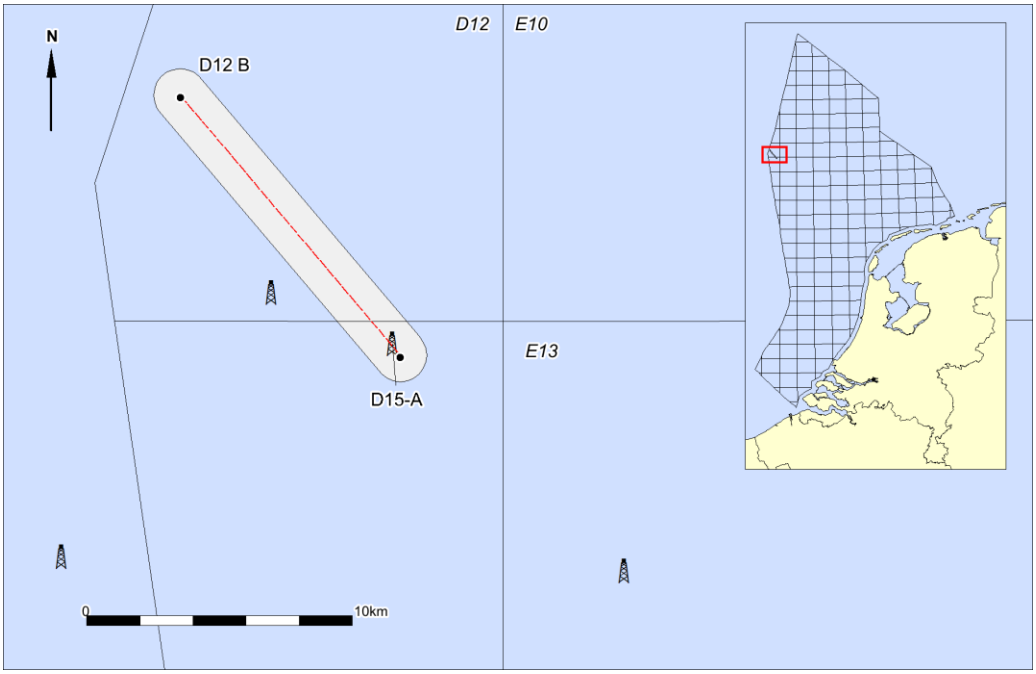
Periplus Archeomare

Pipeline route D12-B to D15-A

Archaeological desk study and assessment of geophysical survey data



Authors
S. van den Brenk and R. van Lil

At the request of:

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Colophon

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Pipeline route D12-B to D15-A
Archaeological desk study and assessment of geophysical survey data
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B.E.J.M. van Mierlo

Periplus Archeomare
Kraanspoor 14
1033 SE - Amsterdam
Tel: 020-6367891
Email: info@periplus.nl
Website: www.periplus.nl

Contents

Table 1. Dutch archaeological periods

Period	Time in Years				
Post-medieval / Modern Times	1500	A.D.	-	Present	
Late medieval period	1050	A.D.	-	1500	A.D.
Early medieval period	450	A.D.	-	1050	A.D.
Roman Times	12	B.C.	-	450	A.D.
Iron Age	800	B.C.	-	12	B.C.
Bronze Age	2000	B.C.	-	800	B.C.
Neolithic (New Stone Age)	5300	B.C.	-	2000	B.C.
Mesolithic (Stone Age)	8800	B.C.	-	4900	B.C.
Palaeolithic (Early Stone Age)	300.000	B.C.	-	8800	B.C.

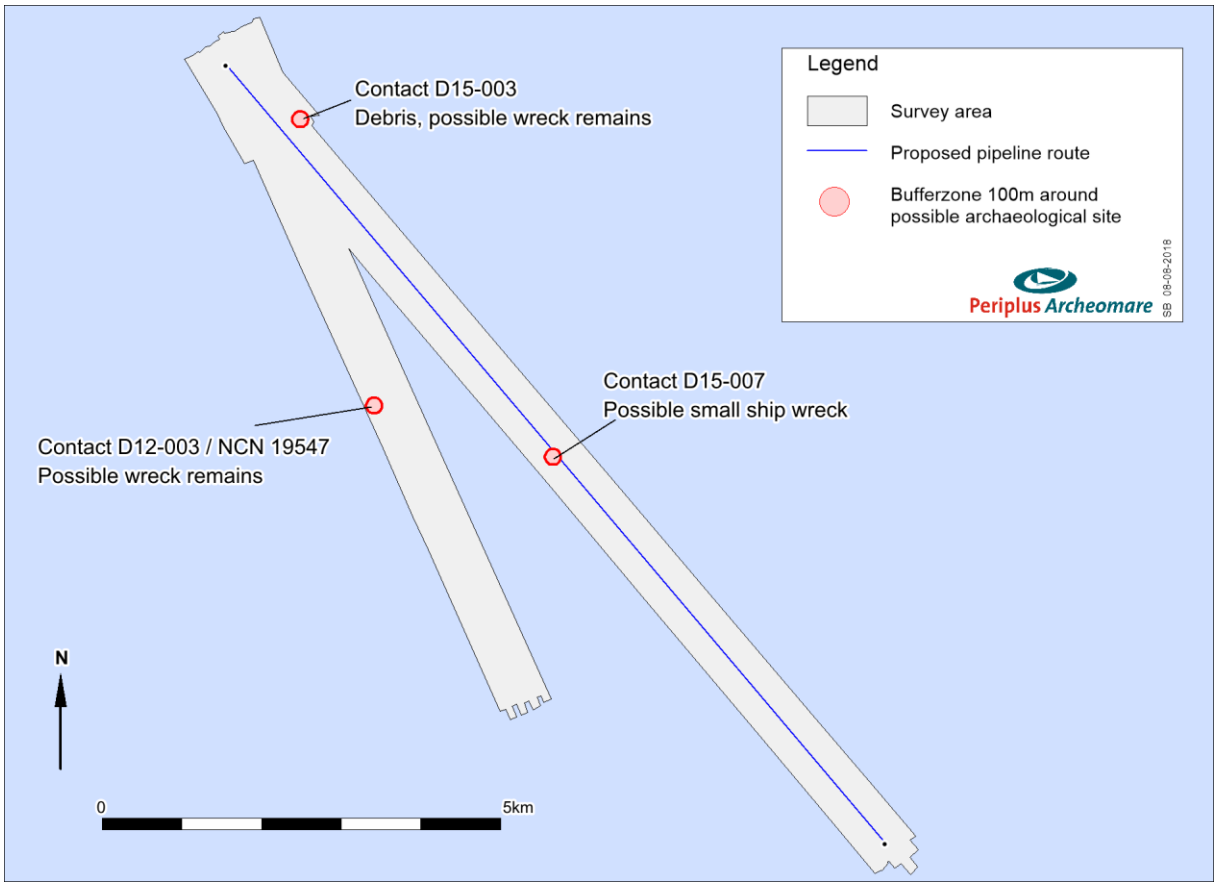
Table 2. Administrative details

Location:	North Sea	
Description	Pipe line route D12B to D15 FA	
Chart:	BA 267	
Coordinates Geodetic datum: ED50 Projection: UTM31N	Start route (D12-B side)	E 487 838, N 6 029 247
	End route (D15-FA side)	E 496 123 N 6 019 469
	Centre	E 492 040 N 6 024 396
Depth (LAT):	28.1 to 43.7 meter, average 31.7 meter	
Surface area	14.0 km^2	
Surface investigation area (buffer 1km)	28.6 km^2	
Environment:	Tidal currents, salt water	
Area use:	Shipping lane, fishing	
Area administrator:	Rijkswaterstaat Zee en Delta	
ARCHIS-research report (CIS-code):	4620323100	
Periplus-project reference:	18A027-01	
Period	July – August 2018	

Samenvatting (in Dutch)

In opdracht van Wintershall Noordzee B.V. heeft Periplus Archeomare een archeologisch bureauonderzoek en een analyse van geofysische surveydata uitgevoerd voor een geplande pijpleidingroute van D12-B naar D15-A op de Noordzee.

Binnen het onderzochte gebied zijn de mogelijke resten van drie scheepswrakken gevonden. Behalve de afmetingen zijn details, zoals naam of datum van vergaan onbekend. Zolang de archeologische waarde van deze locaties niet is vastgesteld wordt geadviseerd om deze locaties inclusief een bufferzone van 100 meter rondom te ontzien bij de voorgenomen activiteiten. In de overige delen van het onderzoeksgebied zijn geen aanwijzingen gevonden voor de aanwezigheid van archeologische objecten.



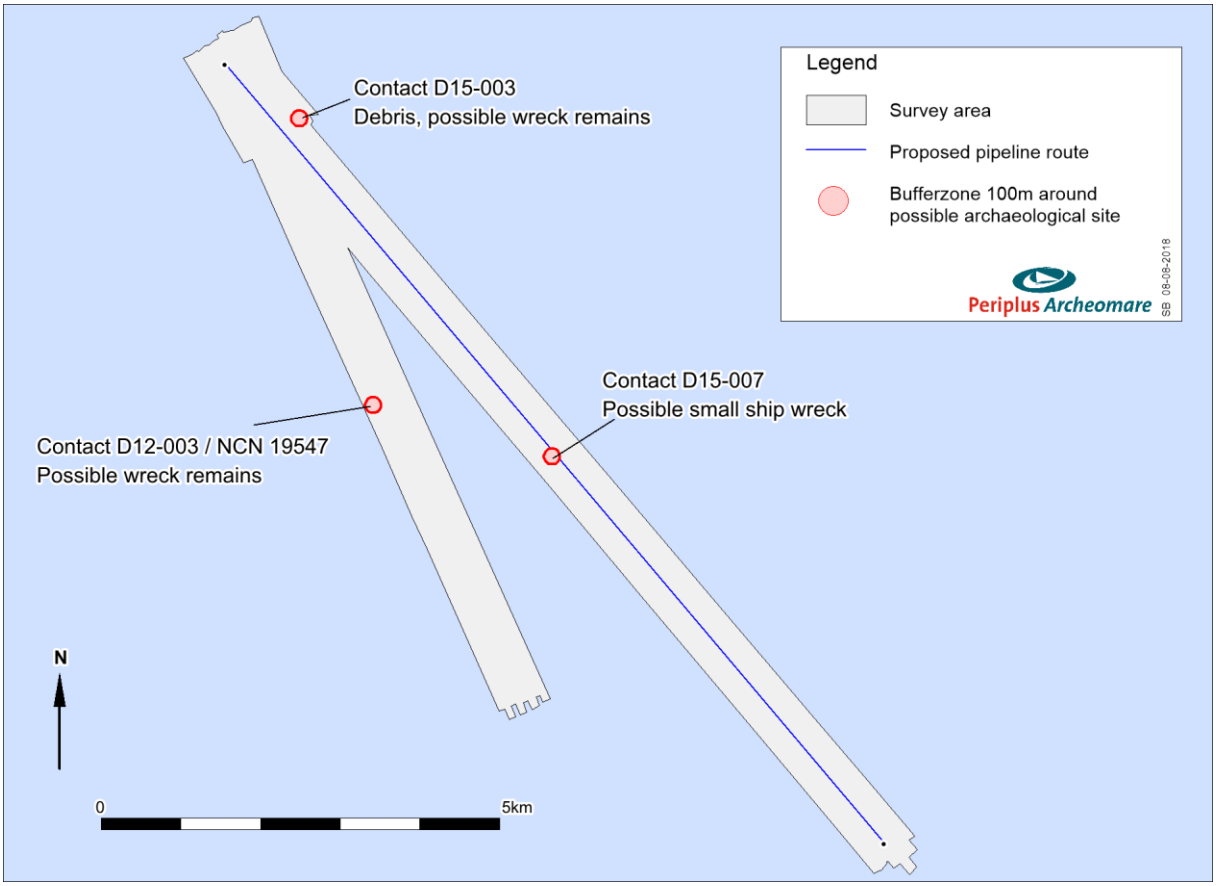
Het bureauonderzoek heeft aangetoond dat prehistorische nederzettingsresten gerelateerd aan het Pleistocene en vroeg Holocene landschap verwacht kunnen worden in het gebied. Deze diepere archeologische lagen zullen echter niet of nauwelijks verstoord worden. Het risico dat eventueel aanwezige archeologische resten tijdens de aanleg van de pijpleiding aangetast worden wordt dus zeer klein geacht.

Tijdens de installatie van de pijpleiding kunnen resten aan het licht komen die tot heden volledig waren afgedekt in de waterbodem of niet als archeologisch object zijn herkend tijdens het geofysisch onderzoek. De uitvoerder is conform de Erfgoedwet verplicht om dergelijke vondsten te melden bij de bevoegde overheid. Deze meldingsplicht voor archeologische vondsten dient in het bestek of Plan van Aanpak van het werk te worden opgenomen.

Summary

Periplus Archeomare was assigned by Wintershall Noordzee B.V. to conduct an archaeological desk study and assessment of geophysical data of the pipeline route from D12-B to D15-A.

Within the research area, possible remains of three ship wrecks were found. Apart from visual dimensions, details like the name or sink date are not known. As long as the archaeological value of those sites is not determined, it is advised not to conduct activities which could affect this location including a buffer zone of 100 meters around. In the remaining part of the research area, no objects with a possible archaeological value were found.



The desk study indicated that camp sites and burials related to the Pleistocene and Early Holocene landscape are to be expected in the research area. The archaeological levels will - except for some very small local sub crops - not be reached by the pipeline trencher. The risk that the installation of the pipeline will jeopardize archaeological values is therefore considered very small.

During the installation of the pipeline, archaeological objects may be discovered which were completely buried or not recognized as an archaeological object during the geophysical survey. In accordance with the Heritage Act (Erfgoedwet), it is required to report those findings to the competent authority. This notification must also be included in the scope of work.

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1 Introduction

Periplus Archeomare was assigned by Wintershall Noordzee B.V. to conduct an archaeological desk study and assessment of geophysical data of the pipeline route from D12-B to D15-A. The research area of 28.6 km^2 is located in the D12 and D15 offshore blocks in the North Sea.

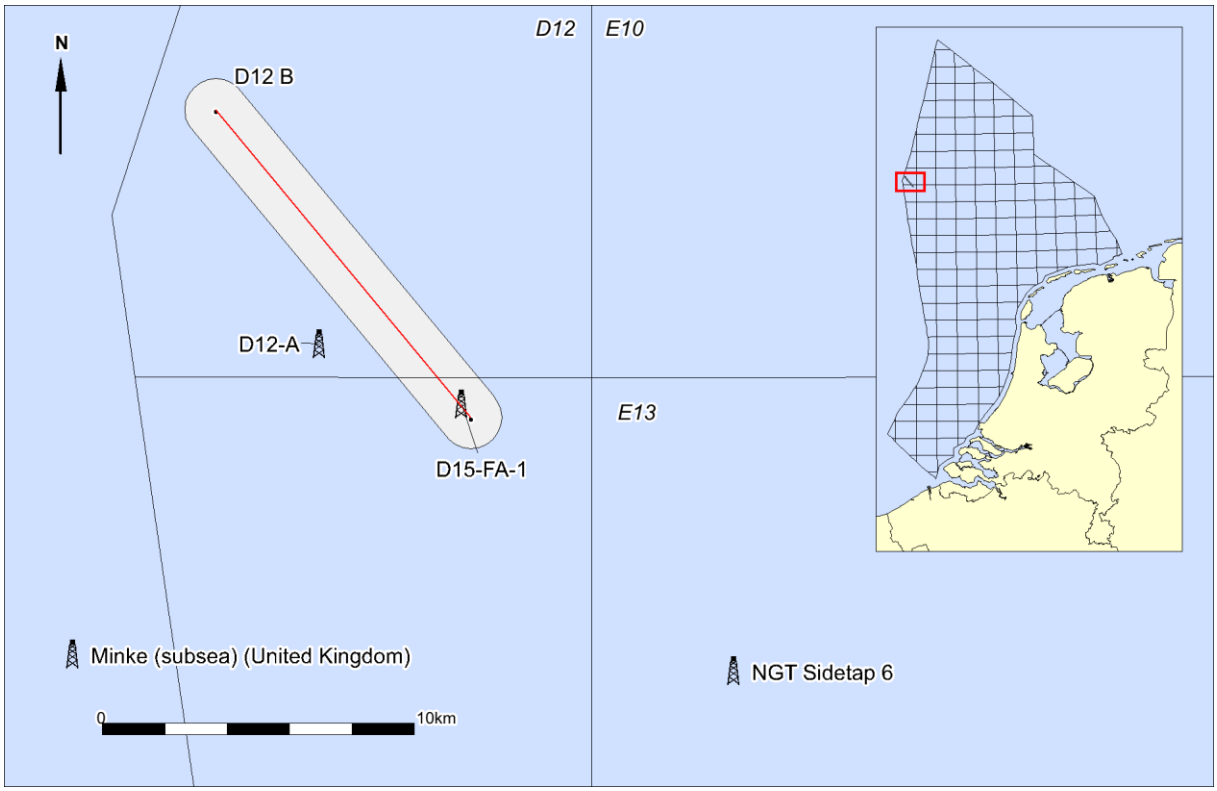

Figure 1. Location map

1.1 Motive

Wintershall Noordzee B.V. intents to connect the D12-B site to the platform D15-FA-1 by means of a pipeline. During installation the seabed will be disturbed.

