensitive periods will be avoided, and the residual effects are expected to be minimal, thus also minimizing the summation of effects.
- The effects on breeding and non-breeding birds from disturbance will be mitigated by keeping a distance from breeding areas and important feeding areas or by shielding noise and moving objects. Residual effects are likely to remain as the disturbance cannot be entirely removed. Multiple cable system installations could result in a summation of residual effects. The risk of significant effects from installing a second cable system exists if done within the birds' recovery period (two years). If the second cable system is installed after the two-year recovery period, the risk of significant effects is likely low. More time may be needed between installations to prevent 'semi-permanent' disturbance, but the necessary amount of time is currently unclear.
- The effects of changes in substrate dynamics on habitat type H1140A and non-breeding birds will be mitigated by avoiding seagrass, shellfish banks, and benthic hotspots. The route will pass through a lower quality part of the habitat type, but residual effects will still be present. The recovery time is 1-10 years. With multiple pipeline installations, the disturbed area increases, reducing the likelihood of quality improvement. The risk of significant effects due to a summation of effects increases with each installation.
- A slight negative effect on habitat types, breeding birds, and non-breeding birds occurs due to increased turbidity. Repeated increased turbidity could potentially cause growth retardation in seagrass and shellfish, but it is currently unclear if this could lead to significant effects.

In conclusion, **multiple cable systems are in prospect as long as sufficient consideration is given to the recovery time of species and habitat types. The project EIA should further investigate the precise effects, including nitrogen impacts.**

VII: Schiermonnikoog Wantij route - pipeline
For this route, **major negative effects of the installation of a pipeline cannot be ruled out and for several effects there is no prospect of mitigation. This also applies to the installation of multiple pipelines**. Chapter 7.3 investigates the possibility of compensation of major negative effects, this is the case. Therefore, there is a prospect of multiple pipelines as long as the recovery time of species and habitat types and compensation measures are taken into account. In the project EIA it should be further investigated what the exact effects are.

VIII: Ameland Wantij route - pipeline
For this route, major negative effects from the installation of a pipeline can likely be ruled out as mitigating

measures are in sight. The effects mainly relate to the disturbance of seals, breeding birds, and non-breeding birds and changes in substrate dynamics on typical species (like shellfish and seagrass). What the exact effects of mitigation measures are uncertain at this stage of the project. After taking mitigating measures, residual effects may still occur:

- By choosing the HDD locations, seal haul-out sites can be avoided during the sensitive period; residual effects are expected to be minimal, reducing the summation of effects.
- The effects on breeding and non-breeding birds due to disturbance can be mitigated by maintaining a distance from breeding areas and HVPs or shielding noise. However, residual effects may still occur as the disturbance cannot be entirely eliminated. When constructing multiple pipelines, a summation of residual effects may occur, possibly leading to significant effects. The risk of a significant effect when constructing a second pipeline is present if installation activities take place within the bird recovery time (two years). If the second pipeline is installed after the two-year recovery time, the risk of significant effects is likely low. More time between the installation of different pipelines may be needed to prevent 'semi-permanent' disturbance, but it is currently unclear how much time is required.
- The effects of changes in substrate dynamics on typical species of mudflats (benthos, seagrass, shellfish) and non-breeding birds can be mitigated by avoiding seagrass, shellfish banks, and benthic animal hotspots. Although the route passes through a part of the habitat type of lesser quality, residual effects still occur. The recovery time is 1-10 years. When installing multiple pipelines, the disturbed area becomes larger, reducing the chance of quality improvement in this area. The risk of a significant effects when installing a second pipeline is moderate, and high for a third pipeline.
- A minor negative effect on typical species (benthos, seagrass, shellfish), breeding birds, and non-breeding birds occurs due to increased turbidity. Repeated increased turbidity may cause growth retardation in seagrass and shellfish. It is currently unclear whether this leads to a significant effect.

In conclusion, **the installation of multiple pipelines is in prospect, provided sufficient consideration is given to species and habitat recovery times and the extent of residual effects. The project EIA should further investigate the exact effects, including the effects of nitrogen.**

IX: Zoutkamperlaag route - pipeline

For this route, major negative effects from the installation of a pipeline can likely be ruled out as mitigating measures are in sight. The effects are similar across the corridor's width and mainly relate to the disturbance of seals, breeding birds, and non-breeding birds, effects of turbidity on breeding and non-breeding birds, and changes in substrate dynamics on typical species. After taking mitigating measures, residual effects may still occur:

- By working near haul-out sites outside the sensitive period of the common seal, significant effects can be prevented. Residual effects are expected to be minimal, reducing the summation of effects.
- The effects on breeding and non-breeding birds due to disturbance can be mitigated by maintaining a distance from breeding areas and HVPs or shielding noise. However, residual effects may still occur as the disturbance cannot be entirely eliminated. When installing multiple pipelines, a summation of effects may occur, possibly leading to significant effects. The risk of a significant effect when installing a second cable system is present if done within the bird recovery time (two years). If the second pipeline is installed after the two-year recovery time, the risk of significant effects is likely low. More time between the installation of different pipelines may be needed to prevent 'semi-permanent' disturbance. It is currently unclear how much time is required.
- By carrying out dredging works outside the January-August and November-December period, major negative effects of turbidity on breeding and non-breeding birds can be prevented. A minor negative residual effect occurs outside the mentioned period. Repeated increased turbidity may cause growth retardation in seagrass and shellfish. It is currently unclear whether this leads to a significant effect.
- The effects of changes in substrate dynamics on habitat type H1140A and non-breeding birds can be mitigated by avoiding seagrass, shellfish banks, and benthic animal hotspots. Although the route passes through a part of the habitat type of lesser quality, residual effects still occur. The recovery time is 1-10 years. When installing multiple pipelines, the disturbed area becomes larger, reducing the chance of quality improvement in this area. The risk of a significant effect when installing a second pipeline is moderate, and high for a third pipeline.

In conclusion, **the installation of multiple pipelines is in prospect, provided sufficient consideration is given to species recovery times and the extent of residual effects. The project EIA should further investigate the exact effects.**

X: Tunnel route

There are no effects from the installation or user phase of the Tunnel route on the OUV ecological processes or biodiversity of the Wadden Sea heritage site. So, **there is no summation of effects**. Therefore, the construction of multiple shafts and tunnel tubes is in prospect. The effects of installing multiple shafts and tunnel tubes are evaluated at the entry point of the North Sea (Chapter 7 and 12 in PAWOZ EIA sub-report Nature) and the exit point on the mainland (Chapter 9 and 14 in PAWOZ EIA sub-report Nature).

Cumulative effects of other projects and activities

Cumulation of effects with other projects and activities have also been considered. This involves projects that have been permitted and have not yet been fully or partially implemented. For example, the gas extraction near Ternaard and the construction of the windfarm Eemshaven west, as further detailed in the following paragraphs. Additionally, an overview is provided of the effects of other activities in the Wadden area, which are not legally required to be included in a cumulative assessment. For each activity and project, it has been identified which disturbance factors (turbidity, sedimentation, sound and optical disturbance, etc.) are relevant and which geological processes and species groups are expected to be affected (Table 6.3 and 6.4). At this stage, it is not possible to quantify these effects or clearly distinguish between the routes.

Gas extraction near Ternaard

NAM intends to extract gas from an untapped gas field located north of Ternaard. A small part of this gas field lies beneath the mainland, while the majority is situated beneath the Wadden Sea. Draft decisions for this project were open for public consultation from Friday, August 27, 2021, to Thursday, October 7, 2021. A final decision on granting permits was expected in 2022 but was delayed due to a ruling by the Council of State on the nitrogen deposition exemption for construction.

The Appropriate Assessment for Gas drilling and gas extraction near Ternaard (Arcadis, 2021) drew the following conclusions:

- There are no negative effects from disturbance during the installation phase.
- Negative effects of subsidence on the natural features of the Wadden Sea are not a concern.
- Considering the prospected mitigating measures, there are no significant nitrogen deposition impacts on the natural features of the Wadden Sea.

This means that the residual effects of sand nourishments and nitrogen deposition must be included in a cumulative assessment. The gas extraction will occur near Route VIII: Ameland Wantij. The cumulative effects of this route and the gas extraction must be examined. Potential cumulative effects that could result in significant effects include:

- Effects of disturbance on birds and marine mammals caused by sand nourishments.
- Effects of nitrogen deposition on sensitive habitat types. (e.g. saltmarshes).

