



A15, B10 Stage 2+ Investigations
WP2 - Geophysical Survey

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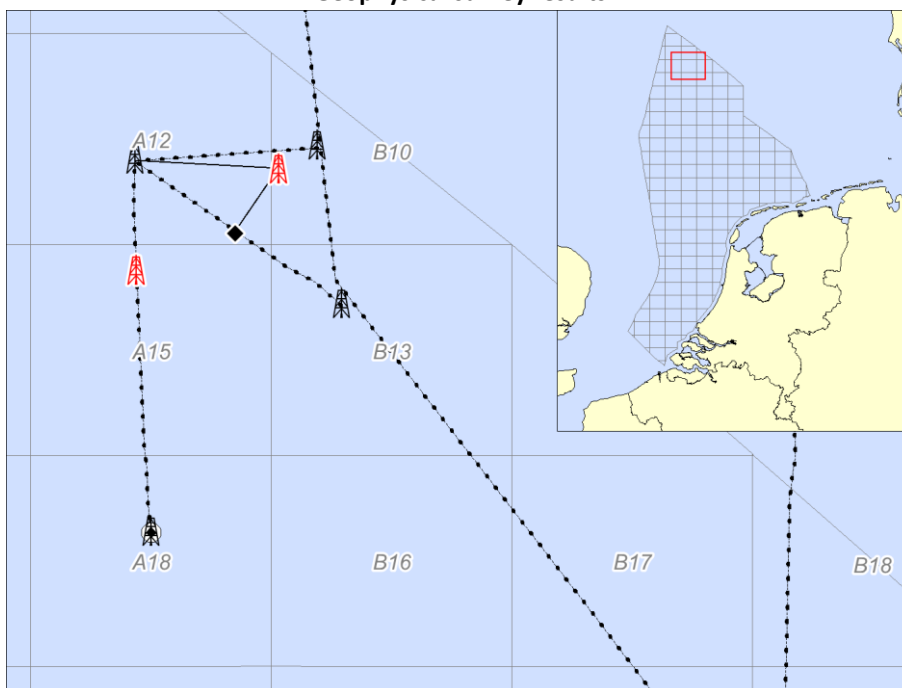
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Field development A15-block, North Sea

An archaeological assessment

Of

Geophysical survey results



Authors

R. van Lil, S. van den Brenk and R.W. Cassée

At the request of



Fugro

P.O. Box 128

2260 AC Leidschendam

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Periplus Archeomare Report 19A024-01

Field development A15-block, North Sea - An archaeological assessment of geophysical survey results

Authors: R. van Lil, S. van den Brenk and R.W. Cassée

At the request of Fugro Survey B.V.

Contact: M. de Bruijn

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Authorization:

B.E.J.M. van Mierlo



Periplus Archeomare

Kraanspoor 14

1033 SE - Amsterdam

Tel: 020-6367891

Email: info@periplus.nl

Website: www.periplus.nl

Client: Fugro Survey B.V.

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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 of the research area

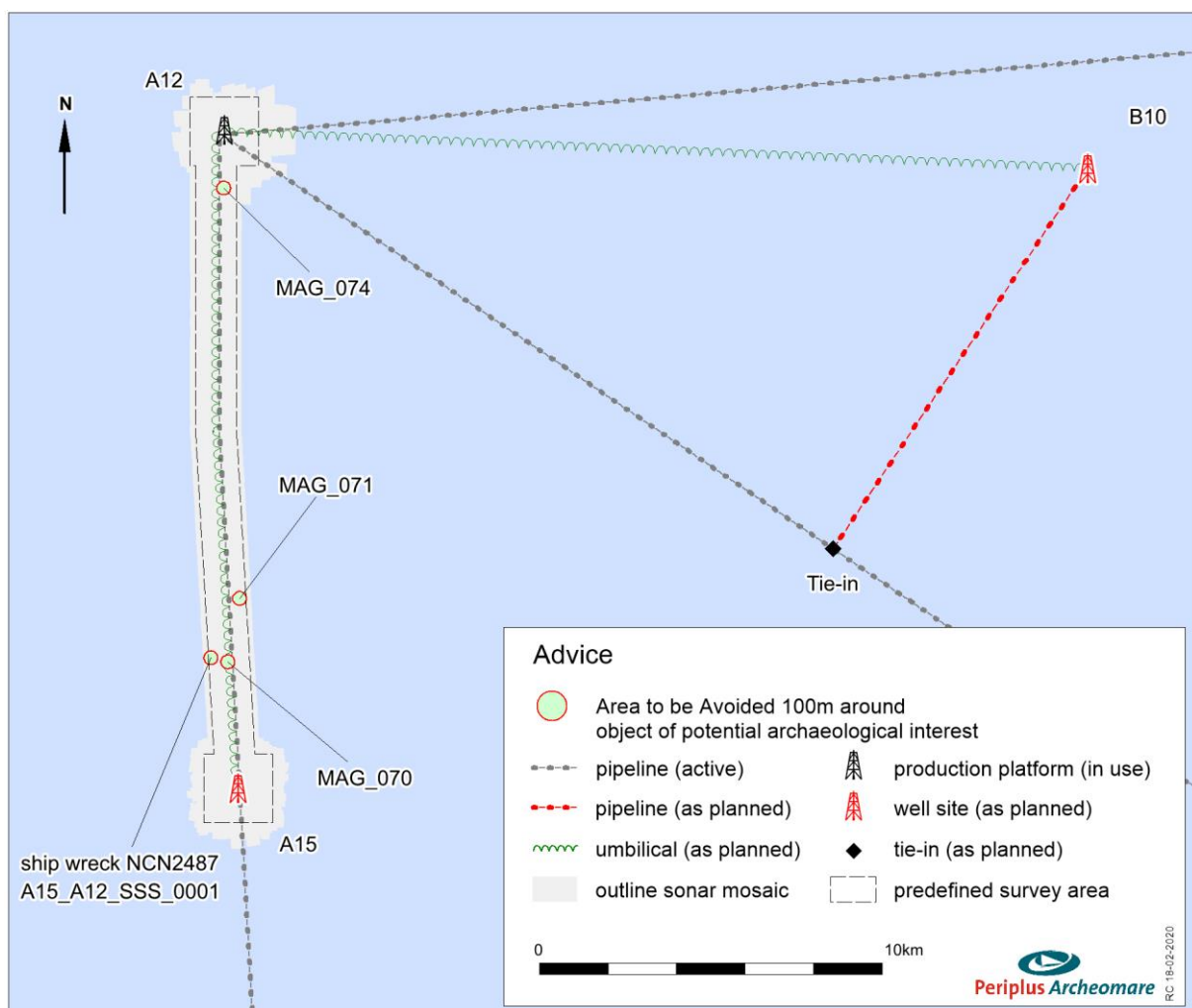
<i>Location:</i>	North Sea		
<i>Toponym:</i>	Field development A15-Block		
<i>Chart:</i>	Hydrografie 1801-1		
<i>Coordinates (ED50 UTM31N)</i>	Location	Easting [m]	Northing [m]
	A15 proposed platform	551600	6130134
	A12-CPP	551404	6139695
<i>Surface Area</i>	10 km ²		
<i>Environment:</i>	Tidal currents, saltwater		
<i>Area use:</i>	Shipping lane, fishing		
<i>Area administrator:</i>	Rijkswaterstaat Zee en Delta		
<i>Enforcing authority:</i>	Rijkswaterstaat Zee en Delta		
<i>Enforcing authority contact:</i>	R. Duijts		
<i>Enforcing authority advisory body:</i>	Rijksdienst voor het Cultureel Erfgoed		
<i>Enforcing authority advisor:</i>	Mrs. M. Snoek, mr. J. Opdebeeck, mr. B.J. Smit		
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<i>Periplus project reference:</i>	19A024-01		
<i>Period of execution:</i>	January - February 2020		
<i>Archive:</i>	Periplus Archeomare BV, Amsterdam		

Samenvatting (Dutch)

Periplus Archeomare heeft in opdracht van Fugro een archeologisch assessment van geofysische data uitgevoerd in verband met de geplande ontwikkeling van een boorlocaties in het A15 blok en de hieraan gerelateerde installatie van een *umbilical* in de zeebodem.

Het onderzoek heeft uitgewezen dat een scheepswrak dat is geregistreerd in de NCN-database (NCN2487) inderdaad is aangetroffen met *side scan sonar* en *multibeam*. Het wrak is mogelijk van archeologische waarde. Naast het gevonden scheepswrak zijn vijf andere *sides scan sonar* contacten gerapporteerd. Geen van deze contacten is van archeologische waarde.

Drie ijzerhoudende objecten in de zeebodem zijn waargenomen aan de hand van de magnetische anomalieën van meer dan 50 nT die zij veroorzaken. Evenals de wraklocatie NCN2487 kunnen deze anomalieën wijzen op de aanwezigheid van objecten van archeologische waarde. Het is belangrijk om te benadrukken dat de aard van de objecten die deze anomalieën veroorzaken niet bekend is. Naast mogelijke archeologische resten kan elk type ijzerhoudend artefact worden aangetroffen inclusief *UXO's*, ankers, stukken van kabels of kettingen, puin, et cetera.



NCN nr	Fugro Target ID	ED50 E (m)	ED50 N (m)	KP (km)	DCC (m)	Interpretatie
2487	A15_A12SSS_0001	551205	6132032	1.921	-260	Scheepswrak
nvt	MAG_070	551452	6131972	2.347	-18	Onbekend begraven object, mogelijk gerelateerd aan scheepswrak
nvt	MAG_071	551621	6132896	3.260	202	Onbekend begraven object
nvt	MAG_074	551391	6138872	9.251	115	Onbekend begraven object

Wij adviseren om geen bodemverstorende werkzaamheden binnen een bufferzone van 100 m rond de vier vindplaatsen met mogelijke archeologische resten. Het aanhouden van een 100 m bufferzone is een beleidsmaatregel ter bescherming van het archeologisch erfgoed. The afstand van 100 m kan mogelijk worden verkleind als kan worden aangetoond dat door de werkzaamheden de archeologische niet worden aangetast. Hierbij dient zowel rekening te worden gehouden met de directe als de indirecte gevolgen van de bodemingreep. Een reductie van de afstand dient te allen tijde te worden beoordeeld en goedgekeurd door Rijkswaterstaat (RWS). Rijkswaterstaat treedt op als bevoegd gezag namens het Ministerie van Economische Zaken. De Rijksdienst voor het Cultureel Erfgoed (RCE) treedt op als adviseur van Rijkswaterstaat.

Als het niet mogelijk blijkt om de wraklocatie (1) en *magnetometer* locaties (3) te mijden, is aanvullend archeologisch onderzoek nodig om de archeologische waarde van de vindplaatsen vast te stellen. Indien dit onderzoek uitwijst dat op de locaties geen resten van archeologische waarde voorkomen kunnen de locaties worden vrijgegeven voor de geplande ontwikkeling.

De opdrachtgever heeft in reactie laten weten dat bij het ontwerp en planning van de werkzaamheden rekening gehouden zal worden met de potentiële locaties, inclusief een bufferzone van 100 meter. Het is dus niet nodig om vervolgonderzoek uit te voeren.

Prehistorie

Op basis van de seismische data kan worden geconcludeerd, dat in het onderzochte gebied de *pleistocene* en vroeg *holocene* landschappen zich op meer dan 10 m onder de zeebodem bevinden. Het is niet bekend of, en zo ja, in hoeverre de prehistorische landschappen en hieraan gerelateerde archeologische resten intact bewaard zijn gebleven.

De installatie van de *umbilical* en het exploratieplatform vormt geen bedreiging voor *in situ* prehistorische resten, omdat de archeologische niveaus ruim onder de maximale verstoringsdiepte liggen. De *conductor* zal door de prehistorische landschappen, en archeologische niveaus hierin besloten, worden geheid. De omvang van de bodemverstoring is echter beperkt. De kans dat prehistorische kampplaatsen worden aangetast door de installatie van de conductor wordt, gegeven de over het algemeen geringe omvang van laat-paleolithische en mesolithische kampplaatsen, klein geacht. Mitigerende maatregelen worden daarom niet nodig geacht. Wel wordt geadviseerd om de informatie die uit eventuele sonderingen en boormonsteranalyses naar voren komt te gebruiken voor het aanpassen en verfijnen van het huidige model van de archeologische potentie van het Noordzeegebied.

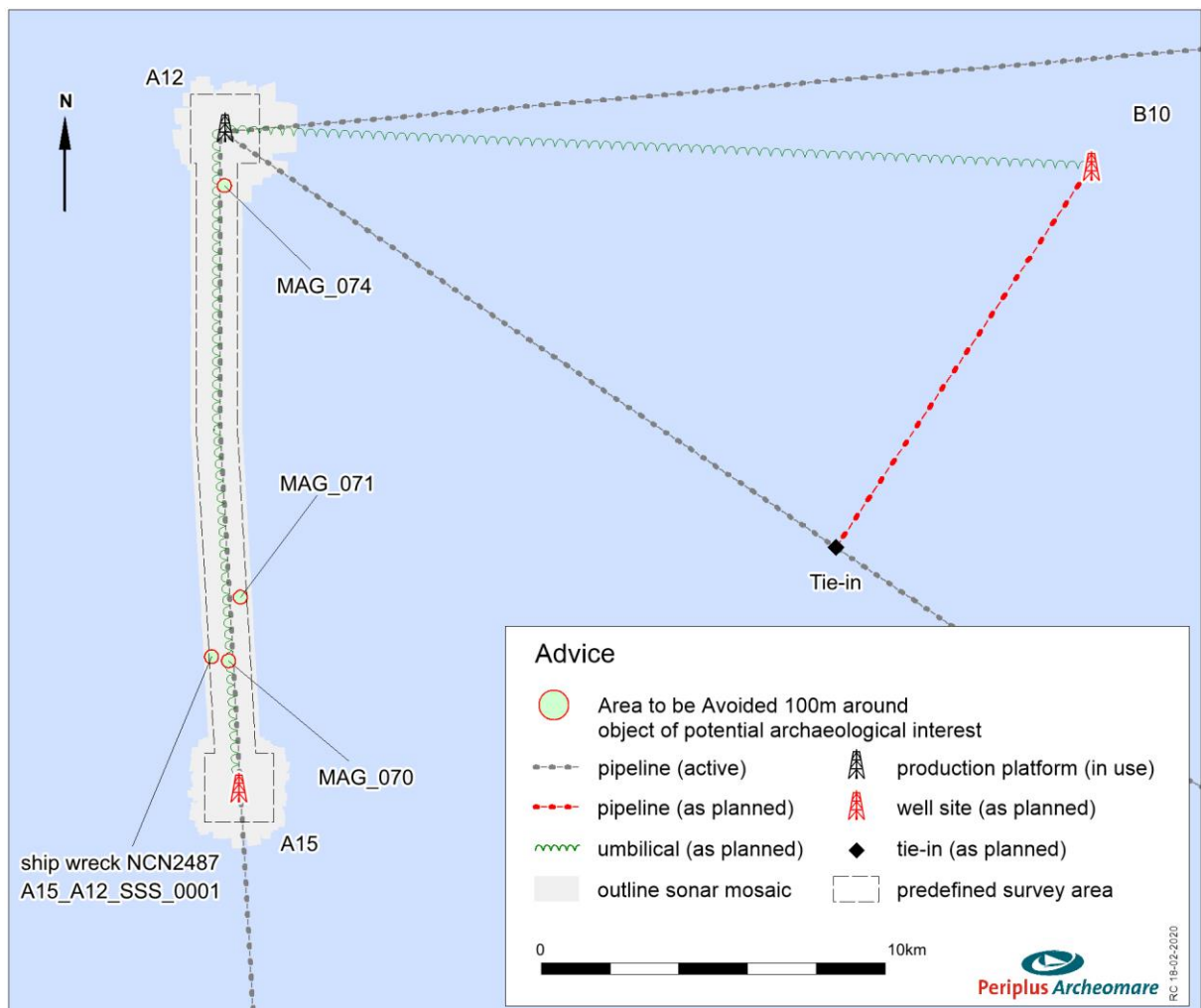
Tot slot kan nooit volledig worden uitgesloten dat tijdens de werkzaamheden archeologische resten aan het licht komen die begraven in de zeebodem lagen tijdens de survey of niet als archeologische resten zijn geïnterpreteerd. In overeenstemming met de Erfgoedwet dienen archeologische vondsten te worden gemeld aan de bevoegde overheid. Het verdient aanbeveling om deze meldingsplicht op te nemen in het bestek (Engels: de *Scope of Work*) voor de werkzaamheden.