The protection of the archaeological and historical heritage is anchored in the Dutch Heritage Act (July 2016).[1] The installation of the pipeline and coherent infrastructure might affect archaeological remains, if indeed present. As the planned activities might jeopardize archaeological remains, Economic Affairs considers a research effort is needed to assess the archaeological potential of the route. The results, conclusions and recommendations of this assessment will be included in the licensing procedure.

1.2 Objective

The objective of this investigation is to compile the archaeological expectancy for the research area and the testing of this expectancy through the analysis and interpretation of the geophysical and geotechnical data acquired.

[1] Dutch: Erfgoedwet.

1.3 Research questions

For the archaeological desk study the following research questions have been defined:

Are archaeological values known in the research are?

If so:

What is the nature, size, and location, depth of occurrence and age of the site?
What is the integrity and conservation of the site?

Are - apart from any known sites - archaeological values to be expected in the research are?

If so:

What is the expected nature, size, and location, depth of occurrence and age of the archaeological remains?
What is the expected integrity and conservation of the anticipated archaeological remains?

Are the known or expected archaeological remains affected by the installation of a pipeline?

For the inventory archaeological field study the following research questions have been defined:

primary question:
Are any archaeological remains present within the Area of Interest and to what extent are these remains traceable?

with respect to side scan sonar, magnetometer and multibeam survey:

Are there any phenomena visible on the seabed?

If so:

What is the description of these phenomena?
Do these phenomena have a man-made or natural origin?

If these phenomena can be designated to be man-made:

What classification can be attached?

If these phenomena can be classified as archaeological:

Is it possible to interpret the nature of the archaeological objects?

If these phenomena can be identified as natural:

What is the nature of these natural phenomena?
Based on the acoustic image is it possible to designate zones of high, middle or low activity on the seabed?

If so:

How can these zones be interpreted?

General:

What is the relation between the observed objects and the topography of the seabed?

If no acoustic phenomena can be observed:

Are there any clues that this is a consequence of either natural erosion, sedimentation or human interference?

with respect to subbottom profiler survey:

Based on seismic profiles and geotechnical data is it possible to map the Pleistocene landscape?

If so:

What is the depth of the Pleistocene landscape compared to the present seabed?
From Pleistocene to Holocene deposits is the transition gradual or instantaneous (erosive)?
Can zones be identified where prehistoric settlement remains can be expected?

If so:

Could these expected settlement remains be affected by the installation of the pipeline based on their vertical position related to the seabed?
Are there any indications observed on the seismic profiles for the presence of buried (man-made) objects?

If so:

Based on the presence of buried objects and its correlation with side scan sonar, magnetometer en multibeam data can something be said about the nature of these buried objects?
Are there any mitigating measures necessary to avoid disturbance of possible archaeological remains?

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2 Methodology

The desk study was conducted in accordance with the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1, Protocol 4002). This concerns in particular the specifications LS01wb, LS02wb, LS03wb, LS04wb and LS05wb. The study is reported in accordance with specification LS06wb.

In order to comply with the main objectives and answer the research questions, the archaeological desk study includes the following steps:

- Description of the Area of Interest and determination of the consequences for future use (LS01wb);
- Description of the current usage of the area of Interest (LS02wb);
- Description of the historical situation and possible disturbances (LS03wb);
- Description of the known archaeological features and objects (LS04wb);
- Description of the geological setting within which the archaeological objects are to be found (LS04wb);
- Definition of a specified archaeological expectancy (LS05wb).

Based on these components the archaeological expectancy is specified. It is expressed whether, and if so, which archaeological values are to be expected. The properties of these values will be indicated in as much detail as possible.

The results of the study are summarized in chapter three. Based on the results the research questions are answered in Chapter 6. The study concludes with a summary and recommendation in Chapter 7.

The desk study and reporting have been conducted by S. van den Brenk and R. van Lil (both senior prospector and authorized by B. van Mierlo (senior prospector).

2.1 Sources

The following sources were consulted for the study:

- National Contact Number (NCN)
- The Hydrographic Service of the Royal Netherlands Navy
- Rijkswaterstaat Zee en Delta
- *TNO-NITG*; geological borehole data and maps
- Archis III, archaeological database of the Dutch Cultural Heritage Agency
- Databases of Periplus Archeomare
- Dutch Federation for Aviation Archaeology (NFLA)
- Various sources from the Internet

For a complete overview of the sources and literature see references on page 40. Words in *italics* and abbreviations are explained in the glossary on page 42.

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3 Results – archaeological desk study

3.1 Definition of the plan area and determination of the consequences of future use

The research area for the desk study comprises a proposed pipeline trajectory from offshore block D12 to D15 including a 1000m buffer zone on both sides of the optional routes (= 2000m corridor). The survey data cover 350 m on both sides of the optional pipeline routes (= 700m corridor). This 700m corridor is considered to be the plan area as the route can be shifted within this corridor, e.g. to avoid obstacles.

3.2 Current constellation

The depth along the route increases from -28.1 mLAT in the northwest to -43.7 mLAT in the southwest.[2]

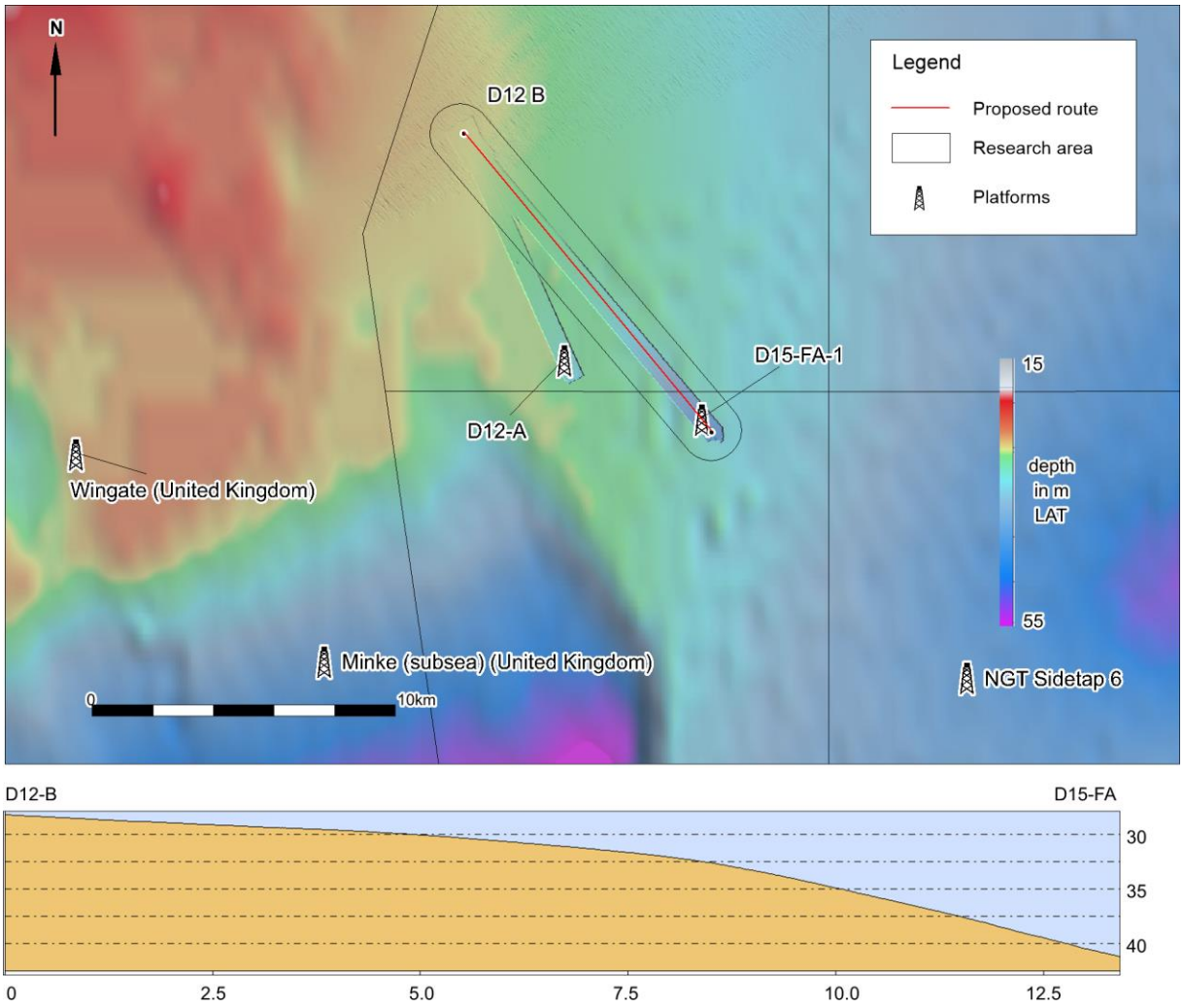

Figure 2. Bathymetry and profile along the route (source DTM: Dienst Hydrografie 2009 and Fugro 2017)

The seabed is smooth, large scale sand waves are not present.

[2] MBes Fugro survey 2017.

Pipelines and cables

A number of pipelines and cables cross the research area.[3] The labelled pipelines and cables are displayed in figure 3.

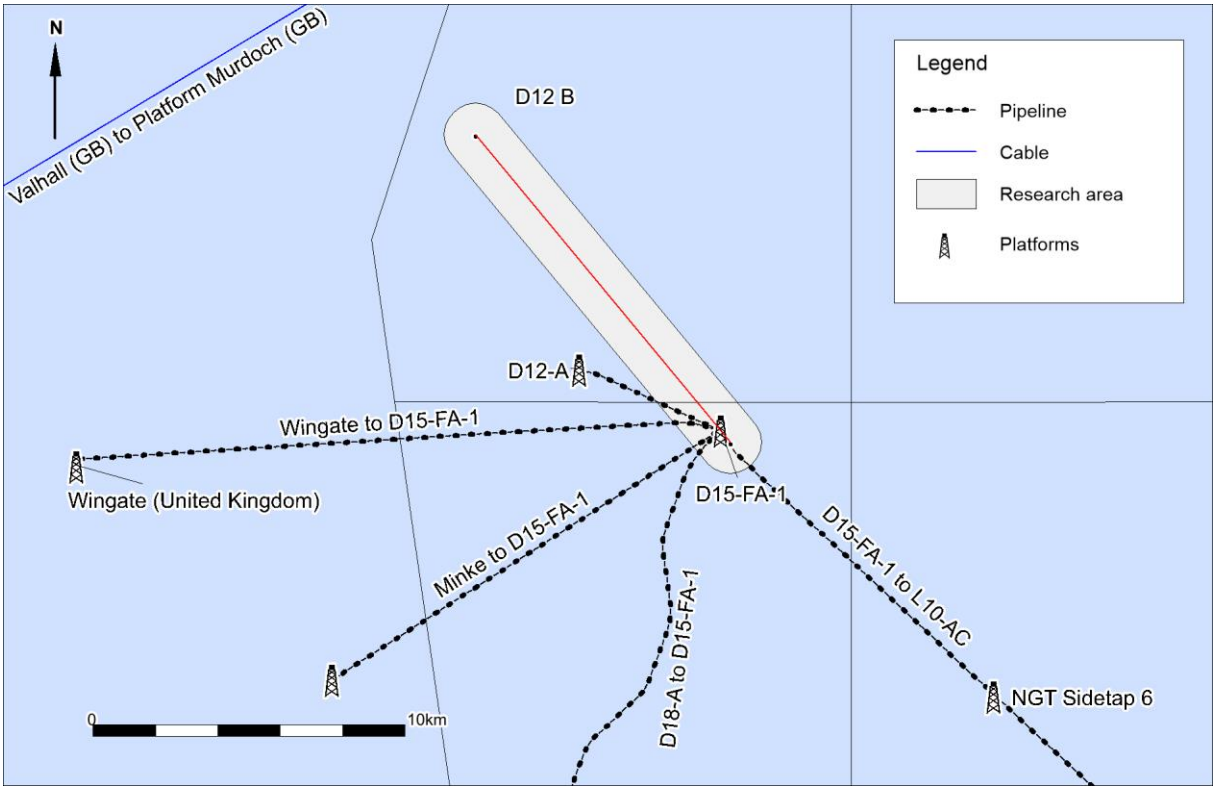

Figure 3. Pipelines and cables

The following pipelines cross the research area:

Operator	From	To	Status	Type	Diameter
Noordgastransport B.V.	D15-FA-1	L10-AC	Active	Gas	36-inch
ENGIE E&P Nederland B.V.	Minke	D15-FA-1	Active	Control	3.6-inch
Wintershall Noordzee B.V.	D12-A	D15-FA-1	Active	Gas/control	10/3.5-inch
ENGIE E&P Nederland B.V.	D18-A	D15-FA-1	Proposed	Methanol	2-inch
Wintershall Noordzee B.V.	Wingate	D15-FA-1	Active	Methanol	2-inch

Table 3 Pipelines crossing the research area

No cables cross the research area.

[3] Rijkswaterstaat cables and pipelines, November 2017.

3.3 Historic situation and known disturbances

The North Sea basin formed about 12,000 years ago as an extensive aeolian sand landscape with a tundra climate. At the end of the last Ice Age (Weichselian, ca 11,500 years ago), the temperature rose and as a result, the northern glaciers melted. The sea level rose and the North Sea basin was gradually filled. The residents of the area had to leave for higher ground. [4] The Dogger Bank in the North of the Dutch Continental Shelf is an example of an elevated area. Remnants of the tundra landscape and its inhabitants are regularly found in the nets of fishermen. Best known are the many fossils that have been caught in the Dogger Bank. Closer to the research area artefacts of bone and antler were found.[5]

Due to the sea level rise the ancient landscapes drowned. These landscapes are depicted through geophysical and geotechnical engineering. Recently, for example, on the basis of seismic data from the oil industry a prehistoric landscape was reconstructed near the east coast of England. [6] The archaeological prehistoric findings from the North Sea known in the Netherlands consist of individual finds in sand extraction areas or by fisher men. For example during the construction of Maasvlakte I en II various bone artefacts from the early *Paleolithicum and Mesolithicum* were discovered.[7]

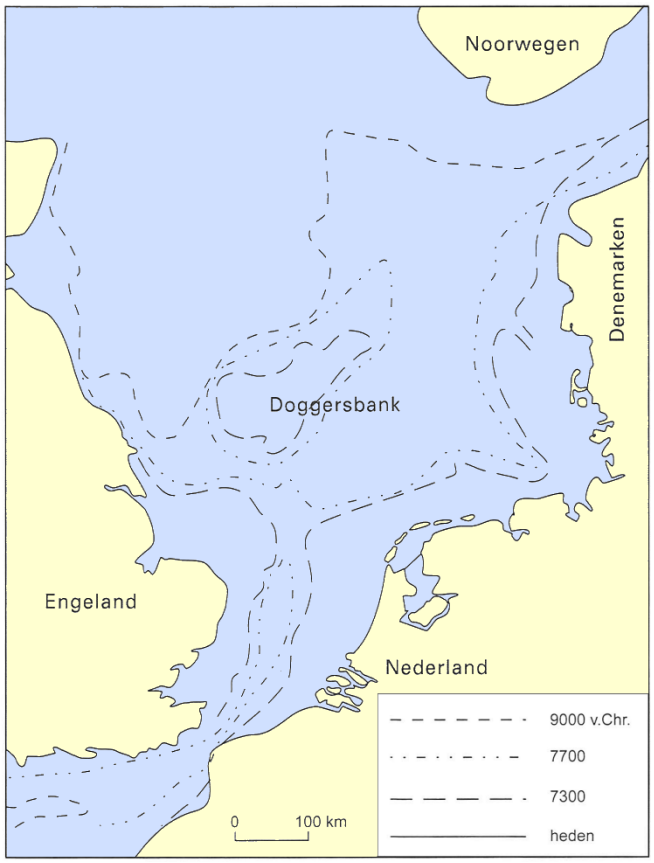

Figure 4. Reconstruction of the historical coast lines in the North Sea basin

[4] Gaffney e.a. 2005.