A cumulative assessment cannot yet be conducted during this planEIA-phase because the residual effects of pipeline construction near Route VIII: Ameland Wantij cannot yet be sufficiently detailed. A more detailed cumulative assessment will need to be conducted in the projectEIA if gas extraction proceeds.

Windfarm Eemshaven-west

Since the end of November 2022, the Province of Groningen has been working on a single spatial plan (Provinciaal Inpassingsplan, Provincial Spatial Plan (in English), PIP) for the entire Eemshaven-West wind area. Earlier plans for the development of the area are thereby nullified. The draft PIP for phase 1 has been revised and expanded to cover the entire area. Due to the intensive preparatory process and the agreements made with stakeholders, the principles of the preferred alternative remain the foundation for the development of the wind area. On December 5, 2023, the Provincial Executive (Gedeputeerde Staten in Dutch) decided to adopt the draft decisions for the windfarm Eemshaven-West.

The Appropriate Assessment in the EIA for the windfarm Eemshaven West (Pondera, 2023) drew the following conclusions:
- Effects of disturbance from above-water noise during the installation and operational phases on birds and marine mammals.
- Effects of disturbance from underwater noise during the installation phase on fish, birds, and marine mammals.
- Barrier effects during the operational phase on breeding and non-breeding Imigratory) birds.
- Collisions during the operational phase leading to casualties among breeding and non-breeding (migratory) birds.
- Disturbance of breeding and non-breeding (migratory) birds during the installation and operational phases of the wind farm.
- Effects on habitat types and/or living areas due to a temporary increase in nitrogen deposition.

Potential cumulative impacts that could result in significant effects include:
- Disturbance from above-water noise during installation on birds and marine mammals.
- Disturbance from underwater noise during installation on fish, birds, and marine mammals.
- Disturbance of breeding and non-breeding birds during the installation phase.
- Effects of nitrogen deposition on sensitive habitat types.

Comparable effects are also caused by PAWOZ and must therefore be examined in the cumulative assessment. A cumulative assessment cannot yet be conducted during this planEIA because the residual effects of cable system and pipeline installation cannot yet be sufficiently detailed. A more detailed cumulative assessment will need to be conducted in the projectEIA.

The following tables present a general overview of possible effects due to present and future developments in or nearby the Wadden Sea on the OUVs of the Wadden Sea. Table 6.3 presents possible effects on the OUV geological processes. Table 6.4 presents possible effects on the OUV ecological processes and biodiversity. Further research is needed to fully comprehend the cumulative effects of present and future developments in and nearby the Wadden Sea on the OUVs of the Wadden Sea.

Table 6.3 Impact of present and future developments on Wadden Sea OUV geological processes

OUV-criteria	Attribute	Developments that could impact the attribute	Effects of developments that could affect the attribute	Impacted geological processes
viii) geological processes	Size of the area where sediment is deposited	- Climate change (sea level rise) - Gas extraction - Civil works and maintenance (e.g. coastal protection)	- Change in seabed levels - Change in mean water level - Change in waves and current dynamics - Sedimentation and erosion	- Natural morphodynamic and hydrodynamic processes
	Quantity of river discharge	- Climate change (mainly rainfall and fresh water inflow)	- Change in current dynamics - Change in salt gradients	- Hydrology - Stratigraphy - Hydrodynamics
	Surface of areas with salt gradients	- Climate change (mainly rainfall and fresh water inflow)	- Change in fresh water inflow from rivers and canals - Change in current dynamics	- Natural morphodynamic and hydrodynamic processes
	Rate of sea level rise	- Climate change: not impacted directly by activities or processes related to Waddensea	N/A	N/A
	Size of barrier islands, sandbanks, channels, mudflats, and salt marshes	- PAWOZ and/or other planned cables and pipelines - Dredging maintenance - Gas extraction - Civil works and maintenance - Salt extraction	- Sedimentation and erosion - Change in substrate dynamics - Change in seabed levels - Change in waves and current dynamics	- Natural morphodynamic and hydrodynamic processes

Table 6.4 Impact of present and future developments on Wadden Sea OUV ecological processes and biodiversity

OUV-criteria	Attribute	Developments that could impact the attribute	Effects of developments that could affect the attribute	Impacted species groups
ix) ecological processes	Primary production	- PAWOZ - Dredging maintenance - Gas extraction - Civil works and maintenance - Climate change - Fisheries	- Increase in turbidity	- Phytoplankton
	Production by animals, from shellfish to marine mammals	- PAWOZ - Dredging maintenance - Gas extraction - Civil works and maintenance - Fisheries - Salt extraction - Climate change	- Increase in turbidity - Increase in sedimentation - Change in substrate dynamics	- Phytoplankton - Benthic animals - Breeding birds - Migratory birds - Fish - Marine mammals
	Numbers of fish, shellfish and birds	- PAWOZ - Fisheries - Dredging maintenance - Salt extraction - Gas extraction - Wind farms - Civil works and maintenance - Military exercises - Recreation - Climate change	- Increase in underwater sound and vibrations - Increase in optical disturbance and light - Increase in turbidity - Change in substrate dynamics - Increase in above water sound and vibrations - Increase in sedimentation - Presence of electromagnetic fields	- Breeding birds - Migratory birds - Fish - Benthic animals
	Food availability for fish, shellfish and birds	- PAWOZ - Fisheries - Dredging maintenance - Salt extraction - Gas extraction	- Increase in sedimentation - Change in substrate dynamics - Increase in underwater sound and vibrations - Increase in turbidity	- Phytoplankton - Benthic animals - Fish - Breeding birds - Migratory birds

OUV-criteria	Attribute	Developments that could impact the attribute	Effects of developments that could affect the attribute	Impacted species groups
		- Civil works and maintenance - Climate change		
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	- PAWOZ - Salt extraction - Gas extraction - Civil works and maintenance - Climate change - Military exercises - Recreation	- Increase in above water sound and vibrations - Increase in optical disturbance and light	- Saltmarsh vegetation - Breeding birds - Migratory birds
	Number of species (plants and animals) occurring in marine and brackish water areas	- PAWOZ - Fisheries - Dredging maintenance - Salt extraction - Gas extraction - Wind farms - Civil works and maintenance - Recreation - Climate change - Military exercises	- Increase in sedimentation - Increase in turbidity - Change in substrate dynamics - Increase in above water sound and vibrations - Increase in optical disturbance and light - Presence of electromagnetic fields - Increase in underwater sound and vibrations	- Benthic animals - Breeding birds - Migratory birds - Fish - Marine mammals
	Number of species of breeding birds	- PAWOZ - Fisheries - Dredging maintenance - Salt extraction - Gas extraction - Wind farms - Civil works and maintenance - Recreation - Climate change - Military exercises	- Increase in above water sound and vibrations - Increase in optical disturbance and light - Increase in turbidity	- Breeding birds

OUV-criteria	Attribute	Developments that could impact the attribute	Effects of developments that could affect the attribute	Impacted species groups
	Fattening areas for migratory birds (foraging area)	- PAWOZ - Fisheries - Dredging maintenance - Salt extraction - Gas extraction - Wind farms - Civil works and maintenance - Climate change - Military exercises - Recreation	- Change in substrate dynamics - Increase in above water sound and vibrations - Increase in optical disturbance and light - Increase in turbidity - Increase in sedimentation - Increase in underwater sound and vibrations	- Migratory birds - Fish - Benthic animals
	Roosting areas migratory birds (High-tide refuge areas)	- PAWOZ - Fisheries - Dredging maintenance - Salt extraction - Gas extraction - Wind farms - Civil works and maintenance - Recreation - Climate change - Military exercises	- Increase in optical disturbance and light - Increase in above water sound and vibrations	- Migratory birds
	Wintering areas for migratory birds		- Not scored, as it is overarching for Fattening areas for migratory birds and Roosting areas for migratory birds	
	- Food supply migratory birds	- PAWOZ - Fisheries - Dredging maintenance - Salt extraction - Gas extraction - Civil works and maintenance	- Change in substrate dynamics - Increase in underwater sound and vibrations - Increase in turbidity	- Benthic species - Fish

OUV-criteria	Attribute	Developments that could impact the attribute	Effects of developments that could affect the attribute	Impacted species groups
		- Climate change; -		
	- Tranquility for migratory birds	- PAWOZ - Fisheries - Dredging maintenance - Salt extraction - Gas extraction - Wind farms - Civil works and maintenance - Military exercises - Recreation - Climate change	- Increase in optical disturbance and light - Increase in above water sound and vibrations - Increase in underwater sound and vibrations	- Migratory birds
	- Relative importance of the Wadden Sea for population sizes of migratory birds	- PAWOZ - Fisheries - Dredging maintenance - Salt extraction - Gas extraction - Wind farms - Civil works and maintenance - Military exercises - Recreation - Climate change	- Increase in optical disturbance and light - Increase in above water sound and vibrations - Increase in underwater sound and vibrations - Change in substrate dynamics - Increase in turbidity - Increase in sedimentation.	- Migratory birds
	- Biodiversity		- Not scored, as it is overarching with the 'Number of species (plants and animals) occurring on the salt marsh' and the 'Number of species (plants and animals) occurring in marine and brackish water areas'.	