Summary

Fugro has contracted Periplus Archeomare B.V. to conduct an archaeological assessment of geophysical route and site survey data. The survey data have been collected in the course of a proposed well site development in the A15 Block and the installation of an umbilical.

The assessment of geophysical survey data has proven that a shipwreck known from database sources (NCN2487) indeed has been found exposed at the seabed with *side scan sonar* and *multibeam*. The wreck is considered to be of potential archaeological value. Apart from the known shipwreck found, five other contacts were reported with *side scan sonar*. None of these contacts is considered to be of archaeological interest.

Further three buried ferrous objects have resulted in peak to peak magnetic anomalies over 50 nT. As wreck site NCN2487 these anomalies could reflect objects of archaeological interest. It should be stressed that the origin of the magnetic anomalies is unknown and apart from possible archaeological remains any type of man-made objects can be encountered including unexploded ammunition, anchors, pieces of chains and cables, debris, etcetera.



NCN nr	Fugro Target ID	ED50 E (m)	ED50 N (m)	KP (km)	DCC (m)	Interpretation
2487	A15_A12SSS_0001	551205	6132032	1.921	-260	Shipwreck
n/a	MAG_070	551452	6131972	2.347	-18	Unknown buried object, possibly related to shipwreck
n/a	MAG_071	551621	6132896	3.260	202	Unknown buried object
n/a	MAG_074	551391	6138872	9.251	115	Unknown buried object

It is advised not to conduct any *trenching* or other seabed disturbing activities within a 100 m buffer zone around the four sites of potential archaeological interest. The buffer zone of 100 meters is a standard that applies to the protection of cultural heritage, this distance may be reduced if it can be substantiated that the applied disturbance has no effect on the archaeological object. For example, when no anchoring is used during cable lay operations the buffer zone can be decreased. Reduction of the distance has to be approved by Rijkswaterstaat (RWS). Rijkswaterstaat is the enforcing authority, acting on behalf of the Ministry of Economic Affairs. The Cultural Heritage Agency of the Netherlands (RCE) acts as an advisor to Rijkswaterstaat.

If it is not feasible to avoid the reported wreck site (1) and *magnetometer* locations (3), additional research is required in order to determine the actual archaeological value of the reported locations. If this indicates that the object has no archaeological value, the location can be omitted.

The client stated in response that the potential locations, including a buffer zone of 100 meters, will be taken into account in the design and planning of the work. It is therefore not necessary to conduct follow-up research.

Prehistory

Based on the interpreted seismic data it can be concluded that the *Pleistocene* and Early *Holocene* landscapes are located at more than 10 m below the seabed throughout the research area. It is not known if those landscapes and possible archaeological remains contained herein have been preserved intact.

The installation of the umbilical and jack-up rig are not expected to affect *in situ* prehistoric remains, because the archaeological levels are located below the maximum depth of disturbance. The installation of the conductor will penetrate the prehistoric landscapes and potential *in situ* archaeological remains contained herein. However, the seabed disturbance is confined to a small area and the change that remains of prehistoric camp sites are affected by the installation of the conductor is, considering the generally small size of Late Palaeolithic and Mesolithic camp sites, small. Mitigating measures are therefore not considered necessary. It is advised to utilize the obtained data and information from the onsite borehole sample analysis for adjusting and fine-tuning the current expectancy model for the North Sea area.

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 2016 (Dutch: Erfgoedwet), it is required to report those findings to the competent authority. This notification must also be included in the scope of work.

1 Introduction

Fugro has contracted Periplus Archeomare B.V. to conduct an archaeological assessment of geophysical route and site survey data. The survey data have been collected in the course of a proposed well site development in the A15 Block and the installation of an umbilical.

The area of investigation includes:

Well site location A15 (Proposed)	1 sqkm site survey
Platform location A12-CCP (Active)	1 sqkm site survey
A15-New to A12-CCP Umbilical Route (Proposed)	600 m corridor route survey

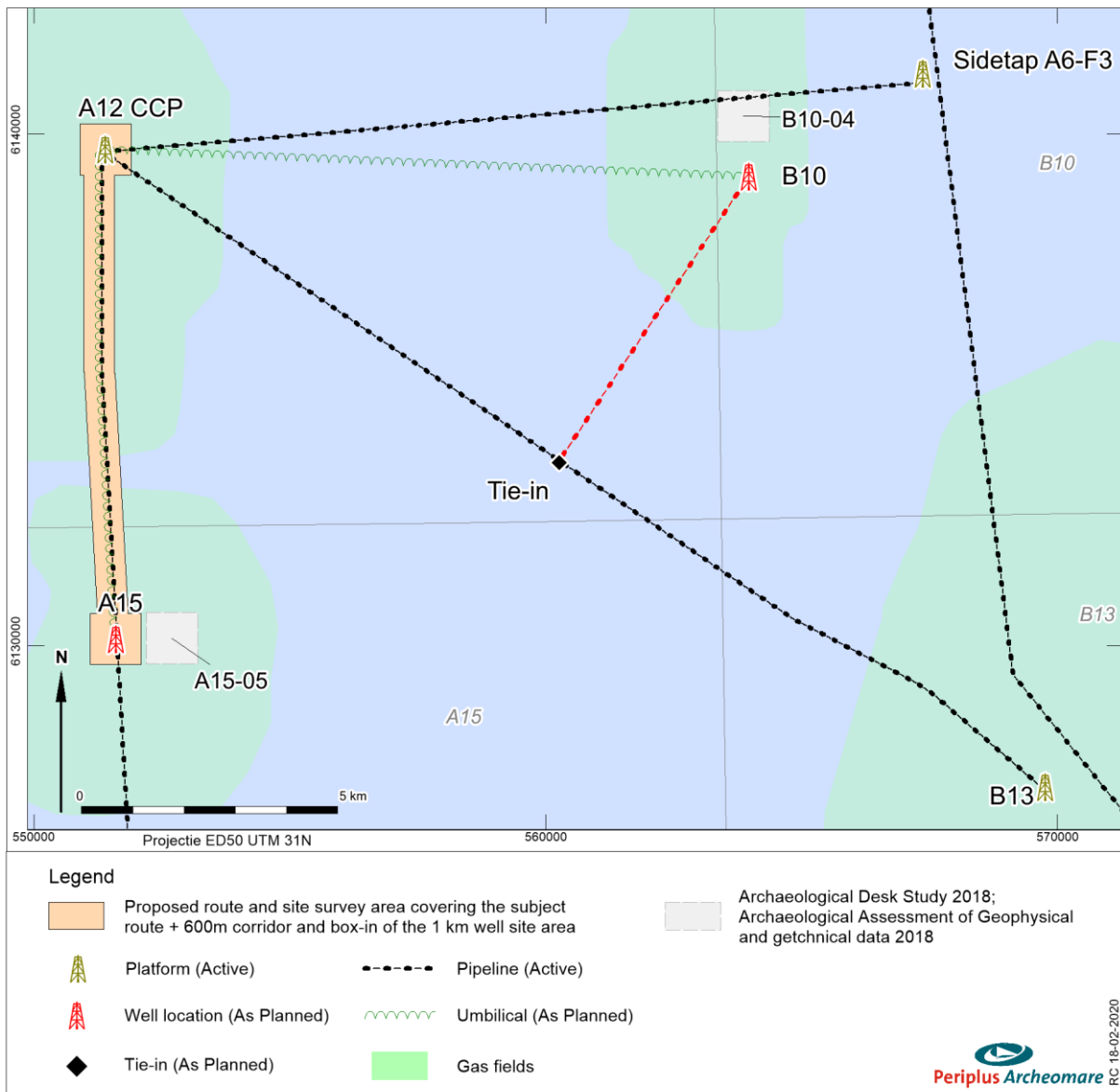


Figure 1. Location map of the research area

1.1 Background

Petrogas Netherlands B.V. intends to develop new fields in in the A- and B-blocks in the northern part of the Dutch North Sea. In the course of this development Petrogas plans to drill an appraisal well at the location A15. The future A15 facility will be remotely controlled from the Central Processing Platform A12-CPP. In order to do so a control umbilical is planned to be installed.

The protection of the archaeological and historical heritage is anchored in the Dutch Heritage Act (July 2016).¹ The installation of platforms, wells 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 area.

The so-called *AMZ* cycle (Dutch: Archeologische Monumenten Zorg cyclus) consists of a series of procedures for the subsequent phases of archaeological research to be performed in order to ensure the protection of archaeological heritage in the Netherlands. The separate phases of the *AMZ*-cycle are embedded in the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1). This standard dictates a mandatory workflow for archaeologists. A detailed description of the different phases of archaeological research is included in appendix 2.

The first step in the *AMZ*-cycle is an archaeological desk study. In 2018 two desk studies have been performed.^{2,3} The first study covers a wide area of the A- and B-blocks; the second study zooms in at the then planned appraisal well sites A15-05 and B10-04 (refer to figure 1).

The second phase of the *AMZ* cycle is an inventory archaeological field study. As a rule, this field study comprises a geophysical survey of the seabed. In accordance with the Dutch Quality Standard for Archaeological Research (Dutch: Kwaliteitsnorm Nederlandse Archeologie; KNA 4.1-waterbodems) an archaeological Program of Requirements was written for the inventory archaeological field study. Along with the technical Scope of Work, the preconditions and deliverables described in the archaeological Program of Requirements were used as an input for the geophysical survey executed by Fugro. The survey data acquired prove therefore to be fit for and archaeological assessment.

Between 06 to 26 November 2019 Fugro conducted route and site surveys to gather sufficient information for drilling, platform and sealine engineering and installation.⁴

During this period a survey was also carried out for the proposed well site location B10, the proposed umbilical route from A12-CPP to the B10 site and the proposed pipeline from B10 to the Tie-in B13-A pipeline Route. The results of the archaeological assessment carried out for this proposed site and umbilical route are summarized in a separate report: 19A024-01. The survey results of the overlapping A12-CPP location are included in both reports.

¹ Dutch: Erfgoedwet.

² Van Lil 2018; report 18A021-01.

³ Van Lil 2018; report 18A021-02.

⁴ Fugro Reports 2019: P906247_GEOP_REP_B10 01 (Draft) and P906247_GEOP_REP_A15 01 (Draft).

1.2 Results desk study

The archaeological desk studies performed in August 2018 and September 2018 has resulted in specific information on the archaeological remains which are to be expected in the area. The desk study has shown that within the research areas ship and aircraft wrecks and, if the *Pleistocene* landscape is intact, in situ prehistoric remains can be expected.

Shipwrecks

Within the currently surveyed route from B10 Proposed Location to A12-CPP one ship wreck site is known (refer to figure 2). This ship wreck is registered in the NCN-database (refer for details to table 3). The wreck position is accurate within 5m. The archaeological value of the wreck has not been appraised yet.

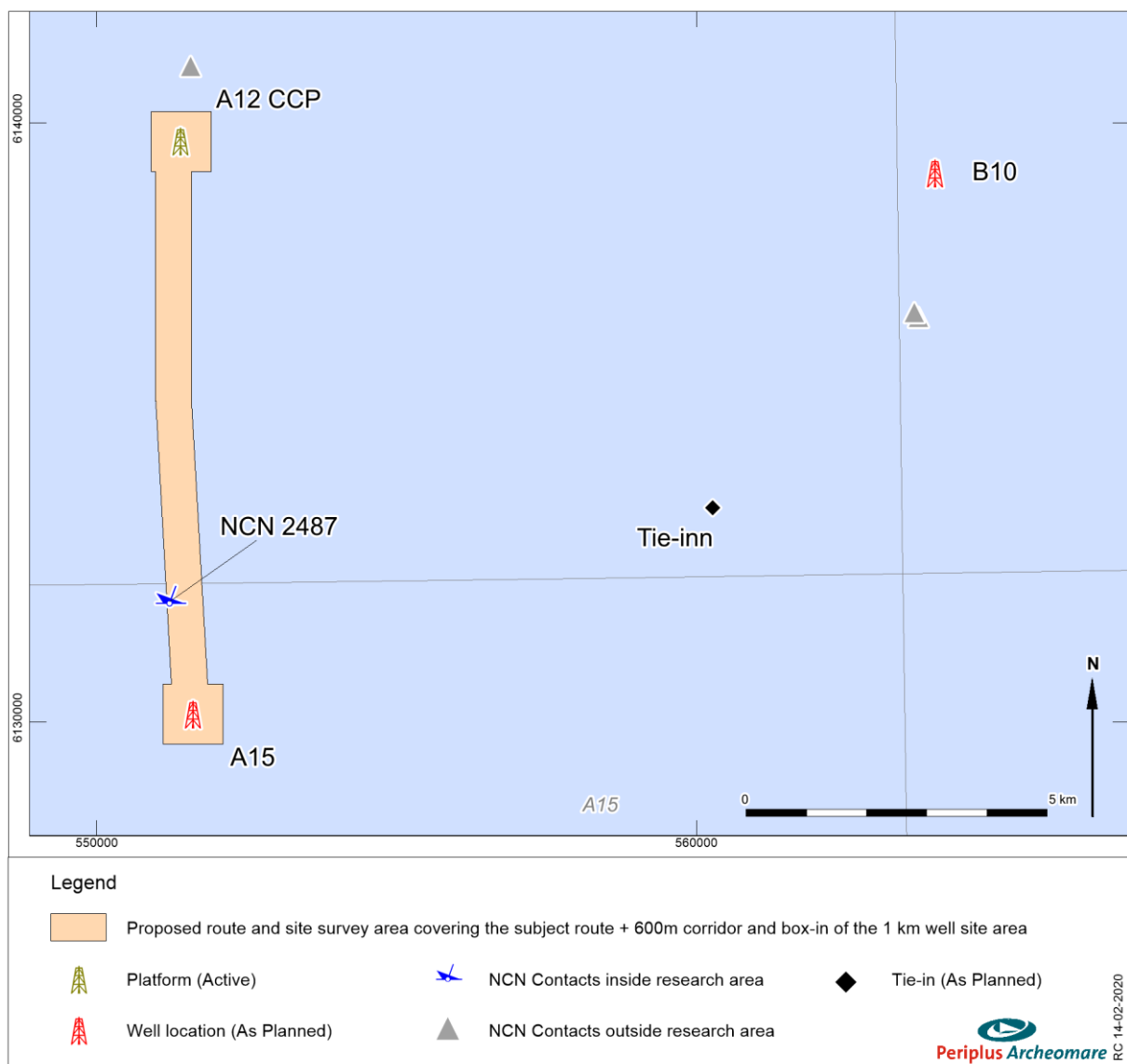


Figure 2. Overview of known objects and contacts in the research area

NCN	SR92	Nlhono	UTM31N ETRS89		UTM31N ED50		R95 (m)	Description
			Easting	Northing	Easting	Northing		
2487	-	2891	551120	6131801	551212	6132013	5	Unknown wreck in 2 parts, surveyed 12-06-1999, researched by duikeam Zeester in 2014, but no additional information available

Table 3. Details on the known wreck (NCN2487) within the research area

Plane wrecks

During World War II, many airplanes crashed into the North Sea. Sources are ambiguous about the number of aircraft still missing, but estimates indicate that it concerns at least hundreds.⁵ Remains are found on a regular base by fishermen or during sand extraction.