[5] Louwe Kooijmans 1970.

[6] Project 'North sea paleo-landscapes' of the University of Birmingham

[7] Verhart 2005 159.

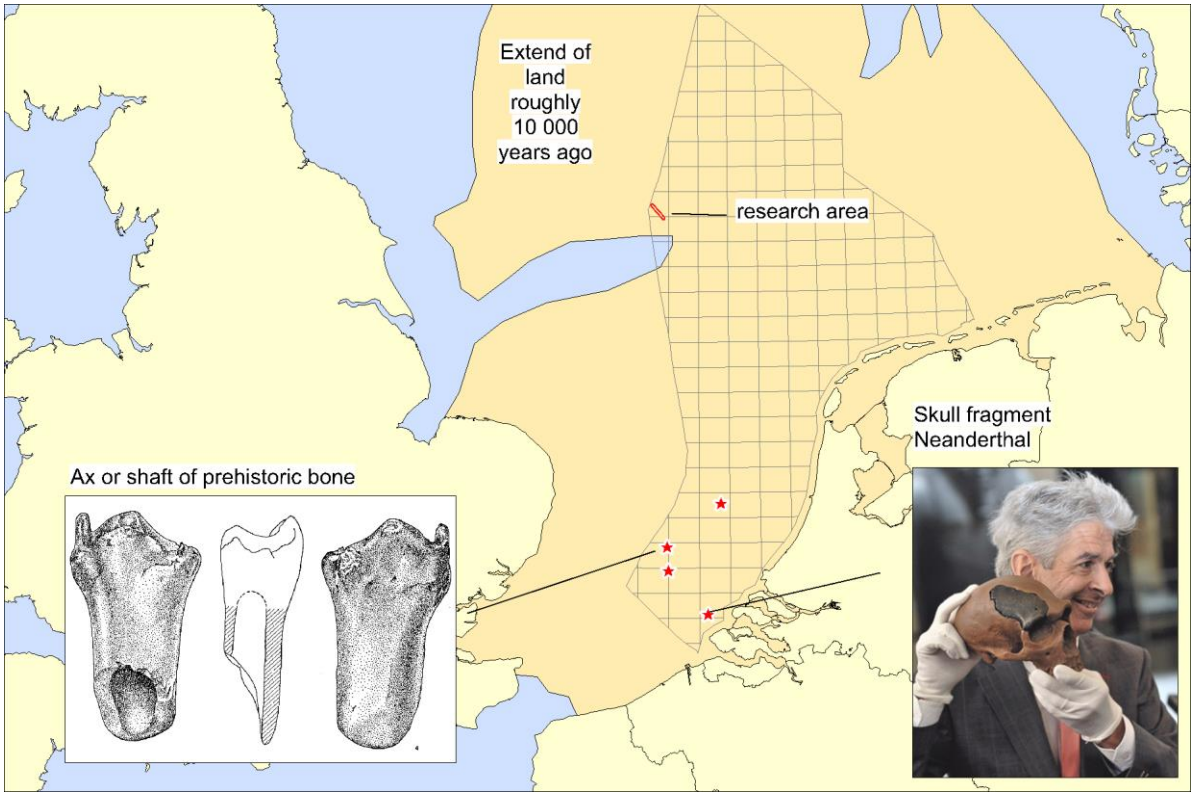

Figure 5. Example of prehistoric artefacts from the North Sea (artefacts from Kooijmans 1970)

The figure above shows some examples of prehistoric finds from the North Sea, and the extend of the land roughly 10 000 years ago.[8]

Shipping

The earliest evidence of shipping in the North Sea dates from the Bronze Age. Since then, there is an increase of shipping in the North Sea with a few well-documented historical peaks. During Roman times, the North Sea and in particular the Channel served as connecting bridge for the empire. From the Early and High Middle Ages new centres of power arose along the North Sea coast. Furthermore, the raids of the Vikings should also be mentioned in this context. From the late Middle Ages, the international trade and the shipbuilding industry developed so that the North Sea was a stepping stone for global shipping routes. In all periods, ships were lost at sea. Shipwrecks are the traces of the maritime past and this can be preserved under favourable storage conditions in sediment.

[8] Gaffney, 2009

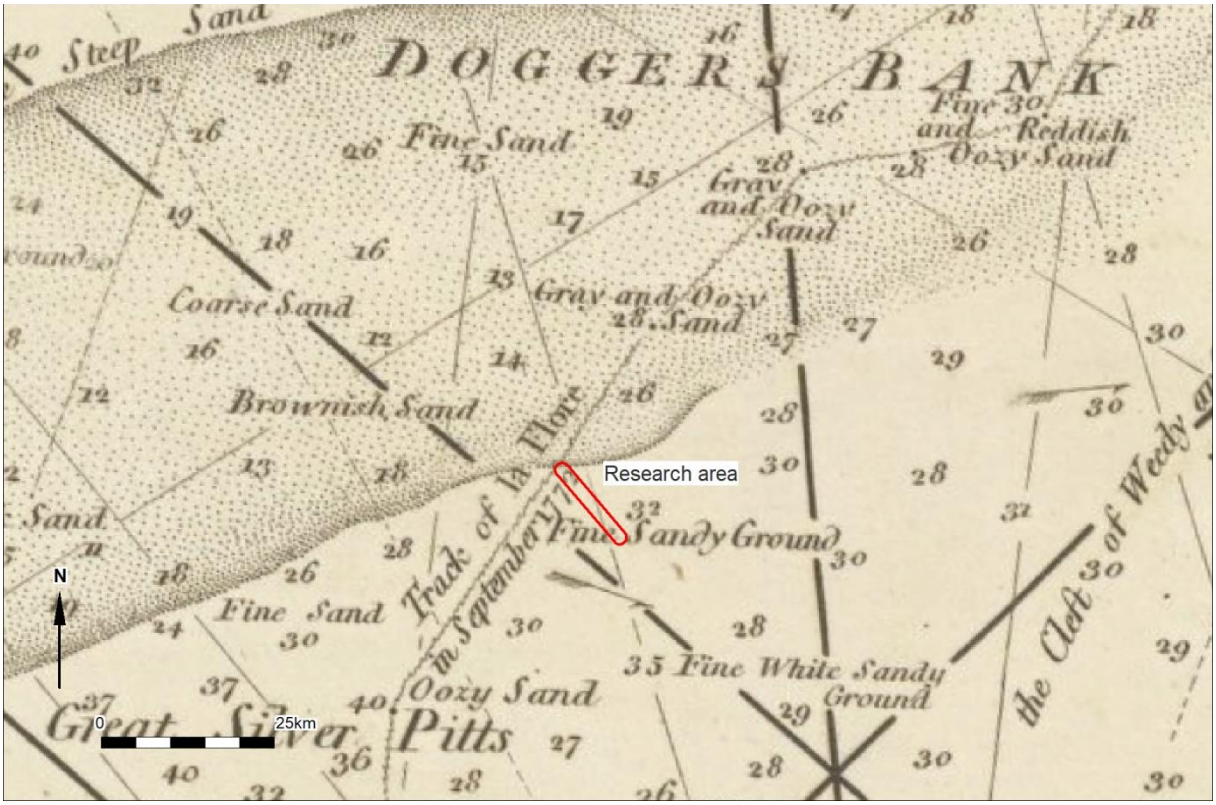

Figure 6. The research area on a historical map of 1777 (William Faden).

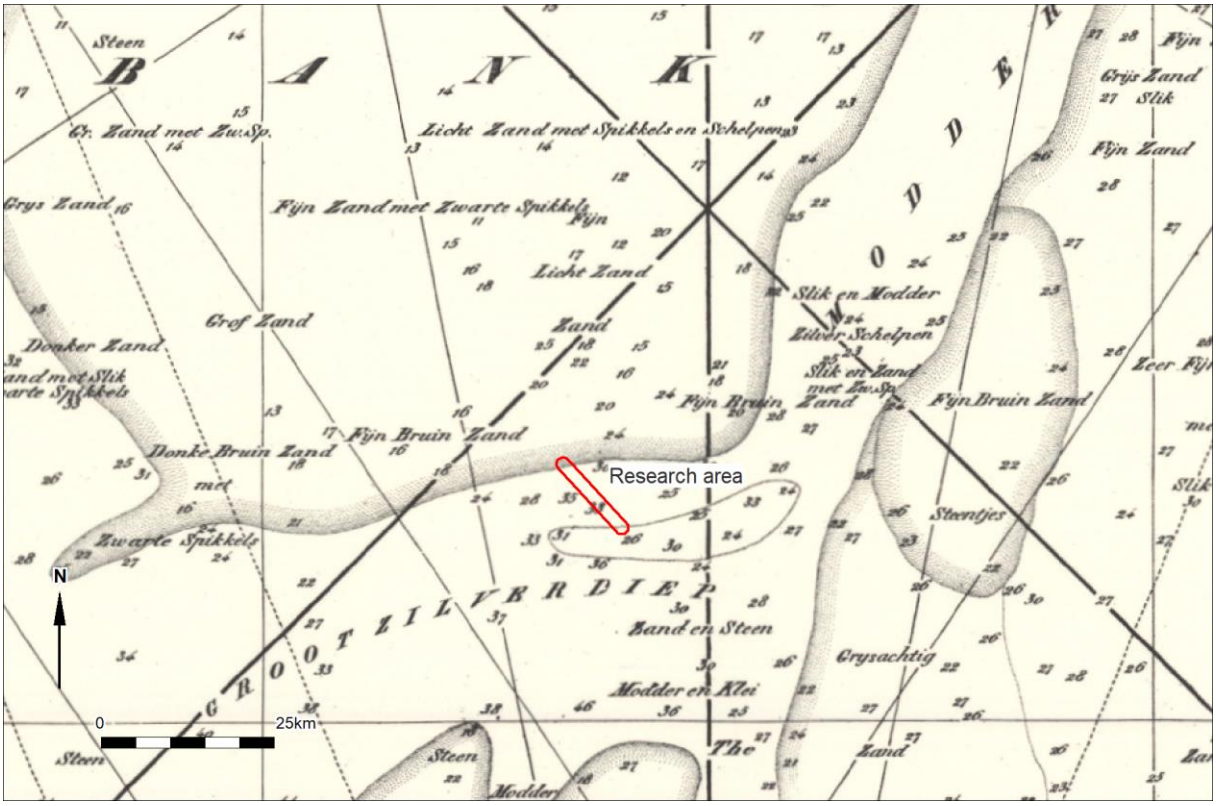

Figure 7. The research area on a historical map of 1852 (Jacob Swart).

Known disturbances of the seabed in the research area

In general, parts of the area may have been disturbed by fishing nets. The pipeline crossing the southern area have been laid in a trench by ploughing or jetting (see also paragraph 3.2). The initial depth of burial of these pipelines is unknown, but should be a minimum of 1 meter according to the environmental permits.

3.4 Description of known archaeological values (LS04wb)

The former National Service for Archaeological Heritage (ROB, now Dutch Cultural Heritage Agency or RCE) in collaboration with Rijkswaterstaat and TNO NITG have developed a comprehensive archaeological map of the continental shelf based on geological and archaeological observations (see figure 8).[9]

This global map will give the chance of presence of well-preserved shipwrecks (and often a ship's discovery of high archaeological value) for the Dutch part of the Continental Shelf. However, this map has a very limited use, partly due to the large scale of 1: 500,000. In addition, the degree of conservation is closely related to geology and morphology.

The idea here is that in channel deposits or regions with soft sediment, a wreck quickly sinks into the seabed and therefore remains in good condition. In other areas with harder top sediments the chance of a find is not necessarily lower, but the chance to find a well-preserved ship with the cargo and equipment still intact is considerably less.

The map also shows areas where peat and clay are preserved. This cover with clay / peat only refers to the possible location of Pleistocene deposits on / near the seabed. Where Holocene clay or peat is eroded Pleistocene layers with artefacts and fauna fossils may be present. The presence of early Holocene sediments could indicate the presence of a well preserved prehistoric landscape.
The map is complemented by the results of the North Sea paleo Landscapes project. This project (2005 - 2006) sought to utilise existing 3D seismic data to generate information on the Mesolithic Landscape of the North Sea in the area known as 'Doggerland'. The North Sea Palaeolandscapes Project utilised a variety of geophysical data sources, in conjunction with more traditional map data to record the Mesolithic landscape of this region.[10] This project was funded by English Heritage, utilising funds made available by the ALSF. Original Survey data for the project was provided courtesy of PGS UK Ltd.

Recent investigations[11] have revealed that the Dogger Bank is internally complex rather than comprising a simple "layer cake" of the Quaternary sediments as previously thought. Detailed mapping of key horizons identified on the high-resolution seismic profiles has led to the recognition of a series of buried palaeo-landsystems which are characterised by a range of features including; glacial, glacifluvial and fluvial channels, a large-scale glacitectonic thrust-moraine complex with intervening ice-marginal basins, a lacustrine basin and marine ravinement surfaces. Interpretation of these buried landscapes has enabled the development of an environmental change model to explain the evolution of the Dogger Bank.

[9] IKAW 3rd generation, RCE 2008.

[10] University of Birmingham, 2011.

[11] Carol et al., 2017

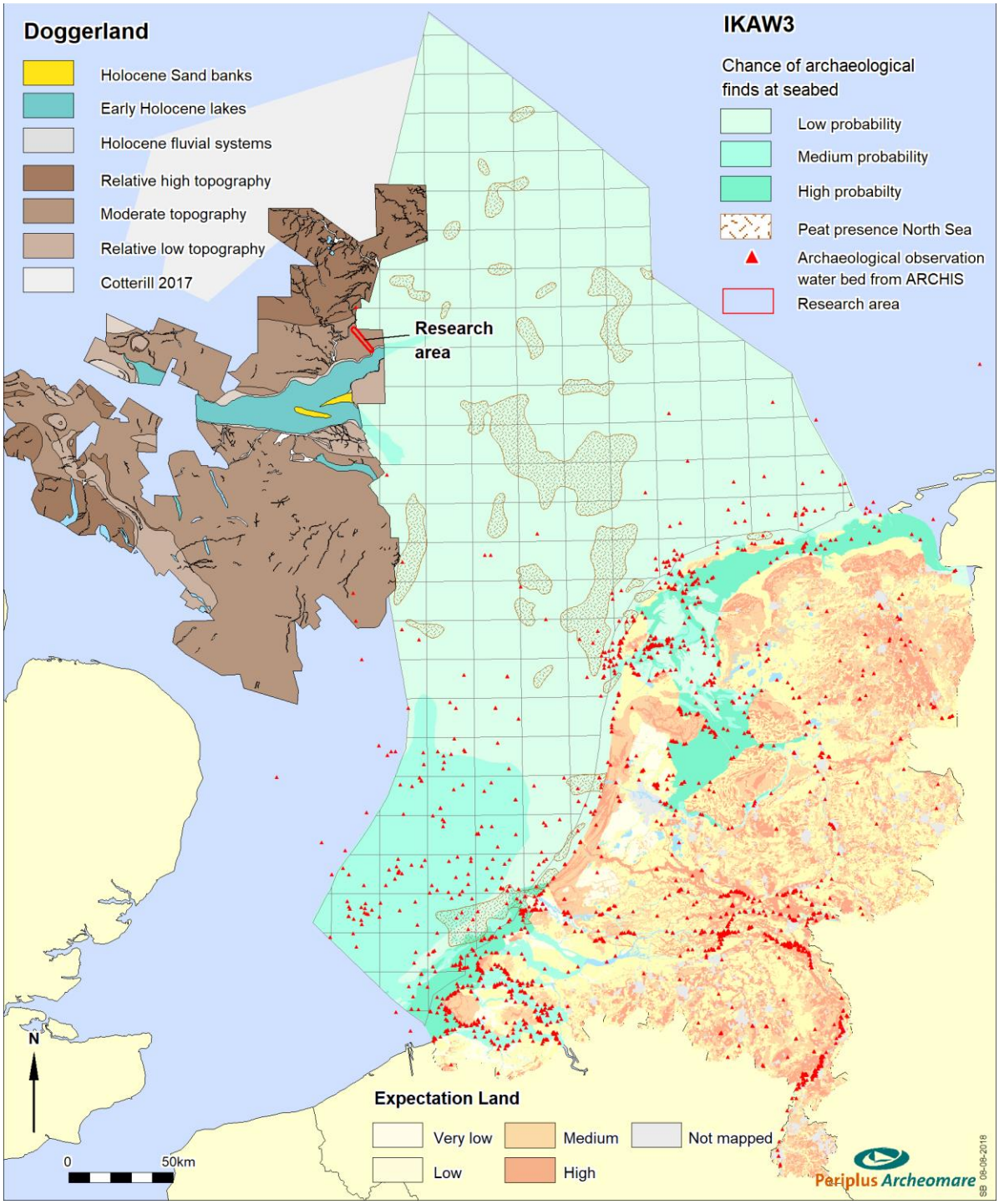

Figure 8. Overview of archaeological expectancy in the Netherlands including the Dutch Continental Shelf

Research in the last decade has shown that the probability of encountering prehistoric residues in the North Sea, is much greater than originally thought. The archaeological map for the Dutch continental shelf will therefore need to be revised.[12]

[12] North Sea Paleolandcapes' of the University van Birmingham and North Sea Research and management Framework 2009 (Peeters e.a. 2009).