For the effects mentioned for PAWOZ, some major negative effects cannot be ruled out after optimization measures are taken and there are no mitigation measures in sight. After optimization and when mitigation measures are in prospect, activities can only have moderate or minor negative impact or neutal impact (see tables in Chapter 5). **Whether minor or moderate negative effects on the OUV of the heritage site become major negative (significant) through accumulation with effects of other activities in the Wadden Sea should be further investigated in a project EIA.**

7

CONCLUSION

Wind energy and hydrogen are needed to reach the sustainability targets of the European Union and Dutch government. This HIA concludes that the installation of one cable system or one pipeline per year on routes in the Wadden Sea has a moderate negative impact on the OUVs of the heritage site. Certain routes, however, have major negative impacts that cannot be mitigated.* These include the II: Oude Westereems route (pipeline), the V: Boschgat route (cable system), and the VII: Schiermonnikoog Wantij route (pipeline). The major negative impacts include turbidity, sedimentation, above and underwater sound and vibrations, and optical disturbance and light as a result of the installation activities. These effects negatively impact food webs and species such as birds, benthos, and the common seal. Further research is required to determine the duration of effects. In this HIA, they are mostly scored temporary, because the majority of actions only take place during the construction phase of the project. The exact duration of the actions and therefore also the duration of the effects, is not yet clear.

*When there are both minor and moderate negative impacts on the attributes of a route, the overall score for the route is considered moderate negative, as moderate impacts have a greater effect than minor ones. Similarly, when major negative impacts occur on a route, these major impacts are decisive in determining the route's overall score.

Firstly, Chapter 7.1 describes the overall impact of the installation of one cable system or pipeline per year on the three OUVs of the Wadden Sea. Chapter 7.2 provides a summary of the effects for each route after optimization and where no mitigation measures are in prospect. It also discusses compensation measures to address any residual impacts (Chapter 7.3). Thereafter, recommendations are provided for further research and for further developing a Wadden Sea specific HIA methodology (Chapter 7.5 and 7.6).

In the HIA Guidelines, it is stated that the impact evaluation results in conclusions regarding the extent to which the proposed action is acceptable regarding the OUV. However, further research to the effects of the mitigation measures on the routes (projectEIA) and improvement of the Wadden Sea-specific HIA methodology is needed to make these conclusions.

7.1 Impact on overall OUV

The table below (Table 7.1) shows a summary of the results of this HIA. The overall impact on the OUVs and integrity of the heritage site is presented per route for the installation of one cable system or pipeline per year after optimization measures. Hereby, prospected mitigation measures are considered. However, the exact effects of mitigation measures are not yet known in this phase of the EIA and are therefore not taken into consideration in this HIA. Cumulative effects and need and feasibility of compensation measures is also included.

Table 7.1 Summary of HIA PAWOZ Wadden Sea

Route	II: Oude Westereems route		V: Boschgat route	VII: Schiermonnikoog Wantij route		VIII: Ameland Wantij route	IX: Zoutkamperlaag route	X: Tunnel route
OUV	cable system	pipeline	cable system	cable system	pipeline	pipeline	pipeline	both
viii) geological processes	Minor	Moderate	Moderate	Minor	Minor	Minor	Moderate	Moderate
ix) ecological processes	Moderate	Major	Major	Moderate	Moderate	Moderate	Moderate	Minor
x) biodiversity	Moderate	Major	Major	Moderate	Major	Moderate	Moderate	Minor
Integrity								
viii) geological processes	Minor	Major	Moderate	Minor	Minor	Minor	Moderate	Moderate
ix) ecological processes	Moderate	Major	Major	Moderate	Moderate	Moderate	Moderate	Minor
x) biodiversity	Moderate	Major	Major	Moderate	Major	Moderate	Moderate	Minor
Cumulative effects								

Route	II: Oude Westereems route		V: Boschgat route	VII: Schiermonnikoog Wantij route		VIII: Ameland Wantij route	IX: Zoutkamperlaag route	X: Tunnel route
Summation of effects within route for multiple cable systems and/or pipelines*	Further research needed	Summation of effects expected	Summation of effects expected	Further research needed	Summation of effects expected	Further research needed	Further research needed	No summation of effects expected
Cumulative effects with other autonomous/future developments and activities	Further research needed	Further research needed	Further research needed	Further research needed	Further research needed	Further research needed	Further research needed	Further research needed
Conclusion	No compensation needed	Compensation needed	Compensation needed	No compensation needed	Compensation needed	No compensation needed	No compensation needed	No compensation needed
Prospect of compensation?	Not applicable	Not sufficient	Not sufficient	Not applicable	Prospect of compensation	Not applicable	Not applicable	Not applicable

7.2 Impact on OUVs per route

Table 7.2 provides a summary of the type of major negative effects of the installation of one cable system or pipeline per route on the attributes that convey the OUVs of the Wadden Sea. It is chosen to only present an overview of major negative effects for readability, while in most cases there are also minor to moderate negative effects. In the following paragraphs, these major negative effects per route are discussed and compared.

Table 7.2 Summary of type of major negative effects per route on attributes per OUV after optimization and prospected mitigation measures

	Route	**II: Oude Westereems route**		**V: Boschgat route**	**VII: Schiermonnikoog Wantij route**		**VIII: Ameland Wantij route**	**IX: Zoutkamperlaag route**	**X: Tunnel route**
OUV	Attribute	cable system	pipeline	cable system	cable system	pipeline	pipeline	pipeline	both
viii) geological processes	Size of barrier island, sandbanks, channels, mudflats, etc.								
	Quantity of river discharge								
	Surface of areas with salt gradients								
	Rate of sea level rise								
	Size of barrier islands, sandbanks, channels, mudflats, and salt marshes								
ix) ecological processes	Primary production		Turbidity	Turbidity					
	Production by animals, from shellfish to marine mammals		Turbidity	- Turbidity - Sedimentation					
	Numbers of fish, shellfish and birds		Turbidity	- Turbidity					

	Route	II: Oude Wes-tereems route		V: Boschgat route	VII: Schier-monnikoog Wantij route		VIII: Ameland Wantij route	IX: Zout-kamperlaag route	X: Tunnel route
				- Sedimen-tation					
	Food availability for fish, shell-fish and birds		Turbidity	- Turbidity - Sedimen-tation					
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh								
	Number of species (plants and animals) occurring in marine and brackish water areas		- Turbidity - Under-water sound and vi-brations - Above water sound and vibrati-ons - Optical distur-bance and light	- Sedimen-tation - Turbidity - Above water sound and vibrati-ons - Under-water sound and vi-brations		- Above water sound and vi-brations - Optical distur-bance and light			
	Number of species of breeding birds		Turbidity	Turbidity					

	Route	II: Oude Westereems route		V: Boschgat route	VII: Schiermonnikoog Wantij route		VIII: Ameland Wantij route	IX: Zoutkamperlaag route	X: Tunnel route
	Fattening areas for migratory birds (foraging area)								
	Roosting areas migratory birds (High-tide refuge areas)								
	Food supply migratory birds								
	Tranquility for migratory birds								

As shown in Table 7.2, a major negative impact is expected on attributes of the OUVs ecological processes and biodiversity for the II: Oude Westereems route (pipeline), the V: Boschgat route (cable system) and the VII: Schiermonnikoog Wantij route (pipeline). For these effects there are no mitigation measures in prospect.