Prehistory

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.

Archaeological levels are formed by the top of the Dogger Bank Member and the entire sequence of the overlying Boxtel Formation. 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.

The research area is located on a plateau, which in Early *Holocene* times bordered a large lake. Those transitions in the landscape attracted hunter-gatherers, because of the possibility the landscape offered to install camp sites at high grounds overlooking hunting grounds, the presence of nearby fresh water from the lake, the animals living in and foraging at the lake-site and variety in plant species available. Therefore, the position of the research areas aid to archaeological expectation for prehistoric remains.

The expected remains include Late Palaeolithic and Mesolithic camp sites, burials, lost or dumped objects such as flint and bone artefacts, hunting gear and canoes. Prehistoric camp sites in the context of sandy deposits of the Boxtel Formation are characterized 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. The 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.

To date it is unknown if the catastrophic tsunami event which occurred around 6250 BC has eroded the Dogger Bank Member and the Boxtel Formation 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.

⁵ Nederlandse Federatie voor Luchtvaart Archeologie, NFLA.

The likelihood 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 umbilical.

1.3 Objective

The purpose of the archaeological assessment is to test the desk study-based expectancy for archaeological remains in the area. Included in this likelihood are remains of shipping related objects (shipwrecks), aircraft from World War II and prehistoric remnants related to the drowned *Pleistocene* landscape.

The goals set for this assessment are:

- To determine the historical or archaeological value of contacts found in the geophysical survey;
- To validate the locations of known wrecks;
- To assess the prehistoric landscape based on the seismic data.

1.4 Research questions

For the inventory archaeological field study, the following research questions have been defined in the program of Requirements:⁶

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 and to prioritize importance?

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?

⁶ Van Lil, 2018.

General:

What is the relation between the observed objects and the topography of the seabed? Based on this relationship can risk-prone areas be marked selectively?⁷

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- and sampling:

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 effected by the installation of the cables 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 and 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?

⁷ Risk-prone areas are areas where the probability of archaeological remains is considered to be high. The risk involves both the degradation of archaeological remains by the installation of the pipeline as the risks in terms of costs, progress and image of the wind energy project itself because of the presence of archaeological remains and the measures to be taken accordingly.

2 Methodology

2.1 Introduction

As part of the planned activities, umbilical route surveys and platform box-in surveys have been carried out by Fugro.

Objective

The objective of the survey was to gather sufficient information for drilling, platform and pipeline engineering and installation in terms of:⁸

1. Meteorological and oceanographical Data
2. Geophysical & Geotechnical Surveys:
 - a. Seabed topography
 - b. Seabed and sub-seabed obstructions
 - c. Seabed profile and sub-seabed layers
 - d. Horizontal and vertical position of existing pipelines/cables crossing the pipeline route
 - e. Seabed soil conditions
 - f. Identify soils and foundation conditions at the proposed jack-up sites.
 - g. Shallow gas prognosis
1. Environmental sampling
2. Archaeological survey
3. Debris surveys
4. Vessel Marine Assurance
5. Documentation

The survey shall provide the data in the selected corridor of the route required to design the proposed umbilical and platform so that it can be safely installed. In addition, the survey shall provide the data required to safely drill the well from a drill rig.

Survey equipment and operations

The survey was conducted by the MV Fugro Pioneer during the period 6 to 26 November 2019, using *multibeam* echo sounder (MBES), *side scan sonar* (SSS), *magnetometer* (MAG), sub-bottom profiles (SBP) and multichannel 2D-UHR seismic equipment.

- Bathymetry was acquired using a *multibeam* echo sounder at a frequency of 400 kHz with 400 beams;
- *Side scan sonar* data was acquired at frequencies of 100/600 kHz and a range of 75/100 m per channel;
- Sub-bottom profiler data was acquired for shallow seabed detail, operated at 8 kHz with a recording length of 55 ms, and with delay of 15 m / 20 m / 22 m;
- The *magnetometer* survey was performed at 10 Hz sampling frequency, by piggybacking the sensor to the *side scan sonar*. The maximum altitude of the sensor did not exceed 6 m from the seafloor, except the areas where client confession was given;

⁸ Drost 2019; Scope of Work Geophysical & Geotechnical Surveys Stage 2+ Project – A15 & B10.

- Multi-channel seismic was acquired using an Ultra Hi-Res 48 channels streamer with 24 channels of 1 m group spacing and 24 channels of 2 m group spacing combined with a two stacked 400 tips LW sparkers source to achieve a penetration of approximately 65 m;

Survey lines – proposed routes

A total of 22 survey lines were run along the proposed umbilical route, main lines with MBES, SSS, SBP, MAG, and crosslines with MBES and SBP.

Proposed Routes	Survey Lines		
	main	cross	total
A15 to A12-CPP umbilical	10	12	22
Survey corridor 600m			

Table 4. Survey lines along the proposed routes

The inner two wing lines were sailed at a distance of 50 meter from the centre line; the outer six wing lines (three on both sides) were sailed at a distance of 75 meter.

Survey lines – proposed platform locations

A total of 30 survey lines were run at the proposed platform location A15, using MBES, SSS, SBP, MAG and multichannel 2D-UHR.

Proposed Platform Location	Survey Lines		
	main	cross	total
A15	15	15	30
Survey area 1.0 x 1.0 km			

Table 5. Survey lines at the proposed platform locations

The centre lines (1 main line + 1 cross line) and adjacent wing lines (8 main lines + 8 cross lines) were sailed with a spacing of 50 m.

The outer wing lines (6 main lines + 6 cross lines) were sailed with a spacing of 100 m.

The results of the survey and geotechnical activities have been recorded in reports, listings, drawings and images.^{9, 10}

⁹ P906247_GEOP_REP_A15 01 | Geophysical Results Report, A15.

¹⁰ P906247_GEOP_REP_B10 01 | Geophysical Results Report, B10.

2.2 Known objects

Fugro has summarized the *side scan sonar* contacts and *magnetometer* anomalies encountered within the survey area in detailed event listings. From different databases the occurrence of objects within the area is known. The contacts included in the survey event listings are compared with the database objects in the area. For this comparison four different datasets are used:

- The Hydrographic Service database (hereafter referred to as NLhono database);
- The Rijkswaterstaat SonarReg database (hereafter referred to as SR database);
- The Dutch Cultural Heritage Agency database ARCHIS;
- The Dutch Nationaal Contact Nummer database (hereafter referred to as NCN);

The National Contact Number (NCN)

The NCN database combines the data from three governmental databases:

- The Dutch Continental Shelf and Westerschelde wrecks register from the Hydrographic Service of the Royal Netherlands Navy;
- The SonarReg object database of Rijkswaterstaat;
- The ARCHIS database (the official archaeological database of the Ministry of Cultural Heritage)

The permission for the use of the NCN database for the analysis was granted by the owner (Rijkswaterstaat Sea and Delta)

The NCN database contains all basic information (E, N and description) of the NLhono, SR and Archis databases. More detailed information is gathered through the other datasets.

All known data is combined and plotted in a GIS. In this way an overview is made of the areas in which archaeological remains are present or to be expected. The known contacts are a reference framework for the assessment of data recorded during the route survey.

2.3 Archaeological assessment of survey data

The geophysical and hydrographic survey techniques employed include *side scan sonar* (SSS), *magnetometer* (MAG), *multibeam* (MBES) and *subbottom profiling* (SBP). With *side scan sonar* all objects and structures larger than 0.3 meter in any dimension on the seabed can be made visible. Seabed sediments of different composition can be distinguished by their characteristic reflection and were validated by core samples. *Multibeam* images reveal the morphology of the seabed. Large objects and scouring can be mapped. Smaller objects, like thin cables, or flat objects lying on the seabed often are impossible to identify in *multibeam* images.

Magnetometer contacts are identified by the presence of ferro-metallic objects which induce an anomaly in the earth magnetic field. These objects comprise both buried objects and objects which lie on the seabed. Unlike *side scan sonar* and *multibeam* the contacts are tagged at the sailed survey line. The actual

object can be located at both sides of the survey line. Given the 50/75/100 meter spacing of the run lines the accuracy perpendicular to the line is in the order of 25/37.5/50 meter.

Fugro processed their survey data and produced detailed event listings of the *side scan sonar* contacts and magnetic anomalies encountered within the survey areas. Both the location of the known objects as well as the locations of the contacts are plotted in a GIS.

In the course of this archaeological assessment a selection is made based on the dimensions of the reported contacts. All contacts have been assessed, and the fraction of contacts larger than or equal to four meter is analysed in more detail, because these objects are considered to be more likely to be related to wreck sites than the smaller contacts. This approach is based on best professional judgment and not prescribed by legislation or the KNA. Purpose of this analysis is to identify contacts that could reflect potential archaeological sites.

This is done by analyses of:

- *Side scan sonar* images included in the survey reports;
- *Side scan sonar* geotiffs (0.15m resolution);
- *Multibeam* geotiffs (0.30m resolution);
- Values of magnetic anomalies reported in the survey reports;
- Comparison of *side scan sonar* and *magnetometer* contacts;

Apart from the survey data studied the geological constellation and seabed morphology of the area are taken into account as outcrops of geological strata and sedimentary structures can lead to (apparent) anomalies in the *side scan sonar* record.

The *side scan sonar* images are scanned in order to define potential archaeological sites. A selection of contacts was made of contacts to be studied in detail. The interpretation and selection of *side scan sonar* contacts is based on best professional judgment. If desired or needed the exact nature of the contacts observed can be established with certainty through the execution of additional research by means of a ROV or divers in a following phase.

Fugro has acquired and processed shallow seismic data using a sub-bottom profiler (SBP). The processing involved an analysis of a seismic profile along the centre line of the proposed umbilical route. Observed seismic reflectors have been digitized and - based on known geological data from the area - lithostratigraphic units have been identified. The results have been summarized in a survey report including two site maps for the proposed A15 platform location and the existing A12-CPP platform site and three overlapping alignment charts for the proposed umbilical route from A15 to A12-CPP. In addition to the identification and occurrence of lithostratigraphic units, seismic anomalies - which are expected to reflect existing pipelines and potential hazardous phenomena - have been identified.

2.4 Data Analysis

The first step in the data analysis is to cross-reference known objects within the surveyed area with the survey data. For the comparison the results of the desk study and the survey datasets were used. All the known objects were projected in a GIS together with the survey data.

For the cross-reference we have assumed that all present possible contacts and anomalies have been reported and described by the survey contractor. The raw data is only used, if available, to verify the description of found objects and anomalies as reported.

The positions of the interpreted contacts from the different surveys were compared with the positions of the known objects collected from the databases. Besides that, all the positions of both the survey contacts and the known objects were plotted on the high resolution *multibeam* grid to visualize the morphological influence of the presence of these objects. This assisted in the determination of possible archaeological value of the present remains. If an object had a potential archaeological value, the description of the object was finalized.

Besides the objects detected from the side scan sonar survey also the magnetometer contacts were plotted on the high resolution multibeam grid. Magnetometer contacts which were found within 25 meters of a side scan sonar contact were considered to be potentially related to this sonar contact. The correlation between the magnetic anomaly and side scan sonar contact was then assessed. When at the position of the magnetometer anomaly no visible object was recognized the size of the anomaly was leading.

If the magnetic anomaly of a contact is more than 50 nT (nano-Tesla) the contact is considered to be of potential archaeological interest. All the magnetometer contacts above 50 nT but within 25 meters of the existing cable and pipeline routes are exempt for further investigation. It has to be stressed that within this assessment no distinction can be made between anomalies related to possible archaeological objects or anomalies related to (for example) unexploded ordinance (UXO's).

An archaeological assessment has been undertaken for all visible contacts. This interpretation is based on best 'professional judgment'.

The interpreted seismic data have been assessed in order to test the archaeological expectation with respect to remains of prehistoric settlements in the area. The archaeological desk study has resulted in the identification of lithostratigraphic units which could contain archaeological levels. The seismic profile produced by Fugro has been used to get an insight both the lateral and vertical distribution of the lithostratigraphic units and the expected archaeological levels herein. Thus, testing the desk study based archaeological expectation. An important factor included in the assessment is the integrity of layer boundaries, because erosion by natural processes poses a significant threat to archaeological levels. Based on the assessment sections of the proposed umbilical route which are expected to contain archaeological remains are mapped and results are put in the context of the activities planned in order to predict of the activities might damage potential archaeological remains.

The analysis was executed in January 2020 by R. van Lil, S. van den Brenk (both KNA senior prospector) and R.W. Cassée (KNA maritime archaeologists in training). The investigation is carried out according to specifications set up within the Dutch Quality Standard for Archaeology (*KNA Waterbodems 4.1; protocol 4103*).

2.5 Used Sources

The following sources were used for the analysis:

- Survey data Fugro, original survey data and reported interpretations;
- Archaeological desk study Periplus Archeomare (18A021-01);
- Archaeological desk study Periplus Archeomare (18A021-02);
- ARCHIS database Cultural Heritage Agency;
- Archeomare Database;
- NLhono database Hydrographic Service of the Royal Netherlands Navy;
- Wrecksite.eu;
- Database, Nationaal Contact Nummer (NCN, Rijkswaterstaat Zee en Delta).

For a complete list of used sources and literature see the reference list at page 43.

Italic written words are explained in the glossary at page 42.