Prehistory

In 2016 Deltares has started with the production of a chart on which the expectancy for archaeological remains from prehistoric times is mapped.[13] For the realization of this map an indicative archaeological model for the Dutch part of the Continental Shelf has been generated. The upper part of the sedimentary sequence (30m) has been translated into an archaeological model of the terrestrial prehistoric remains which are to be expected in the North Sea area. A distinction was made between remains from 'Early and Middle Paleolithic', 'Late Paleolithic' and 'Mesolithic' times. For each of the time frames a distinction was made between areas where remains are expected to occur *in situ* or little disturbed and areas where remains are expected to be disturbed (referred to as residuary). Also a class 'no prehistoric remains intact' has been defined. Additional research is needed to refine these models.

For the research area no prehistoric intact remains are to be expected, except for finds related to Doggerland which can be present under specific circumstances, based on the local geomorphology. The fast area mapped in grey with diagonal striping coincides with areas where glacigenic units are mapped by Laban.[14] Those units include the Bolders Bank Member, the Botney Cut Member and the Dogger Bank Member. Areas mapped in light green (Mesolithic), comprise areas where those glacigenic units are expected to be covered by peat.

[13] Vonhögen – Peeters 2016.

[14] Laban 2004: Top Pleistocene Map.

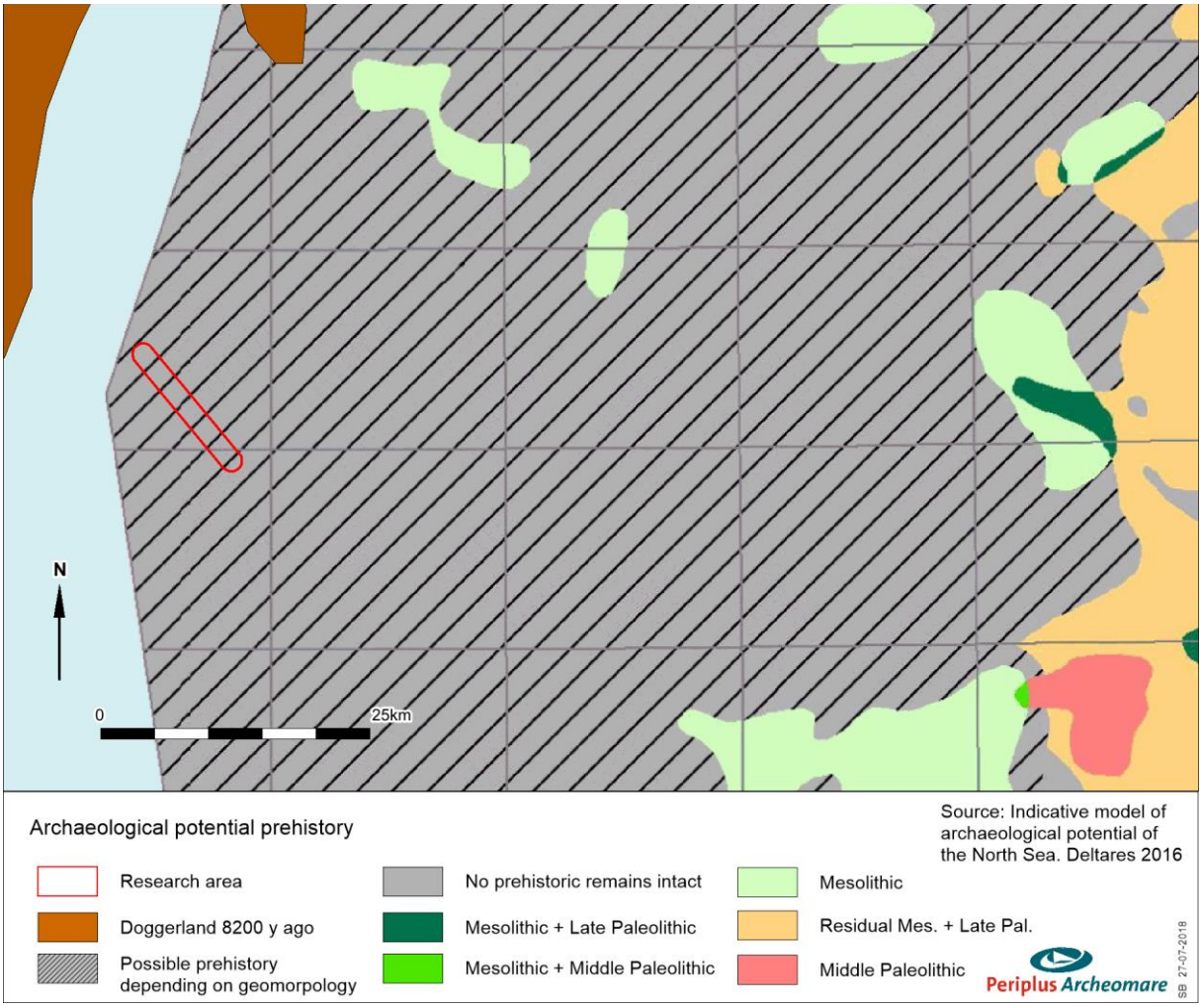

Figure 9. Indicative model of the archaeological potential in the research area

Known objects

Known objects other than the ARCHIS observations have been assessed. For this assessment a variety of sources have been consulted, among which the National Contact Number (NCN). The NCN contains a compilation data from databases of the Hydrographic Survey (Dutch: Dienst Hydrografie)[15], the ARCHIS III database of the Cultural Heritage Agency (Dutch: Rijksdienst voor het Cultureel Erfgoed) and Rijkswaterstaat. ARCHIS III is the official database of the National Cultural Heritage Agency in which all archaeological findings and observations in the Netherlands and territorial waters are stored. The database contains more than 95,000 underwater locations (mainly land-based) where archaeological observations have been made.

Details research area

Figure 10 shows a detailed map of the research area and the officially known archaeological finds in the surrounding area, on top of the available models. The research area is situated at the northern bank of an early Holocene lake. Within the research area no archaeological sites are reported. The nearest know site lies 9km to the north.

[15] The Hydrographic Survey database is known as the 'NLhono' database.

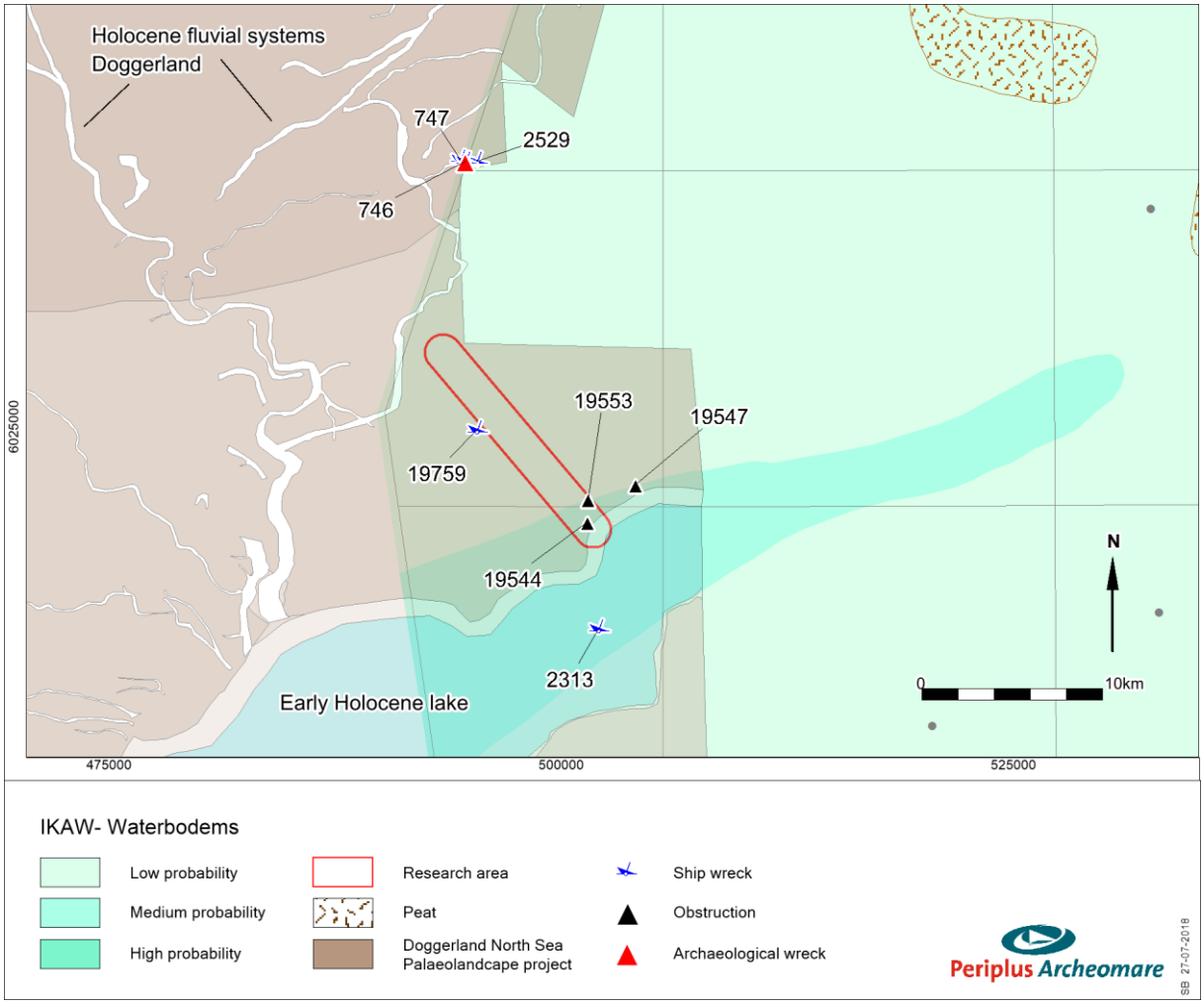

Figure 10. Known object within the research area

In the vicinity of the research area 8 objects are known, 5 wrecks and three obstructions. The contacts are listed in the table below.

NCN	Nlhono	ETRSe	ETRSn	R95	Type	Description
746	307	488991	6039614	5	Wreck	New small wreck, survey 1979. ARCHIS wng 500122
747	308	488686	6039692	500	Wreck	New wreck, survey 1979
2313	2558	496330	6013744	20	Wreck	Unknown wreck, survey 1987
2529	2960	489624	6039609	5	Wreck	Unknown wreck, survey 2000
19544	100388	495730	6019675	5	Obstruction	Wellhead D15-FA-102
19547	4065	498408	6021737	5	Obstruction	Foul ground, survey 2015
19553	10021	495781	6020924	5	Obstruction	Wellhead D12-2/3, survey 2015
19759	4066	489619	6024737	1	Wreck	Unknown wreck, survey 2015

Table 4. Known objects

The two obstructions within the area refer to existing wellheads. For the wrecks, no additional information is available. The possible archaeological value for these wrecks has not been established.

Geology

The seabed consists of sand. Locally outcrops of slightly gravelly sand occur, but not within the research area (refer to figure 11). The sandy seabed sediments form a mobile top layer in which rapidly migrating current ripples have developed.

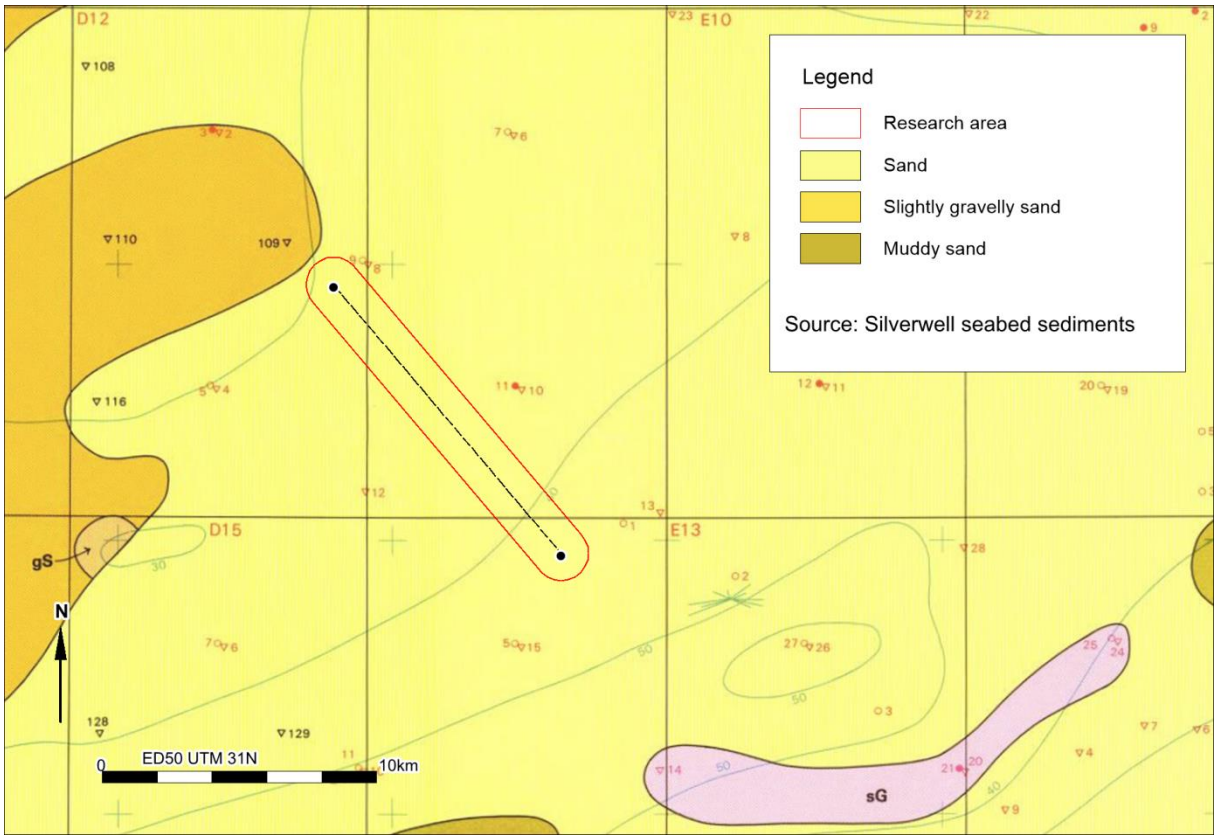

Figure 11. Seabed sediments (source: Geological maps Silverwell)

The top layer of mobile Holocene marine sands is classified as the Terschellinger Bank Member (Nieuw Zeeland Gronden Formation). At the base of the Holocene sequence the Elbow Formation is present in major part of the research area.[16] The Elbow Formation is an old name for a unit which consists of peat and humic clay. The Elbow Formation includes deposits currently classified as the Basal Peat Bed and Velsen Bed.[17] The distribution of the Elbow Formation is shown in figure 12.

The Elbow Formation is described on the Seabed Sediments and Holocene Geology map of Silverwell:

<u>Elbow Formation</u>

> *'Early Holocene brackish-marine and tidal-flat deposits, the Elbow Formation (Oele, 1969), are preserved extensively in much of the eastern part of the sheet. The formation consists predominantly of muddy sand interbedded with clay; in many places there is a basal clay layer and locally basal peat. The colour of the sediments is grey or dark grey but near the surface it is often olivegrey, The sand is shelly with a nearshore fauna including Hydrobia. Mean grain size varies from*

[16] Jeffery 1988.

[17] Rijsdijk 2005.

90-180µm. There is a distinct lithological, faunal and acoustic boundary between the Elbow formation and the overlying sediments.'