II: Oude Westereems route - pipeline

Major negative effects can be expected after optimization measures, because there are no mitigation measures in prospect that can reduce the effects of turbidity, sedimentation, above water sound and vibrations (seals), optical disturbance and light (seals). This causes a major negative impact on attributes that convey the OUV ecological processes and biodiversity (see Table 7.2), which also impairs the integrity of the Wadden Sea World Heritage on this route (see paragraph 5.1.2. for an explanation).

V: Boschgat route - cable system

Major negative effects can be expected after optimization measures, because there are no mitigation measures in prospect that can reduce the effects of turbidity, sedimentation, above and underwater sound and vibrations (for mammals). This causes a major negative impact on attributes that convey the OUV ecological processes and biodiversity (see Table 7.2), which also impairs the integrity of the Wadden Sea World Heritage on this route (see paragraph 5.1.3. for an explanation).

VII: Schiermonnikoog Wantij route - pipeline

Major negative effects can be expected after optimization measures, because there are no mitigation measures in prospect that can reduce the effects of above water sound and vibrations, optical disturbance and light (for mammals). This causes a major negative impact on attributes that convey the OUV ecological processes and biodiversity (see Table 7.2), which also impairs the integrity of the Wadden Sea World Heritage on this route (see paragraph 5.1.5. for an explanation).

Conclusion

Routes with the most effects on the OUVs of the Wadden Sea are the II: Oude Westereems route (pipeline), V: Boschgat route (cable system) and VII: Schiermonnikoog Wantij route (pipeline). Overall, the X: Tunnel route has the least impact on the Wadden Sea OUVs.

7.3 Compensation measures

After optimization measures, there are three routes that have a major negative impact on the OUVs ecological processes and biodiversity of which the effects cannot be mitigated by prospected mitigation measures (Table 7.3). PAWOZ is considered important for reaching climate goals. Therefore, compensation measures are being investigated according to the guidelines of the Dutch Environmental Planning Act (a more elaborate explanation can be found in the EIA). Compensation measures are being investigated when mitigation measures cannot fully prevent or reduce major negative impacts, and the alternatives are still considered despite adverse effects. The table below (Table 7.3) specifies what habitat types and species are significantly negatively impacted after optimization measures. The following paragraphs describe the feasibility of compensation at an abstract level. An elaborate discussion of these compensation measures can be found in Chapter 18 in PAWOZ EIA sub-report Nature.

Table 7.3 Overview of major negative effects on the OUV ecological processes and biodiversity for which no mitigation measures are in sight and for which compensation measures are needed

Route	II: Oude Westereems route		V: Boschgat route	VII: Schiermonnikoog Wantij route		VIII: Ameland Wantij route	IX: Zoutkamperlaag route	X: Tunnel route
Effect type	cable system	pipeline	cable system	cable system	pipeline	pipeline	pipeline	both
Turbidity		H1110A* H1130* H1140A* breeding birds	H1110A H1130 H1140A breeding birds					
Sedimentation			H1110A H1140A, fishcommon seal					
Above water sound and vibrations, and optical disturbance		common seal	common seal		common seal			
Underwater sound and vibrations		common seal	common seal					
Conclusion	no compensation needed	compensation needed	compensation needed	no compensation needed	compensation needed	no compensation needed	no compensation needed	no compensation needed

*Habitat types:

H1110A: Sandbanks which are constantly slightly covered by sea water

H1130: Estuaries (dynamic environments where rivers meet the sea, characterized by a mix of fresh and saltwater)

H1140(A): Mudflats and sandflats not covered by seawater at low tide

II: Oude Westereems route - pipeline
There is no prospect of compensation for the effects of turbidity on multiple attributes in the Wadden Sea OUV. Prohibition of sources of turbidity such as dredging activities and/or shrimp fishing near the route from mid-March to August during the installation years is not realistic.

There is prospect of compensation of disturbance of the tranquility of seal haul-out sites caused by above water sound and vibrations, and optical disturbance and light. The compensation measure entails the prohibition of all disruptive activities on the mudflats for at least the entire calving and pup-rearing period during the installation years of the pipeline between the coast of mainland Groningen and the Wadden island Schiermonnikoog.

There is no prospect of compensation of disturbance of the common seal due to underwater sound and vibrations caused by installation vessels. Reducing other sources of underwater sound and vibrations such as maritime traffic during the installation period of cable systems and pipelines, is most likely not realistic nor sufficiently effective because disturbance sources nearby the route are scarce.

V: Boschgat route - cable system
There is no prospect of compensation for the effects of turbidity on habitat types and birds, because it is not effective to prohibit shrimp fishery and dredging activities nearby the route from January to August during installation years.

There is no prospect of compensation for the effects of sedimentation on habitat types, because it is not effective to prohibit dredging activities and/or shrimp fishery during the installation period of cable systems and pipelines.

There is prospect of compensation of above water sound and vibrations, and optical disturbance and light on tranquility on seal haul-out sites, as explained in the paragraph on the II: Oude Westereems route.

There is no prospect of compensation of disturbance of the tranquility of the common seal on seal haul-out sites due to underwater sound and vibrations, as explained in the paragraph on the II: Oude Westereems route.

VII: Schiermonnikoog Wantij route - pipeline
There is prospect of compensation for disturbance of tranquility on seal haul-sites caused by above water sound and vibrations, and optical disturbance and light, as explained in the paragraph on the II: Oude Westereems route.

Conclusion
Overall, there is no sufficient prospect of compensation of major negative effects of the II: Oude Westereems route (pipeline) and the V: Boschgat route (cable system). There is prospect of compensation measures for the VII: Schiermonnikoog Wantij route (pipeline).

The prospect of compensation considering the summation of effects within a route
This paragraph sets out the prospect of compensation when installing multiple cable systems or pipelines per route. It is assumed that installation of cable systems or pipelines occurs sequentially and not simultaneously. There are two types of compensation measures:
- Compensation measures applicable during the installation phase. These measures address disturbances during installation of one cable system or pipeline and can be repeated annually. They allow for the installation of multiple systems without additional issues.
- Compensation measures applicable before, during and/or after the installation phase. These measures focus on improving the quality of an ecosystem before installation of one cable system or pipeline and maintaining it during and after. The improvement and/or recovery of ecosystems can take years, which requires careful planning to ensure effective compensation.

7.4 Recommendations for further research

To assess the effects of proposed activities on the OUVs of the Wadden Sea in more detail further research is recommended.

Further research to assess effects on geological processes

Seabed elevation data

The impact assessment described in this report is based on seabed elevation data collected as part of the regular monitoring program by Rijkswaterstaat. In many locations, this data was collected three years or longer ago. Between the time of data collection and the moment of installing the cable systems and pipelines along the routes, the topography changes due to natural dynamics, especially in the Wadden Sea area. Based on the available data, the best possible estimate has been made. However, morphological developments have inherent uncertainties, as feedback between soil development and hydrodynamics can reinforce each other. Therefore, the precise bed level at the time of installation of the cable systems and pipelines cannot be determined with certainty at this time. It is recommended to collect new elevation data along the route in the year preceding the installation of a cable system or pipeline and to optimize the design based on this data. Both the exact route location and burial depth can be optimized, potentially limiting impacts on the seabed and water at sea.

Soil composition

For the II: Oude Westereems route through the Wadden Sea, the available information about the soil composition is limited. It is known that hard layers (erosion-resistant layers such as clay) are present in the area, but their exact location and thickness are unknown. Geotechnical research should be conducted prior to the final design of a cable system or pipeline along this route to obtain and incorporate this information into the installation method. It is uncertain what effects digging through a hard layer will have on soil development. This may locally lead to deep erosion pits that subsequently influence the location of channels in the Ems estuary or to erosion patterns that further expand. This is a knowledge gap.

Sedimentation

The effect of spreading very large volumes of sediment on a containment system is insufficiently known. The following aspects may be relevant: (1) spreading a large volume of sand (order of 1 Mm^3 or more) at the same location can lead to sand accumulation and the formation of local seabed features with their own dynamics, prolonging the system's recovery to its undisturbed state; (2) when spreading very large volumes of silt-rich sediment, a density current with very high sediment concentrations may form near the seabed, extending over several km^2; (3) hard layers spread during dredging operations are expected to remain at the spreading location, leading to a permanent disturbance of natural seabed features. If a route requiring large sediment volumes to be dredged is chosen, further research, possibly with pilot excavations, is needed to better understand these aspects and their possible effects.