3 Results

3.1 Seabed bathymetry and morphology

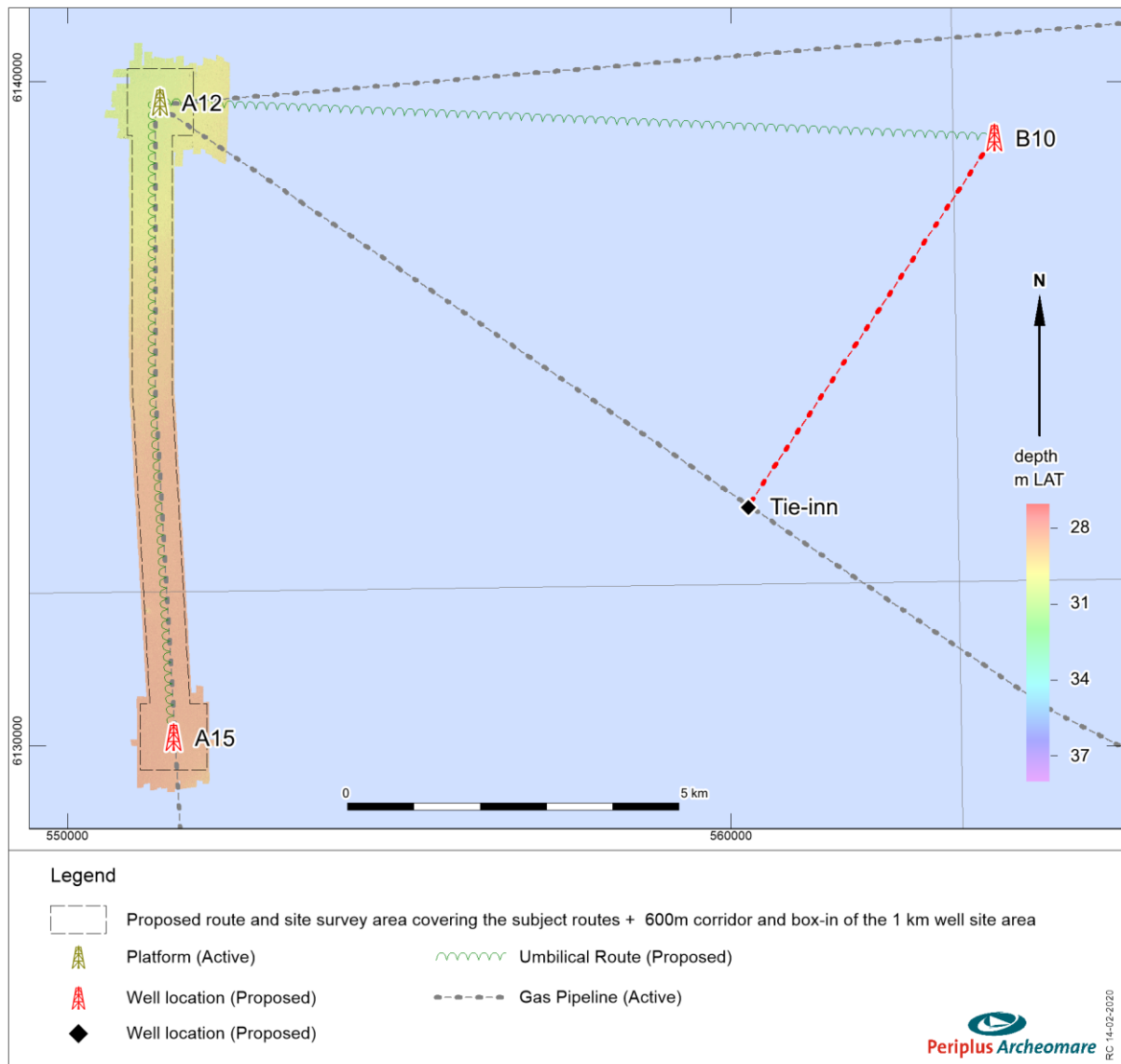


Figure 3. Bathymetry based on the multibeam recordings (source data: Fugro 2019)

The water depth in the survey area varies from 28.0 m in the area of the proposed A15 well site to 31.3 mLAT northwest of the A12-platform location.

Seabed

The seabed lacks visible sedimentary structures and is characterized by a very even surface. However, this even surface shows wide-spread scarring caused by the nets of fishing trawlers. The *multibeam* images do not show any signs of exposures of the existing pipelines. The rock berms which have been installed on these pipelines in the vicinity of the A12-CPP platform are clearly visible. Scouring around the platform is limited.

3.2 Known objects: As Found positions versus database positions

From database sources one object is known in the survey area (refer to section 1.3). The object comprises an unknown shipwreck.

The SSS contacts and MAG anomalies encountered during this survey have been stored in event listings. The positions of the contacts and anomalies in these listings are compared with the theoretical positions of objects in the NCN database. In order to conduct this comparison all SSS contacts and MAG anomalies found within a range of 50 meters around the database locations are selected.

The outcome of this comparison can be:

- The As Found position of a shipwreck is in agreement with the database position of a known wreck;
- The As Found position of a contact is in agreement with the position of a contact listed in the database, but the interpretations do not match;
- The As Found position of a shipwreck is not in agreement with the database position of a known wreck;
- A wreck listed in the database has not been found;
- A new wreck has been found.

An overview of the As Found- versus Not Found known objects is presented in the next figure.

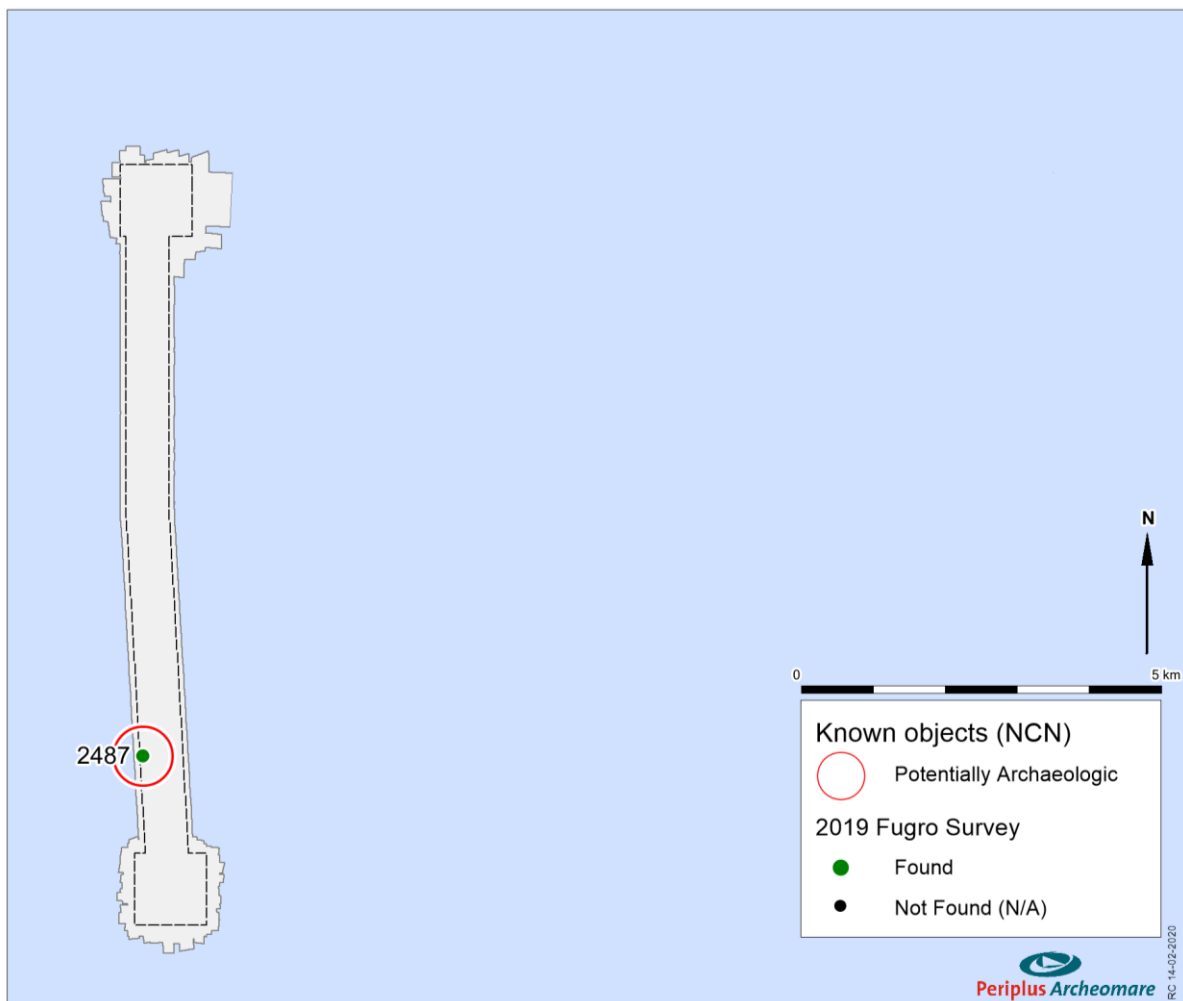


Figure 4. Known objects found or not found during the survey

NCN found

The ship wreck which registered as NCN contact 2487 has been found with *side scan sonar, multibeam, magnetometer and subbottom profiler.*

Database data			Fugro Survey November 2019				
NCN	ED50 E (m)	ED50 N (m)	Target ID	ED50 E (m)	ED50 N (m)	KP (km)	DCC (m)
2487	551212	6132013	A15_A12 SSS_0001	551205	6132032	1.921	-260
Description Unknown wreck in 2 parts surveyed 12-06-1999 researched by duikteam Zeester in 2014			Comments / Dimensions (L x W x H) Shipwreck, 45.3 x 11.1 x 3.2				

Table 6. Known object found during the survey

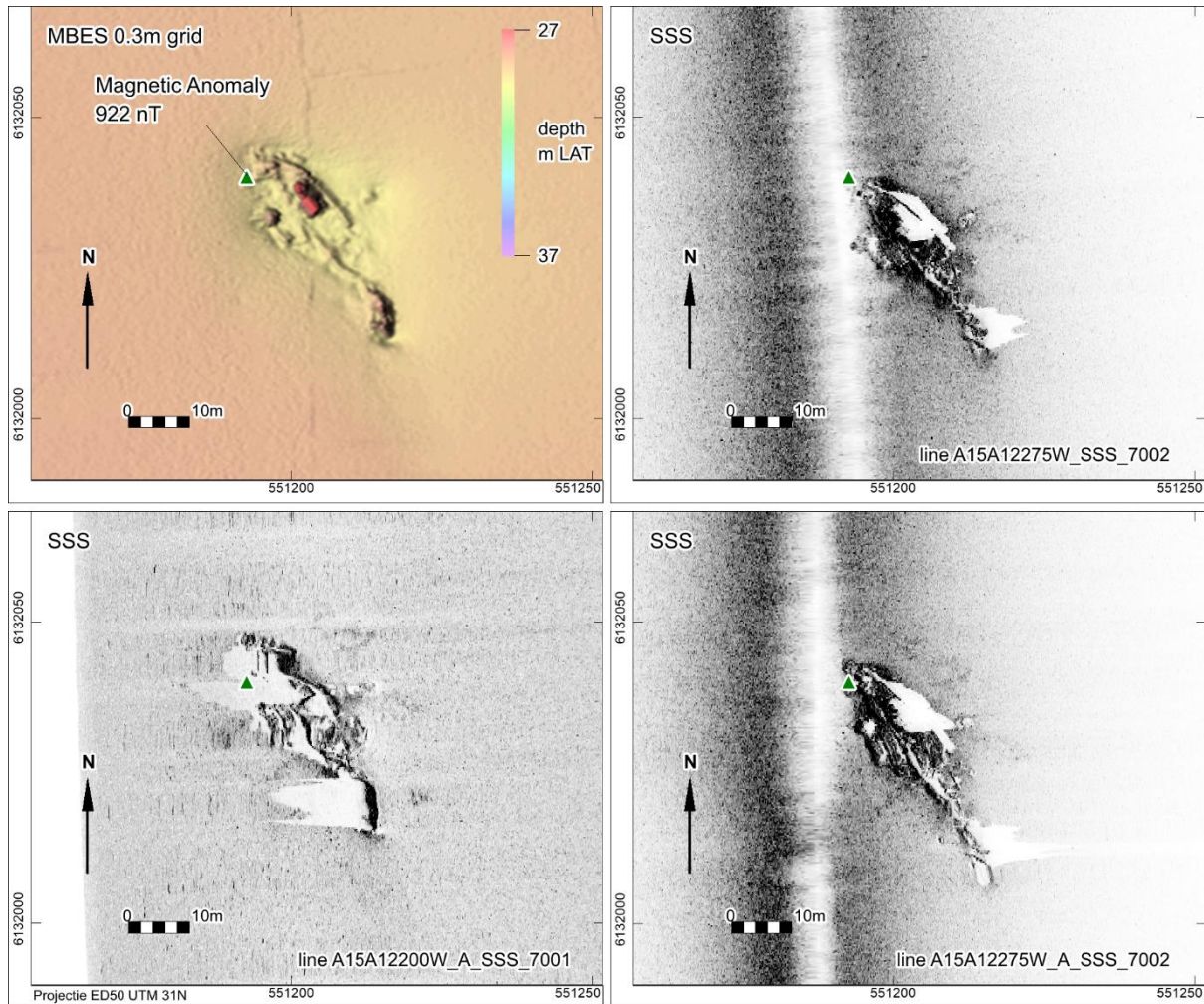


Figure 5. Multibeam and side scan sonar images of the NCN 2487 wreck (data: Fugro survey 2019; Target ID A15_A12_SSS_0001)

The ship wreck found (NCN 2487; Fugro target ID A15_A12_SSS_0001) is considered to be of potential archaeological value. The database position of the NCN contact is located 20 m south-southeast of the current As Found position but still plotting at the edge of the wreck. The measured length of the wreck in the *multibeam* data is 38.5 m; slightly less than the 45.3 m measured in the side scan sonar data. The length measurement of the *multibeam* data is considered to be more reliable. The high resolution side scan sonar image reveals details of the wreck the *multibeam* data do not and vice versa (refer to figure 5). A 922 nT magnetic anomaly has been observed at the northwestern side of the wreck. Both on the *multibeam* image and the side scan sonar image a dome-shaped elevated part of the wreck visible some 10 m east - southeast of the magnetic anomaly. The approximate dimensions of this elevated part are: L = 5.5m; W = 2.5m; H = 2.5m. Based on the shape of this elevated part is interpreted as the kettle of a steam ship. Not so clearly visible on the *multibeam* image but indicated by large shadows in the side scan sonar images are parts of the wreck that rise up from the seabed to a height of up to 3.5 m. These parts are found at the south-eastern side of the wreck.

NCN with an archaeological expectation – not found

The only NCN contact known in the survey area is NCN contact 2487, the ship wreck which has been found during this survey.

3.3 Side scan sonar

Fugro has identified 6 *side scan sonar* contacts within survey area. The classification of the contacts is listed below.

Fugro Classification	Total
Debris	5
Shipwreck	1
Total	6

Table 7. Side scan sonar contacts survey area

The contact which matches the known shipwreck (A15_A12_SSS_0001) has been discussed in the previous section. The other 6 *side scan sonar* contact and images have been scanned and checked for the presence of potential archaeological contacts. This is done by analyses of:

- *Side scan sonar* images as delivered;
- 0.3m *multibeam* grid data (xyz-file);
- Comparison of *side scan sonar* and *magnetometer* contacts.

Apart from the survey data studied the geological constellation and seabed morphology of the area are taken into account as outcrops of geological strata and sedimentary structures can lead to (apparent) anomalies in the *side scan sonar* record.