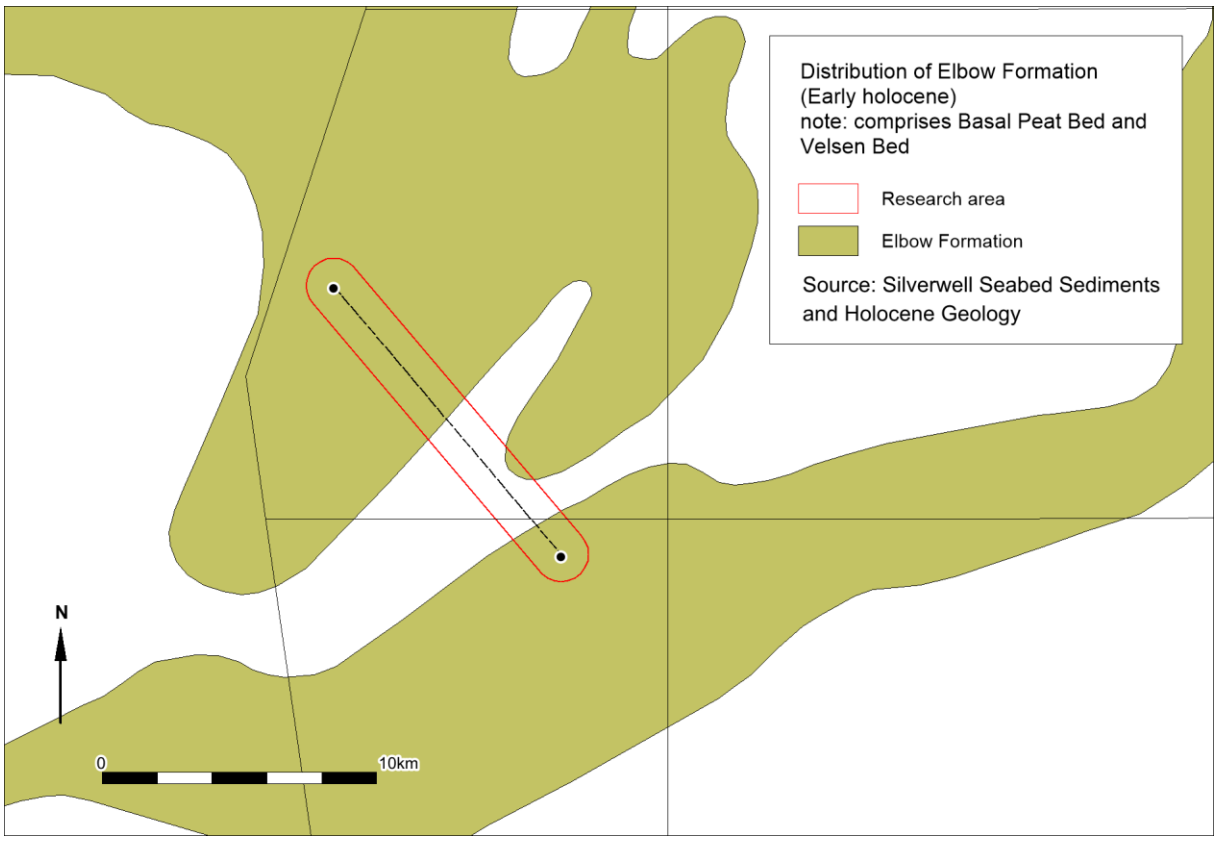

Figure 12. Occurrence of the Elbow Formation (= Basal Peat Bed + Velsen Bed)

The Holocene deposits of the Elbow Formation and Terschellingerbank Member cover Pleistocene sediments of the Botney Cut Formation and the Bolders Bank Formation (refer to figure 13).[18] Apparently the Elbow Formation has not been taking into account in the indicative archaeological model for the Dutch part of the Continental Shelf generated by Deltares in 2016. Currently both the Botney Cut Formation and the Bolders Bank Formation are classified as subunits (members) in the Dogger Bight Formation.[19]

The lithostratigraphic units have been described on the geological map of Silverwell:

Botney Cut Formation

'A system of partly or completely infilled subglacial valleys occurs mostly within the outcrop limits of the Bolders Bank Formation. The valleys, up to 80m deep and with a maximum width of 8km, have been eroded through Weichselian and older sediments. The sediments of the Botney Cut Formation within those valleys can be separated in two discrete members. The lower member structureless on seismic profiles, comprises poorly sorted, gravelly, coarse sands and diamiction. The upper member is parallel-bedded, and consists of very soft slightly sandy mud with partings of fine sand, probably deposited in a glaciolacustrine environment. Areas of acoustic blanking on seismic profiles across Outer Silver Pit and Botney Cut indicate that sediments are locally gas-charged.'

[18] Geological Survey of the Netherlands (Dutch: Rijks Geologische Dienst) and the British Geological Survey.

[19] Rijsdijk 2005.

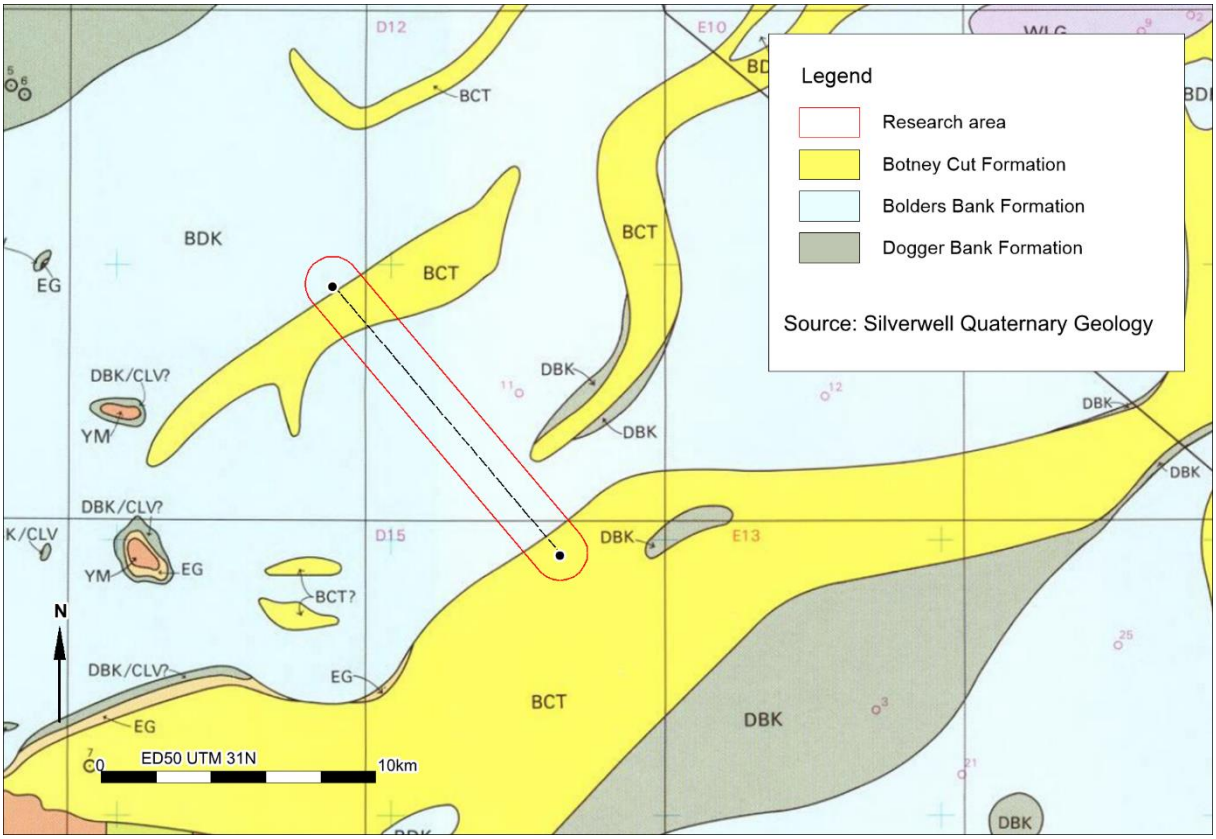

Figure 13. Quaternary sediments (source: Geological maps Silverwell)

The Bolders Bank Fomation

'This formation is characterised by the flat or gently undulating reflector at its base, which is some 42m to 54m below mean sea-level. The seismic texture is chaotic. Short core samples from the west of the area indicate that the formation typically consists of reddish-brown, gravelly, mud-rich, diamictions whereas elsewhere, samples are notably greyer in colour with finer, and often less abundant, gravel. The great variety of gravel is derived from Great Britain. The thickness of the formation is 18-20m in the west, decreasing to 2-6m in the east; the only exception to this is in the area around the Cleaver Bank, where knolls up to 13m high may represent end-moraines. Acoustically, the Bolders Bank Formation passes imperceptibly into the Dogger Bank Formation; the boundary shown in this map is therefore somewhat arbitrary.'

The top of the Pleistocene landscape is expected the depths listed below.

KP From	KP To	Top Pleistocene (m – seabed)
0	9.4	5 - 20
9.4	11.4	1 - 5
11.4	12.7	5 - 20
12.7	12.8	>20

Figure 14. Top Pleistocene in m below seabed

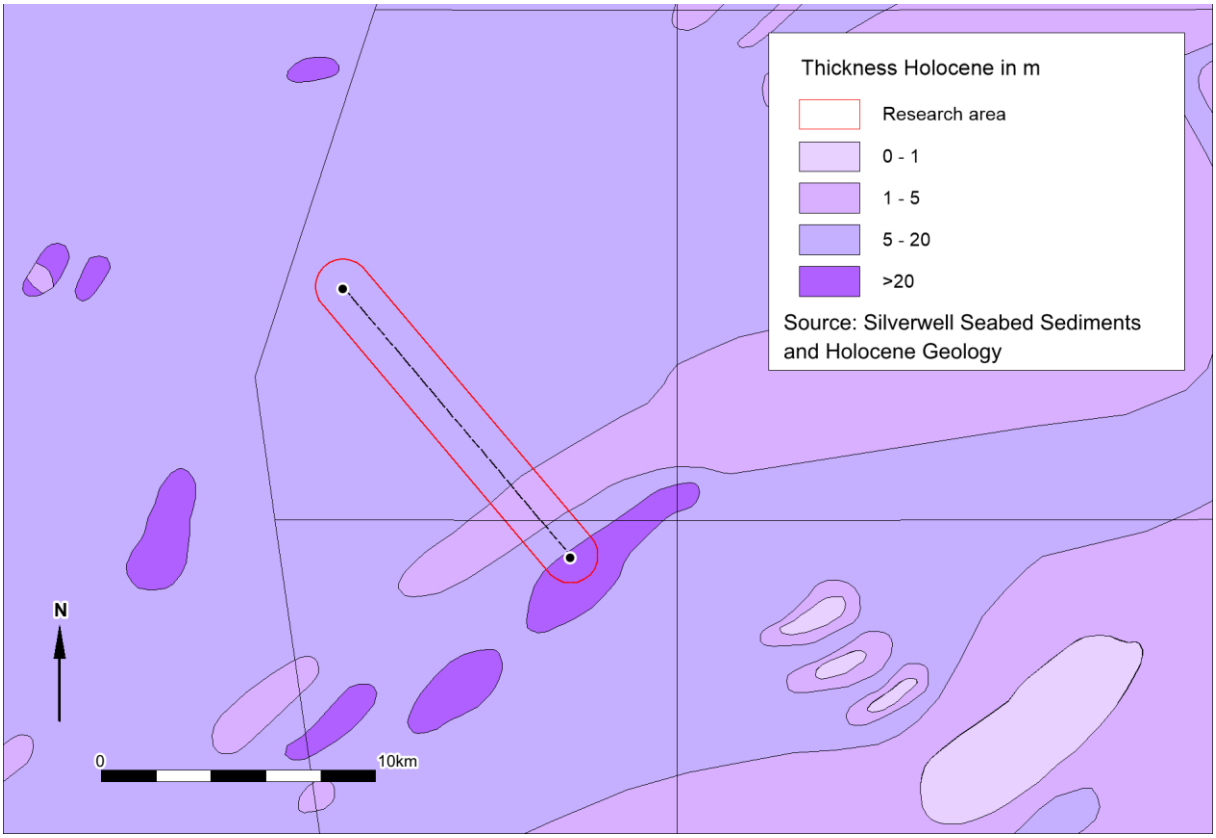

Figure 15. Thickness of Holocene sequence

3.5 Archaeological expectancy

Prehistoric remains

The archaeological expectancy for remains from prehistoric times is related to the geogenesis of the area. The geogenesis is reflected by the current sequence of lithostratigraphic units. Pleistocene and Early Holocene formations are considered to be potential containers of archaeological remains.

The archaeological level is formed by the top of the Dogger Bank Member Member and Botney Cut Member.[20] Especially in areas where those units have been covered by Early Holocene peat (Basal Peat Bed) or clay (Velsen Bed) well-preserved *in situ* remains of high integrity are to be expected.[21] The expected remains include Late Paleolithic and Mesolithic camp sites, burials, lost or dumped objects such as flint and bone artefacts, hunting gear and canoes. Prehistoric camp sites are expected to be indicated by the scattered occurrence of flint artefacts and debris resulting from the production of flint tools accompanied by burnt seeds (hazel nuts), charcoal and bone. Late Paleolithic and Mesolithic camp sites are generally small with little remains, though larger sites with a medium to high density of flint artefacts can occur in case a site has been used repeatedly and/or for a prolonged period of time. Due to the expected clayey context of the Dogger Bank Member the occurrence of a dark charcoal-rich archaeological layer amidst lighter coloured natural clays cannot fully be excluded.

[20] Dogger Bank Member = Dogger Bank Formation (old name)

[21] Basal Peat Bed + Velsen Bed = Elbow Formation (old name)

The top of the Pleistocene landscape is expected at 1m to 5m below the seabed between KP9.5 and KP11.4 and at depths over 5m in the remainder of the route.

To date it is unknown if the catastrophic tsunami event which occurred around 6250 BC has eroded the Dogger Bank Member in the area. If so, the integrity of archaeological remains might be affected to a large extent. Apart from this catastrophic event, the archaeological remains could have been subject to erosion caused by wave action and tidal currents after the area drowned.

The expectancy for prehistoric remains can be tested by a geo-archaeological assessment of subbottom data. If the lithostratigraphic units and coherent archaeological levels are found at depths larger than 3m, it is not considered likely that prehistoric remains will be affected by the installation of the pipelines.

Historic ship wrecks

The research area does not contain any known ship wrecks. The nearest known site is situated just south of the research area, additional information of this site is not available.

Undiscovered wrecks might be present in the research area. When a ship sinks to the seabed, the remains are expected to incise into the loose soft seabed until harder underlying deposits are encountered. A thick top layer of loose material contributes to the covering and preservation of a ship wreck. Especially in areas in which the upper seabed layer contains a significant admixture of clay will seal and thus promote conservation. This effect will be less if the top layer solely consists of sand or gravel. Wooden parts of wrecks which are exposed at the seabed are subject to bio-detoriation by marine fauna like the naval ship-worm (*Teredo Navalis)*.

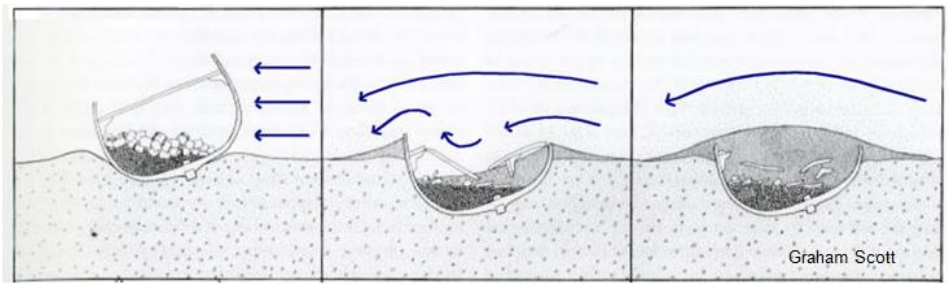

Figure 16. Example of wreck site formation (Graham Scott)

Ship wrecks and aircrafts from World War I & II

The number of aircrafts from the Second World War missing is not exactly known. It is however plausible to assume that to date solely for the North Sea area hundreds of planes have never been found. Also submarines and other ships that were sunk during both World Wars can be expected.

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4 Results geophysical survey

4.1 Methods

The geophysical survey has been carried out in the period 10-14 April 2017 Fugro Survey BV.

The following survey equipment was deployed:

- Side scan sonar (SSS);
- Single beam echo sounder (SBES);
- Multibeam echo sounder (MBES);
- Sub-bottom profiler (SBP);
- Magnetometer;
- Ultra-high sparker (UHRS).