Monitoring and evaluation

The overall task of realizing connections between the sea and the onshore energy network requires various cable systems and/or hydrogen pipelines, several of which may pass through the Wadden Sea area. The interventions in this area involve considerable uncertainty. Examples of processes with uncertainty include:

- The degree of re-sedimentation that occurs when dredging channels and how this can be minimized.
- How long the traces of a trench remain visible on the seabed and how this duration depends on the specific location where the trench is deployed.
- The long-term effect of soil disturbance for the construction of an HDD entry or exit point on soil development.
- How much coastal erosion occurs around a cofferdam.

Conservative assumptions have been chosen for assessing such processes. However, it is expected that significant knowledge can be gained by extensively monitoring the effects of the installation of the first pipeline or cable system. This requires at least measurements of elevation and soil composition in a period before and after the installation of the first cable system or hydrogen pipeline. Results from such a monitoring program can be used to determine the effects of subsequent cable systems and hydrogen pipelines more accurately and where possible, to mitigate them (PAWOZ EIA subreport Seabed).

Further research to assess effects on ecological processes and biodiversity

Due to the scale and level of detail, uncertainties in the available information, and in some cases the nature of the disturbance factors, there are a number of knowledge gaps. Several of these knowledge gaps have been identified in the assessment. These are summarized in this chapter.

Current and location-specific occurrence

Several significant knowledge gaps have been identified regarding the current and location-specific occurrence of marine habitats and species. This includes the lack of insight into the presence of benthic hotspots on the tidal flats, as these change over the years. Mitigation measures are in prospect to avoid these hotspots. However, there is insufficient information about the current and location-specific occurrence of hotspots of sensitive typical species. Therefore, the occurrence of hotspots should be better mapped on and near the design route to avoid them effectively.

Four significant knowledge gaps have been identified concerning non-breeding birds. The first gap concerns insufficient information about the current and location-specific occurrence of hotspots of food species for oystercatchers, eiders, and spotted redshank. Additionally, it is unclear how these bird species use the foraging area. The food hotspots and the use of the area need to be better mapped to determine the actual impact and to avoid the most important food hotspots. The second knowledge gap concerns the lack of insight into the distribution of birds during low tide and the general importance of parts of the Wadden Sea as foraging areas. This gap can only be fully filled by conducting regular low tide counts, which currently do not occur. An alternative approach is to determine the suitability of areas for different species through a detailed analysis of exposure time, location of high tide roosts, and food availability. Such an analysis is beyond the scope of the planEIA phase but can be carried out in the projectEIA phase. Additionally, there is a knowledge gap concerning the occurrence of non-breeding birds on Ameland. Although several waterbird counts are conducted annually on Ameland, just like elsewhere in the Wadden Sea, these could not be provided in the same way as for other counting areas for this nature assessment. This makes it difficult to assess the effects of disturbance on non-breeding birds on Ameland (the VIII: Ameland Wantij route) in the context of conservation objectives. It is desirable to seek a solution for this in the projectEIA phase. The final knowledge gap is the lack of insight into the distribution of non-breeding birds within the waterbird counting units. Therefore, a worst-case scenario has been assumed, where all birds within the counting area are disturbed. This information can be obtained by interviewing bird counters, as they have insights into the distribution of birds within the counting units based on their experiences.

Turbidity

The dose-effect relationships of turbidity on visual hunting birds are not well known. There is a particular lack of realistic threshold values for turbidity for visual hunting birds in turbid coastal waters.

Sedimentation

For the assessment of the ecological effects, a sedimentation model was performed, providing a general insight into the extent of the affected area and the thickness of the sediment layer. However, this does not provide insight into the impact of sedimentation on specific locations, habitat types, and habitats. It is desirable to further elaborate on this in the projectEIA phase to better analyse and assess the effects.

Additionally, a knowledge gap has been identified concerning the effects of sedimentation on (migratory) fish.

Substrate dynamic changes

The tidal flat trencher study investigated the effects of excavation and driving on the tidal flats on the survival and recovery of benthos living in and on top of the seafloor. However, knowledge gaps remain regarding the long-term effects of prolonged sediment compaction, the burial technique, and effects that manifest over time. It is desirable to further investigate these knowledge gaps in the projectEIA phase.

Moreover, the effects of compaction on sandy soils and the potential consequences for benthic animals are still insufficiently known. Here too, it is desirable to conduct monitoring to help filling this knowledge gap.

Disturbance (sound, visual disturbance, and light)

The assessment indicated that the effects of sound on benthos have been poorly studied to date. Current impact studies on this subject also demonstrate varying results. However, it is plausible that disturbance from continuous sound does not lead to direct mortality. It is desirable to conduct monitoring to help filling this knowledge gap.

Electromagnetic fields

The assessment indicated that electromagnetic fields (EMF) may have effects on fish and marine mammals. However, the extent to which these effects manifest is still unclear.

Additionally, the assessment showed that benthos living in and on top of the seabed are sensitive to EMF, but the extent is not always clear. Given the low field strengths resulting from the cable systems, no large-scale effects on the quality of intertidal and subtidal mudflats are expected, but monitoring of the effects on typical species, fish and sea mammals is desirable.

Desiccation

Changes in groundwater levels and sometimes in groundwater quality may potentially lead to a shift in species composition and, in the long term, to a change in habitat types. There are still too few details known about the implementation to determine the effect on hydrology. It is desirable to investigate this knowledge gap with more detailed information in the projectEIA phase.

Monitoring and evaluation

Through monitoring, action-effect relationships are made comprehensible, and the presence of conservation values in the Wadden Sea should be better mapped to avoid potential effects as much as possible. In light of the above knowledge gaps, it is therefore recommended to conduct further research on several points. These include:

- The effects of sedimentation on fish and marine mammals.
- The current and location-specific occurrence of hotspots of sensitive typical species.
- The current and location-specific occurrence of hotspots of food species for oystercatchers, eiders, and spotted redshank and the use of the foraging area.
- Monitoring the use of high tide roosts (HVP’s). The goal is to determine the specific location of the HVP’s, their size, and how they are used by present bird species.
- The distribution of bird species at low tide and the importance of foraging areas in the Wadden Sea.
- The presence of benthic hotspots on the tidal flats, as these change over the years.
- The effects of EMF on fish and harbour porpoises (PAWOZ EIA sub-report Nature).

Further research to assess effects on all OUVs of the Wadden Sea

Climate change

The exact effects of climate change on the OUVs of the Wadden Sea are still difficult to foresee. Further (scientific) research is needed on the broad topic, outside the scope of PAWOZ. For example, to what extent the tidal flats can grow with (accelerated) sea-level rise through sedimentation is subject of scientific research. What impact this will have on the location and dimensions of channels is still unknown. The expectation is that the effects on soil and water at sea will be limited in the coming decades. How climate change will affect the development of the Wadden Sea in the second half of the 21st century is currently unknown and will partly depend on the amount of greenhouse gases emitted in the coming decades. Similarly, more research is needed to consequences of climate change on ecological processes and biodiversity.

Cumulative effects

Further research, outside the scope of PAWOZ, is required to the cumulative effects of present and future developments and activities in and nearby the Wadden Sea. This can then be applied to further assess cumulative effects on the OUV of the Wadden Sea.

7.5 Recommendations for Wadden Sea specific HIA methodology

This section proposes recommendations to further develop a Wadden Sea specific HIA methodology.
In this HIA, the list of OUV attributes as set out in the Memo of the Wadden Sea Academy is used. To assess OUV of the Wadden Sea it is advised to revise the OUVs and attributes that convey the OUV of the Wadden Sea.

Choice of wording for OUVs
Experts prefer to use the word geomorphology instead of geological processes because it is more accurate in the context of this research.

Experts prefer to use ecological processes for readability instead of 'ecological and biological processes' as they are interlinked.

Attributes for geomorphology need to be more clearly defined and quantifiable
The impact on geomorphology (morphology of the seabed, substrate dynamics and current and wave dynamics) is discussed in the planEIA. In this HIA, it is attempted to translate this data to assess the effects on the OUV geological processes. In order to do this more effectively, the attributes that convey this OUV need to be more clearly defined and quantifiable. For example, the natural dynamics of the Wadden Sea and continuity or connectedness of the Wadden Sea could be attributes to assess effects on geomorphology and hydrodynamics.