A summary of the outcome of the detailed inspection of selected contacts is presented in table 8. Three contacts, A15_A12_SSS_0003/0004 and 0005, have a similar appearance on the both the side scan sonar and *multibeam* images. The spherical contacts are all located north of the A12-CPP platform have been interpreted as debris related to the drilling activities in the area. This also applies to the triangular contact A15_A12_SSS_0002 with a spherical elevated structure in its centre to the west of the platform.

Sonar contact A15_A12_SSS_0002 is interpreted as unknown debris, presumably related activities in the past. These activities include the installation of the A18-ALT1 to A12-CPP gas pipeline and the associated rock berm, and the drilling of borehole A12-01 (refer to figure 7).

Two magnetic anomalies found 10 m south and 14 m east of sonar contact possibly are induced by expected debris at the location of the sonar contact. The two magnetic anomaly values are alike: 632 nT (south) and 633 nT (east). Because of the size of the magnetic anomalies (over 600 nT), the distance of the anomalies to the rock dumped pipeline (32 m and 44 m), and the size and location of the magnetic anomalies found in relation to this pipeline, it is considered less likely that these anomalies are related to the A18-ALT1 to A12-CPP gas pipeline.

Target ID	Easting	Northing	Length	Width	Height	Description	Classification
A15_A12_SSS_0002	551280	6139687	3.8	1.1	0.5	Triangular contact with spherical elevated part in centre	Debris
A15_A12_SSS_0003	551179	6139928	2.2	1.2	0.0	Spherical medium reflective contact; no shadow; elevated contact on MBES	Debris
A15_A12_SSS_0004	551114	6140098	1.9	0.8	0.1	Spherical medium reflective contact; small shadow; elevated contact on MBES	Debris
A15_A12_SSS_0005	551355	6140064	1.8	0.8	0.1	Spherical medium reflective contact; small shadow; slightly elevated contact on MBES	Debris
B10_A12_SSS_0001	551379	6140049	1.4	0.8	0.2	Elongated contact; no shadow; not visible on MBES	Unknown*

Table 8. Summary of the archaeological assessment of the side scan sonar records

* Interpreted by Fugro as possible clump weight for wave buoy.

The survey results of the A12-CPP site are contained both in this report as in the B10 report (19A024-02). An overview of the number of *side scan sonar* contacts assessed and contained in both reports is shown in Appendix 4.

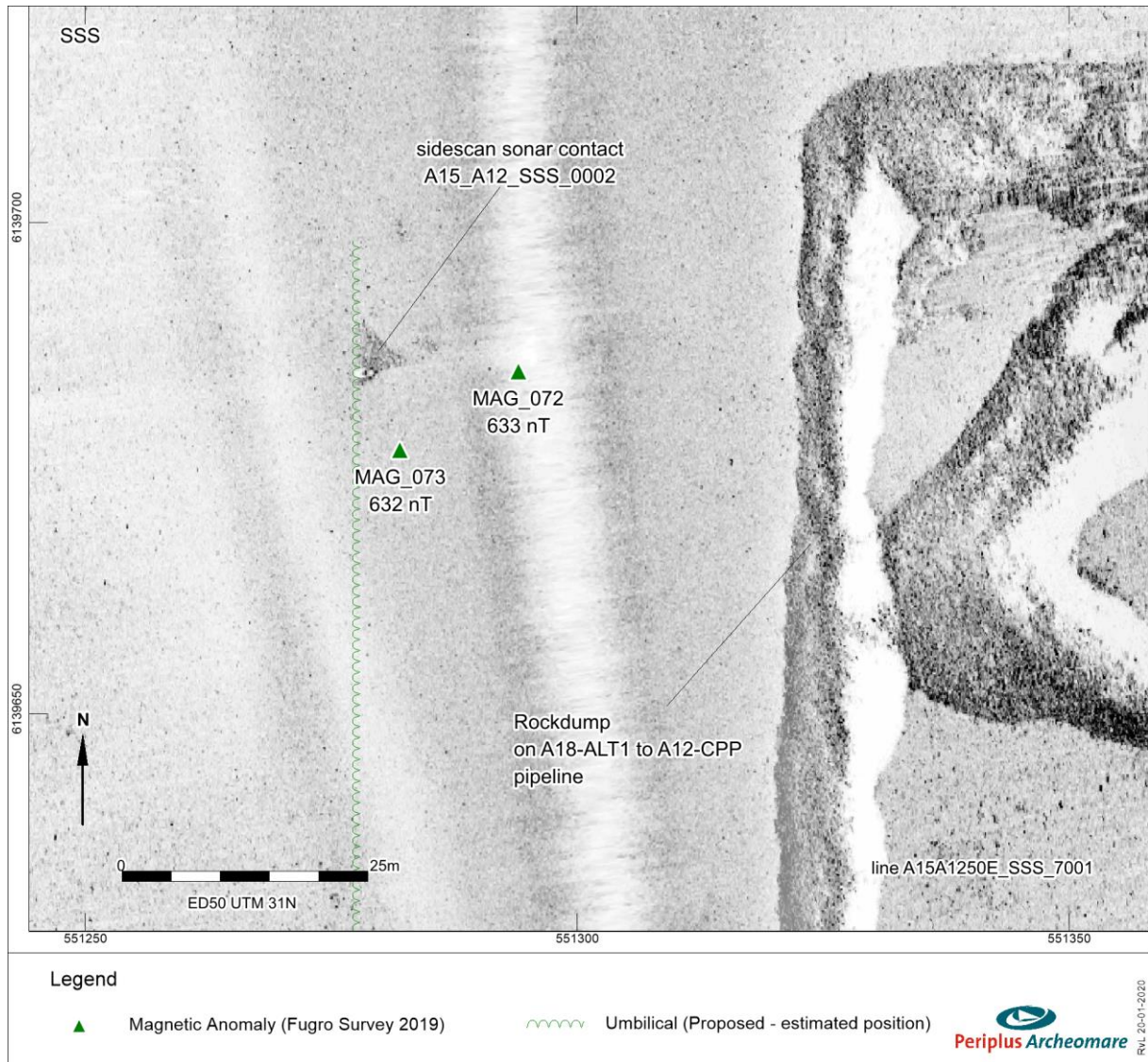


Figure 6. Side scan sonar image of Fugro target A15_A12_SSS_0002

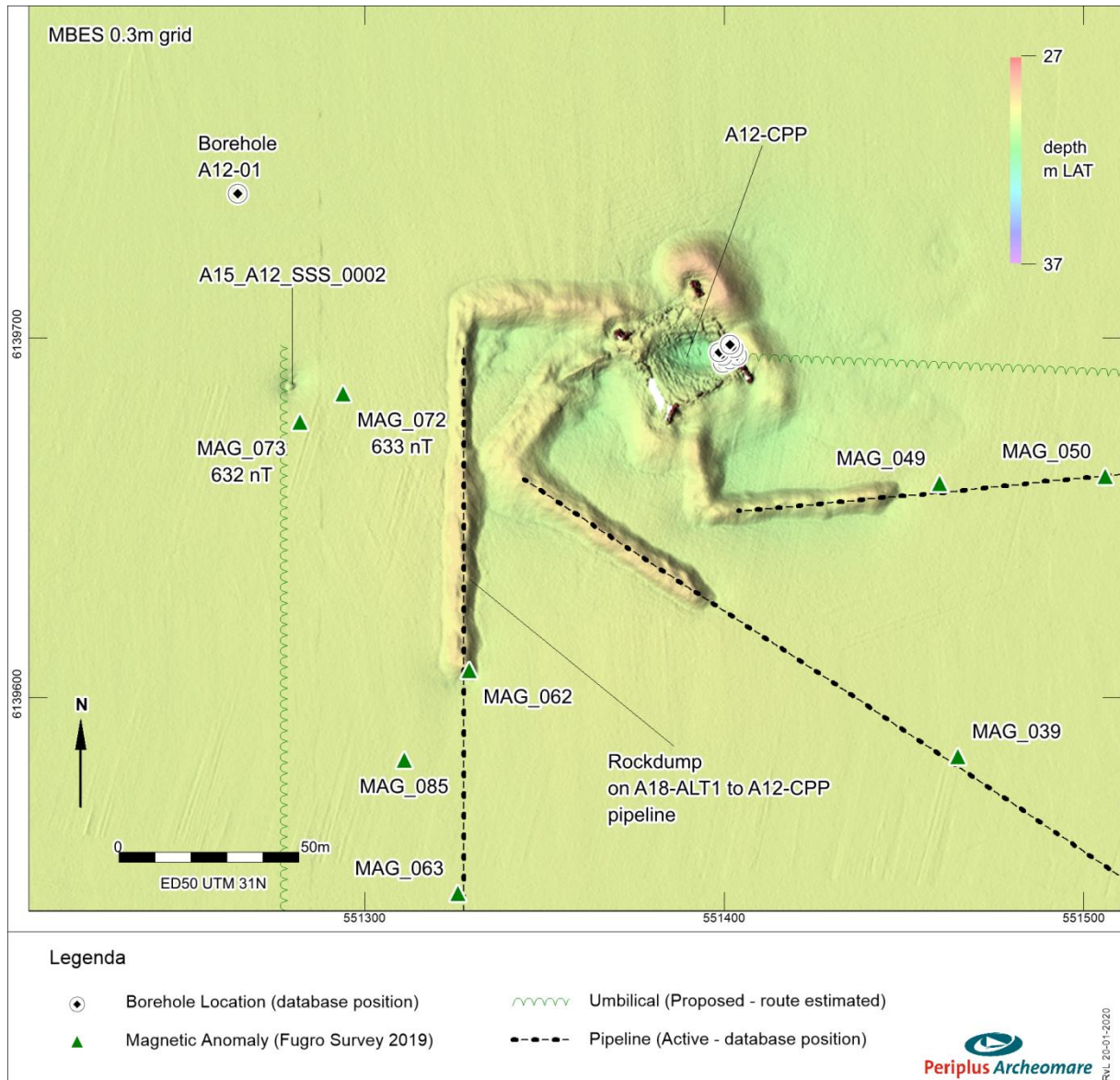


Figure 7. Multibeam image of Fugro target A15_A12_SSS_0002

3.4 Multibeam

All *side scan sonar* contacts have been correlated with *multibeam* images. Refer to the previous (side scan sonar) section for the results of this assessment. No *multibeam* contacts have been found other than the ones that also have been found with side scan sonar.

3.5 Magnetometer

Besides the objects that are visible on the geophysical data and are selected as possibly archaeological valuable there also are large *magnetometer* anomalies which have not been found on the *side scan sonar* or *multibeam* data. Although the nature of these objects is not known it is possible that the anomalies represent archaeological remains buried in the seabed, and therefore have to be taken into account within this assessment.

A total of 63 magnetic anomalies have been observed. A classification is listed in the table below.

Classification		Number	Total
Magnetic anomalies related to infrastructure and objects known from database sources and found during the Fugro 2019 SSS survey	Pipelines	40	47
	Shipwreck NCN 2487 (A15_A12_SSS_0001)	1	
	Shipwreck NCN 2487 related debris	4	
	Side scan sonar contact A15_A12_SSS_0002	2	
Magnetic anomalies induced by unknown ferrous objects			16
Total			63

Table 9. Classification of the magnetic anomalies

47 of these anomalies can be related to known and inferred pipelines (40), a shipwreck (5) and debris found exposed at the seabed (2).

The known shipwreck (NCN 2487; sonar contact A15_A12_SSS_0001) has induced a 922 nT magnetic anomaly (MAG 069). In the vicinity of the wreck 4 magnetic anomalies have been identified (refer to detail map in figure 8). One of these four anomalies has a peak-to-peak value of 409 nT and is located at 240 m east-southeast of the wreck location. The object which induces this anomaly is not visible at the seabed. The origin of the object is not known. Because the origin is not known, the object is considered to be of potential archaeological interest, until proven otherwise.

Target_ID	Easting	Northing	Offset	Kp	PeakToPeak	PPA interpretation
MAG_070	551452	6131972	-18	2.347	409	Unknown object; possibly debris related to known shipwreck NCN 2487 (MAG 069)

Table 10. Unknown object of potential archaeological interest

As discussed in the side scan sonar section 3.3 the 2 large magnetic anomalies which are related debris found exposed at the seabed with side scan sonar contact A15_A12_SSS_0002 are also shown on a detailed map in figure 8. These two large anomalies of 632 nT and 633 nT indicate that the exposed debris contains a considerable amount of ferro-magnetic matter. The contacts do not correlate with known infrastructure, like borehole A12-01 which is located 63 m and 66 m north-northwest of these anomalies and 55 m north-northwest of side scan sonar contact A15_A12_SSS_0002. The debris found and listed as side scan sonar contact A15_A12_SSS_0002 and magnetic anomalies MAG_071 and MAG_072 are not considered to be of archaeological interest.

16 anomalies cannot be related to known pipelines and cables, or visible objects at the seabed surface. They are related to unknown ferrous objects which have been covered by sediments. Two of these

anomalies have peak to peak amplitude of 50 nT. The character of the iron-bearing objects which induce these anomalies cannot be determined from the current data. The anomalies could be induced by pieces of cable, anchors, UXO's, et cetera. Because the character of these iron-bearing objects cannot be determined, the objects present also include objects of potential archaeological interest.