The presence of ship wrecks and remnants of aircrafts which occur exposed at the seabed is investigated by the analysis of *side scan sonar, magnetometer and multibeam eco sounder* data. Also shallowly buried objects which are marked by the presence of scours have been investigated. *Multibeam* images are very useful to identify clear morphological phenomena such as scours cause by buried objects.

Objects which are exposed at the seabed but are not elevated above the seabed and have not caused any scour cannot be distinguished in *multibeam* images. Those types of objects can be identified by means of *side scan sonar*, because they result in a different acoustic signal than the surrounding seabed.

Iron-bearing buried objects can be detected by means of the *magnetometer*. Some indication of the size of the buried object can be obtained from the amplitude of the anomaly. The accuracy of the positions of the objects found is limited, because an anomaly is always tagged on a survey line and the object causing this anomaly can be located on both sides of this survey line. Also the character of the object inducing the anomaly cannot be established.

The subbottom profiler data have been processed to determine seismic reflectors in the subsoil. Those seismic reflectors have been interpreted and correlated with the lithostratigraphic units and boundaries expected in the research area. As the archaeological levels for prehistoric camp sites and burials are contained in the lithostratigraphic units identified, the expectancy defined during the desk study can be tested.

4.2 Data quality

The quality of the survey data is good; the data is fit to be used for an archaeological assessment. The survey reports and the data which were processed, interpreted and provided by the survey contractor Fugro are used for this assessment.

4.3 Bathymetry

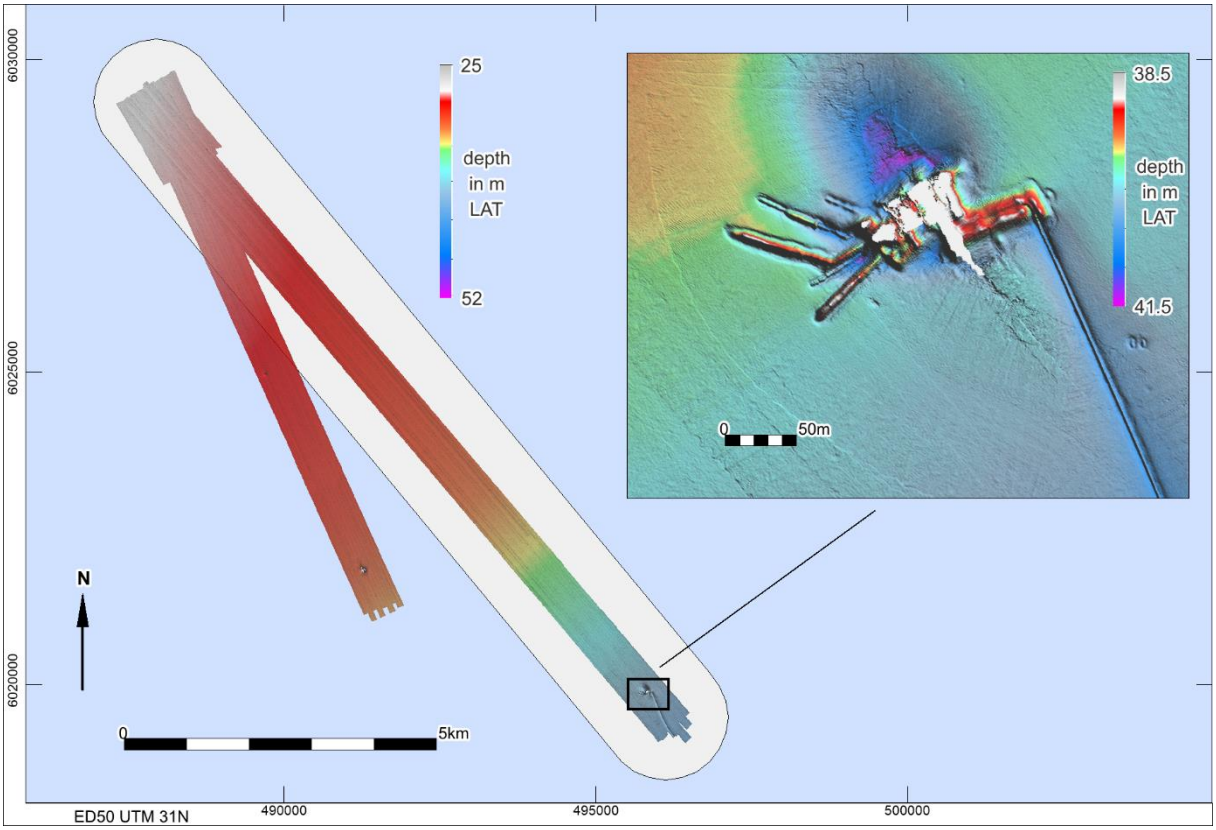
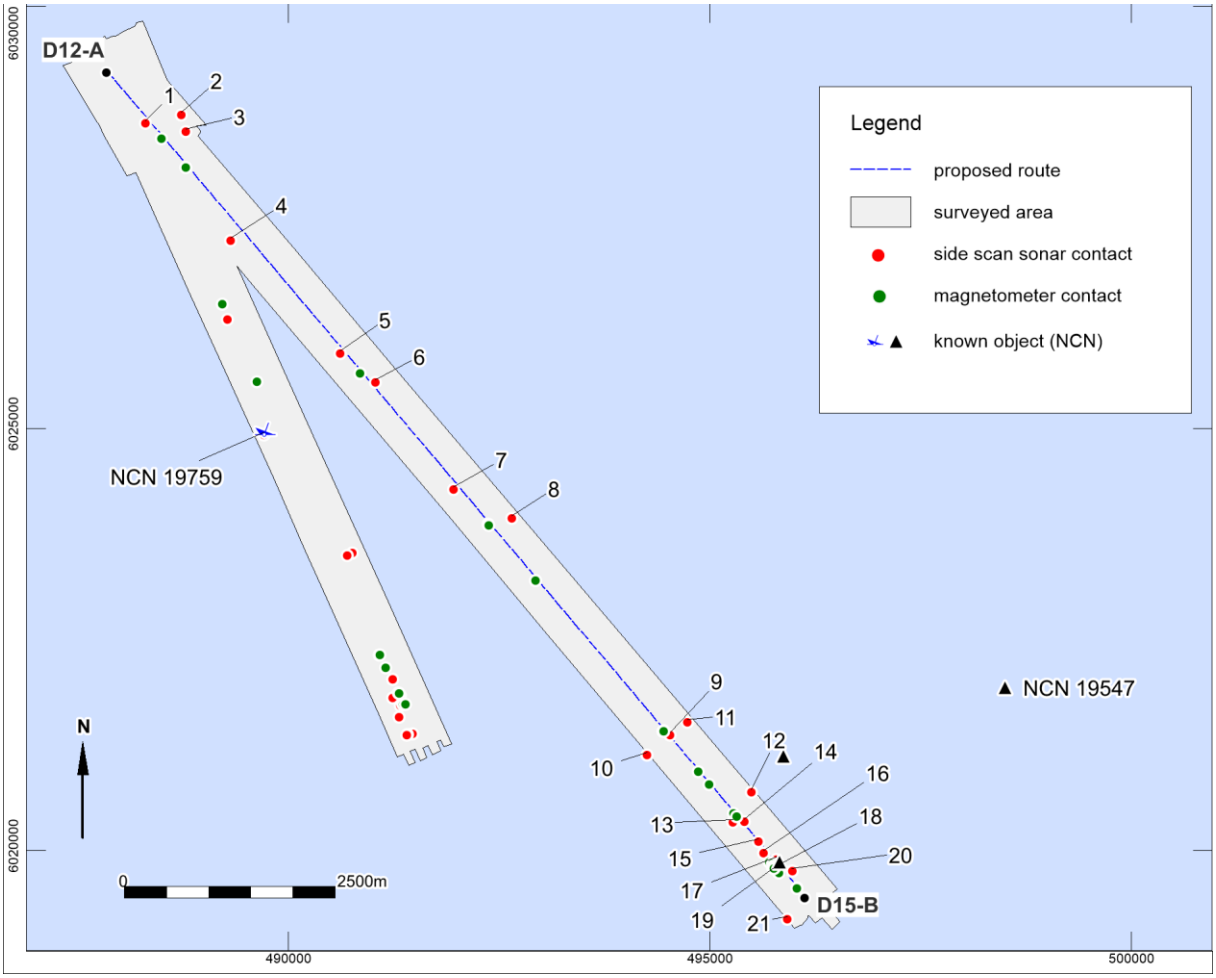


Figure 17. Bathymetry from MBES along the route

The water depth along the route increases gently from 28.1 mLAT in the northwest to 43.7 mLAT in the southeast, with an average of 31.7 meter. The seabed is smooth, large scale sand waves are not present.

4.4 Side scan sonar and magnetometer

The side scan sonar and magnetometer survey along the proposed route has resulted in 22 sonar contacts and 25 magnetic anomalies. A summary of the classification of the sonar targets is listed in table 5.



Classification	Number
Debris	18
Depression	1
Mattress	2
Wreck	1
Total	**22**

Table 5. Summary of classified side scan sonar contacts along the proposed route

The majority of the contacts classified as debris are related to the platform D15-FA and the present pipeline constructions.

The largest contact classified as debris which is not related to the platform location is contact D15-003. The dimensions from side scan sonar are 6.9 x 2.5 x 0.3 m, and the contact lies in a 0.3m deep depression probably caused by scouring. The contact is also visible in the multibeam records as shown below.

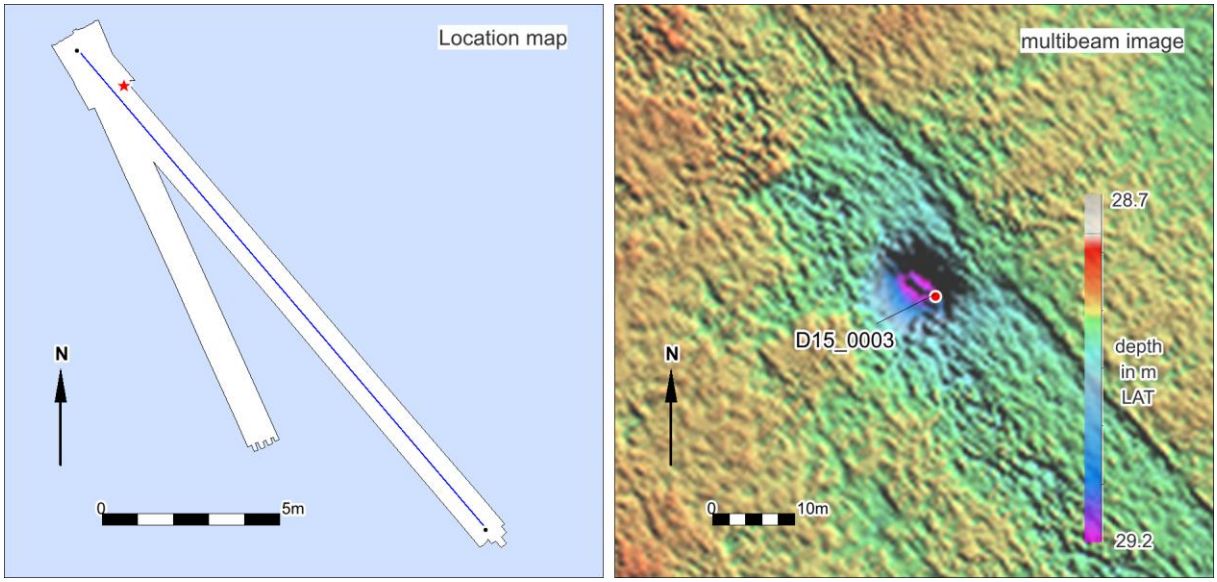
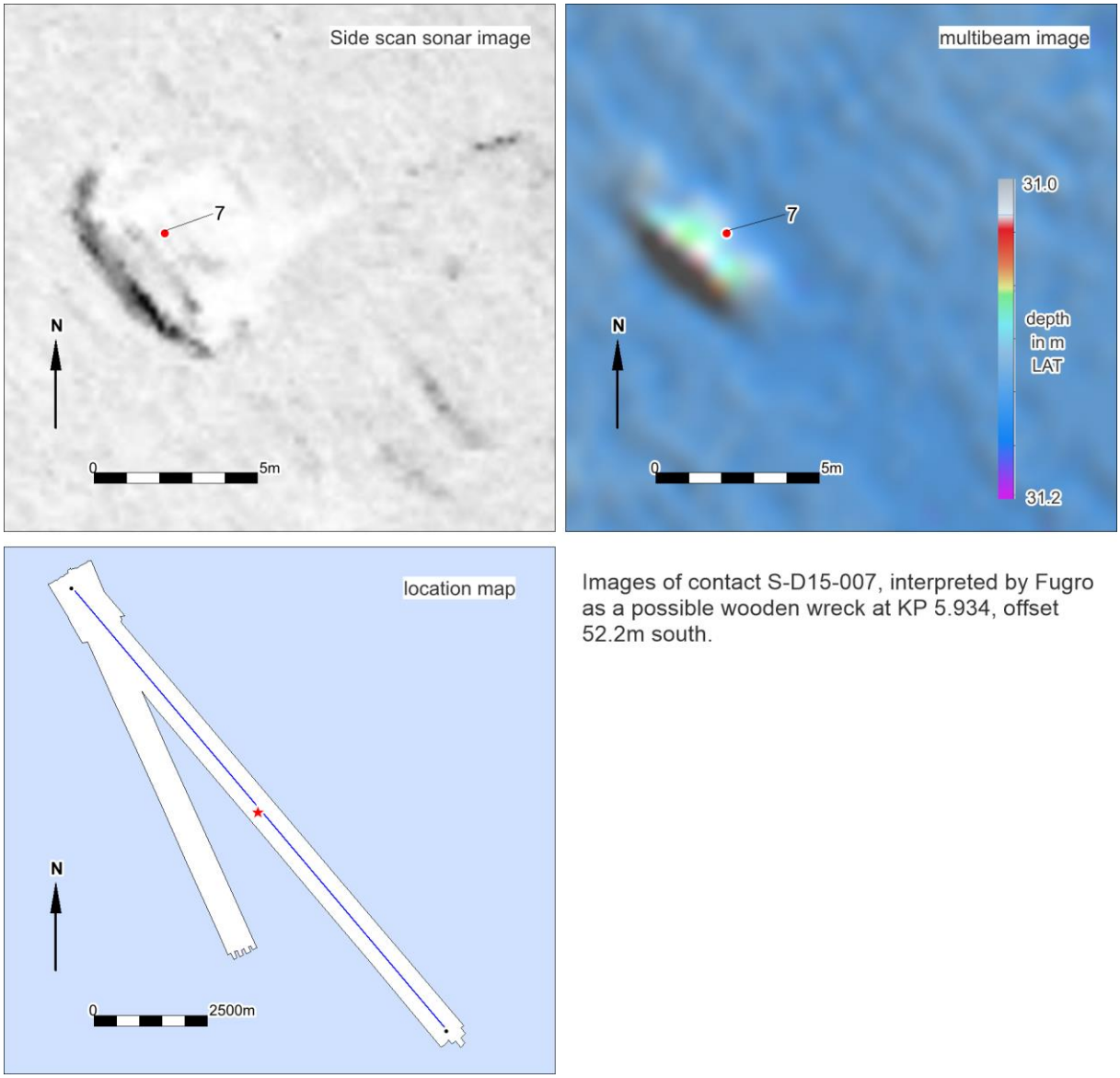


Figure 18. Multibeam image of sonar contact D15-003

The contact is located at KP 0.648 at a distance of 276m from the proposed route.

At KP 5.934, at a distance of 52 m from the route, a contact was found which was interpreted by Fugro as a possible wooden wreck with dimensions 8.8 x 2.7 x 0.7m.



Images of contact S-D15-007, interpreted by Fugro as a possible wooden wreck at KP 5.934, offset 52.2m south.

Figure 19. Images of possible ship wreck

Both the side scan sonar and multibeam image show an elongated structure, bended at the ends. It could be the remains of a small ship wreck, may be a dinghy. No magnetic anomalies have been observed at the location. According to Fugro, this location was also known in the database of the Hydrographic Service, but the nearest shipwreck from the Hydrographic database (NCN 19759, Nlhono 4066) is located 2300m to the west. This location has been verified by both side scan sonar and multibeam.