Overlap between OUV ecological processes and biodiversity
The attributes that convey the OUVs ecological processes and biodiversity overlap thus give similar evaluation descriptions. For example, the attributes conveying the OUV ecological processes relate to food webs. However, there are also attributes related to food webs that convey the OUV biodiversity. Another example is the attribute 'number of fish, shellfish and birds' that conveys the OUV ecological processes which overlaps with the attribute 'number of species occurring on the salt marsh' and 'number of species occurring in marine and brackish water areas' that convey the OUV biodiversity. There is foremostly an overlap in attributes related to food availability for birds. Overall, the distinction between the OUV ecological processes and biodiversity is not made clear with the current attributes.

We suggest making a clear distinction between ecological attributes and biodiversity attributes. In the OUV ecological processes, attributes should be taken into account that involve ecological interactions of species with the environment (habitat related) or food web related. In the OUV biodiversity, there can then be a focus on different species groups (e.g. benthos, seagrass, breeding birds, non-breeding birds, mammals, fish, salt marsh). This clear separation makes it easier to understand the exact effects. In addition, the relationship with EIA is then easier to understand. It will be more efficient to write, read and understand the HIA.

Missing attributes
In the list proposed in the Memo by the Wadden Sea Academy, there are no attributes for assessing effects specifically on mammals, sea grass, and salt marsh vegetation. In the list proposed in the Memo by the Wadden Sea Academy, there are neither attributes for assessing effects on habitat types (intertidal and subtidal habitats). Adding these species and habitat types would be useful, because these are typical species in the Wadden Sea and of great importance from a management and protection perspective.

Evaluating integrity
Integrity is the most challenging aspect to evaluate. The HIA assessment does not give an indication about the severeness of an impact of integrity. A spatial scale related to a measure of impact on integrity would be helpful in this assessment. In addition, the definition of integrity can be clarified. In this HIA, we have formulated questions to help evaluate integrity. It would helpful if the HIA methodology would give more tools and insight how to understand the definition of integrity and how to evaluate it. Hereby it would be useful to create not too much overlap with the impact assessment of the OUVs ecological processes and biodiversity, to avoid repetition in the HIA.

8

TERMINOLOGY

AC: Alternating Current. An electric current that periodically changes direction. Almost the entire electricity grid in the Netherlands uses this type of current.
Autonomous development: Autonomous developments result in changes within the planning area, which occur independently of the proposed activity and for which a decision has already been made. For example, when developments are established in a spatial plan and a permit has been granted.
Appropriate Assessment: An Appropriate Assessment (Natuurtoets in Dutch) is an assessment conducted to determine whether a plan, project, or activity could have negative effects on protected natural areas, such as Natura 2000 sites. This assessment is a requirement under the European Habitats Directive and is part of the permitting process for spatial developments in the Netherlands.
Autonomous processes: Autonomous processes are inevitable for the future state of the site's characteristics. This includes, for example, sea level rise and other consequences of climate change. Generally, these processes only lead to significant changes over an extended period of time.
Ballonplaat: A sandbank in the North Sea, approximately 4 kilometers north of Rottumerplaat. The area is relatively shallow and stable, and the location is being studied for potential tunnel entry/exit points.
Bufferzone: For World Heritage properties, a buffer zone is an area surrounding the World Heritage Site with legal and/or customary restrictions on its use and development to offer additional protection to the property.
Cable system: A bundle of electrical cables consisting of two parallel cable circuits in AC or one cable circuit and a fiber-optic connection in DC. It refers only to the power cables, not the platform or transformer/converter station.
Compensation: Measures taken to offset damage after applying mitigation measures. For example, planting new trees in place of those cut down.
Converter station: A station where direct current (DC) is converted to alternating current (AC) and adjusted to the appropriate voltage level.
Cumulative effects: The combined effects of various developments. These developments can occur within or outside the proposed activity.
DC: Direct Current. An electric current where the direction remains constant, as opposed to alternating current. The 525 kV cable systems operate on DC.
Entry point: The location where the cable system or hydrogen pipeline cross the primary dike and existing cables along the coast.
Entry point Eemshaven: The point where the tunnel begins at Eemshaven. This is where a shaft is located, allowing cable systems and/or pipelines to enter the tunnel.
Environmental Planning Act: The Omgevingswet (Environmental Planning Act) is a comprehensive law in the Netherlands that regulates the planning and management of the physical environment. It aims to simplify and streamline the regulatory process by consolidating and modernizing numerous laws and regulations related to spatial planning, environmental protection, infrastructure, and building permits.
Exit point: The point where the cable system and/or hydrogen pipeline exits to connect with the offshore infrastructure.
Gasunie: Gasunie is a network company for energy. Its subsidiary, HyNetwork Services, develops and manages the onshore and offshore hydrogen network in the Netherlands (Hydrogen Network Netherlands).
GW: Gigawatt. A unit of power equal to one billion watts. It is commonly used to measure large-scale power generation, such as the output of power plants or the energy consumption of entire cities or countries.
Habitat type: A specific type of ecosystem, either terrestrial or aquatic, with characteristic features.

HIA: Heritage Impact Assessment. A project-level assessment identifying and evaluating the potential effects of a proposed activity or project on the heritage or conservation values of a natural or cultural heritage site.
Hotspots: Locations with high ecological value.
ICCROM: International Centre for the Study of Preservation and Restoration of Cultural Property.
ICOMOS: International Council on Monuments and Sites.
IUCN: International Union for Conservation of Nature.
Impact: The result or effect of an activity or event on a given attribute, system, or environment.
Integrity: A measure of the wholeness and intactness of a heritage site, including its physical state, authenticity, and the preservation of its essential features.
IIA: Integrated Impact Assessment. An analysis of the environmental effects, costs, technical aspects, agriculture, planning, and future sustainability of the routes. A separate document for PAWOZ-Eemshaven.
KRW: The Water Framework Directive (KRW in Dutch) is a European regulation focused on maintaining and improving water quality, aiming to achieve "good status" for all water bodies by 2027.
kV: Kilovolt. A unit of electrical voltage, equal to 1,000 volts.
Mitigating measures: Actions taken to reduce or avoid negative effects from activities or physical interventions.
MW: Megawatt. A unit of power equal to one million watts, commonly used to measure the output of power plants or the power consumption of large systems.
N2000: Natura 2000 areas. Ecological network of protected zones designated under the EU Habitat and Birds Directives to preserve biodiversity.
NNN: National Ecological Network (Natuur Netwerk Nederland in Dutch). The national network of natural areas and corridors established by the Dutch government to promote biodiversity.
Offshore: Referring to areas located at sea, typically beyond the 6-mile zone, often in water depths exceeding 10 to 20 meters.
Onshore: Referring to land areas, as opposed to offshore.
PAWOZ: Programma Aansluiting Wind op Zee - Eemshaven. It is a program under the Dutch Environmental Law (Omgevingswet) that aims to plan and regulate the connection of offshore wind farms to the Dutch electricity grid. PAWOZ provides a framework for identifying suitable routes for the cables and infrastructure needed to connect wind farms located in the North Sea to the national grid.
PlanEIA: Environmental Impact Assessment for a plan or program.
Project decision: A project decision is a decision used in the Netherlands to facilitate complex projects of public interest. It serves as an instrument under the Environmental Law (Omgevingswet) and establishes the necessary rules for the execution, implementation, or maintenance of a project. The project decision can amend the environmental plan and includes the legal frameworks for the project, such as the identification of specific locations, routes, and other conditions. It replaces other instruments like integration plans, route decisions, and project plans.
ProjectEIA: An Environmental Impact Assessment for a project decision, focusing on more detailed information than a planEIA.
Proposed activity: A description of the activity that the proponent intends to carry out, including what will be built and how it will be installed.
Residual effects/impacts: Effects/impacts that remain even after mitigation measures have been applied.
Route: A possible layout for the cable systems and/or hydrogen pipelines from an offshore wind energy area to an onshore location for connecting it to the electricity or hydrogen network.
Statement of Outstanding Universal Value: The official statement adopted by the World Heritage Committee, summarizing why a property is considered to have OUV and detailing the required protection and management measures.
TenneT: The network operator in the Netherlands for electricity from 110 kV onwards, also managing offshore networks.
UNESCO: United Nations Educational, Scientific and Cultural Organization.
Hydrogen: A common chemical element and energy carrier. It is used to store and transport renewable energy, especially for heavy industry, large vehicles, and energy storage.
Hydrogen pipeline: Pipelines for transporting hydrogen gas. These can be newly constructed or repurposed pipelines.
Wider setting: Refers to the broader environment surrounding a World Heritage property, including elements like topography, infrastructure, land use, and social or cultural practices.