Target_ID	Easting	Northing	Offset	Kp	PeakToPeak	PPA interpretation
MAG_071	551621	6132896	202	3.26	66	Unknown object
MAG_074	551391	6138872	115	9.251	51	Unknown object

Table 11. Unknown ferro-magnetic objects of potential archaeological interest

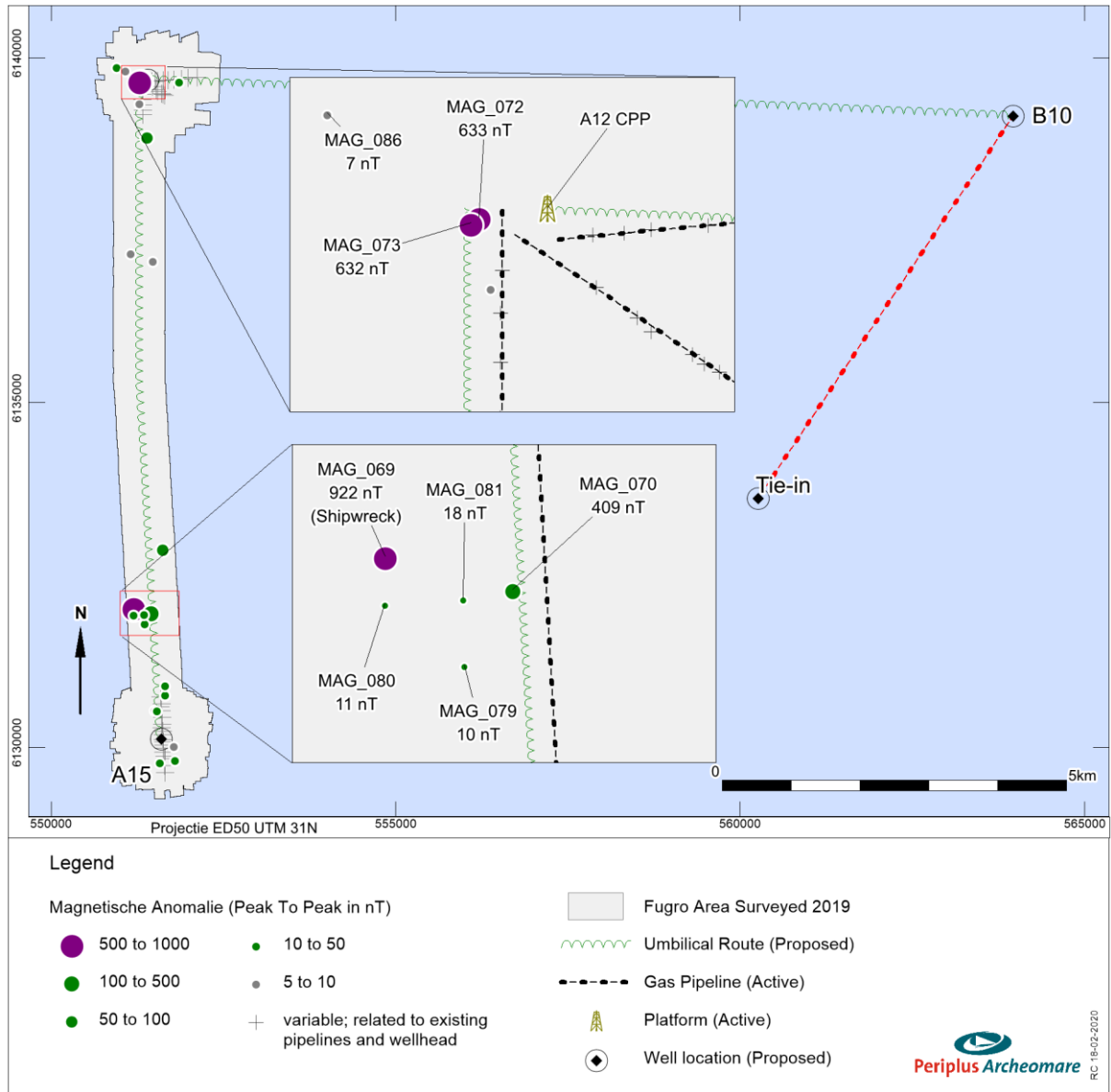


Figure 8. Overview of the magnetic anomalies

The survey results of the A12-CPP site are contained both in this report as in the B10 report (19A024-02). An overview of the number of magnetic anomalies assessed and contained in both reports is shown in Appendix 4.

3.6 Subbottom data

Desk study expectancy

Based on the archaeological desk study the top of the subcropping *Pleistocene* sequence is expected to consist primarily of Late *Weichselian* glaciolacustrine clay of the Dogger Bank Member, locally overlain by terrestrial deposits of the Bortel Formation. Especially in areas where those units have been covered by Early *Holocene* peat (Basal Peat Bed) or clay (Velsen Bed) well-preserved *in situ* prehistoric remains of high integrity are to be expected. An overview of the expected lithostratigraphy is shown in table 12.

The expected remains include Late Palaeolithic and Mesolithic camp sites, burials, lost or dumped objects such as flint and bone artefacts, hunting gear and canoes. Prehistoric camp sites in the context of sandy deposits of the Bortel Formation are characterized 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. The camp sites are generally small with few 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.

Current name		Environment	Old name	
Holocene	Terschellingerbank Mb Part of Southern Bight Fm	Marine (exposed at seabed)	Nieuw Zeeland Gronden Fm	
	Wormer Mb (base)	Tidal clay and fine sand	Elbow Fm	
	part of Naaldwijk Fm	Velsen Bed		Coastal clay
	Basal Peat Bed	Coastal peat		
Pleistocene	Bortel Fm	Local terrestrial	Twente Fm	
	Dogger Bank Mb part of the Dogger Bight Fm	Glaciolacustrine clay	Dogger Bank Fm	
	Uitdam Mb part of the Drente Fm	Glaciolacustrine clay, silt and fine sand	Cleaver Bank Fm	

Table 12. Old and new names of lithostratigraphic units in the area

According to the Sea Bed Sediments and *Holocene* Geology map the thickness of the *Holocene* sequence ranges from 5 to 20m.¹¹ Along the A15 to A12-CPP proposed umbilical route and at the A12-CPP platform location the lower part of the *Holocene* sequence consists of the Elbow Formation, which includes the current units of the Wormer Member and Basal Peat Bed. The mapped thickness of the Elbow Formation is 1 to 5 m.

Subbottom profiling results

An overview of the seismostratigraphic units Fugro has identified at the proposed A15 site is shown in table 13.

¹¹ Jeffery 1990.

Proposed A15 Platform Location

Age	Unit	Horizon	TWTT [s bLAT]	Depth [m BSF]	Description
Holocene	A	Seabed – H2	0.054-0.060	10.2-11.5	SAND to Gravelly SAND Internal reflector H01: thin layer of possibly silt
Pleistocene	B	H02 - H03	0.054-0.060	13.3-17.6	Palaeochannel infill
	C	H03 - H04	0.056-0.064	15.3-21.7	Firm CLAY with SAND beds
	D	H04 - H05	0.073-0.082	30-38.2	

Table 13. Seimostratigraphic units identified by Fugro

Unit A consists of fine to medium sand with few shell fragments. Silty sands could be also occurring as well as gravelly sands within the top of the unit. The sands of Unit A have been deposited in an open marine setting and have been interpreted by Fugro as *Holocene* deposits of the Terschellingbank Member within the Southern Bight Formation.

At the proposed A15 site an internal reflector is mapped (H01). This internal horizon has been identified 11 m below the seafloor; the distance from H01 to H02 at the proposed A15 site is three to four meters. In other words, H02 is found at 14 to 15 m below the seafloor.

Fugro has interpreted the lithostratigraphic sequence from the identified seismic units.¹² A summary of the interpreted geological setting at both proposed sites is shown in table 14.

Unit B is found at 14 meters below seafloor at the proposed A15 site. This depth is coherent with the depth at which the Boxtel Formation is expected to be present according to Fugro: 13 to 18 meters at the proposed A15 site.

The deposits of the Boxtel Formation include gravel sand, loam, clay and peat deposited along the banks of small streams during the Late Weichselian and Early *Holocene*. These small-scaled fluvial deposits are separately classified as the Singraven Member. Occurrences of fine-grained cover sand deposits might also be present. The cover sands are classified as the Wierden Member within the Boxtel Formation. It should however be noted that, according to the Dogger Quaternary Geology map, the Boxtel Formation (formerly mapped as Twente Formation) is not subcropping along the proposed routes and at the proposed sites.¹³

Based on the desk study the Elbow Formation, which comprised the current Basal Peat Bed, Velsen Bed and (part of) the Wormer Member was expected to be present. The 1 to 5 m thick Elbow Formation has not been identified as a separate unit in the studied area. We consider it likely that the top of the former Elbow Formation is reflected by horizon H01. Possibly Unit B consists of Early *Holocene* fresh and brackish

¹² Refer to:
 P906247_GEOP_REP_B10 01 | Geophysical Results Report, B10, Table 2.9, and
 P906247_GEOP_REP_A15 01 | Geophysical Results Report, A15, Table 2.6.
¹³ Jeffery 1991.

water tidal creek deposits and tidal flat deposits. Based on the available data it cannot be concluded if the Boxtel Formation, the former Elbow formation (current Wormer Member + Basal peat bed) or both units are present. The maximum vertical penetration of the *subbottom profiler* is approximately 16 m below seafloor. This depth coincides with the depth at which Unit B has been identified in the 2D-UHR seismic data. The Dogger Bank Member and deeper-seated units could not be identified in the *subbottom profiler* data as those units are located beyond the penetration depth of the *subbottom profiler*. The maximum recovery depth from vibrocores is 5.3m below seafloor. This means that, based on geotechnical data, it cannot be ascertained which units are present below the 5.3m.

Unit	Description	Depth	Comments
		(m bsf)	
Southern Bight / Terschellinger Bank	Fine to medium SAND, with few shell fragments. Silty sands could be also occurring as well as gravelly sands within the top of the unit.	Seabed to 13 - 18	open marine setting
Boxtel	Fine SAND, locally silty	13 - 18	periglacial setting; thin layers; presence at the site is uncertain
Dogger Bank	Stiff to very stiff CLAY, with layers and/or laminae of silt and very dense fine sand	21 - 50	glaciolacustrine and glaciomarine setting
Cleaver Bank	Very dense fine to coarse SAND and stiff to very stiff sandy CLAY, sometimes gravelly		glaciolacustrine setting; presence at the site is uncertain
Egmond Ground and Yarmouth Roads	Very dense SAND with thin to thick beds of CLAY, locally layers of laminated silt and clay, locally silty sand	> 50	marine / deltaic to fluvial setting; The boundary between formations is often difficult to distinguish on seismic data

Table 14. Lithostratigraphic units interpreted by Fugro

Geophysical and geotechnical data were gathered in 2018 at the then proposed B10-04 and A15-05 sites (refer to figure 1 for approximate locations). From the combined data sets we concluded that the transition from the Pleistocene Doggerbank Member to the Holocene Wormer Member was found at 16.0 m below seabed at the A15-05 well site and at 14.3 m below seabed at the B10-04 well site (refer to figure 9). These depths are consistent with the current Fugro data.¹⁴

For the A15-05 and B10-04 we further concluded that the Doggerbank Member in places is covered by tidal deposits of the Wormer Member, comprising laminated clays, silts and fine sands. Evidence for the presence of the Boxtel Formation had not been found, although based on the subbottom profiler and CPT-data the presence of this unit could not be excluded. At the A15-05 site one of the CPT's indicated the presence of a thin peat bed at 17.5 m below the seabed. This peat bed formed an intercalation between clayey sediments and was interpreted to date from the Bølling Allerød interstadial period.

¹⁴ van Lil, 2018

The interpretation of the 2018 geotechnical data differs somewhat from the current Fugro interpretation. In summary it can be concluded that the Late Weichselian and Early *Holocene* landscapes (which are considered to be of potential archaeological interest) are located below H01. This horizon has been found at depths over 10 meters below the seabed. From an archaeological point of view this is an important observation as levels of potential archaeological interest will not be jeopardized by the installation of the umbilical.

In the Executive Summary of both reports of the current Fugro route and site surveys (2019) it is concluded that *'The seismostratigraphic units should be definitely validated by in-situ measurements and borehole description in order to create soil units for rig design and installation.'* From these borehole data analyses can be concluded which Early *Holocene* units are present at the proposed drill sites and if prehistoric landscapes and possible related archaeological remains have been preserved intact.

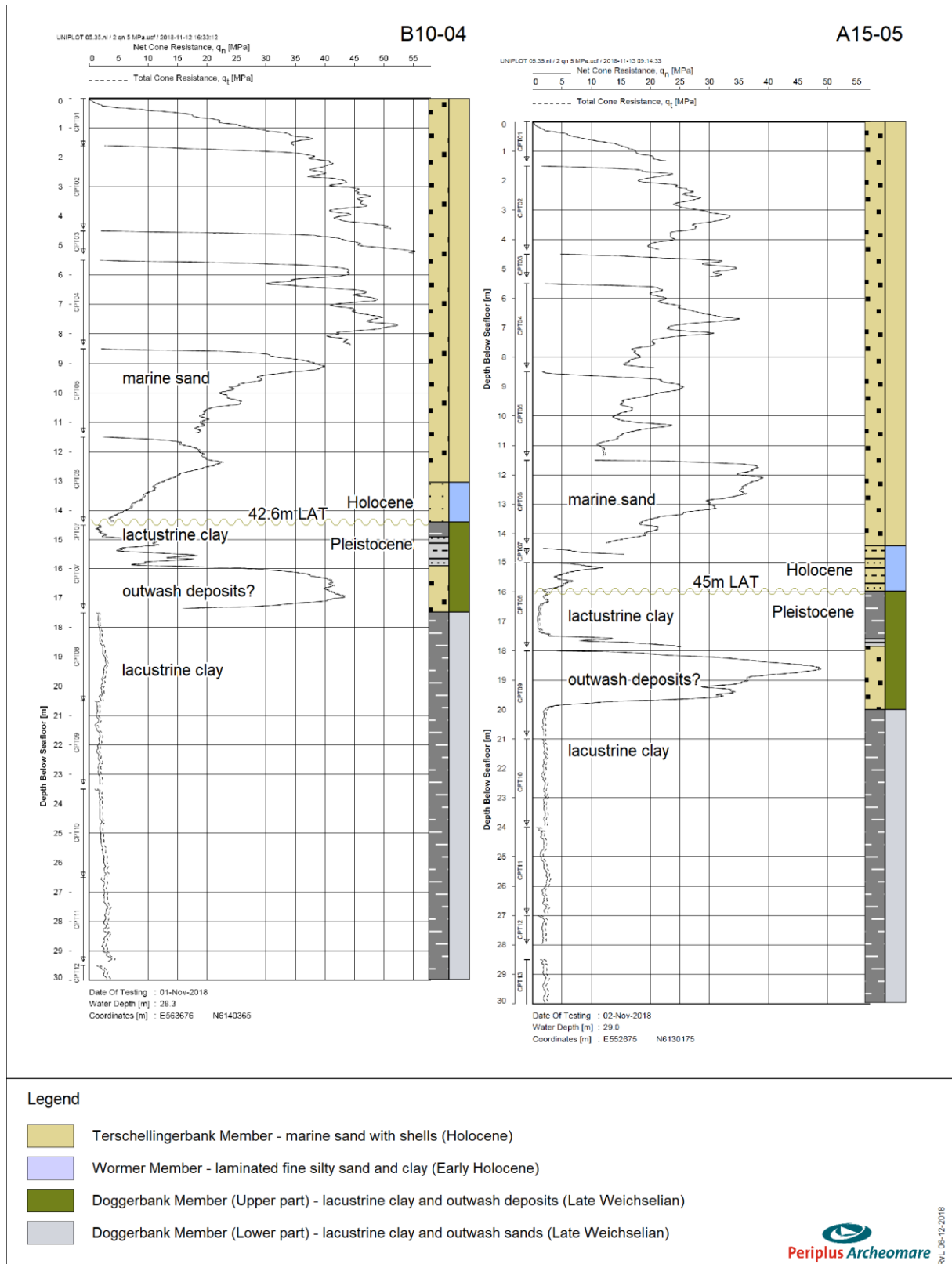


Figure 9. Interpretation of Cone Penetration Tests at the B10-04 and A15-05 site.¹⁵

¹⁵ From van Lil, 2018

4 Synthesis

For this investigation different research questions are defined in the Program of Requirements.¹⁶
Based on the results of the data analysis the research questions are answered.

primary question:

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

Within the research corridor a shipwreck has been found which is known from the NCN-database (NCN 2487). The archaeological value of this wreck has not been determined yet.

NCN nr.	Fugro Target ID	ED50 E (m)	ED50 N (m)	KP (km)	DCC (m)	Length (m)*	Width (m)	Height (m)
2487	A15_A12SSS_0001	551205	6132032	1.921	-260	45.3	11.1	3.2

* The dimensions listed have been determined by side scan sonar; *multibeam* data indicate the wreck length to be 38.5m

Table 15. As Found details of shipwreck of potential archaeological interest

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

Are there any phenomena visible on the seabed?