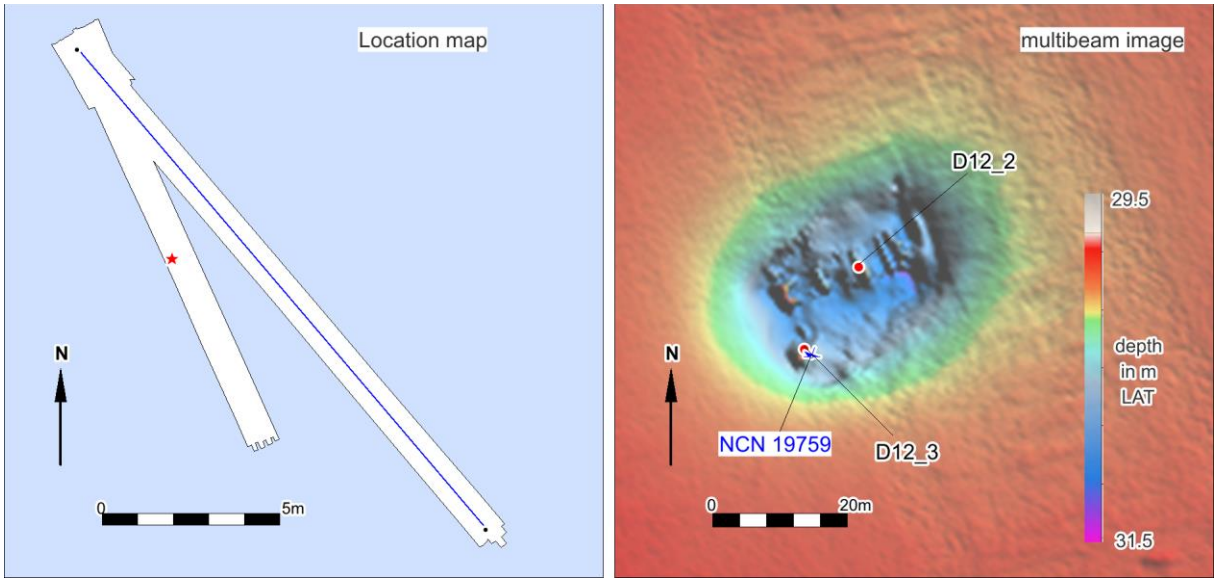


Figure 20. Multibeam image of known site NCN 19759

The multibeam image show several objects or constructions over an area of 25 x 20 m in a depression caused by scouring. No magnetic anomalies have been observed at the location. The site is located in the southern survey area at a distance of 1300m from the proposed route and will therefore not been affected.

The remaining targets are all smaller than 5m and are not of archaeological interest.[22]

A target listing of both side scan sonar contacts and magnetic anomalies is included in appendix 1.

[22] Interpretation based on best professional judgment.

4.5 Subbottom profiler

The results of subbottom profiler survey have been interpreted to determine the shallow geology along the pipeline route. The shallow geology comprises sediments that were deposited during a number of Quaternary glacials and interglacials. The strata within the top approximately 30 m BSF (the limit of SBP data penetration), are interpreted as Saalian (Middle Pleistocene) to Holocene in age.

The subsurface geology is primarily characterised by a series of sub-horizontal reflectors. Based on differences in seismic character, four (4) main seismic units were identified: (see table below).

Age	Unit	Geological Formation	Basal Horizon	Depth to base [m BSF]	Soil Description
Holocene	A	New Zeeland Gronden	H10	3.5 – 15.0	Medium dense to dense fine to medium SAND, with shells and shell fragments, locally silty
Late Weichselian	B	Botney Cut	H15/H20	13.0 – 16.5	Very low strength to medium strength silty, sandy CLAY, with closely spaced very thin to thin beds of silty sand and/or sandy silt
Weichselian	C	Bolders Bank / Dogger Bank	H20	9.5 – >25.0	Medium strength to very high strength silty sandy CLAY or interbedded dense to very dense fine SAND and SILT
Saalian	D	Cleaver Bank	-	>30.0	Interbedded very high strength to extremely high strength slightly sandy CLAY and dense to very dense SAND, locally gravelly

Table 6. Summary of shallow geological units along the route

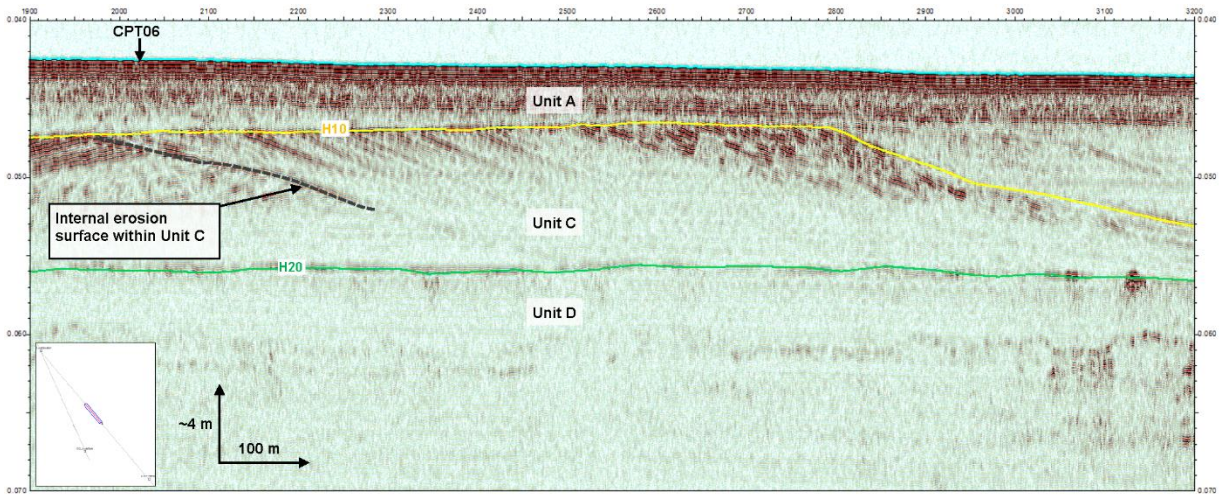


Figure 21. Example of subbottom image along the route

The text below (*italic*) has been copied from the Fugro Survey report 1 of 2: Sillimanite D12-B Geophysical Site and Route Survey:

Unit A represents Holocene marine sediments that were deposited during the last postglacial transgression. The unit comprises fine to medium SAND, locally very silty, as shown by the results of sampling and CPT testing performed within the survey area. The base of Unit A is a sub-horizontal surface, interpreted as erosional, and the unit has a thickness that ranges between approximately 3.5 m and 15.5 m.

Unit B is interpreted as the Botney Cut Formation, deposited in a glaciolacustrine environment. The unit comprises very low strength to medium strength silty, sandy CLAY, often with lamination and/or thin beds of sand/silt. The unit is present only in the northern parts of the pipeline route, until approximately KP 1.6.

Unit C is interpreted to represent glacial deposits of the Bolders Bank and/or Dogger Bank Formations. The two formations have not been differentiated. No geotechnical data are available from this unit. Public domain sources indicate that the unit most likely comprises interbedded dense to very dense fine SAND and SILT and /or medium strength to very high strength silty sandy CLAY.

Unit D is interpreted to represent the Cleaver Bank Formation, which was deposited in glaciomarine and glaciolacustrine depositional environment, with minor intercalations of glacial deposits. The unit comprises stiff to hard sandy CLAY with interbeds of dense to very dense SAND, locally gravelly.

Unit A has been classified as New Zeeland Gronden. Occurrences of the Elbow Formation (currently named Basal Peat Bed and Velsen Bed) at the base of the sequence have not been distinguished as a separate unit but are likely to be present in places.

The top of the mapped Pleistocene units comprise the Botney Cut Member (Unit B) between KP0 and KP1.51 and the Bolders Bank / Dogger Bank Members (Unit C) between KP1.51 and KP12.317 with intermitted sub crops of the Cleaver Bank Member between KP9.45 and KP9.75 and between KP10.73 and KP10.98.

Archaeological expectancy

The desk study based archaeological expectancy specified in section 3.5 is to a large extent confirmed by the seismic data. The reported total thickness of the Holocene sequence is 3.5m to 15.0m is in line with the overall expected thickness of 5m to 20m for major part of the proposed pipeline route and a thickness of 1m to 5m for the section between KP9.5 up to KP11.4.

Also the expected lithostratigraphic units of the Botney Cut and Bolders Bank Member have been found. The sub cropping Cleaver Bank Member was not foreseen. Given the Saalian age of this unit, Middle Paleolithic remains, such as Neanderthal camp sites, can be present in addition to the remains possibly left behind by Late Paleolithic and Mesolithic hunters and gatherers.

5 Answers to research questions and conclusions

Questions with respect to the desk study:

Are archaeological values known in the research area?

Within the research area, no archaeological values are known. Two obstacles, both related to the existing platform D15_Fa 1 are registered in the NCN database. The nearest shipwreck from the Hydrographic database (NCN 19759, Nlhono 4066) is located 800m to the southwest of the research area.

If so:
What is the nature, size, and location, depth of occurrence and age of the site?

This question is not applicable.

What is the integrity and conservation of the site?

This question is not applicable.

Are - apart from any known sites - archaeological values to be expected in the research area?

Yes, prehistoric remains and thus far undiscovered ship and plane wrecks are to be expected in the research area.

What is the expected nature, size, and location, depth of occurrence and age of the archaeological remains?

The expectancy for prehistoric remains is related to the buried Pleistocene and Early Holocene landscape. The archaeological level is located in the top of the Dogger Bank Member and Botney Cut Member.[23] Late Paleolithic and Mesolithic camp sites, burials, lost or dumped objects such as flint and bone artefacts, hunting gear and canoes are to be expected. Prehistoric camp sites are indicated by the scattered occurrence of flint artefacts and debris resulting from the production of flint tools accompanied by burnt seeds (hazel nuts), charcoal and bone. Camp sites of hunters and gatherers are generally small with little remains, though larger sites with a medium to high density of flint artefacts can occur in case a site has been used repeatedly and/or for a prolonged period of time. Due to the expected clayey context of the Dogger Bank Member the occurrence of a dark charcoal-rich archaeological layer amidst lighter coloured natural clays cannot fully be excluded.

The top of the Pleistocene landscape is expected at 1m to 5m below the seabed between KP9.5 and KP11.4 and at depths over 5m in the remainder of the route.

What is the expected integrity and conservation of the anticipated archaeological remains?

Especially in areas where the Pleistocene units have been covered by Early Holocene peat (Basal Peat Bed) or clay (Velsen Bed) well-preserved in situ remains of high integrity are to be expected.[24] The physical

[23] Dogger Bank Member = Dogger Bank Formation (old name).

[24] Basal Peat Bed + Velsen Bed = Elbow Formation (old name).

quality of Mesolithic remains is expected to be high due to the clayey and peaty context of the Basal Peat bed and Velsen Bed and rapid drowning of the area in the Early Holocene.

To date it is unknown if the catastrophic tsunami event which occurred around 6250 BC has eroded the Dogger Bank Member in the area. If so, the integrity of archaeological remains might be affected to a large extent. Apart from this catastrophic event, the archaeological remains could have been subject to erosion caused by wave action and tidal currents after the area drowned.

Are the known or expected archaeological remains affected by the installation of a pipeline?
The pipeline will be installed at a few meters below the seabed. The top of the Pleistocene landscape is expected at 1m to 5m below the seabed between KP9.5 and KP11.4. In this section archaeological remains could be affected. A definite answer to this question based on the results of the seismic survey will be given below.

Questions with respect to the route survey:

primary question:
Are any archaeological remains present within the Area of Interest and to what extent are these remains traceable?
The route survey has resulted in the discovery of a possible small ship wreck. To date it is not known if this wreck is of archaeological value.

with respect to side scan sonar, magnetometer and multibeam survey:

Are there any phenomena visible on the seabed?
Yes, the survey resulted in the identification of 22 side scan sonar contacts. A further 256 magnetic anomalies indicate the presence of ferromagnetic objects which for the major part are not exposed at the seabed.

If so: *What is the description of these phenomena?*
The 22 side scan sonar contacts have been interpreted as debris (18), mattresses (2), depression (1) and wreck (1).

Do these phenomena have a man-made or natural origin?
The debris and wrecks are man-made; the depression is of natural origin.

If these phenomena can be designated to be man-made: What classification can be attached?
The majority of the contacts classified as debris are related to the platform D15-FA and the present pipeline constructions.

If these phenomena can be classified as archaeological: *Is it possible to interpret the nature of the archaeological objects?*
The largest contact classified as debris which is not related to the platform location is contact D15-003. The dimensions from side scan sonar are 6.9 x 2.5 x 0.3 m, and the contact lies in a 0.3m deep depression probably caused by scouring. This could be the remains of a wreck.

If these phenomena can be identified as natural: *What is the nature of these natural phenomena?*
Natural phenomena consist of seabed disturbances (depression).

Based on the acoustic image is it possible to designate zones of high, middle or low activity on the seabed?
No. The seabed is smooth and flat.

If so: *How can these zones be interpreted?*
This question is not applicable as no different activity zones have been designated.

general:
What is the relation between the observed objects and the topography of the seabed?
The seabed adjacent to the observed side scan sonar contacts and present infrastructure displays local scouring, due to tidal currents.

If no acoustic phenomena can be observed: *Are there any clues that this is a consequence of either natural erosion, sedimentation or human interference?*
This question is not applicable

with respect to subbottom profiler survey:

Based on seismic profiles and geotechnical data is it possible to map the Pleistocene landscape?
Yes.

If so: *What is the depth of the Pleistocene landscape compared to the present seabed?*
The base of the Holocene sequence is found at 3.5m to 15.0m below the seabed along the route.

From Pleistocene to Holocene deposits is the transition gradual or instantaneous (erosive)?
The reflector representing the base of the Holocene sequence has been interpreted as an erosional layer boundary.

Can zones be identified where prehistoric settlement remains can be expected?
Yes, the expected Bolder Bank and Botney Cut Member which were identified as potential containers of archaeological remains of the Late Paleolithic and Mesolithic have been found at 3.5m to 15.0m during the seismic survey.

The presence of the Cleaver Bank Member, which was found sub cropping at the top of the Pleistocene sequence between KP9.45 and KP10.95, was not foreseen.[25] Given the Saalian age of this unit, Middle Paleolithic remains, such as Neanderthal camp sites, can be present in addition to the remains possibly left behind by Late Paleolithic and Mesolithic hunters and gatherers.

[25] Cleaverbank Member = Cleaverbank Formation (old name).

If so: *Could these expected settlement remains be affected by the installation of the pipeline based on their vertical position related to the seabed?*
No, the archaeological level lies at more than 3.5m below the seabed. Therefore it is not considered probable that the installation of the pipeline will affect archaeological remains.

Are there any indications observed on the seismic profiles for the presence of buried (man-made) objects?
No. The present hyperbolic reflectors visible in the seismic profiles have been interpreted to be induced by natural phenomena such as shell or gravel beds.

If so: *Based on the presence of buried objects and its correlation with side scan sonar, magnetometer en multibeam data can something be said about the nature of these buried objects?*
Refer to the previous question/answer.

Are there any mitigating measures necessary to avoid disturbance of possible archaeological remains?
Possible remains of ship wrecks were found at three locations, two of which are within 500 meter of the proposed route. As long as the archaeological value of these sites has not been established, these sites must be avoided including a buffer zone of 100 meters during the construction operations. The risk that remains of prehistoric camp sites will be affected is considered very small.

6 Conclusions and recommendations

Within the research area, possible remains of three ship wrecks were found. Apart from visual dimensions, details like the name or sink date are not known. As long as the archaeological value of these sites is not determined, it is advised not to conduct activities which could affect this location including a buffer zone of 100 meters around. In the remaining part of the research area, no objects with a possible archaeological value were found.