World Heritage Site: A cultural, natural, or mixed heritage site inscribed on the World Heritage List and considered to have Outstanding Universal Value for humanity.
Wantij: Is a Dutch word for a tidal channel. A tidal channel is an area between islands and the coast with tidal action but without strong currents.

9

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Annex(es)

ANNEX: OUTSTANDING UNIVERSAL VALUE CRITERIA, UNESCO

Table I.1 Overview of the ten criteria for OUV from the UNESCO Statement of Outstanding Universal Value

Box 3.1. Criteria for Outstanding Universal Value

The property should:

i. represent a masterpiece of human creative genius;

ii. exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design;

iii. bear a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared;

iv. be an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history;

v. be an outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change;

vi. be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance. (The Committee considers that this criterion should preferably be used in conjunction with other criteria);

vii. contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance;

viii. be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features;

ix. be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals; and/or

x. contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of Outstanding Universal Value from the point of view of science or conservation.

Source: UNESCO, 2021.

II

ANNEX: HIA IMPACT ASSESSMENT TABLE

Table II.1 Standard impact assessment table from the HIA Guidelines (tool 3)

Element of propo-sed action	Attribute	Description of poten-tial impact	Frequency of action	Duration of action	Reversibi-lity of action	Reversibility of change to attribute	Longevity of change to at-tribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
			Once/intermit-tent/continuous	Short-term/long-term	Reversi-ble/irre-versible	Reversi-ble/irrever-sible change	Tempo-rary/perma-nent change	None/negligi-ble/some/large change	Positive/nega-tive change	Neutral/mi-nor/moder-ate/major/im-pact (negative and positive)
										Major negative impact
										Moderate nega-tive impact
										Minor negative impact
										Neutral
										Minor positive impact
										Moderate posi-tive impact
										Major positive impact

ANNEX: UNESCO STATEMENT OF OUTSTANDING UNIVERSAL VALUE OF THE WADDEN SEA

“Brief synthesis

The Wadden Sea is the largest unbroken system of intertidal sand and mud flats in the world, with natural processes undisturbed throughout most of the area. The 1,143,403 ha World Heritage property encompasses a multitude of transitional zones between land, the sea and freshwater environment, and is rich in species specially adapted to the demanding environmental conditions. It is considered one of the most important areas for migratory birds in the world and is connected to a network of other key sites for migratory birds. Its importance is not only in the context of the East Atlantic Flyway but also in the critical role it plays in the conservation of African-Eurasian migratory waterbirds. In the Wadden Sea up to 6.1 million birds can be present at the same time, and an average of 10-12 million pass through it each year.

Justification for the Outstanding Universal Criteria

Criterion viii): The Wadden Sea is a depositional coastline of unparalleled scale and diversity. It is distinctive in being almost entirely a tidal flat and barrier system with only minor river influences, and an outstanding example of the large-scale development of an intricate and complex temperate-climate sandy barrier coast under conditions of rising sea-level. Highly dynamic natural processes are uninterrupted across the vast majority of the property, creating a variety of different barrier islands, channels, flats, gullies, saltmarshes and other coastal and sedimentary features.

Criterion ix): The Wadden Sea includes some of the last remaining natural large-scale intertidal ecosystems where natural processes continue to function largely undisturbed. Its geological and geomorphologic features are closely entwined with biophysical processes and provide an invaluable record of the ongoing dynamic adaptation of coastal environments to global change. There are a multitude of transitional zones between land, sea and freshwater that are the basis for the species richness of the property. The productivity of biomass in the Wadden Sea is one of the highest in the world, most significantly demonstrated in the numbers of fish, shellfish and birds supported by the property. The property is a key site for migratory birds and its ecosystems sustain wildlife populations well beyond its borders.

Criterion x): Coastal wetlands are not always the richest sites in relation to faunal diversity; however, this is not the case for the Wadden Sea. The salt marshes host around 2,300 species of flora and fauna, and the marine and brackish areas a further 2,700 species, and 30 species of breeding birds. The clearest indicator of the importance of the property is the support it provides to migratory birds as a staging, moulting and wintering area. Up to 6.1 million birds can be present at the same time, and an average of
0-12 million each year pass through the property. The availability of food and a low level of disturbance are essential factors that contribute to the key role of the property in supporting the survival of migratory species. The property is the essential stopover that enables the functioning of the East Atlantic and African-Eurasian migratory flyways. Biodiversity on a worldwide scale is reliant on the Wadden Sea.

Statement of integrity

The boundaries of the extended property include all of the habitat types, features and processes that exemplify a natural and dynamic Wadden Sea, extending from the Netherlands to Germany to Denmark. This area includes all of the Wadden Sea ecosystems and is of sufficient size to maintain critical ecological processes and to protect key features and values.

The property is subject to a comprehensive protection, management and monitoring regime which is supported by adequate human and financial resources. Human use and influences are well regulated with clear and agreed targets. Activities that are incompatible with its conservation have either been banned or are heavily regulated and monitored to ensure they do not impact adversely on the property. As the property is surrounded by a significant population and contains human uses, the continued priority for the protection and conservation of the Wadden Sea is an important feature of the planning and regulation of use, including within land/water-use plans, the provision and regulation of coastal defences, maritime traffic and drainage. Key threats requiring ongoing attention include fisheries activities, developing and maintaining harbours, industrial facilities surrounding the property including oil and gas rigs and wind farms, maritime traffic, residential and tourism development and impacts from climate change.

Protection and management requirements

Maintaining the hydrological and ecological processes of the contiguous tidal flat system of the Wadden Sea is an overarching requirement for the protection and integrity of this property. Therefore, conservation of marine, coastal and freshwater ecosystems through the effective management of protected areas, including marine no-take zones, is essential. The effective management of the property also needs to ensure an ecosystem approach that integrates the management of the existing protected areas with ot
er key activities occurring in the property, including fisheries, shipping and tourism.

The Trilateral Wadden Sea Cooperation provides the overall framework and structure for integrated conservation and management of the property as a whole and coordination between all three States Parties. Comprehensive protection measures are in place within each State. Specific expectations for the long-term conservation and management of this property include maintaining and enhancing the level of financial and human resources required for the effective management of the property. Research, monitoring and assessment of the protected areas that make up the property also require adequate resources to be provided. Maintenance of consultation and participatory approaches in planning and management of the property is needed to reinforce the support and commitment from local communities and NGOs to the conservation and management of the property. The State Parties should also maintain their commitment of not allowing oil and gas exploration and exploitation within the boundaries of the property. Any development projects, such as planned wind farms in the North Sea, should be subject of rigorous Environmental Impacts Assessments to avoid any impacts to the values and integrity of the property (UNESCO)."

IV

ANNEX: HIA ASSESSMENT TABLE FOR PAWOZ

Table IV.1 presents the overall effects of proposed activities along the routes. This is a standard table from The Toolkit for Impact Assessment in a World Heritage Context (Tool 3) adapted to PAWOZ. The table shows:

1. OUV criteria of the Wadden Sea.
2. Attributes that convey the OUV criteria of the Wadden Sea.
3. Description of potential impact based on findings of the PAWOZ EIA. The effects are described based on the installation of one cable system or one pipeline per year and after optimization of the route and application of mitigation measures.
4. Description of evaluation of impact, including description of frequency, duration and reversibility of action as well as reversibility, longevity, degree and quality of change. The evaluation of impact is scored from major positive impact, moderate positive impact, minor positive impact, neutral impact, moderate negative impact, to major negative impact.