Yes, a total of 6 *side scan sonar* contacts and 63 magnetic anomalies have been found during the survey.

If so:

What is the description of these phenomena?

The classification of the side scan sonar contacts is listed in the table below.

Fugro Classification	Total
Debris	5
Shipwreck	1
Total	6

Table 16. Classification of the side scan sonar found

The classification of the magnetic anomalies is listed in the table below.

Classification	Number	Total
Magnetic anomalies related to infrastructure and objects known from database sources and found during the Fugro 2019 SSS survey	Pipelines	40
	Shipwreck NCN 2487 (A15_A12_SSS_0001)	1
	Shipwreck NCN 2487 related debris	4
	Side scan sonar contact A15_A12_SSS_0002	2
Magnetic anomalies induced by unknown ferrous objects		16
Total		63

Table 17. Classification of the magnetic anomalies found

¹⁶ Van Lil 2018.

Do these phenomena have a man-made or natural origin?

All side scan sonar contacts and magnetic anomalies have been interpreted to be man-made.

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

What classification can be attached?

The man-made objects found with side scan sonar include unknown debris (4), a possible fishing net (1), and possible clump weight for wave buoy and a known shipwreck (NCN 2487).

47 magnetic anomalies are related to objects known from the database sources, including a shipwreck (1), debris related to this wreck (4), existing pipelines (40), and one item of unknown debris exposed at the seabed found with side scan sonar (2).

If these phenomena can be classified as archaeological:

Is it possible to interpret the nature of the archaeological objects and to prioritize importance?

None of the debris items is considered to be of archaeological interest. The archaeological value of the shipwreck (NCN 2487) has not been determined yet.

If these phenomena can be identified as natural:

What is the nature of these natural phenomena?

This question is not applicable.

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

The *multibeam* images show a flat seabed throughout the surveyed area. The absence of clear sedimentary structures is indicative of a low energy environment.

If so:

How can these zones be interpreted?

This question is not applicable.

General:

What is the relation between the observed objects and the topography of the seabed? Based on this relationship can risk-prone areas be marked selectively?

The shipwreck is to a large extent embedded in the seabed. The seabed around the observed objects shows some scouring. The scouring is observed at all sides of the objects.

Risk-prone areas are areas where the probability of archaeological remains is considered to be high. Based on the data studied no risk-prone areas can be designated.

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*- and sampling:

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

Yes, the top of the *Pleistocene* landscape could be mapped by means of the seismic data gathered.

The *Pleistocene* to *Holocene* transition (= boundary between seismic Unit A and Unit B) is found at depths which coincide with the maximum penetration depth of the *subbottom profiler*. The top of

the *Pleistocene* landscape has therefore primarily been mapped by means of the 2D-UHR seismic data.

If so:

What is the depth of the Pleistocene landscape compared to the present seabed?

Fugro has interpreted the seismic Unit B as lithostratigraphic unit of the Boxtel Formation. If this unit indeed reflects the Boxtel Formation, the top of the *Pleistocene* landscape lies at 13 to 18 m below the seabed at site A15. The Boxtel Formation consists of small-scale fluvial deposits of the Singraven Member where the palaeo-channel infills have been mapped, possibly accompanied by cover sand deposits of the where a continuous layer of sandy deposits occurs.

Jeffery has mapped the Elbow Formation and the subcropping *Pleistocene* units in the area.^{17, 18}

The occurrence of both the Early *Holocene* and *Pleistocene* units in the research area has been summarized in table 18.

Geology		A15 site and umbilical	
Formation	Epoch	Jeffery 1991	Fugro 2019
Elbow	Holocene	Yes	No
Boxtel	<i>Pleistocene</i>	No	Yes

Table 18. Geology: geological maps versus seismic survey results

From this table can be read that Elbow Formation has not been identified by Fugro. We consider it possible that the top of the Elbow formation is marked by the internal reflector H01 at the A15 site which was found at 11m below the seafloor.

From Pleistocene to Holocene deposits is the transition gradual or instantaneous (erosive)?

The current data do not provide sufficient information to conclude whether the transition from *Pleistocene* to *Holocene* deposits is erosive or non-erosive.

Can zones be identified where prehistoric settlement remains can be expected?

In places where the prehistoric landscape has been preserved intact in situ remains of Late Palaeolithic a Mesolithic camp sites are to be expected. Of special archaeological interest are the levees of small-scaled fluvial systems which are indicated in the seismic data along the edges of palaeo-channel infills.

If so:

Could these expected settlement remains be affected by the installation of the cables based on their vertical position related to the seabed?

The installation of the umbilical will not affect *in situ* prehistoric remains as the archaeological level for these remains are found in the Late *Pleistocene* and Early *Holocene* landscapes of which the deposits are situated at more than 10 m below the seabed. The installation of the umbilical will certainly not reach that deep. At the drill site a jack-up rig will be installed. Also, the spudding of the legs at the site and possible scouring of the seabed adjacent to the legs after installation will not

¹⁷ The Elbow Formation is an outdated name; currently the deposits of the Elbow Formation are referred to as the Basal Peat bed, the Velsen Bed and the Wormer Member.

¹⁸ Jeffery 1991.

affect the abovementioned archaeological levels. The installation of the conductor will penetrate the prehistoric landscapes and potential in situ archaeological remains contained herein. However, the seabed disturbance is confined to a small area and the change that remains of prehistoric camp sites are affected by the installation of the conductor is, considering the generally small size of Late Palaeolithic and Mesolithic camp sites, small.

Are there any indications observed on the seismic profiles for the presence of buried (man-made) objects?

No.

If so:

Based on the presence of buried objects and its correlation with side scan sonar, magnetometer and multibeam data can something be said about the nature of these buried objects?

Given the answer to the previous question this question is not applicable.

Are there any mitigating measures necessary to avoid disturbance of possible archaeological remains?

It is advised not to conduct any activities within 100 meters from wreck location NCN 2487; *side scan sonar* contact A15_A12_SSS_0001. This advice also applies to 3 *magnetometer* anomalies: MAG_070, MAG_071 and MAG_074.

MAG_070 comprises a 409 nT magnetic anomaly which possibly is related to the NCN2487 shipwreck. MAG_071 and MAG_074 are magnetic anomalies with peak to peak values over 50 nT. The origin of those magnetic anomalies has not been established yet and the objects inducing those anomalies could be of archaeological value.

With respect to the prehistoric camp sites related to the *Pleistocene* landscape no mitigating measures are considered necessary. It is advised to utilize the obtained data and information which comes forward from the onsite borehole sample analysis for adjusting and fine-tuning the current expectancy model for the North Sea area.

5 Summary and recommendations

A large quantity of survey data (*side scan sonar, magnetometer, multibeam echo sounder* and seismics) was recorded within the route survey covering a total area of 10 km². This data were analysed in order to conduct an archaeological assessment.

The current analysis of geophysical survey results is the second step in the archaeological assessment, following the desk study. The desk study has shown that one object is known within the survey corridor. The object comprises a shipwreck (NCN2487). The wreck has been found exposed at the seabed during the *side scan sonar* and *multibeam* survey. The wreck is considered to be of potential archaeological value. As long as the archaeological value of the object has not been determined, it is advised not to conduct activities which could affect the locations with possible archaeological remains including a buffer zone of 100 meters. This also applies to cable *trenching* and anchorages of work vessels.

Apart from the known shipwreck found, five other contacts were reported with *side scan sonar*. None of these contacts is considered to be of archaeological interest.

A total of 63 magnetic anomalies have been identified:

- 40 anomalies can be related to known infrastructure comprising pipelines;
- 3 anomalies are related to object found with side scan sonar including shipwreck NCN2487 (1) and debris A15_A12_SSS_0001 (2);
- 4 anomalies identified in the vicinity of wreck NCN2487 have not been found with side scan sonar or *multibeam*, but possibly are related to the wreck site;
- 16 magnetic anomalies cannot be correlated with known infrastructure or visible objects at the seabed surface. Those anomalies are induced by unknown ferrous objects buried in the seabed.

3 buried ferrous objects have peak to peak magnetic anomalies over 50 nT. As for wreck site NCN2487 it is advised to avoid these locations including a buffer zone of 100 meters during *trenching* operations and other seabed disturbances. It should be stressed that the origin of the magnetic anomalies are unknown and apart from possible archaeological remains any type of man-made objects can be encountered including unexploded ammunition, anchors, pieces of chains and cables, debris, etcetera.

The buffer zone of 100 meters is a standard¹⁹ that applies to the protection of cultural heritage, this distance may be reduced if it can be substantiated that the applied disturbance has no effect on the archaeological object. For example, when no anchoring is used during cable lay operations the buffer zone can be decreased. Reduction of the distance have to be approved by Rijkswaterstaat (RWS). Rijkswaterstaat is the enforcing authority, acting on behalf of the Ministry of Economic Affairs. The Cultural Heritage Agency of the Netherlands (RCE) acts as an advisor to Rijkswaterstaat.

¹⁹ In accordance with the 'Beleidsregels ontgravingen in rijkswateren'; <https://wetten.overheid.nl/BWBR0028498/2010-10-01>.

If it is not feasible to avoid the reported wreck site and *magnetometer* locations, additional research is required in order to determine the actual archaeological value of the reported locations. If this indicates that the object has no archaeological value, the location can be omitted.

The client stated in response that the potential locations, including a buffer zone of 100 meters, will be taken into account in the design and planning of the work. It is therefore not necessary to conduct follow-up research.

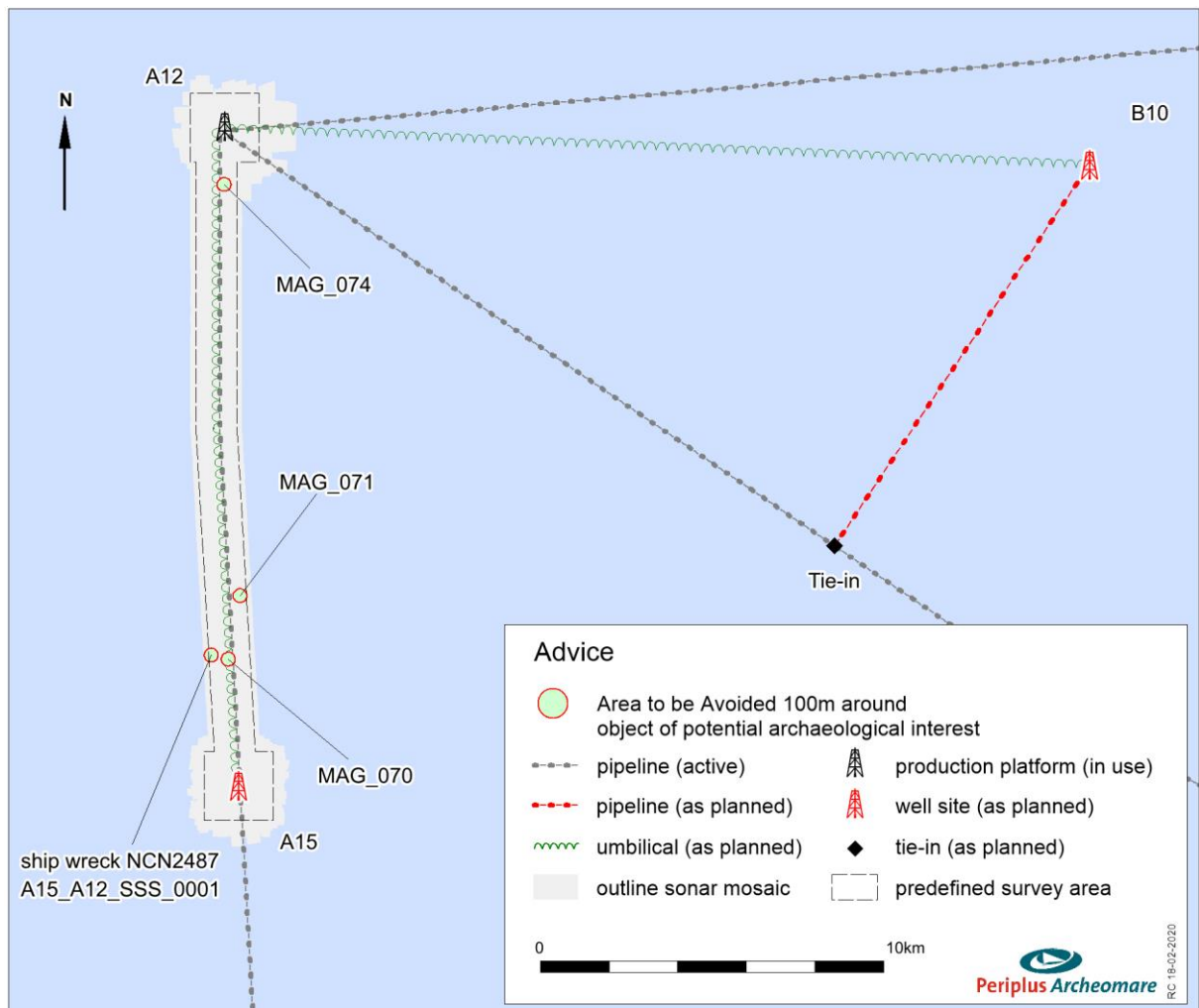


Figure 10. Buffer zones (100m) to scale around contacts with an archaeological expectation

NCN nr	Fugro Target ID	ED50 E (m)	ED50 N (m)	KP (km)	DCC (m)	Interpretation
2487	A15_A12SSS_0001	551205	6132032	1.921	-260	Shipwreck
n/a	MAG_070	551452	6131972	2.347	-18	Unknown buried object, possibly related to shipwreck
n/a	MAG_071	551621	6132896	3.260	202	Unknown buried object
n/a	MAG_074	551391	6138872	9.251	115	Unknown buried object

Table 19. Details on the objects of potential archaeological interest

Prehistory

From the interpreted seismic data can be concluded that the *Pleistocene* and Early *Holocene* landscapes are located at more than 10 m below the seabed throughout the research area. It is not known if those landscapes and possible archaeological remains contained herein have been preserved intact.

The installation of the umbilical and jack-up rig are not expected to affect *in situ* prehistoric remains, because the archaeological levels are located below the maximum depth of disturbance. The installation of the conductor will penetrate the prehistoric landscapes and potential *in situ* archaeological remains contained herein. However, the seabed disturbance is confined to a small area and the change that remains of prehistoric camp sites are affected by the installation of the conductor is, considering the generally small size of Late Palaeolithic and Mesolithic camp sites, small. Mitigating measures are therefore not considered necessary. It is advised to utilize the obtained data and information which comes forward from the onsite borehole sample analysis for adjusting and fine-tuning the current expectancy model for the North Sea area.