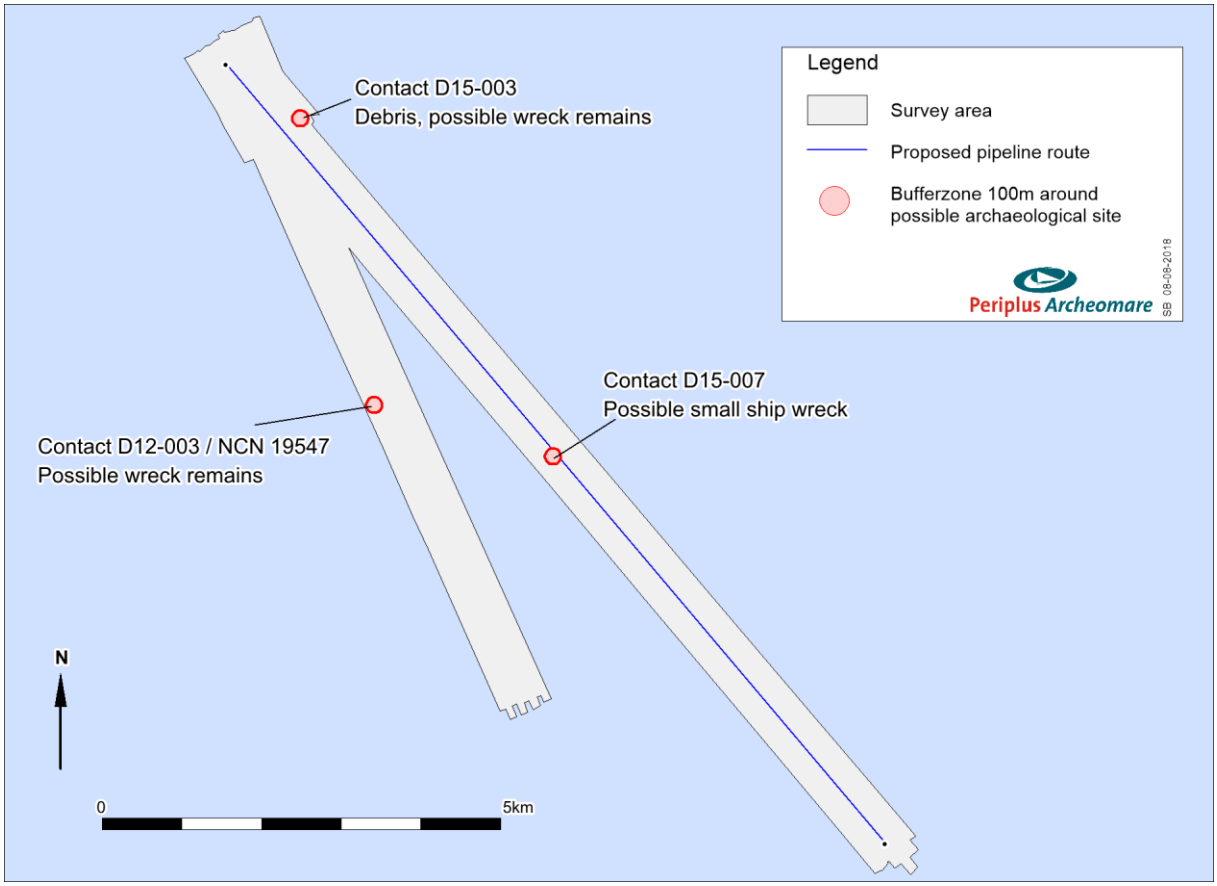


Figure 22. Overview of the potential archaeological object found within the survey area

The desk study and the seismic data assessment indicate that prehistoric remains from the Middle and Late Paleolithic and Mesolithic are to be expected in the research area. The archaeological levels in the top of Bolder Bank Member, the Botney Cut Member and the Cleaver Bank Member covered by the Basal Peat Bed and/or Velsen bed are not expected to be reached by the pipeline trencher. The risk that the installation of the pipeline will jeopardize archaeological values is therefore considered very small.

During the installation of the pipeline, archaeological objects may be discovered which were completely buried or not recognized as an archaeological object during the geophysical survey. In accordance with the Heritage Act (Erfgoedwet), it is required to report those findings to the competent authority. This notification must also be included in the scope of work.

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Glossary and abbreviations

Terminology	Description
AMZ	Archeologische Monumenten Zorg
CPT	Cone penetration test
Ferrous	Material which is magnetic or can be magnetized, and well known types are iron and nickel
Holocene	Youngest geological epoch (from the last Ice Age, around 10,000 BC. To the present)
In situ	At the original location in the original condition
KNA	Kwaliteitsnorm Nederlandse Archeologie
Magnetometer	Methodology to measure deviations from the earth's magnetic field (caused by the presence of ferro-magnetic = ferrous objects)
Multibeam	Acoustic instrument that uses different bundles or beams to measure the depth in order to create a detailed topographic model
Pleistocene	Geological era that began about 2 million years ago. The era of the ice ages but also moderately warm periods. The Pleistocene ends with the beginning of the Holocene
PvE	Program of Requirements (Programma van Eisen)
RCE	Rijksdienst voor het Cultureel Erfgoed
ROV	Remotely Operated Vehicle
Side scan sonar	Acoustic instrument that registers the strength of reflections of the seabed. The resulting images are similar to a black / white photograph. The technique is used to detect objects and to classify the morphology and type of soil
Current ripples	Asymmetrical wave pattern at the seabed caused by currents. The steep sides of the ripples are always on the downstream side.
Subbottom profiler	Acoustic system used to create seismic profiles of the sub surface.
Trenching	Construction of a trench for the purpose of burying a cable or pipeline
Vibrocore	A special drilling technique where a core tube is driven by means of vibration energy in the seabed. In addition, the core tube is provided with a piston so that the bottom material in the core tube remains in place.

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- KNA Waterbodems 4.1
- Nationaal Contactnummer Nederland (NCN)
- Silverwell geological maps; seabed sediments and quaternary
- SonarReg92, objectendatabase Rijkswaterstaat Noordzee en Delta
- Wrecksite, www.wrecksite.eu

Appendix 1. Listing of side scan sonar and magnetometer contacts

KP	Offset	Easting	Northing	SSS Target	Comments/Dimensions (L x W x H)
0.26	32.5	488304	6028647	S_D15_0001	Debris; 3.4 x 1.1 x 0.2
0.461	-357.4	488732	6028745	S_D15_0002	Debris; 1.9 x 1.1 x 0.1
0.648	-267.2	488784	6028544	S_D15_0003	Debris; 6.9 x 2.5 x 0.3 (Debris in 0.3 m deep depression)
1.977	163.7	489314	6027252	S_D15_0004	Debris; 2.0 x 1.5 x 0.7
3.833	33.6	490613	6025920	S_D15_0005	Debris; 1.0 x 0.4 x 0.3
4.366	-67.3	491035	6025578	S_D15_0006	Debris; 3.4 x 0.8 x nmh
5.934	52.2	491957	6024305	S_D15_0007	Wreck; 8.8 x 2.7 x 0.7 Possibly wooden wreck. Also in database Dienst der Hydrografie (**???**).
6.643	-254.8	492650	6023962	S_D15_0008	Debris; 3.1 x 1.3 x 0.2
9.815	-28.1	494527	6021396	S_D15_0009	Debris; 0.9 x 0.3 x nmh
9.819	333.4	494254	6021159	S_D15_0010	Debris; 2.0 x 1.0 x 0.4
9.831	-278.6	494729	6021545	S_D15_0011	Depression 3.7 x 1.1 x 0.2 m deep
10.954	-324.6	495490	6020718	S_D15_0012	Debris; 3.0 x 1.8 x 0.3
11.084	72	495271	6020363	S_D15_0013	Debris; 3.8 x 1.4 x 0.6 Debris in 0.4 m deep depression
11.168	-37.2	495409	6020369	S_D15_0014	Debris; 1.9 x 0.5 x 0.1
11.452	-13.1	495574	6020137	S_D15_0015	Debris; 2.0 x 1.0 x 0.1
11.601	27.8	495639	6019997	S_D15_0016	Possible debris; 2.1 x 0.7 x nmh
11.755	-33.2	495785	6019919	S_D15_0017	Debris; 1.2 x 0.9 x nmh
11.835	29.7	495789	6019817	S_D15_0018	Debris; 1.3 x 0.5 x 0.2 Debris near platform rock dump
11.836	28.2	495791	6019817	S_D15_0019	Debris; 1.4 x 0.7 x 0.1 Debris near platform rock dump
11.978	-90.6	495973	6019786	S_D15_0020	Wet-stored mattress; 5.4 x 3.1 x nmh
11.983	-95.3	495980	6019785	S_D15_0021	Wet-stored mattress 5.6 x 3.4 x nmh
12.376	32.5	495917	6019217	S_D15_0022	Debris; 4.7 x 0.7 x 0.1
2.783	23.4	489280	6026318	S_D12_0001	Depression; 2.2 x 1.9 x 0.2
4.2	178.7	489719	6024962	S_D12_0002	Debris; 23.9 x 9.4 x 1.1
4.207	190.9	489711	6024950	S_D12_0003	Area with debris associated with S_D12_0002; 6.5 x 3.8 x nmh **(= NCN 19759**)
5.914	−193.6	490761	6023551	S_D12_0004	Debris; 2.0 x 0.4 x 0.1
5.916	−124.8	490699	6023521	S_D12_0005	Debris; 2.4 x 1.0 x 0.2
7.469	−17.7	491238	6022060	S_D12_0006	Debris; 2.3 x 0.9 x nmh
7.684	−19.0	491327	6021865	S_D12_0007	Debris in 0.2 m deep depression; 2.1 x 1.4 x nmh
7.671	42.4	491266	6021851	S_D12_0008	Debris; 1.1 x 0.4 x 0.1
7.672	72.3	491239	6021838	S_D12_0009	Debris; 3.0 x 1.3 x nmh
7.796	26.9	491331	6021744	S_D12_0010	Debris; 1.7 x 0.5 x nmh
7.912	102.2	491310	6021607	S_D12_0011	Debris in 0.2 m deep depression; 1.3 x 0.9 x 0.2
8.141	91	491414	6021403	S_D12_0012	Debris in 0.25 m deep depression; 1.6 x 0.9 x 0.4
8.141	100.8	491405	6021399	S_D12_0013	Depression; 1.1 x 1.1 x 0.2 m
8.157	33.5	491473	6021412	S_D12_0014	Debris in 0.5 m deep depression; 1.1 x 1.1 x nmh

Observed magnetometer anomalies

			ED50 UTM31N		Amplitude		
ID	KP	Offset	Easting	Northing	nT	Type	Remarks
D15_01	0.52	5.54	488493	6028466	4.1	Dipole	
D15_02	0.966	7.31	488780	6028124	3.6	Dipole	
D15_03	4.167	5.97	490850	6025683	11.4	Monopole	Same anomaly as M_D15_08
D15_04	4.171	7.56	490852	6025679	10	Monopole	Same anomaly as M_D15_07
D15_05	6.515	3.47	492370	6023893	4.6	Monopole	
D15_06	6.527	4.07	492377	6023884	5.6	Dipole	
D15_07	7.387	7.76	492931	6023225	9.4	Dipole	Same anomaly as M_D15_06
D15_08	7.391	5.13	492935	6023224	10.1	Dipole	Same anomaly as M_D15_05
D15_09	9.726	8.33	494442	6021440	5.4	Dipole	Same anomaly as M_D15_01, M_D15_03
D15_10	9.728	-2.76	494452	6021446	2	Dipole	Same anomaly as M_D15_02, M_D15_03
D15_11	9.729	2.69	494448	6021442	22.2	Dipole	Same anomaly as M_D15_01, M_D15_02
D15_12	10.361	-1.2	494859	6020962	2.4	Dipole	
D15_13	10.556	-3.41	494988	6020814	8.1	Dipole	
D15_14	11.011	-0.38	495279	6020465	3	Dipole	
D15_15	11.061	-6.47	495316	6020431	4	Dipole	
D15_16	11.883	44.68	495808	6019771	72.4	Dipole	Near platform
D15_17	11.894	40.4	495819	6019765	74.7	Dipole	Near platform
D15_18	na	na	495706	6019888			D18a-A to D15-A 8/2 inch bundle
D15_19	na	na	495740	6019873			D12-A to D15-FA 10 inch pipeline
D15_20	na	na	495754	6019847			Wingate to D15-FA-1 12/2 inch bundle
D15_21	na	na	495742	6019827			Minke to D15-FA 8/3 bundle
D15_22	na	na	495769	6019825			D18a-A to D15-A 8/2 inch bundle
D15_23	na	na	495755	6019812			D18a-A to D15-A 8/2 inch bundle
D15_24	na	na	496032	6019584			D15-FA to L10-AC 36 inch pipeline
D15_25	na	na	496034	6019577			D15-FA to L10-AC 36 inch pipeline
D12_01	2.586	7.8	489213	6026504	4.9	Dipole	
D12_02	3.595	8.86	489626	6025583	2.7	Dipole	
D12_03	7.142	9.11	491080	6022347	2.6	Dipole	Same anomaly as M_D12_01
D12_04	7.145	2.66	491086	6022348	3.1	Dipole	Same anomaly as M_D12_02
D12_05	7.316	2.91	491156	6022191	18.3	Dipole	
D12_06	7.647	-15.56	491309	6021897	99	Dipole	Near platform
D12_07	7.657	-18.89	491316	6021889	16.6	Dipole	Near platform
D12_08	7.793	-6.05	491360	6021760			D12-A to D15-A 10 inch pipeline
D12_09	7.806	-32.4	491389	6021759			D12-A to D15-FA 10 inch pipeline

Appendix 2. Geological and archaeological time scale

CHRONOSTRATIGRAFIE				ARCHEOLOGISCHE PERIODE				
SERIE	ETAGE - CHRONOZONE		TIJD	TIJDPERK				DATERING
Holoceen	**Laat Subatlanticum**		**1150 n. Chr**	Nieuwe tijd			C	1850
							B	1650
							A	1500
				Middeleeuwen	Laat		B	1250
							A	1050
					Vroeg		D	900
							C	725
							B	525
							A	450
	Vroeg Subatlanticum		0	Romeinse tijd			Laat	270
							Midden	70 n. Chr.
							Vroeg	15 v. Chr.
			450 v. Chr	Prehistorie	Metaaltijden	IJzertijd	Laat	250
							Midden	500
							Vroeg	800
						Bronstijd	Laat	1100
							Midden	1800
							Vroeg	2000
	Subboreaal		3700		Steentijd	Neolithicum	Laat	2850
							Midden	4200
							Vroeg	4900/5300
	Atlanticum		7300			Mesolithicum	Laat	6450
	Boreaal		8700				Midden	8640
	Preboreaal		9700				Vroeg	9700
Pleistoceen	Weichselien	Laat Glaciaal	Jonge Dryas	11.000		Paleolithicum	Laat	B	12.500
			Allerød	12.000					
			Oude Dryas	12.100					
			Bølling	13.000					
		Pleniglaciaal L		17.000			Jong		16.000
			Late Glacial Max	20.000					
				31.500				A	
			Denekamp	34.000					35.000
		Pleniglaciaal M		40.000			Midden		250.000
			Hengelo	41.500					
				45.000					
		Pleniglaciaal V	Moershoofd	50.000					
				71.000					
		Vroeg Glaciaal	Odderade	74.000			Oud		
			Brørup						
			Amersfoort						
				114.000					
	Eemien			126.000					
	Saalien			236.000					
	Oostermeer			241.000					
	onbenoemd			322.000					
	Belvédère			336.000					
	onbenoemd			384.000					
	Holsteinien			416.000					
	Elsterien			463.000					

Appendix 3. Phases of maritime archaeological research

The Dutch Quality Standard for Archaeology (KNA Waterbodems, version 4.1) describes all procedures and requirements for the archaeological research process. Below a brief description of the steps involved:

1. **Desk study**
   The purpose of a desk study is to collect and report all available historical data, geological information and information about disturbances in the past. The result is an archaeological expectancy map or model. The desk study may be expanded with an analysis of sonar and multibeam data, if available.

   IF the outcome of the desk study shows that there is a risk of occurrence of archeology, then the next phase must be carried out:

2. **Exploratory field research (opwaterfase)**
   In order to test the archaeological expectancy, a geophysical survey is carried out. The type of survey depends on the type of expected objects, local geology and expected depth of the objects below the seafloor. In practice, the research usually consists of a side scan sonar survey, if necessary, supplemented with multibeam echosounder recordings, subbottom profiling and magnetometer measurements. The requirements of the survey are based on the desk study and should be included in a program of requirements which must be approved by the competent authorities.

   IF potential archeological objects are found, then the next phase must be carried out:

3. **Exploratory field research (onderwaterfase verkennend)**
   The suspected sites are investigated by specialized divers in order to identify the objects. The requirements of the underwater research are included in a program of requirements which must be approved by the competent authorities.

   IF as site is identified as an archaeological object or structure then the next phase must be carried out:

4. **Appreciative field research (onderwaterfase waarderend)**
   The archaeological remains at the site are thoroughly investigated and mapped by a specialized archaeological diving team and samples are collected for additional research. Then a decision will be made whether the archaeological remains are worth preserving. If the latter is the case, then there are two possibilities: either the remains can be preserved in situ (adjustment of plans) or the next phase will be conducted:

5. **Archaeological excavation**
   The archaeological remains are excavated under supervision of a senior maritime archaeologist. All remains need to be documented, registered and conserved. The requirements of the underwater research are included in a program of requirements which must be approved by the competent authorities.

The phases described before contain a number of decision points that are dependent on the detected archeological objects. The figure on the next page shows these moments schematically.