Table IV.1 HIA assessment table for PAWOZ (routes for cable system or pipeline installation) in the Wadden Sea. *Only applicable for cable systems

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
			Once/ Intermittent/ Continuous	Short-term/ Long-term	Reversible/ Irreversible	Reversible/ Irreversible change	Temporary/ Permanent change	None/ Negligible/ Some/ Large change	Positive/ Negative change	Neutral/ Minor negative impact/ Moderate negative impact/ Major negative impact
viii) geological processes	Size of the area where sediment is deposited	- Sedimentation and erosion - Change in seabed levels - Change in waves and current dynamics								
	Quantity of river discharge	- Change in current dynamics - Change in salt gradients								
	Surface of areas with salt gradients	- Change in fresh water inflow from rivers and canals - Change in current dynamics								
	Rate of sea level rise	Sedimentation and erosion								

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	Size of barrier islands, sandbanks, channels, mudflats and saltmarshes	- sedimentation and erosion - change in substrate dynamics - change in seabed levels - change in waves and current dynamics.								
ix) ecological processes	Primary production	- increase in turbidity.								
	Production by animals, from shellfish to marine mammals	- increase in turbidity - change in substrate dynamics - increase in sedimentation.								
	Numbers of fish, shellfish and birds	- Increase in underwater sound and vibrations - Increase in optical disturbance and light - Increase in turbidity - Change in substrate dynamics								

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
		- Increase in above water sound and vibrations - Increase in sedimentation - Presence of electromagnetic fields (only applicable for cable systems)								
	Food availability for fish, shellfish and birds	- Increase in sedimentation - Change in substrate dynamics - Increase in underwater sound and vibrations - Increase in turbidity								
x) biodiversity	Number of species (plants and animals) occurring on the salt marsh	- Increase in above water sound and vibrations - Increase in optical disturbance and light								
	Number of species (plants and animals) occurring in	- Increase in sedimentation - Increase in turbidity - Change in substrate dyamics - Increase in above water sound and vibrations								

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	marine and brackish water areas	- Increase in optical disturbance and light - Incrase in electromagnetic fields - Increase in underwater sound and vibrations								
	Number of species of breeding birds	- Increase in above water sound and vibrations - Increase in optical disturbance and light - Increase in turbidity								
	Fattening areas for migratory birds	- Change in substrate dynamics - Incrase in above water sound and vibrations - Increase in optical disturbance and light - Incrase in turbidity - Increse in sedimentation - Increase in underwater sound and vibrations								
	Roosting areas for migratory birds	- Increase in optical disturbance and light - Increase in above water sound and vibrations	-	-	-	-	-	-	-	-
-	Food supply for migratory birds	- Change in substrate dynamics - Increase in underwater sound and vibrations - Increase in turbidity								

OUV	Attribute	Description of impact	Frequency of action	Duration of action	Reversibility of action	Reversibility of change to the attribute	Longevity of change to the attribute	Degree of change to the attribute	Quality of change to the attribute	Evaluation of the impact
	Tranquility for migratory birds	- Increase in optical disturbance and light - Increase in above water sound and vibrations - Increase in underwater sound and vibrations								

V

ANNEX: CABLE SYSTEM AND PIPELINE INSTALLATION TECHNIQUES AT SEA AND LAND

Cable system installation techniques at sea

Deepwater trencher

In sufficient water depth, a cable-laying ship is used, which can be held in place by anchors or dynamic positioning. Several devices are used to bury cable systems in the seabed. Cable plows and jet sleds are dragged along the bottom by a ship or barge. An underwater trencher is a remotely operated underwater robot controlled from a ship. The trencher moves over the laid cable system and buries it, or the cable system is fed directly into the trencher from a barge or cable-laying ship. The seabed can be fluidized with water jets or mechanically opened to bury the cable.

Installation in deeper trenches with the Vertical Injector

A Vertical Injector is a cable burial device that can bury cable systems at relatively great depths in the seabed. It stands on a barge or vessel and consists of a relatively long metal "sword" that is pulled through the ground, taking the cable system with it. These swords can fluidize the seabed with water jets, vibrations, or mechanical excavation. A cable installation plow has a smaller sword mounted on a sled, which buries the cable system by being dragged through the ground. Plows can have water jets or mechanical excavation. The cable system can be pre-laid on the seabed or fed simultaneously from a barge or vessel during plow installation.

Dredging

In areas where there is insufficient depth for a cable-laying vessel, dredging is performed first to create a trench for the installation vessel. In sections where the required burial depth for the cable system is too great for specific burial equipment, a trench is dredged to a depth that allows the burial machine to bury the cable system to the appropriate depth.

Installation in shallow tidal flats

In shallow tidal flats and not too deep trenches, a special tidal trenching machine can be used. This machine moves over the tidal flat on tracks, bringing the pre-laid cable system to depth with a ‘sword’. Burying can be done with water jets, vibrations, or mechanical excavation. First, the cable system is laid on the tidal flat using a shallow-draft barge or a tracked vehicle.

Crossing existing cable systems and pipelines

Various techniques are used to cross existing cable systems and pipelines, depending on the local context and agreements between TenneT and the owner of the cable system or pipeline.

Cable joints

Cable systems can typically be transported in lengths of up to 40 km. For longer distances, joints are used to connect two cable sections. A joint pit is dredged on the seabed where the joint is placed.

Cable system installation techniques on land

Open trenching

The standard method for installing cable systems on land is open trenching. This is the installation technique where a trench is dug, in which the cable systems are laid. Dewatering can be applied to keep the trench dry.

Horizontal Directional Drilling (HDD)

Where there is insufficient space or significant damage is expected, cable systems are installed using HDD. Primary dikes are crossed using HDD. During HDD, work is done at the entry and exit points. The installation consists of three steps:

1 The drilling rig is set up at the entry point.
2 The drilling is executed, and the casing pipes are pulled in. The casing pipes must be laid out as a single continuous string at the exit side beforehand.
3 The cable systems are pulled through the casing pipes.

Pipeline installation at sea

Deep water and deeper trenches

In sufficient water depth (at least 7 meters), a pipelaying ship with burial equipment is used. The ship can be held in place by anchors or dynamic positioning. The pipeline is first laid on the seabed and then buried using plows, fluidizing or spraying away the underlying ground, or mechanical digging arms. Cable plows and jet sleds are dragged along the bottom by a ship or barge.

Dredging

In sections of the route where there is insufficient depth for a pipelaying ship, dredging is performed first to create a trench for the installation vessel. In sections where the required burial depth for the pipeline is too great for the burial equipment, a trench is dredged first to a depth that allows the pipeline to be buried to the correct depth.

Installation in shallow tidal flats

In shallow tidal flats and not too deep trenches, a pipelaying ship cannot be used. Here, open excavation is applied. Open excavation is the most common method for laying pipelines on land. In shallow water and tidal flats, a construction like trench boxes or digging shields is used to stabilize the trench walls and keep the trench dry. The use of multiple HDDs from a wet environment to a wet environment is also being explored. This application of HDDs is less common and considered innovative.

Coastal crossings

For crossing the coast, a HDD from dry to wet is applied. Occasionally, a segment tunnel can also be used. There is a lot of experience with HDDs from land to land (such as crossing roads or waterways) or from land to sea for crossing sea defences. For PAWOZ, the use of segment tunnels is also being considered, requiring a large work area. Segment tunnel construction is complex and is only used when no alternative methods are possible.

Crossing existing cable systems and pipelines

Various techniques are used to cross existing cable systems and pipelines, depending on the local context and agreements between Gasunie and the owner of the cable system or pipeline.

Pipeline installation techniques on land

Open trenching

The standard method is that pipelines on land are installed using open trenching. This is the installation technique where a trench is dug, in which the pipelines are laid. Dewatering can be applied to keep the trench dry.

HDD

Where there is insufficient space or significant damage is expected, a press technique or HDD is used. This method is employed for crossing primary dikes, watercourses, forests, railways, highways, provincial roads, other water management structures, nature reserves, pipelines, high-voltage cable systems, and pipelines, and archaeologically valuable areas.

Tunnel installation techniques

Installation of an entry point
The entry point on the Ballonplaat consists of a reclaimed work area within a seawall. The activities for the construction of the entry point include the following steps: dredging an access channel, constructing a sea-wall, sand reclamation, installing breakwaters, constructing a quay, and dredging the harbour basin. The goal is to complete the entry point within two summer seasons.

Tunnel construction
After the entry point is completed, shafts are built. From these shafts, tunnel pipes can be drilled at depth. The shaft is constructed using diaphragm walls. The construction of the entry point and the shaft takes about 3 years. Subsequently, additional shafts and tunnel pipes can be constructed. The construction of the shaft and the drilling of the first tunnel pipes at the Eemshaven exit point are carried out in a similar manner to those at the entry point.

The tunnel pipes are drilled from both sides: from the entry point and the exit point. The total construction time for a 27 km tunnel pipe is approximately 3 years, in addition to the construction time for the entry point and the shafts.