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 2016 (Dutch: 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
<i>AMZ</i>	Archeologische Monumenten Zorg, a description of procedures to ensure the protection of National archaeological Cultural Heritage
<i>CPT</i>	Cone penetration test
<i>Erratic</i>	An (glacial) erratic is a piece of rock that differs from the size and type of rock native to the area in which it rests. These rocks are carried by glacial ice, often over distances of hundreds of kilometres. Erratics can range in size from pebbles to large boulders.
<i>Ferrous</i>	Material which is magnetic or can be magnetized, and well known types are iron and nickel
<i>Holocene</i>	Youngest geological epoch (from the last Ice Age, around 10,000 BC. To the present)
<i>In situ</i>	At the original location in the original condition
<i>KNA</i>	Kwaliteitsnorm Nederlandse Archeologie
<i>Magnetometer</i>	Methodology to measure deviations from the earth's magnetic field (caused by the presence of ferro-magnetic = ferrous objects)
<i>Multibeam</i>	Acoustic instrument that uses different bundles or beams to measure the depth in order to create a detailed topographic model
<i>Pleistocene</i>	Geological era that began about 2 million years ago. The era of the ice ages but also moderately warm periods. The <i>Pleistocene</i> ends with the beginning of the <i>Holocene</i>
<i>PvE</i>	Program of Requirements (Dutch: Programma van Eisen)
<i>RCE</i>	Ministry of Cultural Heritage (Dutch: Rijksdienst voor het Cultureel Erfgoed)
<i>ROV</i>	Remotely Operated Vehicle
<i>Side scan sonar</i>	Acoustic instrument that registers the amplitude 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
<i>Current ripples</i>	Asymmetrical wave pattern at the seabed caused by currents. The steep sides of the ripples are always on the downstream side.
<i>Subbottom profiler</i>	Acoustic system used to create seismic profiles of the subsurface.
<i>Trenching</i>	Construction of a trench for the purpose of burying a cable or pipeline
<i>Vibrocore</i>	Vibrocore bore is 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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Appendix 1. Listing of all magnetic anomalies

Target ID	Easting	Northing	Offset	Kp	Peak to Peak	FugroComments	Fugro Report	PPAComments
MAG_006	551503	6130566	-46	0.940	8	Unknown MAG contact	A15	Unknown MAG object
MAG_007	551582	6130729	42	1.099	1562	Pipeline A18-A to A12-CPP 12 inch - oblique	A15	Pipeline A18-A to A12-CPP 12 inch - oblique
MAG_008	551652	6130781	115	1.146	11	Unknown MAG contact	A15	Unknown MAG object
MAG_009	551648	6129869	59	0.235	1769	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_010	551602	6130634	57	1.002	20	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_011	551601	6130533	50	0.901	22	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_012	551608	6130434	52	0.802	197	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_013	551612	6130336	51	0.704	19	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_014	551616	6130235	49	0.603	572	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_015	551618	6130185	48	0.553	119	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_016	551622	6130118	48	0.486	854	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_017	551624	6130081	48	0.449	581	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_018	551626	6130032	46	0.400	42	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_019	551629	6129985	47	0.352	622	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_020	551604	6130283	39	0.652	605	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_021	551632	6129930	47	0.298	114	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_022	551650	6129837	59	0.203	719	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_023	551796	6129833	204	0.190	37	Unknown MAG contact	A15	Unknown MAG object
MAG_024	551644	6129736	47	0.103	152	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_025	551652	6129632	48	-0.002	184	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_026	551583	6130589	35	0.959	1777	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_039	551465	6139584	188	9.964	101	Pipeline B13A to A12 - CPP 16 inch	A15 & B10	Pipeline B13A to A12 - CPP 16 inch
MAG_040	551524	6139540	248	9.919	168	Pipeline B13A to A12 - CPP 16 inch	A15 & B10	Pipeline B13A to A12 - CPP 16 inch
MAG_041	551545	6139519	269	9.897	133	Pipeline B13A to A12 - CPP 16 inch	A15 & B10	Pipeline B13A to A12 - CPP 16 inch
MAG_042	551605	6139486	-254	12.850	207	Pipeline B13A to A12 - CPP 16 inch	B10	Pipeline B13A to A12 - CPP 16 inch
MAG_043	551622	6139473	-266	12.830	105	Pipeline B13A to A12 - CPP 16 inch	B10	Pipeline B13A to A12 - CPP 16 inch
MAG_049	551460	6139660	183	10.040	457	Pipeline A12-CPP - B10 Side Tap 16	A15 & B10	Pipeline A12-CPP - B10 Side Tap 16 inch

Target ID	Easting	Northing	Offset	Kp	Peak to Peak	FugroComments	Fugro Report	PPAComments
						inch		
MAG_050	551506	6139662	229	10.042	142	Pipeline A12-CPP - B10 Side Tap 16 inch	A15 & B10	Pipeline A12-CPP - B10 Side Tap 16 inch
MAG_051	551545	6139667	269	10.047	197	Pipeline A12-CPP - B10 Side Tap 16 inch	A15 & B10	Pipeline A12-CPP - B10 Side Tap 16 inch
MAG_052	551628	6139673	-66	12.850	84	Pipeline A12-CPP - B10 Side Tap 16 inch	B10	Pipeline A12-CPP - B10 Side Tap 16 inch
MAG_053	551697	6139679	-55	12.780	149	Pipeline A12-CPP - B10 Side Tap 16 inch	B10	Pipeline A12-CPP - B10 Side Tap 16 inch
MAG_054	551777	6139684	-46	12.700	470	Pipeline A12-CPP - B10 Side Tap 16 inch	B10	Pipeline A12-CPP - B10 Side Tap 16 inch
MAG_055	551887	6139694	-31	12.590	298	Pipeline A12-CPP - B10 Side Tap 16 inch	B10	Pipeline A12-CPP - B10 Side Tap 16 inch
MAG_056	551982	6139707	-14	12.500	97	Pipeline A12-CPP - B10 Side Tap 16 inch	B10	Pipeline A12-CPP - B10 Side Tap 16 inch
MAG_057	552116	6139717	3	12.360	1114	Pipeline A12-CPP - B10 Side Tap 16 inch. Centre of group of anomalies	B10	Pipeline A12-CPP - B10 Side Tap 16 inch. Centre of group of anomalies
MAG_062	551329	6139608	52	9.987	64	Pipeline A18-A to A12-CPP 12 inch	A15 & B10	Pipeline A18-A to A12-CPP 12 inch
MAG_063	551326	6139546	50	9.925	386	Pipeline A18-A to A12-CPP 12 inch	A15 & B10	Pipeline A18-A to A12-CPP 12 inch
MAG_064	551326	6139475	50	9.853	70	Pipeline A18-A to A12-CPP 12 inch	A15 & B10	Pipeline A18-A to A12-CPP 12 inch
MAG_065	551325	6139395	49	9.774	59	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_066	551330	6139324	53	9.703	176	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_067	551328	6139248	51	9.627	48	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_068	551329	6139175	52	9.554	200	Pipeline A18-A to A12-CPP 12 inch	A15	Pipeline A18-A to A12-CPP 12 inch
MAG_069	551192	6132040	-273	2.429	922	Possible shipwreck	A15	Known ship wreck NCN 2487
MAG_070	551452	6131972	-18	2.347	409	Unknown MAG contact	A15	Unknown object; possibly debris related to known ship wreck NCN 2487 (MAG 069)
MAG_071	551621	6132896	202	3.260	66	Unknown MAG contact	A15	Unknown MAG object
MAG_072	551294	6139685	18	10.064	633	Pipeline A18-A to A12-CPP 12 inch	A15 & B10	SSS contact A15_A12_SSS_0002
MAG_073	551282	6139677	6	10.056	632	Pipeline A18-A to A12-CPP 12 inch	A15 & B10	SSS contact A15_A12_SSS_0002
MAG_074	551391	6138872	115	9.251	51	Unknown MAG contact	A15	Unknown MAG object
MAG_075	551576	6129798	-17	0.170	16	Unknown MAG contact	A15	Unknown MAG object
MAG_076	551782	6130040	203	0.398	6	Unknown MAG	A15	Unknown MAG object

Target ID	Easting	Northing	Offset	Kp	Peak to Peak	FugroComments	Fugro Report	PPAComments
						contact		
MAG_077	551533	6130551	-17	0.923	21	Unknown MAG contact	A15	Unknown MAG object
MAG_078	551652	6130921	122	1.286	14	Unknown MAG contact	A15	Unknown MAG object
MAG_079	551354	6131819	-124	2.199	10	Unknown MAG contact	A15	Unknown object; possibly debris related to known ship wreck NCN 2487 (MAG 069)
MAG_080	551192	6131944	-280	2.333	11	Unknown MAG contact	A15	Unknown object; possibly debris related to known ship wreck NCN 2487 (MAG 069)
MAG_081	551351	6131954	-120	2.335	18	Unknown MAG contact	A15	Unknown object; possibly debris related to known ship wreck NCN 2487 (MAG 069)
MAG_082	551477	6137076	200	7.455	8	Unknown MAG contact	A15	Unknown MAG object
MAG_083	551150	6137190	-126	7.568	9	Unknown MAG contact	A15	Unknown MAG object
MAG_084	551280	6139366	3	9.745	8	Unknown MAG contact	A15	Unknown MAG object
MAG_085	551311	6139583	35	9.962	6	Unknown MAG contact	A15 & B10	Unknown MAG object
MAG_086	551074	6139836	-204	10.214	7	Unknown MAG contact	A15 & B10	Unknown MAG object
MAG_092	551644	6139461	-275	12.820	88	Pipeline B13A to A12 - CPP 16 inch	B10	Pipeline B13A to A12 - CPP 16 inch
MAG_097	550952	6139890	-326	10.266	25	Outside survey area	A15 & B10	Unknown MAG object
MAG_101	551855	6139677	-49	12.620	12	Unknown MAG contact	B10	Unknown MAG object

* Anomalies caused by objects of potential archaeological interest indicated in pink; Periplus interpretation added to Fugro listing; projection Easting and Northing: UTM31N ED50.

Appendix 2. Listing of assessed side scan sonar contacts

Target ID	Easting	Northing	User Class	Description	Height	Length	Width
A15_A12_SSS_0001	551205	6132032	wreck	Shipwreck	3.4	45.3	11.1
A15_A12_SSS_0002	551280	6139687	debris	Possible buoy anchor	0.5	3.8	1.1
A15_A12_SSS_0004	551114	6140098	debris		0.2	1.9	0.8
B10_A12_SSS_0001	551379	6140049	debris	Possible Clump weight for wave buoy	0.2	1.4	0.8
A15_A12_SSS_0005	551355	6140064	debris		0.1	1.8	0.8
A15_A12_SSS_0003	551179	6139928	debris		0.0	2.2	1.2

* Listing As given by Fugro; projection Easting and Northing: UTM31N ED50; Sonar contacts interpreted as objects of potential archaeological interest indicated in pink;

Appendix 3. Phases of maritime archaeological research

The care for cultural heritage is legally required according to Dutch law. In order to comply with the requirements, all procedures and requirements for the archaeological research process have been incorporated in the Dutch Quality Standard for Archaeology (KNA waterbodems, version 4.1). 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 expectation 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 Archaeology, then the next phase must be carried out:

2. Exploratory field research (opwaterfase)

In order to test the archaeological expectation, 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 archaeological 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:

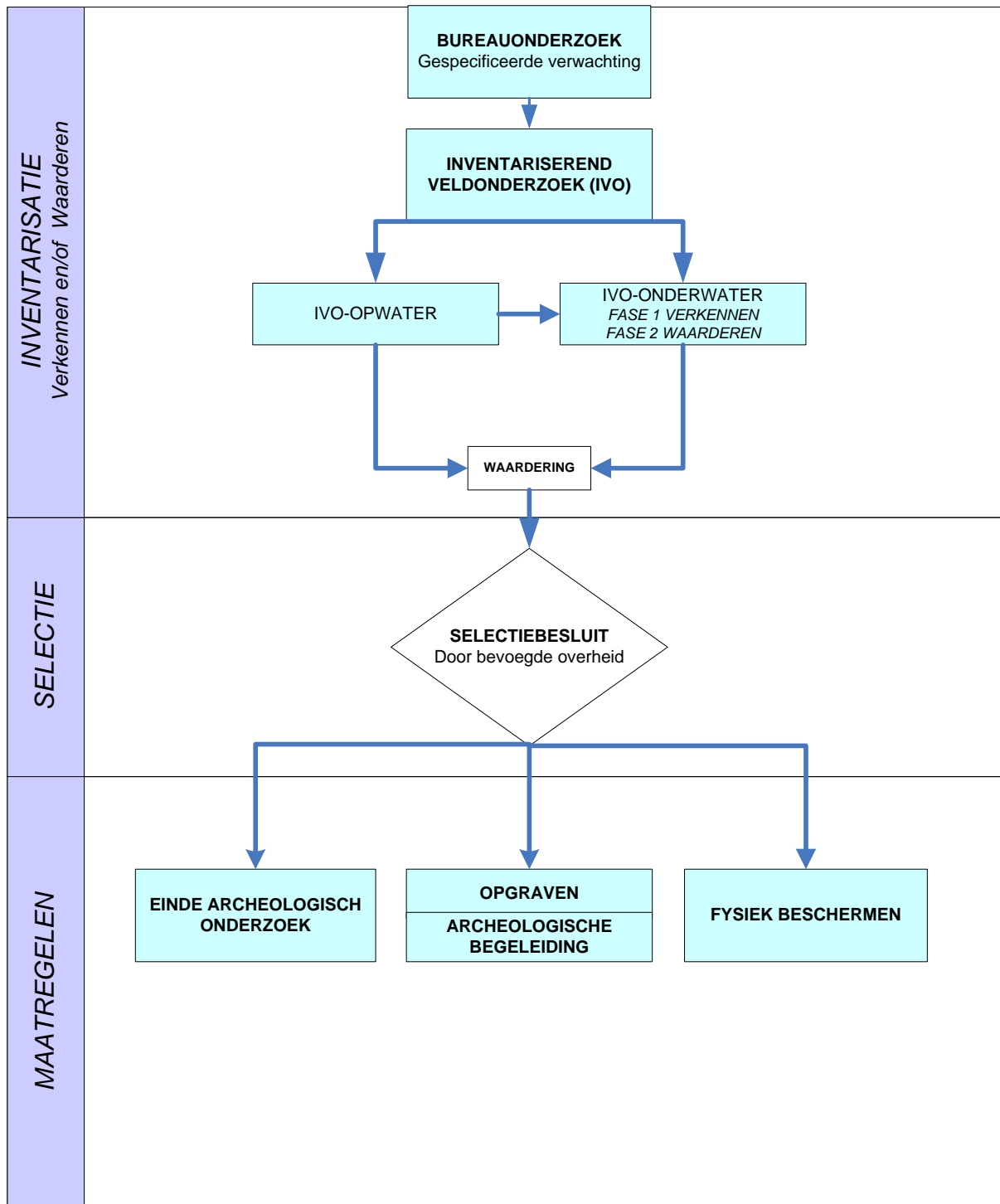
5. Archaeological excavation

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 above contain a number of decision points that are dependent on the detected archaeological objects. The figure on the next page shows these moments schematically.

Schematic overview KNA Waterbodems version 4.1

(AMZ cycle in Dutch)



Appendix 4. Reported contacts in 19A024-01 (A15) and 19A024-02 (B10)

	Side scan sonar		
	Found	Reported	
	Total number	19A024-01 (A15)	19A024-02 (B10)
B10	1	1	
A15	1		1
A12-CPP	5	5	5
Total	7	6	6

	Magnetic Anomalies		
	Found	Reported	
	Total number	19A024-01 (A15)	19A024-02 (B10)
B10	40	40	
A15	34		35
A12-CPP	29	29	29
Total	103	69	64